Report on the

Intercountry workshop on oil fortification: a simple and effective measure to eradicate vitamin A and D deficiency in the Eastern Mediterranean Region

Muscat, Oman
24–26 June 2002
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EXECUTIVE SUMMARY

Consensus statement

The participants of an intercountry workshop on Oil fortification: a simple and effective measure to eradicate Vitamin A and D deficiency in the Eastern Mediterranean Region held in Oman from 24 to 26 June 2002, and representing ten Member States, six major edible oil producers, three international premix manufacturers and five international organizations, agreed the following principles:

?? Based on clinical and/or sub-clinical indicators, vitamin A and D deficiencies are recognized as public health problems affecting the populations of several countries of the Region.

?? In order to meet with the goal of elimination of vitamin A deficiency disorders by 2010, set by the United Nations General Assembly Special Session on Children in 2002, a multi-pronged strategy for the control and prevention of vitamin A deficiency disorders comprising treatment, prophylaxis, dietary diversification and food fortification is required.

?? Oil fortification should be part of an overall strategy to significantly improve vitamin A intake by the population.

?? Achieving this vision will involve coordinated action at national and regional levels.

Recommendations

To Member States

1. Initiate and expand dialogue among public and private sectors, non-governmental organizations and consumer associations through planned advocacy and partnership at all levels to ensure mandatory fortification.

2. Designate a national core group to further develop the recommendations and actions discussed in the country plans of action.

3. Develop a strong communication and social marketing programme to create awareness and product identity using a logo to create the image.

4. Prepare a three to five year programme identifying priority actions for both public and private sector to enable fortification.

5. Design the financing programme and its operating cost in a sustainable manner.

6. Review and recommend financial incentives for fortification.

7. Recommend tariffs and tax exemption policies to support fortification.

8. Develop a monitoring framework to evaluate the effectiveness of the fortification programme.

9. Document lessons learned from implementing fortification programmes in different country situations.
10. The participants recommended that, within six months time, a regional technical committee be formed with representatives from Member States, the World Health Organization (WHO), United Nations Children’s Fund (UNICEF), the Micronutrient Initiative (MI), the United States Agency for International Development (USAID), other international organizations, edible oil producers and vitamin premix manufacturers. The technical committee should prepare a regional plan comprising the following actions:

10.1 Develop standards, regulations, guidelines and quality assurance for fortification of oils and fats and propose these for endorsement by regional bodies such as the Gulf Cooperation Council (GCC) and the South Asia Association for Regional Cooperation (SAARC), regional standards and specification authorities, regional health and municipal authorities, and national governments. Given the wide variations in the types of consumption and levels of vitamin A and D in oils and fats in the Region, each country should determine its own types and levels of fortification.

10.2 Recommend mechanisms to reduce cost, enhance supply and create demand of fortified fats and oils.

10.3 Develop a joint procurement policy to secure optimum prices and quality of vitamins.

10.4 Develop a regional logo based on expertise available in the Region.

10.5 Identify regional centres of excellence (reference laboratories) for monitoring of vitamins in fortified products and provide them with technical assistance.

10.6 Review progress of the programme in the Region in two years time through regional consultation.
1. **INTRODUCTION**

An intercountry training workshop on Oil Fortification: A Simple and Effective Measure to Eradicate Vitamin A and D Deficiency in the Eastern Mediterranean Region was held in Muscat, Oman from 24 to 26 June 2002. The workshop was jointly organized by World Health Organization (WHO) Regional Office for the Eastern Mediterranean (EMRO), the Micronutrient Initiative (MI), United Nations Children’s Fund (UNICEF) Regional Office for Middle East and North Africa (MENARO) and the Department of Nutrition, Ministry of Health, Oman. Participants attended from Bahrain, Egypt, Islamic Republic of Iran, Jordan, Morocco, Oman, Pakistan, Saudi Arabia, Syrian Arab Republic and Republic of Yemen. Also attending were representatives from six major edible oil manufacturers in the Region, from three international premix manufacturers, and from the Health Ministers’ Council for Gulf Cooperation Council States, Micronutrient Operational Strategies and Technologies (MOST) and United States Agency for International Development (USAID).

The objectives of the workshop were to:

- assess the current status of edible oils and fat fortification with vitamins A and D in Member countries of the Region, and to share related successes, constraints and country experiences;
- explore the feasibility of oil fortification;
- identify the appropriate technology for edible oil and fat fortification with vitamin A and D in countries of the Region;
- identify mechanisms for utilizing the public food distribution system for the delivery of fortified edible oils and fats, especially to the economically vulnerable population segments;
- identify necessary support means including advocacy, quality assurance, monitoring, evaluation, regulation and enforcement.

The workshop consisted of three elements: plenary technical presentations by experts in various disciplines; thematic group discussions in the four areas of advocacy and communications, technical issues, standards and monitoring, and resource and financing requirements; and country-based working group preparation of county plans of action. Group reports were presented and discussed in plenary sessions and are included in this report.

Dr. A. Al Ghassani, Undersecretary for Health Affairs, Ministry of Health, Oman welcomed the participants and delivered the inaugural message from His Excellency Dr. Ali Bin Moussa, Minister of Health, Oman. In his message Dr. Moussa emphasized that despite well-developed, successful and comprehensive health care for the population, problems such as micronutrient deficiencies and malnutrition continued to affect health, especially of children. As a consequence, the control and prevention of micronutrient deficiencies were important activities of the Ministry of Health.

Recent studies conducted by the Ministry of Health among school children in Oman indicated that 11% of children between the ages of 6 and 10 years suffered from vitamin A deficiency, primarily of a sub-clinical nature. As a result of this finding, children between 9
and 15 months, and mothers after the second week postpartum, were provided with vitamin A capsules. A study was also conducted to measure the level of vitamin A in women’s breast milk.

Because of the deleterious effect of vitamin A deficiency on pulmonary infections, the Ministry of Health has adopted a permanent strategy to ensure that the population consumes an appropriate amount of vitamin A through the consumption of common foods. To highlight the importance of adequate intake of vitamin A through food, specialists from the Ministry of Health recently organized a workshop jointly with representatives from the Ministry of Regional Municipalities, Environment and Water Resources, from the Ministry of Commerce and Industry and from the oil-producing sector. The private sector subsequently took the initiative of adding vitamin A and D to edible oils at its own expense. Dr Moussa noted that a strong collaboration between community and private sector has always existed in Oman which has further helped to promote positive health for all. He concluded his message by expressing his thanks to the international organizations both for efforts in supporting several health and nutrition activities in Oman and for organizing the workshop.

Dr Ibrahim Abdel Rahim, WHO Representative in Oman, delivered a message on behalf of Dr Hussein A. Gezairy, WHO Regional Director for the Eastern Mediterranean. After welcoming the participants and thanking the Minister of Health for agreeing to host the workshop, Dr Gezairy expressed his gratitude to the Micronutrient Initiative for its unstinting support in promoting micronutrient nutrition within the Region’s population. He also thanked the representatives from the edible oil-producing sector, who were attending the workshop at their own expense. Dr Gezairy pointed out the historic nature of the workshop which, for the first time in the Region, had gathered all the key players involved in the promotion of fortifying edible oils and fats with vitamins A and D.

Dr Gezairy emphasized that micronutrient deficiencies, mainly iodine, vitamin A and iron, were widely prevalent in the Eastern Mediterranean Region. Elimination of iodine deficiency diseases through use of iodized salt had been a success in countries of the Region. A number of workshops and expert consultations in recent years have focused on the issue of anaemia, a continuing significant public health problem in Member countries. Many have developed active programmes to fortify wheat flour with iron and folic acid to remedy the situation.

Vitamin A deficiency (VAD) disorders, although not as obvious as iodine and iron deficiency disorders, existed throughout the Region, especially in sub-clinical forms which are known to greatly increase morbidity and mortality risk. Eye signs were only the tip of the iceberg in VAD disorders. Mortality risks due to VAD disorders increased long before eye signs were present, with pregnant women and young children less than five years of age being at highest risk.

Among the several alternative strategies considered for the mass control and prevention of vitamin A deficiency, fortification of edible oils and fats with vitamins A and D had been practiced in several parts of the world for decades and has been considered an important and sustainable strategy for improving nutrition. Vegetable oils and hydrogenated vegetable oils
have been the most common source of fats in the diets of people, particularly those belonging to poor communities. In several countries of the Eastern Mediterranean Region, vegetable oil and hydrogenated vegetable oil have been provided to poverty-afflicted people through the public distribution system or through cooperative food stores. As a consequence, oils and hydrogenated oils were excellent media for supplying vitamins A and D to economically vulnerable segments of the population. Further, technological measures were fully developed to fortify oils and fats with vitamins A and D in a manner and to such levels that the vitamins could withstand the high temperatures of normal frying and cooking practices common to these areas. Finally, organoleptic tests conducted throughout the world, in both developed and developing countries, had indicated that fortification does not produce any change in the organoleptic qualities of fats and oils.

In concluding, Dr Gezairy stated that this workshop had been organized to assess the status and scope of oil and fat fortification in Member States and to encourage greater involvement of the edible oil producing sector in improving availability and consumption of vitamin A and D fortified oils and fats. As such, the focus of the workshop was the wider dissemination of available information on the fortification of oils and fats.

In his message, Mr Venkatesh Mannar, President of The Micronutrient Initiative, welcomed the participants and commended the cooperation of the national governments of the Eastern Mediterranean Region, the participating edible oil producers, UNICEF and WHO. Mr Mannar praised the efforts of the Government of Oman for bringing the workshop to fruition. Mr Mannar explained that the Micronutrient Initiative (MI) was an international non-profit organization, sponsored by the Canadian International Development Agency (CIDA), the World Bank, UNICEF and other international agencies. MI’s mission was to stimulate and support national actions to eliminate micronutrient malnutrition thereby assuring universal coverage and sustained impact on the health and well being of the population.

Mr Mannar noted that micronutrient deficiencies were among the major causes of death and disability in the developing world, particularly among women and children. In addition to the human and financial costs associated with health care, disability and premature death, micronutrient deficiencies also resulted in tremendous economic loss due to reduced productivity and impaired cognitive power. Therefore, the workshop served to promote a mechanism to provide an essential nutrient to millions of people in the Middle East and North African Region: vitamin A through the medium of cooking oils and fats. The international commitment to do so was there. Leaders at the recent United Nations General Assembly’s Special Summit for Children in New York in May 2002 committed to eliminating or significantly reducing major micronutrient deficiencies by the end of the decade.

Mr Mannar again emphasized that vegetable oils and hydrogenated vegetable oils were the most common sources of fat in the diets of people, particularly in those belonging to poor communities. As such, these oils were excellent media for supplying vitamin A and D to this economically vulnerable segment within which vitamin A deficiency is highly prevalent. Finally, Mr Mannar recognized the importance of public and private sector representatives working together to assess the status of oil and fat fortification in Member States, to broaden
the practice of oil fortification, and to encourage greater involvement in oil and fat fortification by the oil-producing sector.

At the conclusion of the opening session, Ms Deena Alasfour, Director of the Nutrition Department, Ministry of Health, Oman, was elected Chairperson. Dr Samer Arous, the Syrian Arab Republic, and Dr Mohamed Mansour (MI) were elected as Rapporteurs. The objectives and mechanics of the workshop were elaborated by Dr Kunal Bagchi, Regional Adviser for Nutrition, WHO-EMRO. The programme and the list of participants are attached in Annexes 1 and 2. An independent summary of the conclusions and future actions stemming from the workshop is attached in Annex 3.

2. THE MAGNITUDE OF VITAMIN A DEFICIENCY IN THE EASTERN MEDITERRANEAN REGION

Dr Kunal Bagchi

Of the two sources of vitamin A, preformed vitamin A (retinol) and the carotenoids (primarily beta carotene), it is the latter group which provides 70%–90% of the dietary intake of vitamin A in developing countries. However, retinol is estimated to be 6 times more effective than beta carotene and 12 times more effective than other carotenoids (α-carotene, ?-carotene and cryptoxanthins) in terms of bioconversion. Factors affecting the bioavailability of carotenoids may be summarized by the acronym “SLAMENGHI”:

- Species of carotenoids;
- Linkage at molecular level;
- Amount of carotenoids consumed;
- Matrix in which the carotenoids are incorporated;
- Effectors of absorption and bioconversion;
- Nutritional status of the host;
- Genetic factors;
- Host related factors;
- Interactions.

Vitamin A deficiency can be assessed by examining for signs of xerophthalmia or eye dryness but sub-clinical deficiency can only be assessed by laboratory assessment of serum retinol. Sub-clinical vitamin A deficiency is much more common and leads to greater risk of infections and death even in the absence of clinical signs of vitamin A deficiency. Attention has therefore shifted from blindness and eye care to maternal and child health care.

The public health significance of vitamin A deficiency may be defined as mild, moderate or severe based on the prevalence of one functional and two biochemical indicators. These indicators are, respectively, night blindness in children aged 24 to 71 months, serum retinol level, and human milk retinol level. Infant/child mortality may serve as a surrogate indicator of vitamin A deficiency: when a country has an under-five mortality rate (U5MR) of 50 per 1000 live births or more, it is very likely that it has VAD disorders, unless proven otherwise. Therefore, a country with U5MR greater than 50/1000 should start a supplementation programme.
In the absence of reliable clinical and biochemical survey data, ecological, nutritional and diet-related indicators may also be used to determine vitamin A status in a population. These include prevalence of breast feeding, nutritional status (stunting and wasting), low birth weight, food availability at market and household, and dietary patterns as measured by semiquantitative food frequency.

The mapping of vitamin A deficiency in the Region suggested that three countries were free of VAD disorders and three others may present with possible VAD disorders. All others were categorized as countries with VAD disorders of public health significance given clinical or sub-clinical evidence. Based on a serum retinol level of <20 mcg/dl, the prevalence of sub-clinical VAD disorders varies from about 10% in the Syrian Arab Republic and Egypt, 20% to 30% in Oman, Jordan and Pakistan, 40% in Morocco and slightly more than 60% in the Republic of Yemen.

The key components of a national strategy to control VAD disorders would include:

- Prophylactic treatment (supplementation). Treatment in established cases of VAD disorders consists of administering high-potency vitamin A capsules through hospitals and clinics. In the Region, proper treatment is hampered by an insufficient supply of vitamin A in areas of need, and by a widespread requirement for training in the recognition of various stages of VAD disorders.
- Fortification. In industrialized countries, food fortification has been an accepted strategy for improving micronutrient intake, including that of vitamin A and D. Therefore, food fortification offers a direct, effective and sustainable way to correct VAD disorders in the Region. Dietary diversification is a logical approach to the problem. However, low bioavailability of pro-vitamin A in fruits and vegetables makes it difficult to control the problem by dietary improvement alone.
- Infections control. The close association between VAD disorders and infectious diseases suggests that infection control is an effective intervention. A combination of vitamin A supplementation with immunization has theoretical and practical advantages. In many countries in the Region, national immunization days have been effectively used to distribute vitamin A capsules to pre-school children.
- Disaster relief. Finally, in many areas of the Region, victims of natural and man-made disasters are especially susceptible to hunger and malnutrition. An adequate and balanced diet, including the safe intake of vitamin A, should be provided to the victims of disaster.
3. TECHNICAL DISCUSSIONS

3.1 Vitamin A deficiency and oil fortification: an overview

Venkatesh Mannar

Current status

Vitamin A deficiency is a problem of public health significance in over 70 countries in Africa, Asia and some areas of Latin America, the Caribbean and the western Pacific. It affects large numbers of preschoolers, school-aged children and women of childbearing age. Most notably, 250 million children under 5 years of age are affected by vitamin A deficiency putting them at risk in terms of their health and survival. About three million of these children have some form of vitamin A related eye disease ranging from night blindness to irreversible partial or total blindness. The human impact, in terms of suffering, mortality and performance deficits, and the economic impact, in terms of burden of disease and productivity deficits, warrant urgent attention to correct vitamin A deficiency in all affected countries.

