# Micronutrients

## (ii) Micronutrients

- The micronutrients generally do not have any significant energy value
- But they are essential components of the diet
- Of the micronutrients, concern generally involves minerals and vitamins. Irradiation does not alter the mineral content of a food. It could, however, alter the nutritional availability of minerals. Animal-feeding studies have not revealed a problem in this area. In fact, it has been observed that phosphorus in wheat is made more available by irradiation
- While the total number of vitamins is close to 20, their distribution varies from food to food
- Vitamins like thiamin and vitamin E are sensitive to irradiation in some foods. However, these vitamins are also sensitive to other processing methods
- Contribution of a few of these vitamins from different food groups to the human diet is illustrated, next

# Percentage of Total Vitamin Contribution by Food Groups (Bolin, 1984)

| Products | Ascorbic | Vitamin | Thiamin | Riboflavin | Niacin |
|---|---|---|---|---|---|
| Dairy Products | 4.7 | 11.8 | 9.9 | 43.1 | 1.7 |
| Eggs | 0 | 6.8 | 2.5 | 5.9 | 0.1 |
| Flour (cereal product) | 0 | 0.4 | 33.6 | 14.2 | 22.7 |
| Fruits | 35.0 | 7.3 | 4.3 | 2.0 | 2.5 |
| Meat, poultry, fish | 1.1 | 22.9 | 29.4 | 24.6 | 46.0 |
| Potatoes (including sweet) | 20.9 | 5.7 | 6.7 | 1.9 | 7.6 |
| Vegetables | 38.3 | 36.4 | 8.0 | 5.6 | 6.8 |

- With the normal mix of different foods in human diet, the probability of vitamin deficiency due to irradiation of foods is low

# Effect of Freezing, Heat Processing and Irradiation on Vitamin K Activity (mg/100g) of Some Foods[a]

| Food | Frozen | Heat | Irrad, 27.9 kGy | Irrad, 55.8 kGy |
|---|---|---|---|---|
| Asparagus | 33 | 41 | 37 | 46 |
| Broccoli | 63 | 68 | 74 | 44 |
| Cabbage | 56 | 54 | 78 | 56 |
| Spinach | 93 | 125 | 227 | 198 |

[a] Richardson et al., J. Nutr., 73, 369, 1961

- Vitamin K activity is undamaged at a dose of ~60 kGy
- Vitamin E is the most sensitive of the fat-soluble vitamins to irradiation:

Vitamin E > Carotene > Vitamin A > Vitamin D > Vitamin K

# Effect of Irradiation on Vitamin E in Poultry Meat[1]

| Meat | mg/100 g | % of Total |
|---|---|---|
| Chicken | | |
| Control | 0.43 | 100 |
| 5 kGy | 0.21 | 49 |
| Turkey | | |
| Control | 0.09 | 100 |
| 5 kGy | 0.06 | 67 |

[1] Data taken from Sadat, T., M. vassenaix, Radiat. Phys. Chem., 36, 661, 1990

- Poultry is not an important source of vitamin E since it contributes ≤ 10% of the total daily intake

# Changes in Carotenoids on Irradiation In Different Varieties of Mangoes[1]

| Variety | Dose kGy | Total Carotenoids | |
|---|---|---|---|
| | | Unirrad | Irrad |
| | | (mg/100 g of Fresh Fruit | |
| Alphonso | 0.25 | 0.7 | 0.7 |
| Carabao | 0.65 | 9.6 | 9.5 |

[1] Singh (1990a)

# Changes in Vitamin C on Irradiation in Different Varieties of Mangoes[1]

| Variety | Dose (kGy) | Vitamin C Content (mg/100 g) | | Percent Change |
|---|---|---|---|---|
| | | Unirrad | Irrad | |
| Okrong | 0.2 | 15 | 15 | 0 |
| | 0.4 | 15 | 15 | 0 |
| | 0.5 | 15 | 17 | +14 |
| Peach | 0.75 | 14 | 14 | 0 |
| Rubi | 0.75 | 40 | 37 | -5 |
| Sensation | 0.75 | 56 | 67 | +19 |

[1] Singh (1990a)

- The overall effect of irradiation is insignificant
- Most other varieties of mangoes show similar results, whereas some show very small losses of vitamin C

# Effect of Irradiation and Storage on the Thiamin Content of Bread[a]

| Storage time months | Average thiamin content of bread (µg/100g bread) | |
|---|---|---|
| | Unirradiated | Irradiated |
| 0 | 249 | 281 |
| 6 | 226 | 209 |
| 12 | 241 | 246 |
| 18 | 194 | 225 |
| 24 | 222 | 236 |

