REVIEW PAPER

FOOD SCIENCE
RESEARCH JOURNAL

e ISSN-2230-9403 ■ Visit us : *www.researchjournal.co.in*
Volume 6 | Issue 2 | October, 2015 | 381-389
DOI : 10.15740/HAS/FSRJ/6.2/381-389

Food fortification: A complementary strategy for improving micronutrient malnutrition (MNM) status

ANJALI VERMA

Experts estimate that 2 billion people, mostly in poorer countries suffer from micronutrient malnutrition (MNM), also known as hidden hunger. This is cause by a lack of critical micronutrients such as vitamin A, zinc and iron in the diet. Actions that promote an increase in the supply, access, consumption and utilization of an adequate quantity, quality and variety of foods for all populations groups should be important. The control of vitamin and mineral deficiencies is an essential part of the overall effort to fight hunger and malnutrition. MNM impairs the mental and physical development of children and adolescents and can result in lower IQ, stunting and blindness; women and children are especially vulnerable. Fortification of food with micronutrients is a valid technology for reducing micronutrient malnutrition as part of a food-based approach when and where existing food supplies and limited access fail to provide adequate levels of the respective nutrients in the diet. The aim is for all people to be able to obtain from their diet all the energy, macro- and micronutrients they need to enjoy a healthy and productive life.

Key Words : Micronutrient malnutrition (MNM), Hidden hunger, Vulnerable, Fortification, Food-based approach, Productive life

How to cite this article : Verma, Anjali (2015). Food fortification: A complementary strategy for improving micronutrient malnutrition (MNM) status. *Food Sci. Res. J.,* **6**(2): 381-389.

INTRODUCTION

Micronutrient malnutrition (MNM) is widespread in the industrialized nations, but even more so in the developing regions of the world. It can affect all age groups, but young children and women of reproductive age tend to be among those most at risk of developing micronutrient deficiencies. They not only cause specific diseases, but they act as exacerbating factors in infectious and chronic diseases, greatly impacting morbidity, mortality, and quality of life. Deficiencies in some groups of people at special risk require supplementation, but the most effective way to meet community health needs safely is by population based approaches involving food fortification. Micronutrient interventions, and particularly fortification, have been identified by the World Bank as among the most cost-effective of all health interventions (World Bank, 1993). Micronutrient malnutrition has many adverse effects on human health, not all of which are clinically evident. Even moderate levels of deficiency (which can be detected by biochemical or clinical measurements) can have serious detrimental effects on human function. The control of vitamin and mineral deficiencies is an essential part of the overall effort to fight hunger and malnutrition. There were also reports of increased risks of stillbirths and low-birth-weight infants in iodine deficient areas (Thilly, 1980 and Beaton, 1992).

AUTHOR FOR CORRESPONDENCE

Author for correspondence :
ANJALI VERMA, Department of Food and Nutrition, College of Home Science, Maharana Pratap University of Agriculture and Technology, UDAIPUR (RAJASTHAN) INDIA
Email : anjali190191@gmail.com

The population groups most vulnerable to these micronutrient deficiencies are pregnant and lactating women and young children, given their increased demands (WHO 2000 and Black RE: Micronutrients in pregnancy. Br J Nutr., 2001). Experts estimate that 2 billion people, mostly in poorer countries suffer from micronutrient malnutrition, also known as hidden hunger. This is cause by a lack of critical micronutrients such as vitamin A, zinc and iron in the diet. Impairs the mental and physical development of children and adolescents and can result in lower IQ, stunting and blindness; women and children are especially vulnerable. Actions that promote an increase in the supply, access, consumption and utilization of an adequate quantity, quality and variety of foods for all populations groups should be supported. In 2000, the *World Health Report* identified iodine, iron, and vitamin A and zinc deficiencies as being among the world's most serious health risk factors. In addition to the more obvious clinical manifestations, micronutrient malnutrition is responsible for a wide range of non-specific physiological impairments, leading to reduced resistance to infections, metabolic disorders, and delayed or impaired physical and psychomotor development. They can directly impact communicable disease severity, as in the case of HIV, tuberculosis, and measles, and can greatly affect quality of life (Allen *et al.,* 2006).