There has been progress in many countries in combating vitamin A deficiency, but urgent action is needed to accelerate progress and to quickly increase the number of countries bringing this potentially lethal disorder under control. Vitamin A supplementation is a very reliable and effective way to combat vitamin A deficiency and is the programme strategy that can most rapidly be implemented on a national scale to reach most vulnerable groups (children between 6 months and 5 years, and women postpartum). Vitamin A supplementation of deficient children has been demonstrated beyond any doubt to be effective in reducing mortality and illness. Supplementation protocols are well developed and enable rapid progress to be made against vitamin A deficiency in the short to medium term. Indeed, many developing countries have carried on supplementation programmes for decades.

Complementary to the supplementation of most vulnerable age groups, fortification of commonly eaten staple foods in a country increases the threshold of vitamin A intake in the population. However, fortification should be viewed as only one of a range of measures that influence the quality of food; other include improved agricultural practices, improved food processing and storage, and improved food preparation practices. Eventually, as in many developed countries, fortification could become the key intervention to deliver vitamin A on a continuous and self-sustaining basis.

Effective food fortification involves the identification of commonly eaten foods that can not only act as vehicles for one or more micronutrients but that can also be centrally processed on an economical scale. Advantageously, when fortification is incorporated into existing food patterns neither changes to the customary diet of the population nor individual compliance is required. Such fortification can often be dovetailed into existing food production and distribution systems. For these reasons, fortification can often yield results quickly and be sustained over a long period of time. It can thus be the most cost-effective means of overcoming micronutrient malnutrition.
The concept of nutrient fortification of staple foods was developed in the early part of
the 20th century as a means of dealing with mineral and vitamin deficiency diseases that were
prevalent in Europe and North America. Salt was iodized in Switzerland in the early part of
the century. Margarine fortified with vitamin A was introduced in Denmark in 1918. During
the 1930s and 1940s milk was fortified with vitamin A, and flour was fortified with iron and
B vitamins in a number of European countries and in North America. Consequently, in
developed countries where there is a high dependence on processed foods and industries are
streamlined and automated, food fortification has played a major role in the health of
populations over the last 40 years. Several nutritional deficiencies have been eliminated.

Food fortification has also played a major role in substantially reducing vitamin A and
iron deficiency anaemia in many developing countries. Mandatory sugar fortification in
several Central American countries has virtually eliminated VAD as a public health problem
in those areas. In India and Pakistan, it is mandatory for vanaspati ghee (hydrogenated oil) to
be fortified with vitamin A. India is also considering extending this requirement to cover all
edible oils. In the Philippines, vitamin A fortification of margarine is mandatory.

Fortification of oils and fats

Vegetable oils are suitable as vehicles for vitamins A, D, and E fortification as they form
part of the daily diet of a major proportion of the population in most countries. Similarly, in
many countries the production and refining of the oils is a centralized process. As vitamins A,
D and E are fat soluble, they can be uniformly distributed in oil without need for elaborate
equipment. The stability of vitamin A is greater in oils than in any other food and oil
facilitates the absorption of vitamin A by the body.

Vitamin A acetate and palmitate are the most common market forms of vitamin A
available for oil fortification. Both have superior stability compared to pure retinol. Hoffman
La-Roche and BASF are the dominant suppliers of these market forms worldwide. Currently
the palmitate oil products are predominantly used in commercially available fortified
products.

The technology required for the addition of vitamin A to refined oil is simple and low
cost. Dosing technology for adding antioxidants and other micro ingredients to oil is routine.
While for many oils a temperature from 40°C to 50°C is required for uniform mixing, the
threshold to ensure uniform liquid state for soybean oil and other seed oils is about 25°C.
Mixing is easily accomplished in an agitation tank in one hour.

Stability of vitamin A in oils and fats

The Micronutrient Initiative contracted the Food Science Department of the University of
Guelph, Canada, and the Central Food Technology Research Institute, Mysore, India to
determine the storage stability of vitamin A in fortified cooking oils and the retention of
vitamin A in hydrogenated and soybean oils during cooking. The findings of the studies
conducted during 2000–2001 are summarized below:
Oil samples protected from light retained from 78% to 100% vitamin A after 24 weeks of storage.

Exposure to light was the major factor affecting vitamin A stability resulting in greater than a 50% loss within 4 weeks.

Temperature and packaging had a less significant impact on vitamin A stability.

Vitamin A in soybean oil and in hydrogenated oil was relatively stable when the oils were used in traditional cooking recipes:
- 62% to 74% vitamin A retained after pan frying paratta and cutlets;
- 57% retained after cooking dhal channa for 45 minutes;
- 64.5% retained after deep fat frying five batches of potatoes.

**Level, safety and cost of fortification**

The recommended level of oil fortification is 60 IU/g. This level of fortification can deliver from 360 IU (18% safe level\(^1\)) to 2520 IU (126% of safe level) at an average consumption level of 10–70 grams of oil per day assuming normal storage and cooking losses. This is far below the United States Recommended Daily Allowance (USRDA) of 3333 IU and has a significant factor of safety when compared to the NOAEL (No Observed Adverse Effect Level) of 10 000 IU/day and the LOAEL (Lowest Observed Adverse Effect Level) of 30 000 IU/day.

If we assume fortification at 60 IU/g, fortificant will cost US $3.60/tonne. Adding US $0.20 for associated expenses, the total cost of fortification to the refiner would be US$ 3.80/tonne. Annual per-person cost, depending on consumption, would range from US$ 0.014 cents to provide 18% safe level to US$ 0.098 cents to provide 126% safe level. Table 1 shows the projected impact of oil fortification on vitamin A intake in the Eastern Mediterranean Region based on each country’s current daily consumption of oils and fats.

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\(^1\) WHO safe level of 2000 IU/day
Table 1. Projected impact on daily intake of vitamin A with oil and fat fortification at 60 IU/g assuming 40% loss prior to consumption

<table>
<thead>
<tr>
<th>Country</th>
<th>Daily fat and oil consumption (g/day)</th>
<th>Potential vitamin A intake at 60 IU/g fortification (IU/day)</th>
<th>Vitamin A intake assuming 40% loss prior to consumption (IU/day)</th>
<th>Intake as percent of WHO safe level of 2000 IU/day (%)</th>
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</table>

Key issues related to addressing vitamin A deficiency in the Middle East and North Africa through fortification of oils and fats

Vegetable oil and hydrogenated vegetable oil remain the most common source of fats in the diet of people, particularly those belonging to poor communities. In several countries of the Eastern Mediterranean Region, oil and hydrogenated oil are given to poverty affected people through the public distribution system or through co-operative food stores. Therefore, these oils are an excellent vehicle for supplying vitamins A and D to the economically vulnerable among whom vitamin A deficiency is highly prevalent.

Effective use of this strategy calls for a strong public-private collaboration to assess the status of oil and fat fortification in Member countries, to establish the practice of oil fortification widely, and to induce greater involvement of the oil-producing sector in oil and fat fortification programmes. Such a coalition of public and private sector partners will be beneficial to all. Private sector partners will benefit not only from improved performance in the marketplace but also from demonstrating a social as well as an economic interest in the country. It will assist governments in meeting their mandate to improve the lives of their people. It will allow national and international development agencies to provide the technical support and seed money in an efficient, economic way.
The following steps are recommended to take this important initiative forward in the Region:

1. Undertake advocacy and awareness raising in countries to instigate policy and programme action. Key sectors in government (beyond health) and the oil refining industry must be engaged in this process. Strong coalitions need to be created within countries and at the regional and global levels. International assistance efforts (technical and financial) need to be harmonized.

2. Link the oil fortification strategy with other intervention strategies like supplementation, dietary approaches and nutrition education. Oil fortification programmes should be planned to dovetail into existing food production and distribution systems with minimum disruption and cost.

3. Institute regional standards and trade mechanisms for fortified oils and fats including a distinction between food and non-food uses.

4. Monitor and enforce oil quality (vitamin A content) through regulation. Intersectoral and international mechanisms of cooperation and coordination should be established to control the distribution and marketing of fortified oils and fats.

5. Use all available media to educate the population on micronutrient deficiencies, and on the importance and safety of fortified foods. The importance of social communication cannot be over-stressed. All consumers should be educated to demand a better product and to accept a slightly higher price for that product.

6. Institute specialized training in assessment, fortification, quality control, and monitoring/evaluating procedures. Whatever the external input, nothing can succeed without an adequate nucleus of well-trained nationals.

7. Implement effective monitoring of process and outcome variables. Measurement of food quality and fortificant levels in the foods at different stages from production to consumption is an essential step in ensuring that adequate quantities of the nutrient are reaching the population. This must be combined with periodic estimation of clinical and biochemical indicators to evaluate the impact of the intervention. Programmes should be envisioned as long term with evaluation as an essential component to identify progress, problems and needs.

Discussion

- The reason for paucity of data on VAD disorders in the Region is the difficulty in collecting, analysing and interpreting relevant data. An exchange of experiences and expertise in the field of VAD disorder assessment should be used to build this capacity in the Region.

- Clinical VAD is the visible tip of the deficiency pyramid. A rule of thumb is at a clinical VAD rate of 0.5%, it is very likely that a 30% sub-clinical VAD rate exists, as measured by biochemical indices. Sub-clinical VAD should be a priority for global action on vitamin A because of its well-established effects on child health, on development and transmission of infections, and on maternal health and nutrition.

- The assessment of VAD disorders in the Eastern Mediterranean Region does not focus only on the eye but on the overall care of the mother and child. Women and children are equally at risk for VAD disorders.
According to the U5MR, indicators or markers in VAD disorder assessment can be:

- Maternal mortality between 50 and 1000 per 100 000 live births
- Mother’s night blindness
- Child wasting and stunting.

Impact indicators can be:

- consumption, plus retinol levels
- prevalence of exclusive breastfeeding equal to or greater than 60%
- average prolonged breastfeeding of 14 months.

The NOAEL and LOAEL provide guidance as to the recommended level of vitamin A fortification in oils. Based on the US Council for Responsible Nutrition (1997) and the NRC RDA (1987), the safe level of vitamin A is 30 000 IU or 10 times the RDA established at 3300 IU. Many countries fortify to a level of 30%–40% of the national recommended dietary intake (RDI). Given the consumption level in the Region, a fortification level of 60 IU/g of oil will provide approximately 70% of the RDI for vitamin A.

As with vitamin A, vitamin D can be added easily to oils. The level of fortification depends on the extent of vitamin D deficiency and the percentage of RDI to be met through fortification. Vitamin D can be added safely in the presence of vitamin A, as there is no negative interaction. It is generally accepted that the fortification level of vitamin D is 10 times less than vitamin A in terms of IU.

Two forms of vitamin D are commercially available: D2 (ergocalciferol) and D3 (cholecalciferol). Both are destroyed by atmospheric oxygen at ambient temperature but D3 is relatively more stable than D2, possibly due to the fact that it has one less double bond. Both vitamins can be destroyed relatively rapidly if exposed to light, and are adversely affected by acids. Due to the presence of double bonds in their structure, both forms are subject to isomerization and the isomerization rates are almost equal for both forms. Preparations of vitamin D in edible oils are more stable than the crystalline forms. Usually vitamin D is provided for commercial use as an oil preparation or stabilized powder containing an antioxidant (normally tocopherol). The preparations are usually provided in light-proof containers with inert gas flushing.

As part of a Teheran Lipid and Glucose Study in 2000, serum levels of 25-hydroxy-vitamin D (25-OH-D) were measured in 1172 subjects aged 3 to 69 years. The subjects were selected by cluster random sampling from an urban district of Teheran. Measurement of 25-OH-D was performed in fasting serum samples by competitive protein binding technique. Serum levels of 25-OH-D followed a non-Gaussian distribution in both sexes. Across all age groups, mean 25-OH-D was lower than 30 ng/ml in females and higher than 30 ng/ml in males, indicating that females were at higher risk for vitamin D deficiency. Vitamin D deficiency, defined as a serum 25-OH-D level less than 20 ng/ml, was prevalent in all age groups especially in middle-age men (>30 years) and in young girls and women (10–40 years). The highest prevalence rate (75%) was found in females aged 10 to 29 years. Considering the increasing proportion of old people in the general population and the importance of bone health in the quality of life, the authors urged policy makers and health professionals to pay attention to the problem of metabolic bone disease (caused by vitamin D deficiency).

Vitamin D deficiency has been recognized as a public health problem for neonates and infants in Morocco and a supplementation programme has been in place since 1971. A
dose of 600 IU is given at birth and again at 6 months of age. In 1991, a national survey showed that 2.5% of children under two years of age presented radiological rickets, indicating that vitamin D supplements were not reaching the target population. Based on these findings, the Ministry of Health adopted two strategies:

– A targeted strategy for the prevention of rickets focusing on children under one year of age with the objective of providing two doses to more than 80% of the target population;
– A population-based strategy based on fortification of edible oils with vitamins A and D.

The assertion that a fortification cost approximating US$ 1.00 per tonne is cheap and that such cost may not significantly affect the profit margin of oil manufacturers is subject to challenge. The oil manufacturing industry’s profit margin is narrow, usually considered in terms of cents and not in dollars. Thus, most of the fortification cost may need to picked up by consumers. However, the cost of social marketing and a strong media campaign to create consumer demand should be borne by governments.

3.2 Vitamin A stability in fortified vegetable oils
Yukio Kakuda

Objective

A study was undertaken to determine the storage stability of vitamin A in fortified vegetable oils, to determine the stability of vitamin A in vegetable oils when stored in plastic containers and to determine the stability of vitamin A during the cooking of traditional dishes.

Materials and methods

The analysis of vitamin A was based on the high performance liquid chromatography (HPLC) procedure of Thompson et al. (1980), using a SI60 silica column with wet hexane / dry hexane /diethyl ether (49: 49: 1) as the mobile phase. A Waters system controller and auto sampler were used to run the samples at a flow rate of 2.0 ml/min, temperature at 25 °C and UV detector at 325 nm. Vitamin A was quantitated by measuring its peak area in the sample and comparing it to an all-trans retinyl palmitate standard curve.

