

ENRICHMENT AND FORTIFICATION OF FOODS WITH NUTRIENTS

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Attitudes and Approaches to Supplementation of Foods with Nutrients

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Vitamins, minerals, and amino acids are usually added to foods to restore these nutrients to natural levels, to fortify above natural levels, to enrich to the equivalent levels in interchangeable foods, to fortify with public health objectives, to fortify to make food metabolically self-sufficient, or to preserve food stability. White bread enriched according to U.S. standards has the highest over-all nutritional

value in comparison with other types of bread. Because the consumption of sweet goods (cakes, pastries, etc.) has increased dramatically (65%) during the past decade, and because sugar and sugar-rich foods are very low in over-all nutritional value, these two types of food products should be considered for enrichment with vitamins and minerals.

Of all the foods consumed by man, none except human milk can give him complete nourishment, and then for only the first few months of life. In common with other animals, man is nourished by consuming a variety of foods selected from the plants and animals present in his environment.

While each of these foods usually contains the 50 or more nutrients required for man's nutrition, none contains all the nutrients in the proper amounts and proportions. Thus, man must consume several of these foods in each meal if he is to obtain an adequate diet day by day. Few have sufficient training in nutrition and food science to be able to combine the various complementary foods into a mixture which will provide a good diet. The mass of the people must rely upon instinct and chance for the selection of diets, and primitive societies do surprisingly well at it.

The trend toward urbanization which removes the people from sources of food supply has stimulated the development of foods and food products which can be shipped long distances and stored many months. The milling of cereals (Figure 1), and the storage, refrigeration, freezing, canning, and dehydration of fruits, vegetables, meats, dairy products, etc. cause a decrease in the nutritional values of diets consumed by these sophisticated urban populations (Harris and Von Loesecke, 1960). The nutrition problem of these populations is confounded still further by improvements in the flavor and palatability of food products which may subvert basic instincts and induce the people to eat foods which are less nutritious.

Food and nutrition scientists of today can assist sophisticated man toward an adequate diet by: combining individual foods into food products which are more balanced in nutritional value than any of the single components; restoring, enriching, and fortifying individual foods and food products with selected vitamins, minerals, protein concentrates, and amino acids so as to produce

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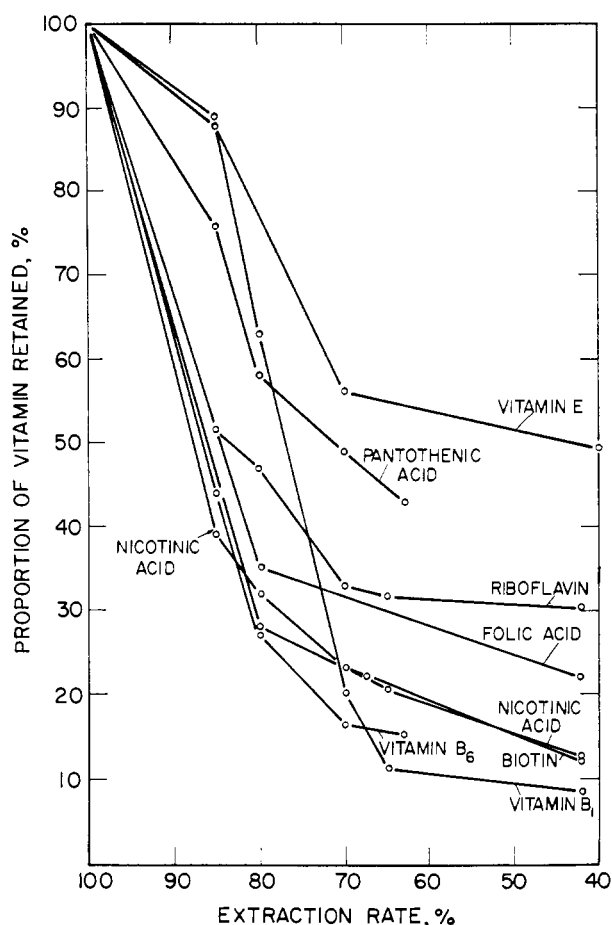


Figure 1. Relation between extraction rate and proportion of the total vitamins of the grain retained in flour (Moran, 1959)

highly nutritious foods at relatively low cost; and compounding single food mixtures which will supply the entire nutritional requirements of infants, the aged, surgical and medical patients, astronauts, etc.