The best way of preventing micronutrient malnutrition is to ensure consumption of a balanced diet that is adequate in every nutrient. Unfortunately, this is far from being achievable everywhere since it requires universal access to adequate food and appropriate dietary habits. From this standpoint, food fortification has the dual advantage of being able to deliver nutrients to large segments of the population without requiring radical changes in food consumption patterns. In fact, fortification has been used for more than 80 years in industrialized countries as a means of restoring micronutrients lost by food processing, in particular, some of the B vitamins, and has been a major contributory factor in the eradication of diseases associated with deficiencies in these vitamins. Because of the increased awareness of the widespread prevalence and harmful effects of micronutrient malnutrition, and in consideration of changes in food systems (notably an increased reliance on centrally processed foods), and successful fortification experiences in other regions, increasing numbers of developing countries are now committed to, or are considering, fortification programmes.

Prevalence of micronutrient malnutrition:

Micronutrient deficiencies are not always clinically apparent or dependent on food supply and consumption patterns. They are associated with physiologic effects that can be life threatening or more commonly damaging to optimal health and functioning. Iron deficiency is the most prevalent nutrition problem in the world. Productivity losses due to poor nutrition are estimated to be more than 10 per cent of lifetime earnings for individuals, and 2-3 per cent of GDP to the nation. Cost of treating malnutrition is 27 times more than the investment required for its prevention (Coalition for sustainable nutrition security for India, 2010).

In world :

Worldwide, the three most common forms of MNM are iron, vitamin A and iodine deficiency. It is estimated that just over 2 billion people are anaemic, just under 2 billion have inadequate iodine nutrition and 254 million preschool-aged children are vitamin A deficient (1-3 year). It has been estimated that micronutrient deficiencies account for about 7.3 per cent of the global burden of disease, with iron and vitamin A deficiency ranking among the 15 leading causes of the global disease burden (World Health Report, 2002).

The major micronutrient malnutrition issues affecting populations in developed and developing countries addressed in the WHO Guidelines are shown in Table 1.

According to WHO mortality data, around 0.8 million deaths (1.5% of the global total) can be attributed to iron deficiency each year, and a similar number to vitamin A deficiency. In terms of the loss of healthy life, expressed in disability-adjusted life years (DALYs), iron-deficiency anaemia results in 25 million DALYs lost (or 2.4% of the global total), vitamin A deficiency in 18 million DALYs lost (or 1.8% of the global total) and iodine deficiency in 2.5 million DALYs lost (or 0.2% of the global total) (World Health Report 2002).

In India :

According to NFHS-3 (National Family Health Survey 2005-2006) data, anemia in women (15-49 yrs) was found in urban rich 49 per cent, urban poor 59 per

Table 1 : Micronutrients deficiency conditions and their worldwide prevalence

Micronutrient deficiency	Prevalence major	Deficiency disorders
Iodine	2 billion at risk	Goiter, hypothyroidism, iodine deficiency disorders, increased risk of stillbirth, birth defects infant mortality, cognitive impairment
Iron	2 billion	Iron deficiency, anemia, reduced learning and work capacity, increased maternal and infant mortality, low birth weight
Zinc	Estimated high in developing countries	Poor pregnancy outcome, impaired growth (stunting), genetic disorders, decreased resistance to infectious diseases
Vitamin A	254 million preschool children	Night blindness, xerophthalmia, increased risk of mortality in children and pregnant women
Folate (Vitamin B6)	Insufficient data	Megaloblastic anemia, neural tube and other birth defects, heart disease, stroke, impaired cognitive function, depression
Cobolamine (Vitamin B12)	Insufficient data	Megaloblastic anemia (associated with *Helicobacter pylori* induced gastric atrophy)
Thiamine (Vitamin B1)	Insufficient data, estimated as common in developing countries and in famines, displaced persons	Insufficient data, estimated as common in developing countries and in famines, displaced persons
Riboflavin (Vitamin B2)	Insufficient data, est. to be common in developing countries	Non specific – fatigue, eye changes, dermatitis, brain dysfunction, impaired iron absorption
Niacin (Vitamins B3)	Insufficient data, estimated as common in developing countries and in famines, displaced persons	Pellagra (dermatitis, diarrhea, dementia, death)
Vitamin B6	Insufficient data, estimated as common in developing countries and in famines, displaced persons	Dermatitis, neurological disorders, convulsions, anemia, elevated plasma homocysteine
Vitamin C	Common in famines, displaced persons	Scurvy (fatigue, hemorrhages, low resistance to infection, anemia)
Vitamin D	Widespread in all age groups, low exposure to ultra violet rays of sun	Rickets, osteomalacia, osteoporosis, colorectal cancer
Calcium	Insufficient data, estimated to be widespread	Decreased bone mineralization, rickets, osteoporosis
Selenium	Insufficient data, common in Asia, Scandinavia, Siberia	Cardiomyopathy, increased cancer and cardiovascular risk
Fluoride	Widespread	Increased dental decay, affects bone health