The storage study used five vegetable oils: soybean, sunflower (refined bleached and deodorized, purchased in Canada); groundnut and mustard oils (Dhara Brand, double filtered shipped from India); and hydrogenated oil (Vanaspati Manufacturer’s Association, shipped from Pakistan). The oils were fortified with retinyl palmitate (donated by Hoffmann-La Roche Inc.) at three levels: 24 – 29 IU/g, 166 – 205 IU/g, and 305 – 349 IU/g. The oil samples were placed into glass bottles (tightly sealed, left open, or nitrogen flushed and sealed) and stored in the dark or under fluorescent lights. The storage temperatures were: 25 °C, 28 °C, 32.5 °C, 36 °C, 40 °C. Individual bottles were removed from storage for vitamin A analysis every 4 weeks for a total of six months.

For the packaging study, fortified hydrogenated oil was stored in tin cans (411 × 400, double seamed with soldered side seam and coated interior). The fortification levels were 30
IU/g, 178 IU/g and 312 IU/g of retinyl palmitate and the storage temperatures were 25 °C, 28 °C, 32.5 °C, 36 °C, 40 °C. Fortified soybean oil was placed into bottles made from the following five types of plastic:

- high density polyethylene (HDPE-Opaque)
- high density polyethylene (HDPE-Brown)
- polyvinyl chloride (PVC-Clear)
- polyethylene terephthalate (PET-Clear)
- polyethylene terephthalate (PET-Brown).

The soybean oil was fortified with vitamin A to 176 IU/g or 188 IU/g, then transferred into clean, dry plastic bottles. All bottles were tightly capped and stored under light at five temperatures: 25 °C, 28 °C, 32.5 °C, 36 °C, 40 °C.

For the cooking study, fortified soybean oil was used to deep fry four batches of French fries, and five batches each of samosa, pakora and plantain chips. In addition, three Pakistani dishes (paratta, cutlets and potato beef curry) and two Indian dishes (daal channa and split peas) were prepared with fortified hydrogenated oil using shallow pan-frying, pressure-cooking or boiling. Fortified soybean oil was used to prepare eight traditional dishes: mango, chicken adobo (Philippines), yekik dich’a (East Africa), mahldoom (Middle East), green pepper and spinach (Africa), mixed vegetables (India), crab fried rice (Indonesia) and fried rice (Thailand).

Storage stability results

Fortified soybean oil protected from light and stored in temperature controlled environmental chambers showed no loss of vitamin A up to four weeks of storage. Longer storage times produced small losses and after six months, the average retention of vitamin A was still 80% to 90% for samples stored at 32.5–36 °C. Under dark conditions at 25 °C, the degradation rate was not affected by initial vitamin A levels or packaging conditions (open, sealed or N₂ flushed). After 5 months of storage at 25 °C, the percentage of vitamin A retained ranged from 90% to 98%. However, after four months of storage at 40 °C, approximately 20% of the vitamin A was lost and close to 50% was lost after six months.

When fortified soybean oil was stored under lights, the stability of vitamin A was dramatically reduced. After 4 weeks of storage, the percent retained dropped to 20%–46%. Continued storage produced a steady decrease in vitamin A levels until negligible levels remained after 6 months. Higher levels of fortification resulted in slightly slower rates of degradation, but even at a very high initial vitamin A concentration (350 IU/g), there was less than 20% vitamin A remaining after 4 months of storage under light conditions.

The results under light and dark storage conditions showed the dramatic differences between light and dark storage conditions. Because of the dominating effect of light exposure on vitamin A stability, there were no significant effects due to initial vitamin A concentration, storage temperature or packaging conditions (open, sealed, or flushed and sealed).
Groundnut and mustard oil stored in glass bottles and protected from light showed good vitamin stability. Groundnut oil after 25 weeks of storage at 25–32.5 °C retained greater than 70% of its vitamin A. Mustard oil stored under the same temperature range retained greater than 50% vitamin A after 22 weeks of storage. These levels dropped to 19%–37% retention for groundnut oil and 34%–57% for mustard oil at a storage temperature of 40 °C.

Similar to the results for fortified soybean oil, the stability of vitamin A in fortified groundnut oil and mustard oil was very poor when exposed to light. After only one week of storage under light conditions, the percentage vitamin A remaining ranged from 28%–55% for groundnut oil and 40%–57% for mustard oil. These values dropped to 0–19% after 8 weeks of storage for groundnut oil and 7%–33% after 10 weeks of storage for mustard oil. The effects of packaging conditions and storage temperature were not significant because of the dominating effect light exposure had on vitamin A degradation.

Both the intensity of light and the duration of light exposure (24 hours) in the environmental chambers were much greater than would be found in most domestic or retail settings. To determine how representative these conditions were, the stability of vitamin A in fortified soybean and sunflower oils was re-examined under more realistic storage conditions. The fortified soybean and sunflower oils were placed into clear glass bottles and stored on the bench in the laboratory. The temperature varied from 20–23 °C and the lights were off during the night. The stability of vitamin A was slightly better under these conditions. The percentage of vitamin A remaining in soybean oil ranged from 44%–56% after 4 weeks compared to 26%–33% at 25 °C in the chambers. The percentage remaining in sunflower ranged from 21% to 36% after 4 weeks on the laboratory bench compared to 11%–17% in the chamber. Again the major factor affecting vitamin A retention was exposure to light: the higher the intensity and the longer the exposure time, the greater the degradation rate of vitamin A.

Packaging stability results

The highest retention of vitamin A was obtained with HDPE-Brown and PET-Brown packaging materials. In both types of plastic bottles, there was very little degradation (<10%) during the first 30 days. However, after 100 days, retention in the PET-Brown bottles was only 40% while in the HDPE-Brown bottles it was 90%. The other packaging materials (HDPE-Opaque, PET-Clear and PVC-Clear) showed rapid vitamin A degradation rates: only 60%–70% retention after 10 days of storage and between 25% and 40% after 30 days. At 100 days, vitamin A was completely degraded in these opaque and clear packaging materials.

Cans were the best containers for protecting vitamin A from degradation because the sealed metal cans completely excluded light, oxygen and moisture. Fortified hydrogenated oil stored in cans retained 100% of the vitamin A over a 6-month period at temperatures ranging from 25 °C to 40 °C.

Cooking stability results

Two batches of soybean oil were fortified to 21 IU/g and 236 IU/g with retinyl palmitate. The oil was heated in a deep fat fryer to 170–180 °C. When a fresh batch of
potatoes was immersed in the oil, the temperature dropped to 110 °C, but as the water evaporated from the potato slices and they started to brown, the temperature increased to initial levels. After the potatoes turned golden brown, they were removed and a sample of the oil was taken for vitamin A analysis. The cooking process was repeated on three more batches of potatoes. Each batch was cooked for about 14–15 minutes. Results indicated that at both levels of fortification, approximately 82%–87% of the vitamin A was retained after cooking four batches of potatoes. The number of batches cooked had only a minor effect on vitamin A retention and initial vitamin A levels had no significant effect on vitamin A levels under these cooking conditions (Figure 1).

Vitamin A stability in fortified soybean oil was also determined during deep fat frying of samosa, pakora and plantain chips. Soybean oil was fortified at 100 IU/g for the samosa and pakora and at 121 IU/g for plantain chips. Results showed that the percentage of vitamin A retained after frying five batches of plantain chips, samosa and pakora was 93%, 80% and 75%, respectively. Despite the high oil temperatures, vitamin A retention remained very high even after repeated frying, contrary to the commonly held belief that vitamin A is rapidly destroyed by high temperatures. One possible explanation could be the cooling effect of the food samples. When wet foods such as fried potatoes or samosa are placed into the hot frying oil, the temperature of the oil drops substantially until most of the water evaporated. This hypothesis was partially confirmed by the high degradation rate of vitamin A when oil was heated without the addition of food. During heating alone, degradation of vitamin A in hydrogenated oil fortified with 26 IU/g retinyl palmitate exceeded 50% after 60 minutes and 85% after 180 minutes. Vitamin A retention was only slightly better when the initial vitamin A level was 302 IU/g (Figure 2).

Figure 1. Retinyl palmitate remaining in fortified soybean oil during the cooking of fried potatoes
Various cooking practices and traditional dishes were used to investigate vitamin A stability in fortified hydrogenated oil. Paratta, cutlets and potato beef curry from Pakistan and *daal channa* and split peas from India were cooked using shallow pan-frying, pressure cooking and boiling. The results showed that vitamin A retained ranged from 58%–83% of initial levels. The cooking time and cooking practice appeared to be important factors in determining vitamin A retention. Shallow pan-frying for 5 minutes resulted in higher retention values (average of 80%) than pressure cooking or boiling for 45 minutes (average of 60%). Fortified soybean oil used for pan frying dishes from Philippines (mango and chicken *adobo*), Africa (*yekik alich’a*, and green pepper and spinach), Middle East (*mahldoom*), India (mixed vegetable), Indonesia (crab fried rice), and Thailand (fried rice) indicated that vitamin A retention ranged from 45% to 92%.

The proportion of vitamin A transferred from the fortified hydrogenated oil into the cooked food was studied using fried potatoes. The results showed that the proportion of vitamin A transferred varies between 6% and 14% of the initial level, with higher transfer values in moderately fortified oil (25 IU/g) and in the initial batches. A higher level of fortification tended to have lower transfer values although the absolute amount in the fried potatoes was substantially greater. These results suggested that fortified vegetable oil used as a heating medium had good carry-through properties and vitamin A would be consumed with the cooked food.

**Conclusions and recommendations**

Vegetable oil is an ideal medium for vitamin A fortification. When protected from light, vitamin A retention values ranged from 80% to 90% over a 6-month storage period at temperatures from 25 °C to 36 °C. Under dark conditions, special storage measures (sealed, nitrogen flushing) are not required if stored at room temperature. Vitamin A is rapidly degraded in light. Sealed metal tins provide the most effective and affordable storage means to protect against light exposure. Dark coloured plastic containers such as HDPE-Brown also
offer excellent protection and should be used in place of clear or opaque containers. Fortified vegetable oils can be used to deep fat fry, pan fry, pressure cook, and boil foods with good retention of vitamin A. When used as a heating medium (deep fat frying), vitamin A showed good carry through properties.

Additional studies are required to determine vitamin A stability in representative samples at the consumer level. While laboratory studies provide valuable information on the stability of vitamin A under various storage conditions, these conditions of light, temperature and packaging are not the same as where the fortified oil will be used. The conditions from the processing plant, to the retailer and finally in the home of the consumer cannot be duplicated in the laboratory. Oil samples should be taken along the distribution chain and finally in the home of the consumer to assess typical retention rates.

Further, specifications for oil are set by the processing companies and are useful for predicting shelf life and quality of vegetable oils. Those specifications, particularly levels of peroxides and free fatty acids, should be tested to see how they affect vitamin A stability.

3.3 Storage and cooking stability of vitamin A in fortified soybean oil: results from trials in Morocco

Mohamed Rahmani

Objective

Recent surveys in Morocco showed a 40% prevalence rate of sub-clinical vitamin A deficiency among preschool children. The Ministry of Health initiated several measures to improve micronutrient intakes including nutrition education, social marketing, food fortification and micronutrient supplementation. One measure already implemented was the fortification of vegetable oils. The current study was designed to determine the stability of vitamin A in fortified soybean oil under storage and during normal cooking procedures.

Materials and methods

Bleached, deodorized soybean oil was fortified to 33.3 IU/g and to 66.6 IU/g. Samples were packaged in ½ litre polyethylene terephthalate (PET) bottles, stored at 20 °C or 42 °C, and exposed to three light conditions: diffuse day light, fluorescent light, and dark. This experimental design provided eight test samples. Replicate samples were left sealed and stored (under dark conditions) for six months. For the cooking study, two traditional Moroccan dishes were prepared using a pressure cooker and the common boiling method. Potatoes were deep fat fried at 180 °C for 5–6 minutes. Fortified and unfortified soybean oil was used and all dishes were sampled in duplicate.

Storage results

Levels of vitamin A fell continuously over the period of storage under all conditions. The fall was markedly significant under light conditions. Oils stored in the dark retained more than 70% of the added vitamin A after 6 months. These results were similar in all samples.
stored in the dark, independent of initial vitamin A concentration or storage temperature. On the contrary, oils stored in daylight retained only 20% to 30% of the added vitamin A after 6 months. Similar results were obtained even when the vitamin A concentration doubled. Exposure to fluorescent lighting at high temperature resulted in an almost complete loss of vitamin A (84%–90%) after only one month. Figure 3 shows the retention of vitamin A in soybean oil fortified to 66 IU/g over time. Similar changes were found in the oils fortified at lower concentration.

Oxidation status of the fortified oils stored at room temperature changed only slightly over the storage period, and remained within the limits allowed by national law. It was therefore not possible to determine the influence of oxidation on vitamin A degradation. The eight oil samples showed a small increase in peroxide value throughout the storage period. No significant finding could be made regarding the effect of peroxidation on degradation of vitamin A. Similarly, only minimal changes in acidity occurred over the six-month period, and therefore no conclusion could be drawn regarding the effect of acidification on degradation of vitamin A.

Cooking results

Frying potatoes at 180 °C caused about 10% vitamin A loss. This high retention rate was only slightly affected by repeated fryings; less than 30% loss was observed after 4 to 5 fryings. Doubling the fortification level from 33.3 IU/g to 66.6 IU/g did not increase the retention rate. Boiling for about 40 minutes resulted in an loss of 44.3% to 46.4%. Pressure cooking for 30 minutes resulted in a loss of 24.2% to 27.7%. In addition to differences in
cooking time, these cooking methods differ in terms of the exposure to air they allow. It is not clear which of these two factors, duration or exposure to air, played a major role in vitamin loss during cooking.

The cooking losses found in this study were higher than reported by Favaro et al. (1991). They observed 88% retention of vitamin A in kidney beans cooked by the common method of boiling for about 90 minutes, and 90% retention in pressure cooking for about 40 minutes. The observed higher losses in this study might be due to the absence of synthetic antioxidants in the samples.

Conclusion

This study indicated that exposure to light is the most important factor affecting vitamin A stability during storage. Exposure of fortified oils to fluorescent light caused complete degradation of the added vitamin A over a six-month period. On the other hand, oils stored in the dark retained more than 70% of the added vitamin A after 6 months, independent of initial vitamin A concentration or storage temperature. Vegetable oil may be considered a good vehicle for vitamin A fortification. However, due to the high sensitivity of vitamin A to light, fortified vegetable oils must be packaged in opaque containers or stored under dark conditions.

Pressure cooking caused lower vitamin A losses when compared to the common boiling method. These losses might be further reduced if synthetic antioxidants are added to the vegetable oil prior to vitamin A fortification.

