

# Food fortification to combat micronutrient deficiency disorders

## 1. Introduction

Dietary supplements and food fortification have permitted humans to consume micronutrients in amounts that are not naturally present in foods. It has been claimed that millions of lives are saved each year, and the quality of life of many more is improved by dietary supplements and food fortification. Vitamin A supplementation and iodine fortification of salt are examples of interventions that have had enormous positive impact on health in several populations. Other micronutrient supplements, like iron and zinc, show promising results as well.

In recent years a number of food items have been targeted for fortification with micronutrients. For example, sugar has been fortified with vitamin A and iron, breakfast cereals with a wide range of micronutrients, milk with vitamin D, fish sauce with iron, salt with iodine and wheat flour with iron and folic acid.

Micronutrient deficiencies prevalent in the Region include deficiencies in iodine, vitamin A, folate, zinc, vitamin D and iron. Several countries of the Region have instituted national programmes to control, prevent and eventually eliminate some of these micronutrient deficiencies.

In 2002, the Forty-ninth session of the Regional Committee for the Eastern Mediterranean adopted resolution EM/RC49/R12, in which it urged Member States to: sustain efforts and enact legislation for the universal iodization of salts for human consumption at the safe level recommended by WHO, UNICEF and the International Council for the Control of Iodine Deficiency (ICCIDD) in 2000; establish adequate monitoring and evaluation systems to measure IDD-free status of the population; commit to the rapid and comprehensive fortification with iron and folic acid of all wheat flour for human consumption; and consider strongly the fortification of edible oils and fats with vitamin A and D to overcome the widely prevalent forms of sub-clinical vitamin A deficiency disorders.

This report describes progress made in the fortification of three food items in a number of countries of the Region. These fortification activities comprise fortifying wheat flour with iron and folic acid, the addition of iodine (potassium iodate/iodide) to edible salt, and the addition of vitamin A and D to edible fat and oils.

## 2. Fortification of flour with iron and folic acid

Iron deficiency and iron deficiency anaemia have been reported as a public health problem by countries of the Region for the past several decades. Data from 1995 and 2001 show no improvement in the situation (Table 1). Even in resource-rich situations where consumption of meat and other haeme-containing food items are well documented, iron deficiency continues to persist. Current information available in the Region shows prevalence of between 15% and 73% in preschool children; 11%–40% among women of childbearing age and 14%–45% among pregnant women.

A number of factors have been cited by experts to explain this somewhat paradoxical situation, such as low intake of haeme-rich items, parasitic infections, low bioavailability of dietary iron, and dietary agents that interfere with absorption; however, there is no conclusive evidence of the role of these factors, either singly or in combination, in the persistence of iron deficiency as a public health problem in the Region.

In consideration of the multifactorial nature of iron deficiency, WHO recommends a comprehensive intervention strategy that comprises treatment of causes leading to anaemia, dietary diversification, iron supplementation for vulnerable age groups and fortification of staple food items with iron.

The first trials of flour or bread fortified with iron go back 30 or 40 years in countries such as Egypt, Islamic Republic of Iran and Tunisia. These trials failed to show any significant impact because of unresolved technical problems at that time and, therefore, never succeeded in gathering public support. In 1978, Saudi Arabia started fortifying wheat flour with iron, folic acid and vitamin B complex.

Table 1. Anaemia rates in selected countries of the Region in 1995 and 2001

Country	Children aged 6–59 months (%)		Pregnant women (%)		Women of childbearing age (%)	
	1995	2001	1995	2001	1995	2001
Bahrain	34	48	NA	34	40	37
Egypt	75–90	25	21	26	NA	11
Jordan	NA	NA	NA	35	23	28
Iran, Islamic Republic of	>30	15–30	20–50	20–43	NA	33
Lebanon	NA	23	NA	NA	NA	NA
Morocco	27–47	35	20	46	NA	30
Oman	60	NA	54	38	15–48	40
Pakistan	65	60	45	NA	NA	23
Palestine	58–76	53	23–44	45	NA	36
Saudi Arabia	NA	15	11–19	16	NA	18
Syrian Arab Republic	53	23	49	NA	NA	41
United Arab Emirates	28–76	34	22–62	14	NA	NA
Yemen	17–66	74	NA	NA	5–36	NA

Source: WHO NA: Data not available

Between 1995 and 2001, in collaboration with UNICEF and the Micronutrient Initiative, WHO/EMRO organized a series of technical consultations that identified effective strategies for the control of iron deficiency anaemia, including the fortification of wheat flour with iron and folic acid. These consultations also examined the practical implications of flour fortification, built consensus on the flour fortification strategy and developed regional standards. A regional fund was established in collaboration with WHO, UNICEF and the Micronutrient Initiative to assist countries in the implementation of flour fortification with iron and folate.