Source: Adapted from Allen *et al.*, 2006 : Table 1.2 pp. 6-10.2

cent and in rural people 57 per cent and 3/4th young children, 1/2th of women and 1/4th of married men are anemic.

According to NNMB data, 0.6 per cent preschool children have bitot spot and 0.2 per cent has night blindness (National Nutrition Monitoring Bureau, 2006) and also according to NIDDCPA (2009-10) 70 million, 2.2 million and 6.6 million people have goiter, cretins and mild neurological deficits, respectively.

Food fortification :

Food fortification is usually regarded as the deliberate addition of one or more micronutrients to particular foods, so as to increase the intake of these micronutrients in order to correct or prevent a demonstrated deficiency and provide a health benefit. The concentration of just one micronutrient might be increased in a single foodstuff (e.g. the iodization of salt), or, at the other end of the scale, there might be a whole range of food–micronutrient combinations. The public health impact of food fortification depends on a number of parameters, but predominantly the level of fortification, the bioavailability of the fortificants, and the amount of fortified food consumed. Compared with other interventions, food fortification may be cost-effective and, if fortified foods are regularly consumed, has the advantage of maintaining steady body stores (Serdula, 2010).

Fortification is defined by the Codex Alimentarius *Principles for the Addition of Essential Nutrients to Foods* (General Principles for the Addition of Essential Nutrients to Foods, 1991) defines "fortification", or synonymously "enrichment", 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". When new foods are being introduced into a community it may be possible to modify their nutritive value through fortification to obtain the maximum effects. Multiple fortification of foods is a possible way of addressing deficiencies of two or more micronutrients at the same time in a cost-effective manner, although some organizational, technical, and micronutrient-interaction constraints need to be addressed in developing countries. Nevertheless, progress is being made, e.g., in double fortification of salt with iodine and iron (Ranganathan *et al.*, 1996). Multiple fortification has been successful in the more developed countries, particularly in fortification of cereals and infant-weaning foods (Lotfi *et al.*, 1996).

Philosophies of food fortification:

Harris (1968) has described 6 distinct philosophies of food fortification. They are as follows:

Restoration:

Restoration is the addition of essential nutrients to foods to restore amounts originally present in the natural product that are unavoidably lost during processing (e.g. milling), storage or handling.

Fortification above natural levels:

Nutrients may be added to certain types of special purpose foods (e.g., infant and geriatric foods, and foods for use in weight reducing diets) in quantities well above the natural level with intention of supplying the total nutrient requirements in the minimum amount of food consumed, perhaps in a normal daily portion of the particular food.

Enrichment with public health objectives:

The use of a food or series of foods as a vehicle for distributing nutrient supplements for the improvement or maintenance of public health. Presumably, the nature and amount of nutrient added will be linked to a demonstrated need for these nutrients in the population generally or in a significant segment of the population.

Enrichment of substitute foods to equivalent nutrient levels:

Nutritional equivalence is achieved when an essential nutrient is added to a product that is designed to resemble a common food in appearance, texture, flavour and odour in amounts such that the substitute product has a similar nutritive value, in terms of the amount and bioavailability of the added essential nutrient. An example is the addition of vitamin A to margarine sold as a butter substitute, in an amount equal to butter's natural content.

Fortification to make a food complete in itself:

Under this philosophy, each food might contain adequate amounts of the nutrients required for its metabolism. For e.g., suitable quantities of group B vitamin might be added to heavily sweetened foods to provide for the demands of carbohydrate metabolism. In such case fortification might be proportional to energy value of the food.

Addition of nutrients for non-nutritional purposes:

A few nutrients might be added for technological reasons (ascorbic acid and vitamin E as antioxidants and carotene as a colouring agent, for example).