3.4 Stability of vitamin A in edible oils: results from trials in India

K.K Bhat, V.D. Sattigeri, J.A. Satyabodha and B.S. Ramesh

Objective

It is well known that the stability of added vitamin A in edible oils is dependent on several factors, most notably exposure to light and air, type of packaging, storage atmosphere, duration of storage and cooking method. In India, those with low income purchase less than one litre of oil and store it in small opaque or translucent containers for periods of a few days to a few weeks. During storage at home, the oil in these containers is partially exposed to daylight and to fluctuations in temperature and humidity. In the kitchen, the oil is used for frying, seasoning or in the preparation of curry. In India, ground nut oil and mustard oil together account for more than 60% of all edible oils consumed. Unrefined oils of groundnut and mustard are more commonly used by poor and lower middle class families. Hydrogenated vegetable oil consumption accounts for about 10% of the total. Over recent years, palmolein has become available to consumers. Against this backdrop, work was undertaken to study the stability of vitamin A and beta (?) carotene in unrefined groundnut oil, filtered mustard oil, hydrogenated vegetable oil and palmolein.
Methodology

Unrefined groundnut oil, filtered mustard oil, palmolein and hydrogenated vegetable oil were fortified at levels of 50, 100 and 200 IU/g by adding equivalent quantities of retinyl palmitate. The fortified samples were put into transparent glass bottles and placed in corrugated fibreboard boxes. Samples were drawn at monthly intervals and vitamin A and \( \beta \)-carotene were estimated by high performance liquid chromatography (HPLC); normal phase or reverse phase chromatography was employed depending on the type of extraction and the mobile phase. Storage was planned on a factorial basis \( (4 \times 2 \times 5 \times 2 \times 2 \times 2 \times 5) \) corresponding respectively to 4 oils, with and without antioxidant, 5 levels of fortification (vitamin A at 50, 100 and 200 IU/g oil, and \( \beta \)-carotene at 100 and 200 IU/g oil), 2 storage temperatures \( (27 \, ^\circ\text{C at 65% relative humidity and 38 \, ^\circ\text{C at 92% relative humidity})\), 2 types of packaging (open and closed glass bottles), 2 replicates and 5 withdrawals. To obtain a global indicator of stability, statistical analysis was applied taking into consideration all variables. Studies on loss of vitamin A during frying/cooking were also designed on a factorial basis. Four common deep fried snacks were chosen for testing vitamin A stability during frying. Four fryings were conducted and vitamin A and \( \beta \)-carotene were estimated after each.

Storage results

Considering all variables, mustard oil had the highest retention level (39.3%) while groundnut oil had the lowest (25.8%). Palmolein and hydrogenated oil had an overall retention of 37.2% and 36.2% respectively. Variation in storage condition had little impact on overall retention values. Almost identical retention values were determined for oils kept in open or closed bottles. Addition of antioxidant was not effective in offering extra protection.

Overall, the results indicated significant loss of vitamin A during storage under the experimental conditions. Maximum loss was observed during first month of storage. For example, retention of vitamin A in mustard oil and groundnut oil fell to 58% and 46% respectively after one month; after four months, retention had declined to 22% and 10% respectively. A similar trend was shown in oils fortified with \( \beta \)-carotene.

Cooking results

Deep fat frying studies revealed that variation in the stability of vitamin A was dependent not only on the oil used and but also on the nature of the fried food product. For example, from samples fortified at 100 IU/g, palmolein showed the highest retention at the end of four fryings of each of the products, with retention ranging from 61.1% (poori) to 43.8% (pakora). On the other hand, hydrogenated oil had the lowest retention values ranging from 48% (poori) to 30% (pakora). Stability of \( \beta \)-carotene was similar to that observed in oils fortified with vitamin A.

The nature of the food product affected cooking time. Bhujia and poori required shorter frying times (15 and 18 minutes respectively for all four fryings) and samosa and pakora required longer frying times (35 and 30 minutes respectively). Higher retention levels were found in all four oils than when bhujia and poori were cooked; greater loss was found in all
four oils when *samosa* and *pakora* were cooked. For example, after four fryings of *poori*, the retention of vitamin A in palmolein was 61.2%. After four fryings of *samosa*, the retention of vitamin A in palmolein dropped to 41.7%.

**Conclusion**

Statistical analysis of the influence of all variables revealed that mustard oil showed the highest retention (39.3%) and groundnut oil showed the lowest retention (25.8%) during storage under the defined experimental conditions. Use of antioxidants did not exert significant influence on the stability of vitamin A. Loss of vitamin A during deep fat frying depended on the type of food as well as the duration of frying. At the end of four fryings, loss was in the range of 40%–60%. Palmolein showed higher retention of vitamin A. Oil fortified with ? carotene in fortified oil showed similar trends in stability both during storage and frying. Based on these findings, it can be estimated that approximately 50% of vitamin A is lost from fortified oils used to fry common Indian snacks.

**Discussion**

Factors that most affect vitamin A stability in oils are oil quality and exposure to light. Quality is defined by the level of oxidizing factors such as peroxide, acidity, moisture, existence of pigments, etc. While exposure to light is the most significant factor in degrading vitamin A in refined oils, it does not work alone. Its effect is exacerbated by several elements existing in the oil itself or within the storage environment. These include the presence of oxygen, peroxide, high acidity, high humidity, pigments, trace elements, and so on. Just the same, packaging materials that are light proof or minimize exposure to light are of crucial importance to vitamin A stability.

Studies have suggested that higher concentrations of vitamin A correspond to a higher degradation rate. The reason for this finding is unclear.

Oxidation of oil is through peroxidation and not free fatty acidity. Chlorophyll pigment catalyses oxidation. Its removal is normally done through deodorization. Trace elements in oils also carry an oxidative influence, hence their removal is critical to the quality of oils.

Discrepancies in the results of the stability studies might possibly reflect differences in such variables as the quality of oil, storage conditions (whether in a laboratory or at the household level) and the quality of fortificant. Whereas the University of Guelph and the Morocco studies used refined oils and fats, the Indian study used local filtered groundnut and mustard oils. The latter may not conform to the common standards for refined oils in terms of peroxide content, acidity, humidity, etc. In addition, these oils are known to have naturally occurring antioxidants and carotenoids which are not completely removed through processing. The storage conditions also differed between the studies, essentially in that fortified products in the University of Guelph and the Morocco studies were stored in the laboratory whereas the India study mimicked household storage conditions. The quality of fortificant may also differ between studies in terms of purity, potency, antioxidants, etc.

The effect of antioxidants and whether their addition to edible oils or premix would improve the stability of vitamin A is a grey area; each oil behaves differently with
antioxidant and has its own requirement for antioxidant. It is important to find the pattern for each oil. The action of antioxidant in the presence of light was not studied and there is a need to research the optimal effect of antioxidants under differing experimental conditions.

?? The duration/turnover of commercial oil products in the Region is estimated to be between 3 to 6 months. A one-year shelf life of oil is generally acknowledged as common practice in the Region. The standard shelf life in Canada, for example, may not be applicable to the Region because of the environmental differences, particularly temperature. Therefore, any guidelines for shelf life should take into consideration site-specific temperature fluctuations. Shelf life curves need to be establish for the Region.

?? For a fortified oil product to reach consumers with the amount of vitamin A specified on the label, it appears that approximately 20%–30% more vitamin A has to be added at production. Oil producers suggest that, from a cost perspective, any loss greater than 30% over a 6-month period becomes unaffordable.

?? Light is recognized as the most significant factor affecting vitamin A stability. One way of cutting down light penetration is by using light proof or brown packaging material. Different packaging materials have different light penetration rates. The following are the most common materials using for oil packaging:

- high density polyethylene (HDPE) opaque (cannot see through) and brown (no light coming through)
- polyvinyl chloride (PVC) clear
- polyethylene terephthalate (PET) clear and brown.

?? In general, materials with brown pigment protect vitamin A from light degradation. Studies have shown that brown containers retain more than 80% of vitamin A after storage during 30 and 100 days. The best packaging material is tin cans, which has zero degradation. As PET permits penetration of both oxygen and light, research on adding a coating/brown pigment to PET is required to improve retention rate in PET containers.

?? Although light is a serious problem, oil bottles are usually exposed to light 24 hours a day for only a few days, particularly in supermarkets. To prevent this exposure, bottles could be coloured with a dark pigment or entirely wrapped. However, as consumer choice is usually guided by the look of the oil, these may not be feasible options. Research is needed to develop a UV-barrier for PET packaging materials.

?? Because of confounders, there is a problem with the reliability of these studies. For instance, there was no measurement of light intensity and no measurement of oxygen diffusion rate across the packaging materials. In future studies, these factors should be taken into account and measured in order to assess their affect on vitamin A retention, especially in view of the fact that PET permits penetration of both oxygen and light.

3.5 Vitamin A fortification of vegetable oils

*Max Blum*

*Fortification as a strategy*

Despite considerable efforts undertaken by governments, WHO, UNICEF and nongovernmental organizations, vitamin A deficiency today remains an important health problem in many countries of the world. Mainly women in their childbearing years and
children under the age of 5 years are affected. Reasons for marginal vitamin A intake and deficiency are lack of vitamin A rich foods such as milk, butter, eggs, liver and fish; and low availability of vegetables rich in pre-vitamin A carotenoids, such as carrots, pumpkins and spinach.

Four strategies are advocated to eliminate vitamin A and other micronutrient deficiencies:

- dietary diversification (horticulture, animal production)
- food fortification (staple foods)
- dietary supplementation
- nutrition education.

Each of the four strategies has its strengths and all should be employed to gain maximum efficacy. Numerous intervention studies have documented that food fortification and dietary supplementation are highly effective in reducing vitamin A deficiency, child mortality, maternal mortality and morbidity from infectious diseases.

Vegetable oils such as sunflower, soybean, canola (rapeseed) and corn oil are perhaps the most suitable food vehicles for vitamin A and the other fat-soluble vitamins such as vitamin D3 and vitamin E. At the oil manufacturing plant, oily premixes containing vitamin A and vitamin D3 are easily dissolved in pure refined vegetable oil. In case vegetable oils are not found to be the most suitable vehicle for vitamin A, other foods such as crystalline sugar, wheat flour, maize meal and milk products may be food vehicles of choice. These foods are successfully being fortified in a number of countries.

Technical issues

Vitamins are highly sensitive compounds that need appropriate protection during storage, handling and fortification. Vitamin A is particularly sensitive to oxygen, heat, light, high pH (acidity) and presence of trace metals. A combination of factors results in even more accelerated degradation. To retain potency, vitamins therefore need to be protected, at a minimum, from oxygen, light and heat.

Vegetable oils suitable for fortification should be of high purity. The peroxide value should be below 3.0 and preferably below 1.0. The oil should contain a sufficiently high amount of antioxidants, either added or naturally present as tocopherol. If the vegetable oil has been stripped of its natural antioxidants (e.g. tocopherols), either tocopherol or synthetic antioxidants such as BHT should be added to avoid peroxidative damage during storage in hot tropical environments.

Vegetable oils are usually fortified to provide between 30 000 IU and 60 000 IU of vitamin A per kg. Depending on the fortification level, a tablespoon of 20 grams of oil therefore provides from 600 IU to 1200 IU (180 to 360 retinol equivalents) of vitamin A to the consumer.
Handling the vitamin A premix

Oily forms of vitamin A palmitate or vitamin A acetate stabilized with tocopherol or BHT are available. The most important product forms include:

- vitamin A palmitate 1.7 million IU/g (stabilized with tocopherol or with BHA/BHT)
- vitamin A palmitate 1.0 million IU/g (stabilized with tocopherol or with BHA/BHT)
- vitamin A acetate 1.5 million IU/g (stabilized with tocopherol)
- vitamin A acetate 2.3 million IU/g (stabilized with BHA/BHT)
- vitamin A palmitate 1.0 million IU/g and vitamin D3 100 000 IU / g
- tailor made premixes with vitamins A, D3 and E available on request.

Vitamin A palmitate and vitamin A acetate are initially sealed under nitrogen and held under refrigeration. To use the premix, the original container is taken out of the refrigerator and gently heated in a water bath to approximately 40 °C. Only when warm is the sealed container opened and a pre-defined amount of oily vitamin A weighed into a clean container. As a next step, the pre-weighed quantity is added to a storage tank holding a defined quantity of vegetable oil. The addition rate is usually kept at a constant rate of grams of oily vitamin A premix per metric ton of vegetable oil to be fortified. The oily vitamin A is then poured into the oil holding tank under gentle agitation. Gentle agitation is carried out for at least 30 minutes to allow complete distribution of vitamin A through the oil. Care must be taken to avoid excessive agitation and air inclusion into the oil as this may dissolve oxygen into the oil.

Handling the fortified oil

From each batch of fortified oil, a sample is withdrawn and immediately analysed for its vitamin A content. If the content meets specifications the batch can be released for packaging. Packaging should take place without delay. Today the industry primarily uses high density polyethylene (HDPE) or polyethylene terephthalate (PET) bottles; metal cans (tins) and glass bottles are also occasionally used. Clear HDPE and PET bottles are not light and oxygen proof. Because the combined action of oxygen and light may lead to rapid degradation of vitamin A during storage, it is of utmost importance to store plastic bottles in lightproof carton packaging protected from direct sun exposure and heat. It is highly recommended to use light proof or stained plastic bottles to minimize vitamin A degradation during storage.

Ideally, fortified vegetable oils are labelled to indicate nutrition information, particularly vitamin A content per serving and per 100 grams of oil. Appropriate instructions on how to handle, store and use the oil should be provided. The food label may also be used to convey educational information to the consumer such as the importance of vitamin A fortified oil and vitamin A rich foods for vision and health. For proper identification and tracking, packaging should also carry information on the nature of the oil, the plant or refinery of origin, production date, shelf life and expiration date.
3.6 BASF Health and Nutrition  

*Claus Soendergaard*

With its current 92,500 employees, BASF provides expert support to its customers in such areas as dairy products, dietetic foods, dietary supplements, beverages, cereals, fats and oils, and the fortification of staple foods for health programmes in developing countries. BASF Division of Health and Nutrition is a basic producer and one of the world’s leading suppliers of nutrients, with more than 50 years of experience in the field. It supplies vitamins, carotenoids, long-chain polyunsaturated fatty acids and premixed nutrients to leading food-processing and pharmaceutical companies all over the globe.

BASF Health and Nutrition is represented worldwide through the BASF sales organization, which has sales companies or representative offices in more than 170 countries. Through its Regional Division, BASF has established business centres in Moscow, Istanbul, Morocco, Dubai, and Johannesburg. The Regional Division is supported by technical services in areas of controlling, technical coordination, strategic planning and communications, and by administrative services in areas of business management, regional marketing, and product management. The business centre in Dubai has 100 employees and covers the area through representatives in Egypt, the Islamic Republic of Iran and United Arab Emirates. It provides services and supplies in functional polymers, coating, detergent and formulators, automotive and oil industry, petrochemicals, inorganics, and agricultural products.

BASF Health and Nutrition is at the forefront of research in the area of micro-encapsulation. For example, BASF recently completed development of a particularly stable form of encapsulated vitamin A for use in the fortification of sugar and flour. This development originated from a serious technical conundrum: to prevent separation of the vitamin from the foodstuff, the particle size of the vitamin A powder must be as small as possible. However, the finer the product, the more prone it is to deterioration through oxidation. A balanced solution was achieved by using micro-encapsulation technology. The result is a vitamin A preparation that combines optimal particle size with superior stability.

