



# **VITAMIN FORTIFICATION OF LIPID-BASED PRODUCTS**

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# FORTIFICATION

**Addition of nutrients in amounts significant enough to render the food a good to superior source of the added nutrients. This may include addition of nutrients not normally associated with the food or addition to levels above that present in the unprocessed food.**

# **ADVANTAGES OF FOOD FORTIFICATION**

- ✓ **Probably one of the most efficient as well as one of the most cost-effective means of eliminating micronutrient malnutrition.**
- ✓ **Requires no change in food habits.**
- ✓ **Does not change the characteristics of the food.**

# **AMA-IFT-FNB GUIDELINES**

## **GENERAL CRITERIA**

- ✓ **The intake of the particular nutrient is inadequate for a substantial portion of the population.**
- ✓ **The food (or category) is consumed by most individuals in the target population.**
- ✓ **There is reasonable assurance that excessive intake will not occur.**
- ✓ **The cost is reasonable for the intended population.**

# **U.S. FOOD AND DRUG ADMINISTRATION GUIDELINES**

## **FORTIFICANT**

- ✓ **Stable under customary conditions of storage, distribution, and use.**
- ✓ **Physiologically available from the food.**
- ✓ **Present at optimal levels, without increasing the risk of excessive intake or toxic effects.**
- ✓ **Suitable for its intended purpose and in compliance with provisions (i.e. regulations) governing safety.**

# **FOOD VEHICLE FOR FORTIFICATION**

- ✓ **Consumed by a sizeable proportion of the target population.**
- ✓ **Processed centrally to allow controlled fortification.**
- ✓ **Distributed through a widespread network so that it reaches all regions of the country.**
- ✓ **Inexpensive, so that it can be consumed by all income groups.**

# **FOOD VEHICLE FOR FORTIFICATION**

- ✓ **Not change in taste, colour, or appearance on fortification.**
- ✓ **Not lose the nutrient on further processing or cooking.**
- ✓ **Have a stable and uniform per capita daily intake, so that the fortification levels can be accurately assessed.**

# PROCEDURE FOR FORTIFICATION

- ✓ **Demonstration of need to fortify.**
- ✓ **Determination of the food vehicle(s) which would reach the population target group.**
- ✓ **Assurance that the additions are not detectable by changes in taste, smell or texture.**
- ✓ **Availability of the appropriate skilled technology and equipment.**



# PROCEDURE FOR FORTIFICATION

- ✓ **Availability of means of sampling the enriched food at the consumer stage, analysis of the product to ensure correct level of fortification, and the establishment of a means of enforcement of the regulations.**
- ✓ **Estimation of maximum likely consumption, in order to establish safe fortification level.**

# MAJOR TECHNICAL PROBLEMS

- ✓ **It is difficult to disperse very small amounts of nutrients in very large amounts of food - a few grams per ton.**
- ✓ **The nutrient must be compatible with the food: water-soluble nutrients added to aqueous media and fat-soluble nutrients to fatty foods.**
- ✓ **The added nutrients must not react with any ingredient of the food.**
- ✓ **It must be bioavailable.**

# **The following practices in the United States continue to be endorsed**

- ✓ **The restoration of thiamin, riboflavin, niacin, and iron in processed food cereals.**
- ✓ **The addition of vitamin D to milk, fluid skimmed milk, and nonfat dry milk.**
- ✓ **The addition of vitamin A to margarine, fluid skimmed milk, and nonfat dry milk.**
- ✓ **The addition of iodine to table salt.**
- ✓ **Inclusion of folic acid in enriched cereal-grain products.**

# FORTIFICATION TECHNOLOGY FOR VITAMINS

- ✓ ***Dissolution in oil.*** For oily products such as margarine.
- ✓ ***Adhesion.*** For sugar fortification. Vitamin A in powder form is adsorbed on to the surface of the sugar crystals using a vegetable oil.
- ✓ ***Coating.*** For rice. The vitamins sprayed over the grain must be coated to avoid losses when the grains are washed before cooking.
- ✓ ***Pelleting.*** For rice the vitamins are incorporated into pellets reconstituted from broken kernels.

# FORTIFICATION TECHNOLOGY FOR VITAMINS

- ✓ ***Dry mixing.*** For foods like cereal flours and their products, powder milk, beverage powders, etc.
- ✓ ***Dissolution in water.*** For liquid milk, drinks, fruit juices, bread, pastas, cookies, etc.
- ✓ ***Spraying.*** For corn flakes and other processed foods requiring cooking or extrusion steps that would destroy vitamin activity.