Oman started fortifying some of its wheat flour in 1996 and was followed by the Islamic Republic of Iran, which introduced fortification of flour in one province. In 2001, the regional fund supported the World Food Programme (WFP) in fortifying flour with iron, folic acid and several B complex vitamins for bakeries providing subsidized bread to female-headed households in Kabul. Further assistance was provided to WFP to fortify flour for a feeding programme in three Afghan refugee camps in Pakistan. Since then, Bahrain, Jordan, Kuwait, Qatar and the United Arab Emirates have embarked on national scale flour fortification. Translated into coverage, an estimated 30 million people in the Region currently have access to iron-fortified bread.

It is expected that Morocco will soon begin nationwide flour fortification, and Egypt and the Syrian Arab Republic are initiating flour fortification trials at the provincial level. Pakistan has completed feasibility tests for flour fortification in the informal milling sector and for assessing the bioavailability of iron and efficacy of iron fortified flour from the large mills. In recent months, technical support was provided to Iraq, Palestine and Yemen for conducting feasibility trials of flour fortification.

The Regional Office has conducted a number of activities over the past two years in support of flour fortification. These activities also received technical and financial support from the Centers for Disease Control and Prevention, Atlanta, USA.

- A standardized anaemia survey protocol was developed to permit intercountry and intracountry comparisons of data on iron deficiency anaemia. Based on this protocol, a baseline micronutrient survey was carried out in Jordan and will be conducted in Oman in 2004.
- A computer-based training module to improve national communication strategies for the improvement of micronutrient deficiencies was introduced at the regional and national levels for wider dissemination of the concept.
- Nutrition surveillance techniques to assist Member States monitor the impact of fortified flour on the iron and folic acid status of the population were introduced at the regional level.

### 3. Fortification of salt with iodine

Iodine deficiency disorders (IDD) were not recognized as a serious public health problem in the Eastern Mediterranean Region until the mid 1980s. Iodine deficiency was believed to exist only in isolated areas, particularly mountainous areas, and few countries had conducted systematic studies to understand the public health significance of iodine deficiency disorders.

In 1990, an intercountry workshop on IDD was held to exchange experiences and to develop approaches. This was followed by the presentation of a technical paper to the Thirty-seventh session of the WHO Regional Committee for the Eastern Mediterranean, alerting the ministers of health of countries in the Region to the devastating effect of IDD on brain development and cognitive function. By late 1998, 18 countries had recognized IDD as a public health problem.

The initial strategy for the control of IDD was the distribution of iodized oil to hyperendemic areas. Later, universal salt iodization was adopted as a long-term sustainable method for the control and eventual elimination of IDD. The Islamic Republic of Iran and Syrian Arab Republic were the first countries in the Region to start iodizing salt. The first regional meeting of salt producers in the Eastern Mediterranean Region, held in 1995, led to the establishment of a regional association of iodized salt producers.

Subsequent meetings included a symposium workshop on the assessment and monitoring of IDD in countries of the Region in 1999; a regional meeting for promotion of iodized salt in April 2000, and an interregional technical consultation to promote sustainable IDD programmes in the South-East Asia and Eastern Mediterranean regions in 2003.

By 2002, 18 countries of the Region had recognized IDD as a public health problem requiring urgent attention, 16 had enacted legislation and 17 had implemented universal salt iodization programmes. Universal iodization of salt was achieved in 8 countries, and 2 countries had declared that IDD was under control as a public health problem.

In 2001 and 2002, WHO sponsored two regional training courses on the monitoring and evaluation of IDD programmes in the Islamic Republic of Iran, in collaboration with the Ministry of Health and Medical Education and the Endocrine Research Centre of Shaheed Beheshti University for Health Science. A total of 44 participants from countries of the Region attended the two courses. Based on sustained information that IDD was not a public health problem, Bahrain was selected as a reference country for a global thyroid volume reference study sponsored by WHO.