Micro-encapsulation technology of vitamin A for food fortification offers the following important benefits:

- transformation of vitamin A into a free-flowing powder suitable for addition to products such as flour and sugar
- homogeneous formulation of the fortified product
- prevention of oxidation and other harmful interactions.

BASF research has indicated that cooking oil is a very suitable food for fortification with vitamin A. No specialized processing equipment is required as vitamin A mixes easily with other oils. At ambient temperatures in factory-sealed containers, vitamin A oil has rather good stability. However, its retention characteristics when mixed with cooking oil depend on the way the end product is packaged, handled, stored and used, and in particular, the temperature to which it is heated during cooking.
BASF produces routine vitamin A fortificant according to the following specifications:

- vitamin A acetate 1.5 million IU/g
- vitamin A palmitate 1.7 million IU/g
- vitamin A palmitate 1.0 million IU/g
- vitamin A propionate 2.5 million IU/g

The products are viscous yellowish oil at room temperature (20 °C), are soluble in fats and oils, comply with the current Ph. Eur., USP and FCC monographs, and are available unstabilized or stabilized with tocopherols and/or BHT. A customized fortificant and/or blending with other vitamins can also be produced. The products are packed in 1 kg and 5 kg aluminium flasks or in 25 kg and 50 kg tinplate drums. Shelf life in unopened containers is as follows:

- at room temperature (20 °C to max 25 °C)
  - vitamin A acetate up to 12 months
  - vitamin A palmitate up to 9 months
  - vitamin A propionate up to 6 months
- cool store at 5 °C (the vitamin may crystallize)
  - all products up to 24 months

Prior to use or to sampling, the products must be heated in the unopened container and homogenized:

- vitamin A acetate heated to 60–80 °C
- vitamin A palmitate heated to 40 °C
- vitamin A propionate heated to room temperature

Vitamin A must be handled in accordance with the safety data sheet.

Discussion

Additional information from Hoffmann La Roche may be found at [www.roche-vitamins.com](http://www.roche-vitamins.com) and [www.nutrivit.org](http://www.nutrivit.org).

The BASF representative in Oman may be contacted at Reem Scientific and Energy Technologies LCC Attention: Mr Muthu Kumar, obd@omzest.com

### 3.7 Overview of the edible oil market and opportunities for fortification

*Jan Wessling*

Oils and fats are the most concentrated energy sources and as such they are essential components of the diet. It is recommended that fats and oils contribute 20% to 30% of total dietary energy. (world average is 24%). Fats and oils also provide essential fatty acids that the body is unable to synthesize. The ratio of polyunsaturated to saturated fatty acids (PUFA/SAFA) also has an important effect on serum cholesterol. Fats and oils add flavour to
food and therefore enhance palatability. They act as lubricants and are key ingredients in dressing, sauces, and relishes. They serve as a heat transfer medium for cooking other foods such as meat, fish, cereals and vegetables.

Oils and fats are generally divided into two types: visible and invisible. The visible type is found in liquid oils, hydrogenated oil, butter and margarine, olive oil and animal fats. The invisible type is found in meats, wheat, nuts, sorghum and other cereals, and in industrial baked or cooked products. The total world average oil and fat consumption from all sources is 75 grams per person per day. Overall, the consumption of visible and invisible fats and oils is approximately equal: out of the average 75 grams consumed per person per day, 37 grams are the visible type and 38 grams are the invisible type.

On a world scale, the global breakdown of consumption of visible oils and fats is as follows: 63% oils, primarily soybean, palm, canola and sunflower oils; 7% edible tallow; 7% industrial lard; 6% margarine; 6% butter; 5% hydrogenated oil (vegetable ghee); 3% olive oil and 3% other. Total world consumption amounts to approximately 170 million tonnes per year, the annual value of which is estimated to be over US$ 120 billion.

Based on the 1999 Food Balance Sheets prepared by the Food And Agriculture Organization (FAO) of the United Nations, the average consumption 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 16g per person per day in Egypt to a high of 57 grams in Tunisia. Moderate levels (25–30 grams) are consumed in the Islamic Republic of Iran, Morocco, Pakistan and United Arab Emirates, and slightly higher levels (40–50 grams) are consumed in Jordan, Saudi Arabia and Syrian Arab Republic. The solid to liquid vegetable oil ratio (ghee to liquid oil ratio) in the Region is thought to be 50:50, with a higher ratio of 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).

In addition to the widespread consumption of vegetable oils in the Region, the following factors also make oils and fats good vehicles for vitamin A fortification:

- consumed by people at risk
- consumed regularly at constant amounts
- small number of production units
- vitamin A can easily be mixed with oil
- no effect on organoleptical properties
- simple fortification/addition process
- low cost (estimated at 0.005 % of total cost of oil)
- butter already contains vitamin A.

At the average consumption of 28.6 grams and a fortification level of 60 IU/g, a daily intake of 1716 IU vitamin A, or 85% of the 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. Based on a rough estimate, this cost 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).

### 3.8 Fortification technology, addition methodology and quality assurance

*Jan Wessling*

The fortification process begins with refined oil. The process of refining oils comprises degumming, bleaching, neutralizing, and deodorizing. Each step is designed to remove contaminants from the crude product such as cell residues, water, hexane, metals, dirt, free fatty acids, colour, oxides, flavours, pesticides, volatiles, etc. The processes and the outcome of each step are schematically presented in Figure 4.

In the fortification process, a known quantity of vitamin is added to the oil at any point after refining, either during or after storage, or at the filling line of the oil manufacturing chain. The vitamin A can be added in one of two ways, through a continuous process or through a batch system. In a continuous process, the premix is stored in premix tanks of 50 kg to 100 kg per 100 storage tonnes. These tanks are equipped with agitators to keep a uniform distribution of vitamin A in the fluid premix. A dosing pump that is synchronized with the flow rate of refined oil determines the amount of vitamin A added. Further blending of the premix with the refined oil takes place at an appropriate point before storage to ensure optimum distribution of the premix through the refined oil.

![Figure 4. The refining process](image)

In a batch system, a precise quantity of vitamin is added directly to a run tank equipped with agitators and mixed thoroughly for at least 15 minutes before filling. The volume of the tank determines the quantity of vitamin (premix) to add. For instance, fortification at 33 000 IU per kg (9.9 mg/kg or 9.9 g/tonne) of oil will require 99 to 100 grams of vitamin (premix) for a 10 tonne tank of oil. Both fortification processes are schematically represented in Figures 5 and 6.
The Fortification process

Continuous process

Premix tanks
50–100 kg per 100 tons storage

Storage tanks
100–("S") tons

Flow meter
Dosing pump
Static mixer

The Fortification process

Add to storage tanks (circulation)

Premix tanks
Dosing pump
100–1000 kg per hour

Figure 5. Fortification process – continuous system
Despite the simple principle of oil fortification, there are two concerns: one is related to the vitamin A concentrate and the second to the analysis of vitamins in the food vehicle. Vitamin A concentrate should be diluted in oil substrate to form a premix which is easy to handle and measure without high error risk. Dilution should conform to the highest quality control procedures and is better performed by the supplier. The premix should be stored at room temperature for a reasonable time.
Analysis of vitamin content is of two types: qualitative and quantitative. The standard method for quantitative determination is high performance liquid chromatography (HPLC). It takes 0.5 hour to prepare a sample for analysis. The cost of HPLC equipment ranges from US$ 25 000 to US$ 35 000. Special requirements to properly conduct HPLC analysis include a computer for the control of most of the more modern equipment, special skills to operate the equipment, and a temperature controlled laboratory environment. The estimated cost to analyse one sample ranges from US$ 50 to US$ 100. Quality assurance based on the quantitative method is expensive and difficult. It is only feasible for larger companies or when conducted through a centralized analytical service.

The qualitative or semiquantitative approach is based on a colorimetric method; a blue colour is produced when retinol reacts with a chromogenic reagent. The test involves saponification of the sample, extraction with petroleum ether, and a reaction with antimone-trichloride as the chromogenic reagent. The qualitative method is somewhat complicated and its usefulness is questionable.

As an alternative to these analytical tests, a quality assurance system based on strict adherence to good manufacturing practices (GMP) holds the potential to be both effective and practical. A GMP quality assurance programme might consist of the following steps:

- Prepare premix batch per production batch (use “tracer” where possible).
- **Daily** check batches prepared against batches produced.
- **Weekly** check the quantity of vitamin A used against quantity of fortified product produced.
- **Regularly** check vitamin A level through an outside laboratory.

### 3.9 Oil fortification with vitamins A and D: levels, costs, financing and economic impact

*Louis Laleye*

**Rationale for vitamin A and D fortification of oils and fats**

Vitamin A is essential for human health. Vitamin A functions in vision cell differentiation, embryonic development, spermatogenesis, immune response, taste, hearing, appetite, and growth. Vitamin A deficiency can cause eyesight problems, blindness, reduced resistance to infection and an increased risk of mortality.

Oils and fats are an important energy source in the human diet, along with carbohydrates and proteins. They can be of animal or vegetable origin. The production of vegetable oils (canola, corn, cottonseed, coconut, olive, palm, peanut, soybean, sunflower, groundnut, mustard) is high throughout the world, and increasing at a rate of 3%–4% per year. The average consumption per capita is 14 kg per person per year.

During the last decades, an important change in eating habits has taken place in many countries. The use of vegetable oils in the form of liquid oil, vegetable ghee and margarine has climbed year by year at the expense of the traditional products based on milk fat. These
vegetable products are in many respects equal to or even superior to the traditional fat products. However there is one difference between these two products that has an enormous impact on the nutritional value of the fats and oils: the vegetable products do not contain vitamin D or preformed vitamin A. Therefore, fortification of edible fats and oils with vitamin A and D has become a pressing issue.

Due to the dramatic vitamin deficiency experienced in Denmark in the early 1920s, margarines are now fortified with vitamins A and D in practically all countries. Also, most other hydrogenated oil (vegetable ghee) contains these vitamins. Although a few countries have implemented fortification by law, in most countries fortification is done on a voluntary basis. Still, there are large amounts of unfortified vegetable oils and fats on the market in some countries. The vitamins A and D deficiencies found in these same countries indicate that fortification must become general practice.

**Costs, levels, financing and economic impact**

The concerns surrounding fortified oils include product integrity, cost and affordability, feasibility and safety. However, many of these concerns may be mitigated by the fact that retinol is an oily vitamin. First, its addition to an existing edible oil causes minimal product change. From a consumer perspective, this means high acceptance. Since the fortificant retains its naturally oily state, retinol palmitate and acetate are less expensive than their encapsulated counterpart forms. Therefore the incremental price of fortifying is minimal. From an industry perspective, both cost and consumer acceptance are critical, as are the ease and low cost of in-plant implementation. Thus, the combination of these factors means that industry is able to offer a value-added product at a minimal price increment.

For both public and private sectors, price is a major marketing feature of vegetable oil. Costs per tonne for production in India are projected to vary from INR 151 (US$ 3.20) for a small 5000 tonnes/year plant, to INR 181 (US$ 3.86) for a large plant producing more than 100 000 tonne of product annually. Gross expense remains relatively large, ranging from about US$ 20 000 to US$ 32 000 annually depending on the size of the plant. However, this represents about one-third of one percent (0.003%) of the wholesale price of 1 tonne of vegetable oil (soybean). Therefore, while the absolute financial liability from the producer’s point of view is large, fortification costs are very low in the context of the total business. At a consumption rate of 10 kg oil per year, the above figures for India suggest an annual per person cost of fortification between US$ 0.03 and US$ 0.04. In terms of comparative costs with other potential vehicles for vitamin A and D fortification, oil is the least expensive. Calculations applying widely accepted levels of fortification as well as assumptions for stability indicate that oil fortification is two to four times more cost effective, per IU of vitamin A delivered, than other common food vehicles such as sugar, wheat and maize.

**Fortification cost in perspective**

If all the oil produced for food use (there is negligible use in processing industries according to Food Balance Sheet) was fortified at 60 IU/g, even assuming 40% loss prior to consumption, most countries in the Region except Afghanistan, Egypt, Sudan and Republic of
Yemen would be provided with a vitamin A intake of approximately 1000 IU per person per day. At this level of fortification, the fortificant would cost about US$ 3.30/tonne. Adding US$ 0.20 for associated expenses, the costs to fortify would range from:

?? US$ 50 000 to US$ 5 million per country, depending on total national production;
?? US$ 0.01 to provide 12% safe level\(^1\) to US$ 0.08 to provide 92% safe level per person per year.

Trade is a significant factor in the cost of fortification. While the proportion of imported oil in relation to total supply will vary depending on a number of factors, it appears that imported oil accounts for more than 65% of supply in every country except Sudan. At the same time, exports are high from the Islamic Republic of Iran and notable from Tunisia and United Arab Emirates. This suggests that importers, distributors and re-packers, as much as crushers and refiners, contribute to the total cost of oil fortification. Still, at only US$ 0.02 to US$ 0.07 per person per year, the total cost of oil fortification is relatively low, including all related contributory factors such as the cost of fortificant, storage, equipment, plant quality control/assurance, marketing and promotion.

3.10 Assessment, monitoring and evaluation

Mohamed Mansour

Assessment of vitamin A status

When dealing with the fortification of oils and fats, the issue of “assessment” must be approached from two angles. The first is the assessment of vitamin A status among populations. Results of this type of assessment are crucial for policy formation and for identifying a strategy, or a mix of strategies, to address the vitamin A deficiency problem. The second is the assessment of the oil production sector and the fortification programme. In some countries, vitamin A fortification of oils and fats is taking place but the status of these programmes needs to be established.

The earliest function identified for vitamin A was its importance in the maintenance of vision and the integrity of the cell membrane of the eye. Therefore, the earliest and most traditional diagnostic indicators of VAD at the population level were ocular signs and symptoms, grouped under the name of xerophthalmia. Among these signs are night blindness, Bitot’s spots, corneal xerosis, keratomalacia and corneal scars (Table 2).

\(^1\) WHO safe level of 2000 IU per day
Table 2. Criteria for assessing the public health significance of xerophthalmia and vitamin A deficiency, based on the prevalence among children less than six years old (WHO Expert Group, 1982)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Minimum prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical (primary):</td>
<td></td>
</tr>
<tr>
<td>Night blindness (XN)</td>
<td>1.0%</td>
</tr>
<tr>
<td>Bitot’s spot (X1B)</td>
<td>0.5%</td>
</tr>
<tr>
<td>Corneal xerosis and/or ulceration/keratomalacia (X2 + X3A + X3B)</td>
<td>0.01%</td>
</tr>
<tr>
<td>Xerophthalmia-related Corneal scars (XS)</td>
<td>0.05%</td>
</tr>
<tr>
<td>Biochemical (supportive):</td>
<td></td>
</tr>
<tr>
<td>Serum retinol (vitamin A) less than 0.35 µmol/l (10µg/dl)</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

Clinical VAD does not occur until the body’s stores of vitamin A are severely depleted. For effective prevention and control of VAD, it is recommended that intervention begins earlier, when the first signs of vitamin A depletion begin. Normal serum levels of retinol are 30 µg/dl or greater, with mean levels ranging between 45 µg/dl and 65 µg/dl. When liver stores become low, serum levels of retinol decline and become insufficient to provide the required amounts of vitamin A to peripheral tissues. Therefore, assessment of vitamin A status should include serum retinol as a sub-clinical indicator.