The art and science of applied nutrition has developed so rapidly in recent years that man need not depend upon instinct in the selection of his diet, that food manufacturers may undo the damage to vitamins and amino acids resulting from food processing and storage by restoration and supplementation with synthetic forms of these nutrients, and that young, old, obese, and infirm may be fed simple food mixtures which supply full nutrition requirements.

RESTORATION, ENRICHMENT, FORTIFICATION, AND SUPPLEMENTATION DEFINED

Four terms will be used here which deserve definition. In this context, restoration refers to the addition of one or more nutrients to processed foods to restore them to pre-processing (or natural) levels; enrichment refers to the addition of specific amounts of selected nutrients to a processed food in accordance with official regulations (such

as the standard of identity of enriched white bread defined by the U.S. Food and Drug Administration); fortification refers to the addition of nutrients to foods and food products at levels which may exceed natural levels; and supplementation refers merely to the addition of nutrients.

PHILOSOPHIES OF FOOD SUPPLEMENTATION

Foods and food products have been supplemented with nutrients in different countries for so many different reasons that the kinds and amounts of nutrients added to the same type of food vary considerably in different areas. The author pointed out several years ago (Harris, 1959) that the different types of nutrient supplementation generally fall into one of the following categories.

Restoration to Natural Levels. Rather significant amounts of nutrients are either destroyed or extracted when foods and food products are stored, milled, dried, canned, baked, cooked, roasted, toasted, or otherwise processed. These treatments have become necessary if urban man is to be fed throughout the year. Certainly some of these losses may be minimized by improved processing and storage procedures. Some manufacturers attempt to undo the processing damage by restoring those nutrients which have been most affected.

Fortification Above Natural Levels. Infant foods, geriatric foods, and products designed for weight control frequently supply nutritional requirements in a single serving. These products alone may supply all of the nutrients, or they may be designed to complement the nutrients in a serving of milk with which they are to be consumed. Special purpose foods of this type should supply optimal levels of all nutrients in each daily portion. These levels vary according to the needs of each individual, rather than according to the composition of the foodstuffs used in the product. Generally these products are fortified with nutrients above natural levels.

Enrichment with Public Health Objectives. The enrichment formula of white flour and bread in the United States is based on public health objectives. The enrichment formula was so designed that six slices of enriched bread in the average daily diet would supply sufficient amounts of thiamine, riboflavin, niacin, and iron to raise the levels of these nutrients sufficiently to protect against deficiencies. This public health approach permitted the nutritional improvement of diets without requiring changes in food habits. The enriched white bread had the same color, texture, and aroma as unenriched white bread. This philosophy may be criticized because the enrichment formula is based on the average diet which people were eating over 30 years ago. The enrichment formula is greatly in need of revision. On the basis of today's average diet, this formula probably provides excess amounts of certain nutrients and inadequate amounts of others. Furthermore, it should be determined whether the inclusion of other vitamins (vitamin B₆, vitamin B₁₂, vitamin E), minerals (phosphorus, magnesium), and amino acids (lysine, methionine) should also be added to enriched bread to improve the health of the population through better nutrition.

Enrichment of Interchangeable Foods to Equivalent Nutrient Levels. Since margarine is frequently used as a substitute for butter, it is being enriched with 15,000 USP units of vitamin A to bring it up to the average potency of butter. Since the juices of apples, pineapples, grapes, and other fruits, as well as artificial juices, are used as substitutes for orange juice, these juices are being enriched with 30 mg. of ascorbic acid per 100 grams to bring the vitamin C content up to that of orange juice.