Beginning in 2002, a series of meetings were held by WHO/UNICEF and ICCIDD to identify a process for recognizing the achievements of countries claiming to have eliminated IDD as a public health problem. Information was sought from seven Member States with well-performing IDD control and prevention programmes.

At present, IDD is not considered a public health problem in Bahrain and Qatar and it is reported as under control in the Islamic Republic of Iran and Tunisia. IDD prevalence is considered mild in 8 countries of the Region (Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Oman, Palestine, Syrian Arab Republic and United Arab Emirates). IDD prevalence is considered moderate in 5 countries (Egypt, Morocco, Saudi Arabia, Sudan and Yemen). Adequate data on the prevalence of IDD are lacking in Afghanistan, Iraq, Pakistan and Somalia.

### 4. Fortification of fats and oil with vitamin A and D

Vitamin A deficiency disorders (VADD) are a problem of public health significance in several countries of the Region. These disorders affect large numbers of preschool and school-aged children and women of childbearing age. The human impact in terms of suffering, mortality and performance deficits, and the economic impact in terms of burden of disease and productivity deficits, both warrant urgent attention to correct VADD.

In 2002, the United Nations General Assembly Special Session on Children established the goal of elimination of vitamin A deficiency disorders by 2010. In order to meet this goal, a multi-pronged strategy for the control and prevention of vitamin A deficiency disorders is required:

- Infection control: administration of high-potency vitamin A capsules in established cases of VADD;
- Dietary diversification;
- Prophylactic treatment (supplementation): use of national immunization days to distribute vitamin A capsules to pre-school children;
- Disaster relief: provision of vitamin A to the victims of disaster;
- Fortification: food fortification, particularly the fortification of fats and oils, as a direct, effective and sustainable way to improve the intake of vitamin A by the population.

The conventional functional and biochemical indicators for VADD are night blindness in children aged 24–71 months and low levels of retinol in serum and human milk. An under-five mortality rate of 50 per 1000 live births or more in a country is also considered indicative of the presence of VADD.

Available information, based on a serum retinol level of  $<20 \mu\text{g/dl}$ , indicates the prevalence of sub-clinical forms of vitamin A deficiency disorder of around 10% in Egypt and Syrian Arab Republic; 17% in Jordan; 20%–30% in Oman and Pakistan; 40% in Morocco and over 60% in Yemen. Additional epidemiological data on the magnitude of VADD among populations of the Region are limited and are not considered representative.

Vegetable oils are suitable vehicles for vitamin A and D fortification as they are part of the daily diet of most populations in the Region. Moreover, as vitamins A and D are fat soluble, they can be uniformly distributed in oil without need for elaborate equipment.

Based on 1999 Food Balance Sheets prepared by the Food and Agriculture Organization of the United Nations (FAO), the average availability of vegetable oils and fats in the Region is 28.6 grams per person per day, slightly higher than the world average of 26 grams per person per day. This average varies from a low of 16 grams per person per day in Egypt to as high 57 grams in Tunisia. Moderate levels (25–30 grams) are available in the Islamic Republic of Iran, Morocco, Pakistan and United Arab Emirates, and slightly higher levels (40–50 grams) in Jordan, Saudi Arabia and Syrian Arab Republic.

The consumption ratio of solid to liquid vegetable oil in the Region is estimated at 50:50, with a higher percentage of solid vegetable oil (*ghee*) consumption in Pakistan (90%), moderate consumption in Egypt and Jordan (45% and 55%, respectively), and low consumption in Oman and Saudi Arabia (15% and 5%, respectively).

At the average consumption of 28.6 grams and a fortification level of 60 international units (IU) per gram, a daily intake of 1716 IU of vitamin A, or 85% of the recommended daily intake (RDI), could be provided per person per day. Even taking into consideration vitamin loss, this level of fortification will provide at least 60% of the RDI for vitamin A.

The cost of fortification for the entire Region is estimated to be US\$ 20 million per year or US\$ 0.004 per litre of oil. Roughly estimated, this represents approximately 0.005% of the total cost of producing edible oil. This calculation is based on the cost of 1 tonne of crude sunflower oil (US\$ 500), the refining cost (US\$ 50–90), the packing cost (US\$ 60–110), and the fortification cost (US\$ 4).