Assessment of the oil industry sector and fortification programme

If there is no oil fortification programme, the recommended assessment should include:

?? A survey of the extent and severity of VAD through an assessment of vitamin A status as described above;
?? A situation analysis of the oil production and/or importation, processing, distribution and consumption patterns.

This approach was applied in Morocco. Over the last 2 to 3 years, realizing the extent of sub-clinical VAD following a vitamin A survey in the country, a decision was taken to fortify oil with vitamins A and D. A situation analysis of the oil industry sector was undertaken in 2001.

If a fortification programme exists but is not effective and/or does not have a significant impact on vitamin A status in the population as indicated by survey data, the recommended assessment should include:

?? Review of oil production and/or importation, processing, distribution and consumption patterns to identify the bottlenecks that hamper successful implementation of oil fortification;
?? Review and analysis of the quality assurance programmes and procedures including internal quality control, government monitoring and inspection, food regulatory system, and enforcement.
A case in point here is Pakistan. According to the Pure Food Law of 1965, ghee manufacturers were mandated to add vitamin A to their hydrogenated oil product with a fixed amount of vitamin A, i.e. 33 IU/g or 9.9 mcg/g of product. In 1993, a study of 80 samples of ghee and oil randomly selected from the market showed that not one single sample was fortified at the required level, and that 60% of the samples contained less than half the required amount of fortificant. Some of the factors identified as contributing to this ineffective fortification included low fortificant quality, diffuse (programme) responsibility, and weak inspection and enforcement capability. Where an oil fortification programme exists and is effective, assessment should include identifying key elements leading to success, analysing programme costs, implementation patterns and procedures, and determining possible points of stress hindering long-term sustainability. Impact evaluation should be conducted to ensure sustained support for the programme.

Process monitoring

Process monitoring is defined as a management function used to track the progress of a programme and oversee, periodically, its implementation. If problems are detected, the information gathered can be used to take timely corrective action. As applied here, the objective of process monitoring is to ensure that a vitamin A fortified product contains a sufficient amount of vitamin A and that it reaches the target population. Process monitoring can occur at three levels: at the production and/or importation level, at the wholesale and retail level, and at the household level. Monitoring can be internal, through product quality control programmes implemented by producers; or external, through checks of vitamin A content and safety conducted by government agencies.

Internal monitoring by producers

Monitoring at the production level is the most crucial part of any monitoring system. It is not enough for producers to simply add fortificant to their products. They should also have a quality assurance plan and a process for monitoring their system continuously; a process that, at minimum, includes routine and periodic collection and analysis of samples to ensure that fortification meets government or industry standards. A quality assurance plan should include:

- Controls for production and mixing procedures;
- Designation of individuals responsible for specific QA activities (food sampling, nutrient analysis, equipment checks, packaging and labelling checks, storage checks);
- Established sampling protocols (frequency of sampling, method of analysis, criteria for the acceptability of results);
- An equipment maintenance schedule;
- Reports and records procedures (log books and control charts available for inspection).

As an example, an MI consultant summarized the quality assurance procedures utilized by flour mills to ensure that flour is properly enriched. The six steps identified can effectively be adapted to an oil production unit:
Use a quality feeder which ties delivery of premix to the flow rate of the oil and which will stop when the oil flow stops.

Regularly check feed rates on feeder: once per 8-hour shift is recommended.

Regularly spot test vitamin A content in oil: once per 8-hour shift is recommended.

Check premix usage against production of enriched oil: typically once a month.

Conduct quantitative testing of vitamin A: once a week at an outside laboratory.

Record all tests and make available for inspection when requested.

Some useful indicators in internal monitoring can be: number of tonnes of vitamin A fortified product per unit of time; proportion of fortified product failing to meet industry standards; amount of premix used per day in relation to amount of final product; amount and shelf life of fortificant in stock.

External monitoring by government

External monitoring by government should reveal that:

Internal QC is being carried out correctly.

Records show that government standards are consistently met.

Independent vitamin A testing verifies the producer’s reports.

Equipment is properly maintained to maximize production of vitamin A fortified products to government standards.

The level of staff training is adequate.

Some useful indicators in external monitoring are the proportion of products adequately fortified on external inspection, and the number of external monitoring (QA) checks per year. The following are some methods for data collection that should be included in external—preferably unannounced—inspections:

Observe production process;

Take random samples of the fortified food being produced;

Review the QA plan and records to ensure compliance with legal standards and corrective action taken when needed;

Inspect product packaging and labelling;

Inspect storage areas to ensure proper storage practices;

Review conditions of storage and transportation.

An example of external monitoring is that conducted by the Food Control Division (FCD) of the Guatemalan Ministry of Public Health for the Guatemala sugar fortification programme. FCD personnel take sugar samples for testing at a central laboratory. From 1991 to 1993, tests revealed that although 85%–90% of the sugar was fortified, the level of fortification was not uniform. However, under external monitoring, now more than 60% of sugar reaches homes with sufficient amounts of vitamin A.
Household-level monitoring

After ensuring that adequate fortification occurs at production level, the next step is to ensure that the product reaching consumer households still contains the required amount of vitamin A. Some useful indicators in household level monitoring are:

- Proportion of households in which fortified oil is available;
- Proportion of at-risk household members consuming an adequate amount of fortified oil;
- Proportion of samples taken at household-level that meet government requirements for vitamin A content.

The methods of data collection can be coverage, population-based surveys every two years, and in case of low results, Lot Quality Assurance Sampling (LQAS) methodology may be useful.

Impact monitoring

When “monitoring” refers to the systematic checking of conditions such as the health and nutritional status of selected target groups, it is sometimes referred to as “impact monitoring” because it is used to measure the effectiveness of interventions and the progress towards the goal. The aim of impact monitoring is to answer the question: “Did health and nutrition improve with fortification?” The question may be answered through routine reporting data and/or household and special surveys. Useful indicators include time trends in serum retinol levels and time trends in deaths, hospital admissions, etc. In Guatemala, for instance, impact monitoring was carried out through a special survey that showed that the prevalence of low plasma retinol (<20 µg/dl) in children under five years of age had been reduced, and that the prevalence of VAD was only 15% in this age group, effects mainly attributed to the availability of vitamin A in sugar.

Discussion

There is no easy way to estimate the impact of a single food when multiple foods are fortified. One method is to conduct impact evaluation on typical groups targeted primarily by each fortified food. For instance, if milk and oil are both fortified with vitamin A, a primary target for milk may be preschool children, whereas adults may be the primary target for oil fortification. Impact can also be assumed from programme implementation effectiveness, that is, the programme is running well and the fortified product is reaching the intended target. If fortification and supplementation are both in place, the same approach of selecting differential groups for each intervention is recommended to estimate programme impact. Usually the fortification level is limited to 25%–50% of RDI. Impact is hard to measure when fortification is combined with supplementation.

There may be a number of reasons why vitamin A levels are constantly below the level indicated on the labels, especially for fortified oils and fats in Asia. It may be due to inadequate fortificant addition (as was the case in Pakistan despite mandatory
regulations); or to mishandling at different points in the distribution chain (prolonged storage, for example). The problem can also be caused by insufficient vitamin A overage to compensate for losses during storage and transportation.

One tool that can be used to address deterioration of vitamin A is the ability to trace the distribution chain and production history at any point in the product’s life cycle. Therefore, if one sample checked in the market is found to be sub-optimal, the product can be traced back to the production lot in an attempt to identify and correct the cause of the deterioration.

The dynamic of monitoring varies greatly between oil producing or refining companies. Multinational companies have elaborate monitoring procedures whereas smaller manufacturers simplify systems and try to minimize costs. Adequate quality assurance systems do not exist in many oil refining companies in the Region. An exception, however, is Saudi Arabia which has in place elaborate internal and external monitoring systems.

3.11 Regional trade and international regulatory environment

Salah M. el-Zedjali

The Directorate General of Specifications and Measurements (DGSM), as the national standards authority in Oman, is at the forefront of national efforts to ensure food quality and safety and to protect population health. Major contributions of DGSM include providing standardized formulations for the health, food and nutrition sectors; supporting food enforcement agencies in the collection and testing of samples of foodstuffs and related items; sharing test results with the concerned national agencies, consumers, manufacturers and retailers; and enforcing necessary corrective measures.

Food standards in Oman are largely based on international standards. However, vitamin A fortification of edible oil has not received adequate attention until recently. This may due to a number of factors related to social traditions, living habits, culinary practices, food patterns and a sense of self-satisfaction and security regarding nutrition.

Since standards are the most effective tools for transferring scientific findings and validated results to industrial practices and public regulations, DGSM would like to use the recommendations of this workshop to guide further examination and evaluation, so as to decide whether vitamin A fortification requirements should be included in the Oman standards for cooking oils and fats.

DGSM offers the following suggestions:

- Strategies should concentrate on achieving tangible benefits through practical need-based, priority-driven activities.
- Projects should be prioritized within a definite time frame.
- More emphases and inputs should be placed on trade agreements in favour of promoting fortified oils and fats; on technical assistance, training and human resource development; and on mutual recognition and accreditation in areas of standards, technical regulations and quality assurance.
4. GROUP WORK

4.1 Advocacy and communication

Topics considered

- What organizations and what population groups should be the target for advocacy and communication concerning fortifying edible oil with vitamin A and D?
- What type(s) of methodology(ies) should be used for advocacy and communication purposes?
- How do we communicate with the consumers at a country/region level?
- What kind of regional/national support is/are required?
- Is there a need for a logo?
- What are the target areas for social marketing (packaging, quality of oil, etc.)?
- What are the advocacy strategies that should be used for the key stakeholders?

Target groups

<table>
<thead>
<tr>
<th>Producers</th>
<th>Consumers</th>
<th>Government and other agencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil producers</td>
<td>Schoolchildren</td>
<td>Policy-makers</td>
</tr>
<tr>
<td>Unions</td>
<td>Religious leaders</td>
<td>Ministry of Health</td>
</tr>
<tr>
<td>Associations</td>
<td>NGOs</td>
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<td>School Teachers</td>
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<td>Technology and scientific community</td>
<td>Ministry of Standards and Specifications</td>
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<td>Ministry of Health</td>
<td>Ministry of Information</td>
</tr>
<tr>
<td></td>
<td>Ministry of Education</td>
<td></td>
</tr>
</tbody>
</table>

Methodology and strategy for advocacy

- Television/radio/newspaper (media)
- Advocacy workshop/seminars
- Training the trainers: health workers, schoolteachers, and religious leaders
- Pamphlets, posters, video sessions
- Focus groups

Strategy by target groups

- Seminar for stakeholders (high-level policy makers): national level
- Seminar for trainers (TOT): national level representatives of the collaborative ministries to communicate message to their departments

Regional/national support

- Financial support (government, international organizations, private sector, foundations)
- Research material (background information)
Formative research (feasibility study)

Technical experts

Lessons learned at regional and international level

**Logo for product is very important:**

- Identification of product, especially for illiterate users
- Marketing of product
- Guarantee of healthy content of product

**Criteria for logo**

- Simple, colourful, attractive, clear
- Acceptable and meaningful to the culture
- Shape of logo a distinct form
- Culturally sensitive

**Criteria for awarding logo**

- Product complies with standards and specifications
- Complies with good manufacturing practices (GMP)

**Authority for endorsing logo**

- Ministry of Health in collaboration with Ministry of Commerce and Industry
- Bureau of Standards
- Industry associations

**Target areas for social marketing**

- Health message put on the package
- Attractive colour (highlighted)
- Product is safe, no change in colour, flavour
- Added value for the same price

**Advocacy strategies**

- Knowledge of what programme's various stakeholders are likely to support
- Formation of National Fortification Committee, including all stakeholders

### 4.2 Technical issues

**Topics considered**

- Given available information, what is the best strategy to set up oil fortification with 30% retention of vitamin A with up to six months of storage? What are implications for packaging, storage, and specifications for premix and oil quality?
What are the next steps to proceed with the implementation of the programme?

What are the needs for training in quality control (QC), good manufacturing practices (GMP), and quality assurance (QA)?

How should analytical services be organized at the provincial/national and regional levels?

Existing situation

Type of oils being processed in the Region are soybean, corn, sunflower, palm/olein, canola, cotton seed, hydrogenated and blended oils.

Percentage varies widely between hydrogenated and soft oil by country. Shelf life is between 9 months to 2 years. Average consumption period is between 4 to 6 months. Antioxidant addition is from 0 to 100%.

Packaging includes tin cans (35%), HDPE and PET bottles (65%).

Storage is under shade, ambient temperature 25–40 °C.

Recommendations

Oil processing

Good manufacturing practices to be adopted to produce good quality oils.

Quality management tools such as ISO 9000, HACCP, MRP, etc to be implemented.

Specifications for processed oils

Free fatty acids < 0.1%

Peroxide value (PV) = 0 at time of fortification

Trace metals <0.1 ppm

Soap in oil < 5 ppm

Moisture < 0.1 or at least regional applicable standard

Packaging

Oxygen and light permeability to be avoided

UV protection for PET bottles

Better plastic material

Alternate packaging material

Storage

Storage instruction on cartons

Public awareness for better storage at the point of use
Fortification

Follow manufacturer’s recommendation for preparation and addition
Continuous monitoring of fortified products throughout product life cycle to determine the vitamin retention with the collaboration of regional health laboratories, WHO/MI and vitamin manufacturers

Training

Training with the assistance of regional health departments, professional organizations such as AOCS, PORIM, through WHO/MI, and vitamin manufacturers

Additional recommendations

Collective efforts from oil producers at country level toward a joint strategy for oil fortification
Regional technical committee under WHO/MI collaboration comprising oil producers, health authorities, regional representatives of WHO/MI and vitamin manufacturers
Joint procurement policy to optimize prices of vitamins

4.3 Standards, regulations and monitoring

Topics considered

What are the criteria for setting standards and regulations for oil fortification?
Is there a need for regional standards and if so how should these be set?
What aspects of the oil fortification programme should be monitored (process management, impact, etc.)?
What are the standard procedures that need to be put in place for monitoring?
How should the oil producing sector be linked with the national programme office for monitoring purposes?
Who should be responsible for monitoring the programme?
What are the most suited (and new) methods for monitoring the impact?

Rationale

Oil fortification should be part of a global Micronutrient Deficiency Control Programme addressing multi-micronutrient deficiencies.
VAD should be recognized as a public health problem, based on sub-clinical indicators.
Fortification strategy should not be dependent on evidence that VAD reaches severe dimensions in a country.
Appropriate food vehicle should be used; that is, a food that is consumed by almost all the population, particularly the most at-risk groups, and that is centrally produced/processed.
Criteria for fortification level

?? National intake in relation to the acceptable national recommended dietary intakes (RDI). Household-level fortified food should cover at least 50% of the RDI of the most vulnerable groups.

?? It is assumed that loss of vitamin A is around 30%. Fixed level of fortification with acceptable error margin of ±15%–20% at the start of the programme, given that final products should be of a good quality and comply with the provisions of Codex Alimentarius.