# **RATIONAL FOR MULTIPLE FORTIFICATION**

- ✓ **Fortification with multiple nutrient only causes a minimal increase in cost compared to single nutrient fortification.**
- ✓ **Diets are seldom deficient in one nutrient alone and health problems related to micronutrient deficiencies are due to a lack of more than one nutrient.**

# **PUBLIC HEALTH INTERVENTION STRATEGIES**

- ✓ **Supplementation with high dose capsules.**
- ✓ **Fortification of a common food vehicle.**
- ✓ **Dietary diversification.**

# **ADVANTAGES OF VITAMIN A FORTIFICATION OF LIPID-BASED PRODUCTS**

- ✓ **Vitamin A is fat-soluble.**
- ✓ **Lipids increase bioavailability of vitamin A.**



# **FORTIFICATION OF MARGARINE – PHILIPPINES**

**Reference: Solon *et. al.*, 2000**

## **BACKGROUND**

- ✓ **Vitamin A deficiency has been a consistent public health problem in the Philippines.**
- ✓ **A 1998 survey market found that margarine (a coconut oil-based, shelf-stable, non-refrigerated margarine) was consumed by 94% of the population.**
- ✓ **It is used as a spread on bread, topping for rice, and an ingredient in cooking.**
- ✓ **In 1992 margarine was fortified with adequate amounts of vitamin A as a decision of its manufacturer, Proctor & Gamble Philippines.**

# FORTIFICATION OF MARGARINE – PHILIPPINES

- ✓ **Vitamin A content:** increased from 131 retinol equivalents to 431 RE per 15-g serving. This met 115% of the RDA for 3- to 6-year old children. Each serving also contained 326  $\mu\text{g}$   $\beta$ -carotene as colorant.

# FORTIFICATION OF MARGARINE – PHILIPPINES

- ✓ **Stability study**: More than 50% vitamin A retention in the margarine after 8 months of storage. At least 80% of vitamin A was recovered after cooking with margarine.
- ✓ **Field trial**: A significant increase in the mean serum retinol level as well as 60% reduction in the prevalence of low serum retinol in 3- to 6-year-old rural children that consumed vitamin A–fortified margarine daily for 6 months.

# **FORTIFICATION OF VANASPATI WITH VITAMIN A – INDIA**

**Reference: Chakravarty, 2000**

**VANASPI (all-purpose cooking fat  
or vegetable ghee)**

- ✓ **It is mandatory in India for vanaspati to be fortified with vitamin A to a level of 40% of the RDA.**
- ✓ **The rural population consumes very little vanaspati (0.3 to 1 g per day) and therefore receive very little vitamin A through this vehicle.**

# FORTIFICATION OF VANASPATI WITH VITAMIN A – INDIA

- ✓ Consumption of vanaspati is higher in higher-income group (10 g per day) resulting in vitamin A availability of 12.5% of the RDA.
- ✓ The urban population consumes between 3.5 and 17 g per day, but there is wide regional variation.
- ✓ A sizable amount of vanaspati is lost on heating.

# STABILITY OF VITAMIN A IN FORTIFIED SOYBEAN OIL – INDIA

**Reference: Atwood *et. al.*, 1995**

## **Child Feeding Programs**

- ✓ **The vitamin A content ranged from 303 to 727  $\mu\text{g}/10\text{g}$  oil (compared with the expected value of 491  $\mu\text{g}/10\text{g}$  .**
- ✓ **This was not due to settling, but the oil might not have been mixed well enough when it was added or the fortificant was not measured precisely enough.**

**Recommendation: If oil fortification is done on a large scale, the measuring and mixing process should receive careful attention.**

# **STABILITY OF VITAMIN A IN FORTIFIED SOYBEAN OIL – INDIA**

- ✓ **Stability of vitamin A in unopened pails of fortified oil was good under varying climatic conditions, but once the pails were opened, there were losses.**
- ✓ **The vitamin A content in oil decreased to 93% after 15 min. of heating and to 90% after 30 min. of heating.**
- ✓ **Cost calculations suggest significant savings in using oil as the vehicle instead of cereal flours.**

# VITAMIN A IN SOYBEAN OIL – BRAZIL

**Reference: Favaro *et. al.*, 1991**

- ✓ **98.5% of vitamin A added to refined soybean oil (600  $\mu\text{g}/10\text{g}$  of oil) with BHA was retained after 9 months of storage at 23°C in sealed metal cans.**
- ✓ **Vitamin A in opened cans stored in the dark and opened cans stored in the light deteriorated more easily.**
- ✓ **Retention of vitamin A in the fortified oil cooked with rice and beans ranged from 90 to 99%.**



# FORTIFICATION WITH $\beta$ -CAROTENE

- ✓ **Bioavailability** is the fraction of an ingested nutrient that is available for utilization in normal physiologic functions and for storage.
- ✓ **Bioconversion** is the fraction of a bioavailable nutrient (absorbed provitamin A carotenoids) that is converted to the active form of a nutrient (retinol).
- ✓ **Bioefficacy** is the efficiency with which ingested nutrients (e.g., provitamin A carotenoids) are absorbed and converted to the active form of the nutrient (retinol).