[a] Bread made from irradiated and unirradiated wheat. Data from Schonborn, W. and Ehrhardt, G. (1974) Technical Report IFIP-R 16, International Project in the Field of Food Irradiation, Federal Research Centre for Nutrition, Karlsruhe, F.R. Germany

- Low loss most likely due to low moisture level in wheat
- Wheat is an important source of thiamin in human diet

# Effect of Gamma Irradiation (0.75 kGy) on Niacin, Thiamin and Riboflavin in Mangoes[1]

| Mango Variety | VITAMIN (mg/100 g pulp) | | | | | |
|---|---|---|---|---|---|---|
| | Riboflavin | | Niacin | | Thiamin | |
| | Unirrad | Irrad | Unirrad | Irrad | Unirrad | Irrad |
| Kent | 0.06 | 0.05 | 0.042 | 0.038 | 0.06 | 0.05 |
| Peach | 0.06 | 0.05 | 0.09 | 0.07 | 0.05 | 0.03 |
| Zill | 0.09 | 0.08 | 1.65 | 1.78 | 0.09 | 0.09 |

[1] Singh (1990a)

- The losses are negligible in most varieties of mangoes

# Effect of Post- Irradiation Cooking on Thiamin Content of Pork

| Irradiation dose (kGy) | Thiamin[a] (µg/g) pork | | Thiamin loss[b] on cooking |
|---|---|---|---|
| | Raw | Cooked | % |
| 0 | 8.89 | 7.88 | 11.29 |
| 0.57 | 8.20 | 7.26 | 11.48 |
| 3.76 | 5.50 | 4.75 | 13.59 |
| 5.52 | 4.46 | 3.86 | 13.54 |
| 7.25 | 3.77 | 3.20 | 14.99 |

[a] Mean from data pooled (n=18) with respect to storage treatments
[b] Percentage expressed as the average of 18 values of the form (Jenkins et al., J. Food Sci., 54, 1, 1989

- The increase in thiamin loss on cooking as a function of dose is very small

# Vitamin Losses Due to Radiation Pasteurization of Pork Chops and Chicken Breasts Impact on Human Diet (American)

| Meat | Thiamin | Riboflavin | Niacin |
|---|---|---|---|
| Pork Chops | 1.5% | 0.1% | 0.4% |
| Chicken | 0.1% | 0% | 0% |

Fox et al. Int. J. Radiat. Biol. 55(4), 689-703, 1989
(Radiation dose 1 kGy at 0°C)

- In light of the contribution of pork and chicken in the American diet to the overall intake of these vitamins, the loss of thiamin and niacin is not very significant

- In Comparison

## Effect of Conventional Canning on Nutrients in Vegetables[1]

| Nutrient | % Loss |
|---|---|
| Vitamin C | 26-90 |
| Thiamin | 16-83 |
| Riboflavin | 25-67 |
| Niacin | 0-75 |
| Folacin | 35-84 |
| Pantothenic acid | 30-85 |
| Vitamin $B_6$ | 0-91 |
| Biotin | 0-78 |
| Vitamin A | 0-84 |

[1] From D. Lund (1987) in Nutritional Evaluation of Food Processing (Eds. Karmas and Harris) Avi Publishing