Regional standards

?? Try to harmonize oil fortification at the regional level. However, because of the wide variation in consumption levels of oils and fat in the Region, it is not realistic to recommend a uniform fortification level in oil as has been suggested for fortification of flour with iron.

?? For premix, common standards should be sought; provisions of Codex Alimentarius should be respected and manufacturer’s specifications checked systematically at entry point.

?? Packaging should not be transparent and, at least, should be opaque or brown.

?? In labelling, priority should be given to the national labelling specifications. On labels of fortified products phrases such as “fortified with…” can be added. Nutritional facts should emphasize proportion of national RDIs covered by a serving unit (100 g for instance) for a special population group such as children or adults.

Quality assurance

?? For internal quality assurance, producers should have a good QA system. QA plan should be clear and easy to check by regulatory and external monitoring agencies.

?? External QA should have import and export certification system; certificate of analysis of fortificant and other imported items should be required from manufacturer/supplier.

?? Oil fortification programme should include quality of fortificants, quality of oil, level of fortification, HACCP, functional quality assurance system.

?? For programme management, Micronutrient Control Programme Officer (usually at Ministry of Health) should establish the appropriate linkage with producers and maintain effective communication with them. The Ministry of Health should play a leading role in monitoring the programme.

Impact monitoring

?? Baseline data on vitamin A status and dietary intake at national and subnational levels.

?? Intermediate indicators (surveillance or annual surveys)

?? Average consumption of fortified oil at household level

?? Level of vitamin A in the fortified food reaching the consumers

?? Population-based surveys to detect sub-clinical indicators (prevalence and distribution in population)
4.4 Resource needs and financing assumptions

Topics considered

?? What are the different elements of the cost of the fortification (production and programme support)? Who pays for each of the components of the cost? How is it going to be financed?

?? What should be the understanding between government and private industry with regards to sharing of programme cost?

?? What is the most sustainable manner of financing the programme needs?

?? What are the means of minimizing the cost of the premix?

Assumptions

?? Government of the country to make oil fortification mandatory

?? Initial time frame five years (including one year initial preparation time)

?? Levels of vitamin A 33 IU/g and vitamin D 3.3 IU/g oil

?? Financing of operating and programme costs to be done in a sustainable manner

?? Fixed cost of equipment may vary depending upon individual plant, hence not considered

?? Analysis of samples to be done externally as well as plan for in-house analysis subsequently

Components of operating cost

<table>
<thead>
<tr>
<th>Recurring cost component</th>
<th>US$ per 1 tonne of oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fortificant</td>
<td>2.00</td>
</tr>
<tr>
<td>Analysis</td>
<td>0.50 to 1.00</td>
</tr>
<tr>
<td>Duties and transportation</td>
<td>0.10 to 0.30</td>
</tr>
<tr>
<td>Labour</td>
<td>0.00 to 0.50</td>
</tr>
<tr>
<td>Utilities</td>
<td>0.10</td>
</tr>
<tr>
<td>Inventory</td>
<td>0.10</td>
</tr>
<tr>
<td>Total operating cost range</td>
<td>2.80 to 4.00</td>
</tr>
</tbody>
</table>

Financing of operating costs

?? Government to exempt premix and equipment costs from customs duty

?? Reimbursable procurement of premix through UNICEF Global Tenders to minimize cost while ensuring quality

?? Premix funding to be subsidized by government for limited period with or without assistance from international agencies

?? Producers to pass on fortification cost to consumer from the second year onwards
Programme costs

<table>
<thead>
<tr>
<th>Components</th>
<th>US$ per anum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media development</td>
<td>300 000 (first year)</td>
</tr>
<tr>
<td>Air time</td>
<td>100 000 to 300 000</td>
</tr>
<tr>
<td>Advocacy</td>
<td>60 000</td>
</tr>
<tr>
<td>Training of health professionals</td>
<td>60 000</td>
</tr>
<tr>
<td>Social mobilization</td>
<td>100 000 (first year)</td>
</tr>
<tr>
<td>Information/Education/Communication</td>
<td>60 000</td>
</tr>
<tr>
<td>Total cost range</td>
<td>680 000 to 880 000</td>
</tr>
</tbody>
</table>

Means of financing

<table>
<thead>
<tr>
<th>Component</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media development</td>
<td>Government/international agencies</td>
</tr>
<tr>
<td>Air time</td>
<td>Government (subsidized)</td>
</tr>
<tr>
<td>Advocacy</td>
<td>Government</td>
</tr>
<tr>
<td>Training of health professionals</td>
<td>Government</td>
</tr>
<tr>
<td>Social mobilization</td>
<td>Government</td>
</tr>
<tr>
<td>Information/education/communication</td>
<td>Government/international agencies</td>
</tr>
</tbody>
</table>

5. COUNTRY GROUPS: PLANS OF ACTION

5.1 Islamic Republic of Iran

Dr Houshang Nikoupoor and Dr Minoo Hadjian

Current surveys conducted in the Islamic Republic of Iran show that vitamin A deficiency is prevalent in some provinces. Vitamin D deficiency has also been reported from some urban areas. Mini-surveys are being conducted in provinces to determine the extent of deficiencies of vitamin A and D.

For the purpose of prevention and control, focus will be on the fortification of solid and liquid vegetable oils in such areas. Edible oil producers are encouraged to fortify their products with 33 IU/g vitamin A and 3.3 IU/g of vitamin D. The Iranian Institute of Standards will be requested to assess and if necessary, revise the existing standards concerning vitamin A and D in edible oils and fats. The goal is to fortify all vegetable oils over the next three years.

The Government intends to inform the population about the benefits of vitamin A and D fortified food products through television, radio and print media. The population would also be encouraged to pay attention to the labels of edible vegetable oil products. Seminars and workshops related to the control and prevention of vitamin A deficiency in the provinces will be conducted. External monitoring of the oil fortification programme using the inputs of the
Central Food and Drug Laboratories, the Ministry of Health and the Institute of Standards would be undertaken. The cooperation of WHO and UNICEF would be sought.

5.2 Egypt and Jordan

Dr Mohamed Ahmed Abdullah, Dr Abdel Azim Abdul Razak, Dr Abdul Mon’em Sallaj and Mr Abbas Al Qatarneh

The plan of action was developed jointly by the participants from Egypt and Jordan, and is recommended for both countries. The overall objectives are to reduce the number of affected preschool children to 50% of children under three years of age, to reduce vitamin A and D deficiency by 20%, and to prevent and control vitamin A and D deficiency among children and mothers. The strategies for vitamin A and D control will comprise vitamin A and D supplementation, nutrition education, dietary diversification and the promotion and support of breastfeeding.

The activities of the action plan are to conduct a national survey focusing of target groups to assess the extent of vitamin D deficiency; to fortify edible oils and fats with vitamins A and D; to provide vitamin A to undernourished children below the age of five years, at 9 months with measles immunization and later at 18 months with the booster DPT vaccine. Over the next three years, a seminar will be organized to present the magnitude of the problem to attending policy-makers; and advocacy will be undertaken through media (television, radio and the print media) in collaboration with related ministries.

Appropriate mandatory standards and regulations will also be established over the next three years. The monitoring process will include random samples from the producers and markets analysed for vitamins A and D at the National Institute of Nutrition and Central Laboratories; cooperation with other countries in the Region and international organizations; and improving the necessary equipment and resources.

5.3 Oman, Saudi Arabia and Syrian Arab Republic

Dr Samer Arous, Ms Roula Midani, Ms Deena Alasfour, Mr Saleh Mahmood Somar El-Zedjali, Dr Mohamed Ismail El Hamz, Mr Zaher Belgami and Mr Mohamed Al-Hadzlag

Action plan objectives are to control and prevent vitamin A and D deficiencies in order to reduce the prevalence of VAD to less than 5% of children under 5 years and to control vitamin D deficiency by 2005. The strategy consists of fortifying selected edible oils and fats with specified levels of vitamin A and D (exact level to be determined by each country).
<table>
<thead>
<tr>
<th>Action</th>
<th>Responsible</th>
<th>Time-frame</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy decision, resource allocation, monitoring plan</td>
<td>Ministry of Health, Nutrition Department, industry and other related ministries</td>
<td>2002–2003</td>
<td>Budget allocated for NGOs; technical capacities, guidelines established</td>
</tr>
<tr>
<td>Advocacy and communication</td>
<td>Ministry of Health</td>
<td>2002–2004</td>
<td>Target groups</td>
</tr>
<tr>
<td>Guidelines for the premix, equipment, process monitoring and evaluation</td>
<td>WHO, MI, Industry</td>
<td>2002–2005</td>
<td></td>
</tr>
<tr>
<td>Procurement of equipment, premix, and identification of internal monitoring venues, purchasing laboratory equipment wherever possible</td>
<td>Industry, possible donors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training for the industry, health inspectors</td>
<td>Government and NGOs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop and enforce required standards and regulations</td>
<td>Ministry of Health, Legislative authorities</td>
<td>2003</td>
<td></td>
</tr>
<tr>
<td>Develop monitoring and evaluation standard operating procedures; training of relevant responsible personnel</td>
<td>Ministry of Health, Ministry of Commerce and Industry, Food control authorities</td>
<td>2003–2004</td>
<td></td>
</tr>
</tbody>
</table>

**Regional cooperation**

?? Funding: the industry, with assistance from donor agencies will develop a coalition for strategic procurement of fortification needs, especially the fortificants.

?? Technical expertise: 3–4 laboratories will be identified as centres of excellence across the Region under the central laboratory of the Ministry of Regional Municipalities, Environment and Water Resources (Oman); other laboratories in the Region can be identified. Technical expertise of these laboratories can be upgraded by assistance from recognized international bodies.

?? Social marketing: donor agencies to develop adequate social marketing plan that can be adopted by countries.

?? Regulation: legislation in the Region should be complementary, and control authorities should agree on a standard control procedure.

?? Technical assistance needs: international agencies should provide technical assistance in identifying laboratories and follow up on the procedures for quality assurance and control of the fortified product.
5.4 Morocco

Dr Hamid Chekl, Dr Mustapha Mahfoud, Dr Mohamed Rahman and Ms Najat Sarhani

Objectives

The objective of the action plan is to contribute to the elimination of VAD in the medium and long term. The strategy will involve the national government and international organizations and will have the following components:

- Feasibility and stability studies to determine appropriate fortification levels;
- Development of technical dossier for the establishment of standards and regulation for oil fortification;
- Development of legal documentation for mandatory oil fortification;
- Signing a memorandum of understanding between the Ministry of Health and the Ministry of Agriculture;
- Ratification of a convention between the Ministry of Health and the Oil and Fats Association;
- Advocacy of Ministry of Health for tax and tariff reduction for the premix, doser and other related equipment to be purchased by oil industrials;
- Advocacy, communication and social marketing strategy to promote fortified oil focusing on mass media and information, education and communication materials;
- Reinforcing to health professional the importance of vitamin A and D fortification, and enhancing the capacity of inspection, regulatory and oil industry personnel in quality assurance procedures;
- Development of monitoring indicators in collaboration with international organizations;
- Normative evaluation and impact evaluation after three years of project implementation (focus on health and behaviour change).

For the private sector, the inputs to the strategy will be:
- Feasibility and stability study;
- Process improvement: from batch to continuous;
- Post-production product monitoring;
- Quality assurance and control set;
- Distribution of the product nationwide;
- Marketing of product;
- Media and promotion campaign;
- Training of sales staff on oil fortification with vitamin A and D;
- Adoption of new marketing strategies.

Steps over the next three years

- Policy decision: government and private sector consensus on vitamin A and D oil fortification.
- Advocacy and communication: media campaign, IEC of health professionals, oil producers and the population regarding oil fortification, advocacy to reduce the cost of fortification.
- Implementation: government and international organization activities.
Standards and regulation: in concert with regulatory governmental departments and the private sector.

Monitoring and Evaluation: normative evaluation, and impact evaluation on subclinical and behavioural aspects.

Regional cooperation: participation in regional meetings to share information and experiences, and organization of a regional conference in Morocco.

Technical assistance needs: technical dossier development, advocacy and communication, quality assurance and quality control, fortification technologies, development of monitoring indicators and evaluation standards.

Steps for the private sector

Monitoring vitamin A and D levels in different regions of the country to adapt product to the various conditions.

Reinforcing the marketing, quality and sales staff to promote fortified oil consumption in areas where consumption is low.

Implementing process and quality control improvement to preserve the levels of vitamins in oils and fats.

5.5 Pakistan

Mr Mohammad Saleem and Dr Noor Ahmad Khan

Strategies

The prevalence of sub-clinical vitamin A deficiency falls within the WHO category of public health problem. Sub-clinical vitamin A deficiency increases morbidity and mortality in children and requires multiple interventions for control and prevention. The objectives of the strategy are to combat VAD through a successful programme of hydrogenated oil and liquid vegetable oil fortification; to ensure, promote, monitor, evaluate and recommend measures for the implementation of food laws for the fortification of hydrogenated oil and other edible oils; and to strengthen the existing oil fortification programme through building an alliance of stakeholders to ensure adequate level of fortification in terms of quality and quantity.

A programme by the Ministry of Health, “Improve Nutrition through Primary Health Care and Nutrition Education Awareness”, has been launched with a budget of US$ 5.3 million. Vitamin A capsules (200,000 IU) are provided to mothers at the time of delivery together with nutrition education. Periodic assessment is carried out including the measurement of serum retinol levels in women and children included in the project.

Steps to be taken over the next three years

Policy decisions: fortification policy in place.

Advocacy and communication: Government of Pakistan committed to public awareness programme and all channels of communications are being employed.

Implementation: Government of Pakistan is determined to implement this project; plans have been developed and an Oil Fortification Task Force established in two provinces to
ensure, promote, monitor, evaluate and recommend measures for the fortification of hydrogenated oil and other edible oil with vitamin A.

?? Implementation: terms of reference for the task force established.

?? Standards and regulations: existing legislation concerning oil fortification has been established, Pure Food Ordinance 1960 and Pure Food Rules 1965. Standards for hydrogenated oil and edible oil prepared by Pakistan Standard and Quality Control Authority are also mandatory for the oil producers.

?? Monitoring and evaluation: vitamin A fortification improvement through monitoring; assessment of retinol levels in mother and children.

?? Regional cooperation: regional forum on oil fortification; exchange visits among regional countries related to monitoring and technical expertise development; identification of regional centre of excellence and laboratories.

?? Technical assistance: technical and financial assistance to improve monitoring of vitamin A fortification levels through consultancy on various industrial aspects of vitamin A fortification is desired, such as GMP and HACCP techniques; strengthening of analytical laboratories in public sector for which funding is needed.

5.6 Bahrain and Republic of Yemen

Ms Leena Iryani, Ms Imman and Mr Nagib

Objectives

The objectives of the action plan are to contribute to the reduction of vitamin A and D deficiencies among vulnerable groups of the population and to make more than 70% of hydrogenated vegetable oil and other oil available in the market for human consumption adequately fortified with vitamins A and D by 2005.