# EFFECT OF FOOD MATRIX AND PROCESSING ON BIOAVAILABILITY OF CAROTENOIDS

Reference: Boileau *et. al.*, 1999

**Very high bioavailability**

**Natural or synthetic**

**Carotenoids – oil form**

**Papaya, peach, melon**

**Fruits**

**Squash, sweet potato**

**Tubers**

**Tomate juice**

**Processed**

**Carrot, pepper**

**Mildly cooked yellow/  
orange vegetables**

**Tomato**

**Raw juice**

**Carrot, pepper**

**Raw yellow/orange vegetables**

**Spinach**

**Raw green leafy vegetables**

**Very low bioavailability (<10%)**

# RED PALM OIL – INDIA

## Reference: Mahapatra & Manorama, 1997

- ✓  $\beta$ -carotene in red palm oil was as effective as high-dose retinyl palmitate as a supplement to restore and preserve vitamin A nutriture in school children and may be an effective food-based strategy to combat hypovitaminoses A.

## Reference: Radhika *et. al.*, 2003

- ✓ Red palm oil supplementation significantly improved maternal and neonatal vitamin A status and reduced the prevalence of maternal anemia.

# RED PALM OIL – HONDURAS

**Reference: Canfield and Kaminsky, 2000)**

- ✓ **Improvement in the vitamin A status of lactating mothers and their nursing infant following maternal oil consumption was comparable to that following supplementation with purified  $\beta$ -carotene. Both treatments significantly increased serum and milk  $\beta$ -carotene and infant serum retinol.**

# RED PALM OIL – TANZANIA

**Reference: Lietz *et. al.*, 2001**

- ✓ **Consumption of red palm oil incorporated in household preparations (~12g per day) increased concentrations of  $\alpha$ - and  $\beta$ -carotene in both breast milk and serum and maintained breast-milk retinol concentration.**

# RED PALM OIL-BASED SPREAD – SOUTH AFRICA

**Reference: van Stuijvenberg *et. al.*, 2004**

- ✓ **Seven-month intervention study with primary school children, aged 6-11 years from a poor rural community.**
- ✓ **Each child received one slice of bread with 15 g of spread or peanut butter per school day. The red palm oil-based spread supplied 2.3 mg  $\beta$ -carotene.**
- ✓ **There was a significant improvement in serum retinol in the red palm oil group compared to the peanut butter group, the response being greater in children with low initial serum retinol concentration.**

# **$\beta$ -CAROTENE IN SOYBEAN OIL – BRAZIL**

**Reference: Dutra de Oliveira *et. al.*, 1998**

- ✓ **Cooking at 100°C for 20 min. -  $\beta$ -carotene retention was 92.3%.**
- ✓ **Frying at 170°C/3 times –  $\beta$ -carotene retention was 65.4%.**

# **SURVEY OF VITAMIN A AND D FORTIFICATION OF MILK – NORTH CAROLINA**

**Reference: Hicks *et. al.*, 1996**

- ✓ **General conditions under which vitamin preparations were stored.**
- ✓ **The method used to add vitamin preparation to milk.**
- ✓ **The point during processing at which vitamin preparations were added.**



# **SURVEY OF VITAMIN A AND D FORTIFICATION OF MILK – NORTH CAROLINA**

## **Storage of vitamin A preparations**

- ✓ **46% of 13 dairies stored under refrigerated conditions.**
- ✓ **54% stored at ambient temperatures.**

# **SURVEY OF VITAMIN A AND D FORTIFICATION OF MILK – NORTH CAROLINA**

## **Addition of vitamin A preparations to milk**

- ✓ **By metered injection in 64% of the dairies.**
- ✓ **By batch addition techniques at 36%.**

# **SURVEY OF VITAMIN A AND D FORTIFICATION OF MILK – NORTH CAROLINA**

## **Point of addition**

- ✓ **Vitamin preparation added before fat content standardization and separation by 23% of the dairies.**
- ✓ **77% added after this point.**



# **SURVEY OF VITAMIN A AND D FORTIFICATION OF MILK – NORTH CAROLINA**

**“Although other sources of error could also contribute to inconsistent concentration of vitamin fortification, differences in fortification procedures may have a large impact upon the problem.”**

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