Food fortification techniques:

Once the micronutrients to be added and the suitable food vehicle are selected, fortification is done basically in a mixing process. The goal is to deliver adequate micronutrients without adversely affecting the characteristics of the vehicle. Depending on the food processing technologies, different methods have been developed:

– Dry mixing for cereal flours and products, powder milk, powder beverages;

– Dissolution in water for liquid milk, drinks, fruit juices, and in the water to be used for making bread, pastas, and cookies;

– Spraying as in iodization of salt and corn flakes where the vitamins do not support the cooking or extrusion step;

– Dissolution in oil for the liposoluble vitamins for enrichment of oily products like margarine;

– Adhesion for sugar fortification where the vitamin A in powder form is adhered to the crystals surface by a vegetable oil;

– Coating as in rice where the vitamins sprayed over the grain must be coated to avoid the losses when washing the grains before cooking; and

– Extrusion as in rice where vitamins are mixed with powdered cereal using binding agents and extruded into whole cereal grains.

Types of fortification:

Food fortification can take several forms:

Mass fortification (World Health Organization, 2000):

Mass fortification is the term used to describe the addition of one or more micronutrients to foods commonly consumed by the general public, such as cereals, condiments and milk. It is sometimes called "universal fortification". It is usually instigated, mandated and regulated by the government sector. Mass fortification is generally the best option when the majority of the population has an unacceptable risk, in terms of public health, of being or becoming deficient in specific micronutrients.

Targeted fortification:

In targeted food fortification programmes, foods aimed at specific subgroups of the population are fortified, thereby increasing the intake of that particular group rather than that of the population as a whole. Examples include complementary foods for infants and young children, foods developed for school feeding programmes, special biscuits for children and pregnant women, and rations (blended foods) for emergency feeding and displaced persons. In South Africa (country), biscuits (food) are fortified for school children (target population).

Market-driven fortification (De Benoist, 2004):

It is sometimes called "industry-driven fortification", "open-market" or "free-market" fortification. The term "market-driven fortification" is applied to situations whereby a food manufacturer takes a business-oriented initiative to add specific amounts of one or more micronutrients to processed foods. Although voluntary, this type of food fortification usually takes place within government-set regulatory limits. Market-driven fortification can also improve the supply of micronutrients that are otherwise difficult to add in sufficient amounts through the mass fortification of staple foods and condiments because of safety, technological or cost constraints. Examples include certain minerals (e.g. iron, calcium) and sometimes selected vitamins (e.g. vitamin C, vitamin B2).

Other types of fortification :

Household and community fortification:

This approach is a combination of supplementation and fortification, and has been referred to by some as "complementary food supplementation". For example soluble or crushable tablets, micronutrient-based powder and micronutrient-rich spreads and they are especially useful for improving local foods fed to infants and young children, or where universal fortification is not possible. Major challenges to local-scale fortification programmes include the initial cost of the mixing equipment, the price of the premix, achieving and maintaining an adequate standard of quality control, and sustaining monitoring and distribution systems.

Biofortification of staple foods:

Biofortification is the process by which the nutritional quality of food crops is improved through conventional plant breeding and/or use of biotechnology. Biofortification differs from conventional fortification in that biofortification aims to increase nutrient levels in crops during plant growth rather than through manual means during processing of the crops. Biofortification may therefore present a way to reach populations where supplementation and conventional fortification activities may be difficult to implement and/or limited. The potential for plant breeding to increase the micronutrient content of various cereals, legumes and tubers. Examples of biofortification include:

– Iron-biofortification of rice, beans, sweet potato, cassava and legumes;

– Zinc-biofortification of wheat, rice, beans, sweet potato and maize;

– Provitamin A carotenoid-biofortification of sweet potato, maize and cassava; and

– Amino acid and protein-biofortification of sourghum and cassava.

Agronomic Biofortification:

Anther approach, seeks to improve the mineral content of food crops through fertilizers application. It is a strategy, along with breeding/genetic engineering, for increasing micronutrient concentrations to reduce dietary deficiencies. Especially in the case of foliar application, it is highly effective for zinc and selenium, while also effective for iodine and cobalt. For e.g., increased uptake of zinc, by crops such as wheat and increase the bioavailable zinc concentration in the edible portion of the plant.