Overall strategies

?? Fortification of oil

?? Supplementation with vitamin A (Republic of Yemen)

?? Dietary diversification

?? Breastfeeding promotion

Standards and regulations

?? Amend the current standard specification of oil in coordination with GCC Standardization Committee – Bahrain

?? Legislation has been adopted – Republic of Yemen

At production sites

?? Train technicians of oil factories on fortification techniques and the internal quality control of fortified food produced – Republic of Yemen. Target date 2002.

At market levels

?? Assess the current capacity of government laboratories involved in food quality control. This exercise has been carried out in Republic of Yemen.
?? Procure chemical reagents and other supplies needed by both governmental laboratories and food inspectors for routine monitoring (2002).
?? Train technicians of government laboratories and food inspectors on monitoring measures of fortified items (2002).

For programme management

?? Train project focal points and technicians at Nutrition Department at the Ministry of Health on tools and indicators that have been developed by WHO, MI and UNICEF for assessing the progress in implementation, coverage and impact of the fortification project (2003).
?? Train project focal points and technicians at the Ministry of Health (Nutrition Department) on computer software designed to analyse data and to build databases (2004).
?? Provide appropriate technical guidelines for programme management (2004).
?? Establish surveillance unit for programme management within Ministry of Health Promotion Nutrition Department and train concerned staff on nutrition surveillance–Republic of Yemen. Target date 2002–2005.

Dietary diversification

?? Develop the Educational Dietary Diversification approach (2003).
?? Develop and disseminate related materials such as posters, leaflets and television and radio spots (2003–2005).

Project monitoring

?? Assessing regulatory indicators of process: proportion of adequately fortified food in the market.
?? Assessing progress indicators: proportion of households consuming adequately fortified food.

Evaluation

?? Pre and post intervention surveys.
Technical assistance required

- Formulate standards.
- Conduct training for oil producers.
- Train nutrition programme focal points and technicians on management as specified previously.
- Initiate an information and surveillance system, including development of surveillance indicators and training on the information and surveillance system.
- Train technicians at government laboratories for the analysis of vitamin A and D in edible oils and fats and in the assessment of serum retinol.

6. RECOMMENDATIONS

Following the technical presentations, discussion of thematic and country reports and review of available information, the participants agreed the following principles:

- Based on clinical and/or sub-clinical indicators, vitamin A and D deficiencies are recognized as public health problems affecting the populations of several countries of the Region.
- In order to meet with the goal of elimination of vitamin A deficiency disorders by 2010, set by the United Nations Special Session on Children in 2002, a multi-pronged strategy for the control and prevention of vitamin A deficiency disorders comprising treatment, prophylaxis, dietary diversification and food fortification is required.
- Oil fortification should be part of an overall strategy to significantly improve vitamin A intake by the population.
- Achieving this vision will involve coordinated action at national and regional levels.

To Member States

1. Initiate and expand dialogue among public and private sectors, non-governmental organizations and consumer associations through planned advocacy and partnership at all levels to ensure mandatory fortification.

2. Designate a national core group to further develop the recommendations and actions discussed in the country plans of action.

3. Develop a strong communication and social marketing programme to create awareness and product identity using a logo to create the image.

4. Prepare a three to five year programme identifying priority actions for both public and private sector to enable fortification.

5. Design the financing programme and its operating cost in a sustainable manner.

6. Review and recommend financial incentives for fortification.
7. Recommend tariffs and tax exemption policies to support fortification.

8. Develop a monitoring framework to evaluate the effectiveness of the fortification programme.

9. Document lessons learned from implementing fortification programmes in different country situations.

To WHO, MI, UNICEF and other partners

10. The participants recommended that, within six months time, a regional technical committee be formed with representatives from Member States, the World Health Organization (WHO), United Nations Children’s Fund (UNICEF), the Micronutrient Initiative (MI), the United States Agency for International Development (USAID), other international organizations, edible oil producers and vitamin premix manufacturers. The technical committee should prepare a regional plan comprising the following recommended actions:

10.1 Develop standards, regulations, guidelines and quality assurance for fortification of oils and fats and propose these for endorsement by regional bodies such as the Gulf Cooperation Council (GCC) and the South Asia Association for Regional Cooperation (SAARC), regional standards and specification authorities, regional health and municipal authorities, and national governments. Given the wide variations in the types of consumption and levels of vitamin A and D in oils and fats in the Region, each country should determine its own types and levels of fortification.

10.2 Recommend mechanisms to reduce cost, enhance supply and create demand of fortified fats and oils.

10.3 Develop a joint procurement policy to secure optimum prices and quality of vitamins.

10.4 Develop a regional logo based on expertise available in the Region.

10.5 Identify regional centres of excellence (reference laboratories) for monitoring of vitamins in fortified products and provide them with technical assistance.

10.6 Review progress of the programme in the Region in two years time through regional consultation.
PROGRAMME

Monday, 24 June 2002

08:00–09:00 Registration

09:00–09:10 Recitation of Holy Qur’an

09:10–10:30 Welcome address from His Excellency, Dr Ahmed Al Ghassani, Undersecretary for Health Affairs, Ministry of Health, Oman. Message from Dr Hussein A. Gezairy, WHO Regional Director for the Eastern Mediterranean. Message from Mr Venkatesh Mannar, President, Micronutrient Initiative. Election of Chairperson and Rapporteur

10:30–10:45 Objectives and mechanics of the workshop

10:45–11:15 The magnitude of vitamin A deficiency in the Eastern Mediterranean Region, Dr Kunal Bagchi, WHO/EMRO

11:15–11:45 Vitamin A deficiency and oil fortification: an overview Mr Venkatesh Mannar, President, Micronutrient Initiative

11:45–12:15 Overview of the edible oil market and opportunities for fortification, Mr Jan Wessling, Micronutrient Initiative, Netherlands

12:15–14:00 Poster session

14:00–14:15 Introduction to technology, Mr Jan Wessling, Micronutrient Initiative, Netherlands

14:15–16:15 Panel discussion: stability of vitamin A in edible oils. Moderator: Dr Louis Laleye, Micronutrient Initiative, Canada Results from Guelph University, Canada, Dr Yukio Kakuda, Micronutrient Initiative, Canada Results from trials in Morocco, Dr Mohamed Rahmani, Morocco Results from trials in India, Mr K. Bhat, Central Technological Research Institute, India

16:15–16:45 Fortification technology, addition methodology and quality assurance Mr Jan Wessling, Micronutrient Initiative, Netherlands

16:45–17:15 Oil fortification levels, cost, financing and economic impact on vitamin A status, Dr Louis Laleye, Micronutrient Initiative, Canada
Tuesday, 25 June 2002

08:00–08:30  Assessment, monitoring and impact, Dr Mohamed Mansour, Micronutrient Initiative

08:45–12:30  Field visit: Government Lab–Food Control Laboratory, Measurement Laboratory

12:30–14:00  Regional trade and international regulatory environment
Mr Saleh M. El-Zedjali, Ministry of Commerce and Industry, Oman

14:00–15:00  Panel discussion: vitamin A and suppliers, premix specifications and procurement
Moderator: Mr Venkatesh Mannar, Micronutrient Initiative, Canada
Nicholas Piramal, BASF, Roche
Discussion

15:00–17:00  Group discussions on the following thematic areas:
Advocacy and communication
Technical issues and resource implications
Monitoring implications

Wednesday, 26 June 2002

08:30–09:30  Presentation of group sessions

09:30–12:00  Group work: preparation of country action plans

12:00–14:00  Presentation of country action plans

14:00–15:30  Plenary session:
Conclusions and recommendations
Consensus statement

15:30–15:45  Closing session
LIST OF PARTICIPANTS

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Annex 3

CONCLUSIONS AND FUTURE ACTION

Workshop summary

Oil quality

To ensure good vitamin A stability the refined oil should meet certain quality standards. Draft standards have been defined during the workshop. In particular the oxidative status of the oil (peroxide value) and the level of heavy metals are important. Modern refineries using physical refining and many of the refineries using the chemical process will not have difficulty meeting the quality standards. Some of the smaller refineries may.

Future action: Detail the oil quality standards and collect guidelines to improve oil quality when necessary.

Oil producers

The oil producers present in Oman were very positive and cooperative. They agreed that the total costs are low but are reluctant to carry all the costs. There should at least be the possibility of passing those costs which are not covered, e.g. tax exemptions, on to the consumer. It was proposed to formally provide (via Ministries, WHO, MI?) information to owners/CEOs of the companies. Such information documents should be clear and concise.

Future action:

?? Draft an information document for companies and agree on company information methodology.
?? Make a complete list of the oil producers in the Region. Possible sources are: producers present at the Oman workshop, Ministries of Commerce etc.

Vitamin A supply

Three reputable suppliers produce vitamin concentrates. Their internal QA appears to be excellent; no frequent testing of the quality is required. It can be assumed that the vitamin suppliers have great interest in oil fortification. Their market for only the Middle East region is estimated at approximately US$ 15 million. Where relevant, input/help from vitamin suppliers should be requested.

Typically the concentrates contain 1.6 million IU per gram. The price per kg concentrate is approximately US$ 85 (calculated from the Roche leaflet “Fortification Basics-Oils and Margarine”), resulting in US$ 3.40 per tonne of oil at a dosing level of 60 IU per gram. The costs per litre oil will be less then US$ 0.004. There is clearly room to negotiate significantly lower prices, in particular when larger quantities are purchased.
The national and/or regional preparation of secondary premixes should be evaluated and cost estimates should be made. Aspects such as import duties, local/regional transport etc. should be taken into account. Input of the vitamin producers is essential.

**Future action:**

?? Make a pre-design for a secondary premix facility. Oil producers should be involved in this process.
?? Start discussions with the vitamin suppliers on price and participation.

**Vitamin A addition level**

All vegetable ghee and a small part of liquid oil are already fortified. The levels vary from 25 IU per gram to 60 IU per gram. Because of the wide spread in vitamin A needs and oil-usage throughout the Region no uniform regional vitamin A level is proposed. Each company/country should decide on the level it would apply. General guidelines should be developed. (For example, fortified oil should cover 60% of RDIs, based on the average vegetable oil consumption in the country and on losses during distribution and food preparation at 40%.) Consideration could be given to developing an overall guideline taking into account all fortification vehicles (sugar, flour, vegetable oil).

**Future action:** Develop overall guidelines for vitamin A addition levels for the various food vehicles.

**Vitamin A addition technology and QA**

The addition process is in principle a simple process; approximately 100 grams of concentrate are added to 1 tonne of refined oil. Accurate measuring and adequate mixing are essential. There is a wide variation in size and design of storage tanks and/or run-tanks that feed the filling lines. Because of that, various addition methods can be used for the addition of the micro ingredients. A manual should be prepared with a description of the various methods together with the appropriate GMP and QA guidelines.

**Future action:** Prepare a manual for vitamin addition methods and related GMP and QA methods. It is important to involve oil producers in this process.

**Distribution and packaging**

The stability of the fortificant is affected by the quality of the oil (discussed above), light, oxygen, temperature and duration of the distribution process. The permeability of packaging for light and oxygen determines the stability to a great extent. Cans are the most effective in this respect and clear PET bottles the least, with opaque plastic in between. Clear bottles should be avoided, but this is very difficult because of the high preference by consumers.
**Future action:**

?? The following should be investigated: the effect and costs of plastic added UV absorbers and the effect of full (light absorbing) labels, collars, etc.

?? The net effect of the current clear bottles on stability should be established in a “real life” study. In a few target countries fortified oil in clear bottles is on the market (Morocco and Côte d’Ivoire). All companies marketing fortified oil in clear bottles should be asked to cooperate.

?? Recommendations (where possible with a cost estimate) on headspace, nitrogen flushing, protection against sun and high temperatures, shelf life reduction, etc. should be made.

**Analyses**

Quantitative analysis of vitamin A requires sophisticated equipment (high performance liquid chromatography) and skilled personnel. The cost per analysis is estimated at US$ 50–100. Only the larger companies can afford to carry out their own analyses. For the other companies a local or regional laboratory needs to be organized.

**Future action:**

?? Establish by country which (governmental) laboratories are capable and willing to carry out quantitative analyses. Ask for cost estimates. Central resources should be made available to train and/or to check the accuracy.

?? Publish a “MI recommended” procedure for quantitative analyses of vitamin A.

?? Identify a rapid spot test for vitamin A to be used as a routine quality control in oil factories.

**Marketing**

Communication with the consumer takes place at 2 levels:

?? General information on VAD, ways to cure it, the importance of fortification etc. (social marketing) is the task of the government.

?? For the development of social marketing programmes the experience of countries running or developing these programmes should be used. Countries with experience are: Morocco, Cote d’Ivoire, South Africa. Company marketers could be invited to participate in the information gathering process and the development of international programmes and guidelines.

**Future action:**

?? Collect all available information on social marketing programmes and assess the feasibility of international/regional programmes. Vitamin suppliers should participate.

?? Product marketing is the responsibility of the companies. No central involvement is required.
Training

Most of the bigger plants have sufficient knowledge/experience to prepare their own training manuals and carry out their own training programmes. For the others input is required for the training of middle management, supervisors and operators. The training manuals should be based on the vitamin addition manuals and contain general information on VAD. A “train the trainer” system should be considered.

Future action: Prepare a training manual for producers.

Hydrogenated oil (vegetable ghee): current status

A considerable part of the visible oils and fats consumed in the area is hydrogenated oil although at this time no detailed data are available. It is estimated that the ratio liquid oil/hydrogenated oil is 6/4. It is not confirmed that the claimed amounts of vitamin A are actually added and or what the losses during distribution are. To assess the current status of fortified vegetable ghee, it is proposed to collect throughout the Region vegetable ghee samples for analysis of vitamin A level and possibly for oxidative status and heavy metal content. It should be considered to have the analysis carried out by a few local laboratories, if necessary, supported by laboratories with experience with vitamin A analyses. Reporting of the results should be done without mentioning the producers.

Future action: Arrange for collecting hydrogenated oil samples throughout the Region and arrange for analysis.

Test market

There is a general belief that oil fortification with vitamin A has a positive effect on the VAD problem. However, the effect is difficult to prove. This lack of proof or evidence is often used to delay or even prevent fortification. The best way to prove that fortification works is to organize a controlled test-market. A country or a considerable part of a country should be supplied with fortified oil through the normal distribution system. Non-fortified oil from other sources should be minimal. Through measuring the level of VAD at the start of the test-market, and after 9 and 18 months, the effect of fortification can easily be established. Criteria for selecting the test-market area are:

?? There must be a clear VAD problem.
?? It should be a predominately “oil area” and not a mixed “vegetable ghee/oil area”. Fortified ghee would blur the test results.
?? The number of producers for the area should be small.
?? The amount of imported products in the poorer areas should be small.
There is no need to do social marketing and labelling should be limited to “contains vitamin A”. If Oman was to be the test-market, the costs for vitamins would be approximately US$ 70 000 at an addition level of 60 IU per gram. Vitamin suppliers should be asked to supply the vitamin for free! The test-market could also be used to measure the effect of packaging, etc. on stability.

**Future action:** Assess the possibilities/needs for an oil fortification test-market.