- Canning process appears to cause rather large losses of most of the vitamins

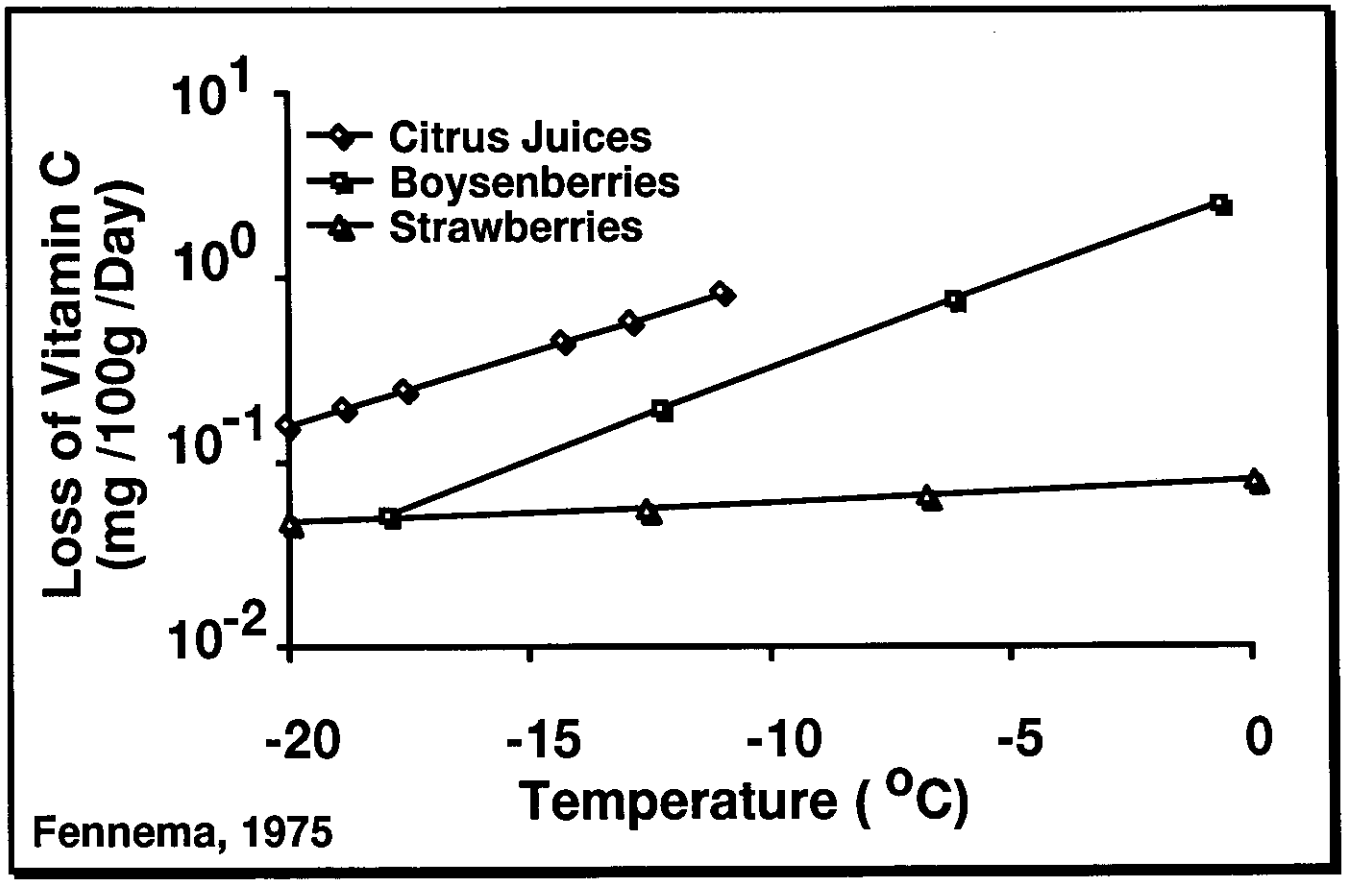
# Effect of Blanching on Nutrients in Vegetables

| Blanching method | Nutrient | % Loss |
|---|---|---|
| Water | Vitamin C | 16-58 |
| | Riboflavin | 30-50 |
| | Thiamin | 16-34 |
| | Niacin | 32-37 |
| Steam | Vitamin C | 16-26 |
| | Vitamin $B_6$ | 21 |

[1] From D. Lund (1987), in Nutritional evaluation of food processing (Eds. Karmas and Harris) Avi Publishing.

- Since Vitamin C is very soluble in water, many fruits and vegetables can lose this vitamin merely on excessive washing. This extraction process becomes more efficient at the high blanching temperatures
- However, loss of vitamin C in frozen storage is lower for blanched vegetables

# Loss of Vitamin C in Frozen Fruits




- There is better retention of Vitamin C at lower temperatures (in frozen foods) but its loss continues during storage

# Conclusions

- Under most processing and storage conditions, losses of some micronutrients occur. The losses on irradiation are similar to those in other processes

- Vitamin E and thiamin are amongst the most sensitive vitamins to irradiation, as they are to other processes

- Depending upon the intake of processed foods (including irradiated foods) supplementation of some micronutrients from other sources may be required

# Nutritional Loss Concerns (contd)

# Induction of Anti-Vitamin Activity

- An earlier study had suggested that irradiation may cause formation of anti-metabolites to thiamin and pyridoxine in meats
- A study on the possible occurrence of antithiamin and antipyridoxine factors in irradiated chicken and beef was carried out at the Letterman Army Institute of Research in San Francisco (Skala et al., J. Food Protection, 1987)
- This bioavailability study produced no evidence of anti-vitamin factors in irradiated meats