Fortified foods:

One of the important ways that plant scientists are working to improve the lives of malnourished people in developing countries is through the development of staple crops that improve human nutrition. Some fortified foods are

Double fortified salt:

Salt has been the vehicle for the world's most successful food fortification initiative to date - Universal Salt Iodization. Double Fortified Salt is an innovative new fortified food product - delivering small but crucial amounts of iodine and iron to human beings through their diet. Keeping iodine and iron together in the salt, borrowing a technique from the food industry referred to as microencapsulation.

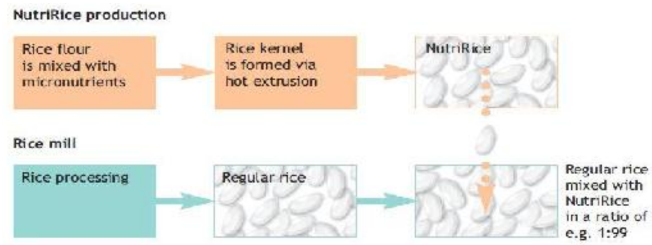
DFS is stable during storage and transportation, biologically available, acceptable to consumers easily and effective in iron deficiency anaemia. DFS premix formula- Soy btearin, Titanium dioxide, Hyproxyproplyl methyl cellulose, Sodium hexametaphosphate. Recommended shelf life -24 months.

Golden rice:

It is Genetically modified (GM) which contain high amounts of Vitamin A. Rather than end up on dinner plates, the rice will make human proteins useful for treating infant diarrhoea in the developing world. Golden rice also improved vitamin A uptake in children who needed it.

Nutri rice:

Rice fortification is an effective, easy and affordable way to improve the nutritional status of whole populations. The addition of essential vitamins and minerals to rice helps to reduce hidden hunger and improve the health of people whose staple diet consists mainly of rice. Nutri Rice is made of natural, non-GMO rice. It looks tastes and cooks exactly like ordinary rice. Fortified kernels deliver the added micronutrients to the consumer as intended. Kernels can be customized in shape, colour and micronutrient composition.



In the manufacturing process of Nutri Rice, kernels made of natural rice with encapsulated micronutrients by a hot extrusion method. The nutrients embedded in the kernel are efficiently protected from external influences during washing and cooking and are therefore retained.

Orange sweet potato :

The most successful of these "biofortified" crops in Africa is the orange sweet potato, which should serve as a model for future enhanced varieties. Orange-fleshed sweet potato varieties contain more than 50-fold more β-carotene, which is converted to vitamin A after ingestion, than the yellow or white varieties commonly eaten in African countries. Vitamin A is critical for the development of good vision.

Adapted from:

Office of Dietary Supplements, National Institutes of Health. Vitamin D and healthful diets. Dietary Supplement Fact Sheet. Available from URL: http:// dietary-supplements. info.nih.gov/factsheets/vitamind. asp (Updated 13 November, 2009 and accessed 9 March, 2010).

Advantages of food fortification:

– Food fortification does not require people to change their eating habits thus it is socially acceptable.

– If consumed on a regular and frequent basis, fortified foods will maintain body stores of nutrients more efficiently and more effectively than will intermittent

Table 2 : Other commonly used fortified foods

Food Vehicle	Fortifying agent
Salt	Iodine, iron
Wheat and corn flours, bread, pasta,	Vitamin B complex, iron, folic acid, vitamin B_{12}
Milk, margarine, yoghurts, soft cheeses	Vitamins A and D
Sugar, monosodium glutamate, tea	Vitamin A
Infant formulas, cookies	Iron, vitamins B1 and B2, niacin, vitamin K, folic acid, zinc
Vegetable mixtures amino acids, proteins	Vitamins and 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 and minerals

supplements.

– The effect of fortification is both fast and broad.

– Fortification does not affect organoleptic properties.

– Food fortification is the safest strategy as the added nutrient is provided in the diet is low but constant amounts.

– Way to deliver necessary amounts of micronutrients.

– Fortified foods are also better at lowering the risk of the multiple deficiencies that can result from seasonal deficits in the food supply or a poor quality diet.