In 2002, the Regional Office organized an intercountry workshop to review wide-ranging technical issues related to fat and oil fortification. An important outcome of the workshop was the development of national plans of action among Member States for the fortification of oil and fat with vitamin A and D.

Ten countries have developed national action plans for the fortification of oils and fats with vitamin A and, in some places, also vitamin D. The overall objective in 70% of the action plans was to reduce the prevalence of VADD in the population, particularly among women and children. Fortification of oils

and fats was identified as part of a comprehensive strategy to control and prevent VADD in over 80% of the action plans; only 20% mentioned fortified oils and fats as the main measure for the control of VADD. Available information indicates that fortification of oils and fats with vitamin A follows specific standards in only 20% of the national action plans.

## **5. Conclusions**

### **5.1 Flour fortification**

Evidence of the public health benefit of consuming flour (or any carbohydrate staple) fortified with iron for the purpose of preventing or controlling iron deficiency is still limited. With the exception of folic acid fortification, which prevents neural tube defects, fortification efforts have yet to yield conclusive evidence of any kind. The body of available knowledge regarding the principles and practice of fortifying flour with iron (and other micronutrients) needs re-assessment, and information on the long-term effects of continuing high intakes of flour fortified with iron should be collected.

The exact proportion of anaemia caused by iron deficiency has remained a subject of speculation among public health specialists. A national survey in Jordan conducted in mid 2002 reported that 22% of the women surveyed and 10% of children under five years were suffering from iron deficiency anaemia. A study in Bahrain reported that while over 51% of the population studied was anaemic, only 24.5% of the patients suffered from iron deficiency. Most of the flour fortification projects in countries of the Region were started without the benefit of any baseline epidemiological information on iron deficiency.

The costs of premix/feeders in Bahrain, Jordan, Kuwait, Qatar, Saudi Arabia and United Arab Emirates, are currently paid by the national authorities. In Oman and Morocco, they are paid by the national millers association. In other Member States, where bread consumed by the masses is heavily subsidized, sustainable funding sources for premix need to be identified.

Food-based strategies to treat and prevent micronutrient deficiencies should be the eventual goal of public health interventions. The importance of whole diets (as opposed to supplements or single-nutrient fortification) for the prevention of chronic diseases must be reinforced. Equal emphases must be put on food supplementation, food fortification and dietary diversification.

### **5.2 Salt iodization**

Available data show that the national IDD prevention and control programmes in several countries of the Region are not performing at satisfactory level. The two major constraints are lack of adequately iodized salt at the household level and absence of effective national quality control and monitoring systems. Unavailability of adequately iodized salt has been reported from resource-rich and resource-poor Member States. More emphasis needs to be placed on improving performances of the national IDD control and prevention programmes and coordinating with UNICEF to provide the necessary technical support to countries with underperforming IDD control programmes.

The Regional Office is collaborating with UNICEF and ICCIDD in planning assessment visits to countries that have achieved success in the elimination of IDD.

### **5.3 Fortification of oils and fats with vitamin A and D**

With the gradual reduction in the number of National Immunization Day campaigns, currently the most effective means of providing vitamin A to populations, routine maternal and child health services are expected to assume the main role of providing vitamin A to the public. However, additional effective routes of providing vitamin A (and D where required) to vulnerable populations should be identified.

Fortification of fats and oils with vitamin A and D holds much promise; however, a number of technical, operational and financial hurdles need to be overcome. While laboratory studies provide valuable information on the stability of vitamin A under various conditions of storage and use, the conditions encountered at the consumer level must also be taken into account.

Stability studies on vitamin A in fortified vegetable oils conducted in temperate countries have shown positive results. However, studies within the Region, for example in Morocco, have shown that exposure to light was the most important factor affecting vitamin A stability during storage. In several parts of the Region, where temperatures are often high and sunlight is abundant, both the light and temperature factors need to be examined more closely. Similarly, studies carried out in temperate countries on the shelf-life of fortified oil may not reflect the situations encountered in this Region, where storage of oil for a year or more is generally acknowledged as common practice. The positive effect of antioxidants on the stability of vitamin A remains a grey area, as each oil responds differently to antioxidants.

National plans to fortify oil and fats with vitamins A and D are in their infancy in the Region. While providing support to strengthen these activities, the Regional Office should also alert countries to the need to understand the epidemiology of vitamin A (and D) in the population as well as the political, economic and public health implications of the fortification approach.