– Way of increasing the content of vitamins in breast milk and thus reducing the need for supplementation in postpartum women and infants by supply of micronutrients to women of fertile age. In addition, fortification will reach secondly target risk groups, such as the elderly, the all and those who have an unbalanced diet.

– It is feasible to fortify foods with several micronutrients simultaneously. It is usually possible to add one or several micronutrients without adding substantially to the total cost of the food product at the point of manufacture.

– When properly regulated, fortification carries a minimal risk of chronic toxicity.

– Fortification is the most cost effective approach to prevent nutrient deficiencies.

– It can be introduced quickly through existing marketing and distribution system.

– Benefits of fortification are readily visible.

Limitations of fortification:

– They are not a substitute for a good quality diet that supplies adequate amounts of energy, protein, essential fats and other food constituents required for optimal health.

– Infants and young children, who consume relatively small amounts of food, are less likely to be able to obtain their recommended intakes of all micronutrients.

– Fortified foods often fail to reach the poorest segments of the general population who are at the greatest risk of micronutrient deficiency due to low purchasing power and an underdeveloped distribution channel.

– The nature of the food vehicle, and/or the fortificant, may limit the amount of fortificant that can be successfully added. For example, some iron fortificants change the colour and flavour of many foods to which they are added, and can cause the destruction of fortificant vitamin A and iodine. Ways of solving some of these problems (e.g. microencapsulation of fortificants with protective coatings) have been developed, but some difficulties remain.

– A thorough knowledge of dietary habits and nutrient intake in the target groups.

– A complementary educational programme is required particularly when the fortification influences organoleptical characteristics of the food.

– Food fortification is not the ultimate solution of a nutritional deficiency.

Estimating the cost-effectiveness and cost–benefit of fortification:

Food fortification is frequently more *cost-effective* than other public health interventions that have the potential to achieve the same health or nutritional outcome, such as supplementation.

The cost-effectiveness of an intervention is expressed in terms of the cost of achieving a specified outcome. Most cost-effectiveness analyses rely on a single indicator or outcome measure to reflect the change brought about by the intervention, usually a measure of nutritional status. In assessments of health interventions, the two most widely used effectiveness measures are "cost per death averted" and the "cost per disability adjusted life-year saved" (cost per DALY saved). The cost-effectiveness of fortification interventions is likely to vary considerably according to the prevailing conditions, since it is heavily dependent on the following factors:

– The food vehicle used, the storage conditions and the stability of the fortificant during storage;

– The initial level of deficiency in the population;

– Dietary patterns, especially with respect to the consumption of foods which inhibit or enhance absorption of the micronutrient of interest in the same meal;

– Marketing and processing patterns, and whether the chosen vehicle is consumed by all households in the groups likely to be deficient, including the poor and those living in remote areas.

A cost–benefit analysis compares the monetary cost of an intervention with the monetary value of a specified outcome (*i.e.* the benefit). Because cost–benefit analyses are able to compare interventions whose potential benefits or outcomes extend beyond health, they can be used to evaluate the relative merits of health interventions and other kinds of government spending. Cost–benefit analyses are thus especially helpful for advocating for increased resources for nutrition and health.

Cost-effectiveness and cost-benefit analyses have shown that:

– Both iodine and iron fortification have the potential to achieve high cost–benefit ratios, given the prevailing levels of micronutrient deficiency and the economic situation of many low-income countries.

– Food fortification with vitamin A is highly cost-effective in reducing mortality in children, as is supplementation with iron in pregnant women.

– Fortification becomes increasingly cost-effective the higher the proportion of the population in need of the intervention (Allen *et al.,* 2006).

Future challenges of food fortification :

– Create community awareness about benefits of food fortification on improvement of productivity and health in general

– Private sectors, governments and international agencies need to make commitments for investing in food fortification

– Ensure increased availability of fortified foods to the vulnerable groups of populations

– Governments and international agencies should encourage food processors to take up food fortification of their products by way of concessions or duty rebates

– Regulatory authorities in geographical regions to recommend uniform food fortification guidelines to the group countries

– Develop technologies that will produce the futuristic foods.

Summary and conclusion :

Food fortification is necessary for developed and developing countries to ensure essential nutrients in processed foods, improving their suitability for human nutrition. Vitamin and mineral fortification and supplementation policies need to be promoted as the epidemiologic, nutritional, and sociological scientific basis of human nutrition expands, specifically addressing widespread deficiencies of micronutrients essential for individual and population health. Use of other strategies such as foods suitable for fortification should be mandated under governmental responsibility for safe and healthful food products. To ensure their success and sustainability, especially in resource-poor countries, food fortification programmes should be implemented in concert with poverty reduction programmes and other agricultural, health, education and social intervention programmes that promote the consumption and utilization of adequate quantities of good quality nutritious foods among the nutritionally vulnerable. Food fortification should thus be viewed as a complementary strategy for improving micronutrient status.

LITERATURE CITED

Allen, L., de Benoist, B., Dary, O. and Hurrell, R. (2006). Guidelines on food fortification with micronutrients. World 8. Health Organization and Food and Agricultural Organization of the United Nations. Geneva: World Health Organization.

Beaton, G.H. (1992). *Effectiveness of vitamin A supplementation in the control of young child morbidity and mortality in developing countries*. Geneva, Administrative Committee on Coordination – Sub-Committee on Nutrition, (ACC/SCN Nutrition policy paper No. 13).

Black, R.E. (2001). Micronutrients in pregnancy. Br. J. Nutr., **85**(S2):S193–S197.

De Benoist, B. (2004). eds. *Iodine status worldwide. WHO Global Database on Iodine Deficiency*. Geneva,World Health Organization.

Harris, R.S. (1968). Enrichment and fortification of foods with nutrients. *J. Agric. Food. Chem.,* **16**(2): 149-152.

Iron deficiency anaemia: assessment, prevention, and control (2001). A guide for programme managers. Geneva,World Health Organization, (WHO/NHD/01.3).

Lotfi, M., Mannar, M.G.V., Merx, R.J.H.M. and Naber-van den Heuvel, P. (1996). Micronutrient fortification of foods: current practices, research, and opportunities. Ottawa: Micronutrient Initiative/International Development Research Centre/International Agricultural Centre.

National Family Health Survey (NFHS-3), (2011). International Institute of population Sciences, Mumbai, India, 2005-2006; Jan., 96 (1)

National Nutrition Monitoring Bureau (NNMB) (2006). Diet and nutrition status of populations and prevalence of hypertension among adults in rural areas;Technical Report No 24. National Institute of Nutrition, ICMR,

Ranganathan, S., Reddy, V. and Ramamoorthy, P. (1996). Large-scale production of salt fortified with iodine. *Food Nutr Bull.*, **17** : 73-78.

Serdula, M. (2010). The opportunity of flour fortification: building on the evidence to move forward. *Food Nutr. Bull*, **31**(1 Suppl):S3.

Theodore, H.T. and MD, M.P.H. Micronutrient Deficiency Conditions:Global Health Issues Public Health Reviews, Vol. 32, No 1.

The World Health Report (2002). reducing risks, promoting healthy life: overview. Geneva,World Health Organization, (WHO/WHR/02.1).

Thilly, C.H. (1980). Impaired fetal and postnatal development and high perinatal deathrate in a severe iodine deficient area. In: Stockigt JR et al., eds. *Thyroid Research VIII.* Canberra, Australian Academy of Science,: 20–23.

World Bank. Investing in health. World Development Report 1993. New York: Oxford University Press, 1993.

WHO (2000). World Health Report. Geneva: World Health Organization.

WEBLIOGRAPHY

Coalition for sustainable nutrition security for India, Leadership agenda (2010). *http://www.nutritioncoalition.in/publication.asp*

Codex Alimentarius Commission (1987). *General Principles for the Addition of Essential Nutrients to Foods CAC/GL 09-1987 (amended 1989, 1991).* Rome, Joint FAO/ WHO Food Standards Programme, CodexAlimentarius Commision (*http://www.codexalimentarius.net/download/standards/299/CXG_009e.pdf.accessed 7 October 2005*).

*http://cowbridgehs.lea.valeofgamorgan.sch.uk/*learning_resources

Office of Dietary Supplements, National Institutes of Health. Vitamin D and healthful diets. Dietary Supplement Fact Sheet. Available from URL: *http://dietary-supplements.info.nih.gov/factsheets/vitamind.asp* (Updated 13 November, 2009 and accessed 9 March, 2010).

Received : *04.09.2015***; Accepted :** *19.09.2015*