Fortification to Make a Food Self-Sufficient. The major function of many nutrients is to assist in metabolism. For instance, thiamine and niacin are highly active components of enzymes which are essential in the metabolism of carbohydrates. This means that definite amounts of vitamins, minerals, and amino acids are needed for the metabolism of 1 gram of sugar. Nutrition science has advanced near to the point where one can use the proximate analysis of a food to calculate the amounts of nutrients required for its metabolism. On the basis of this information, it is possible to fortify that food with nutrients so that it will be self-sufficient metabolically and no longer lean on other foods in the diet to supply the nutrients in which they are inadequate. This philosophy of food supplementation is the most rational of all, because it is based on fundamental metabolic needs.

Addition for Nonnutritional Reasons. Besides being a vitamin, ascorbic acid is a reducing agent. Similarly, tocopherol is an antioxidant as well as a vitamin (E). On occasion, these nutrients are added to foods primarily to protect and stabilize them during storage.

EFFECT OF ENRICHMENT ON THE NUTRITIONAL VALUE OF WHITE BREAD

Wheat breads are important staple foods in many countries. Breads made with whole wheat flour usually are not preferred by consumers if they can choose white breads. This explains why less than 5% of the bread consumed in the U.S. is made with whole wheat flour. The bran portion of wheat contains substances which interfere with the leavening of dough, and the resulting bread is heavy and has a tight structure. Mild flavored breads are generally preferred by those who consume large amounts of bread daily.

Ordinary white bread is nutritionally inferior to whole wheat bread because significant amounts of nutrients are removed during milling (Table I, Figure 1). The more critical of these (thiamine, riboflavin, niacin, iron, calcium, and vitamin D) are added as enrichment ingredients in the production of enriched white bread in the United States and elsewhere (Harris, 1959) (Table II).

To determine how this enriched white bread compares nutritionally with other breads of the world, Harris *et al.* (1961) undertook a study of the over-all nutritional values of 44 samples of bread collected in 14 countries. Each of these breads was analyzed for content of 20 nutrients, including three minerals, five vitamins, and three amino acids which tend to be limited in human diets.

The sample highest in over-all nutritional value was a semi-white bread from Finland which had been made with a mixture of white and whole wheat flour and 4.3% milk

Table I. Nutrient Content of Wheat Flours

Flour	Mg./100 grams of flour					
	Thia- mine	Ribo- flavin	Niacin	Cal- cium	Iron	Pyri- doxine
Whole wheat	0.50	0.12	4.3	41	3.3	0.60
80% extraction	0.26	0.07	2.0	24	1.3	0.26
70% extraction	0.08	0.06	1.0	16	0.9	0.12
70% extraction (enriched)	0.44	0.26	3.5	110	2.9	0.12

Table II. Composition of British Flours According to Extraction Rate^a

Extraction Rate	Protein, 1%	Thiamine, Mg. %	Riboflavin, Mg. %	Niacin, Mg. %
100% whole meal	12.0	0.40	0.12	6.00
85%	11.6	0.30	0.07	1.70
80%	11.4	0.24	0.05	1.40
75%	11.2	0.15	0.04	0.77
72%	11.0	0.10	0.035	0.72
50%	10.0	0.08	0.03	0.70

^a Kent-Jones (1958).

solids. The second highest was a sample of enriched white bread (U.S.) that was made with 70% extraction flour and 4% milk solids and was enriched with thiamine, riboflavin, niacin, and iron according to U.S. standards.

When these samples were compared according to type of bread, the white breads which had been enriched according to U.S. bread enrichment standards ranked highest in over-all nutrient content. Rye breads ranked second, semi-white breads ranked third and fourth, mixed wheat-rye breads were fifth, and unenriched white bread ranked lowest in over-all nutrient content. On the basis of these data, the enrichment formula used in the United States is effective in raising the nutrient content of white bread from the lowest rating to the highest rating, and it now compares favorably with the breads of the world.

Brooke (1968) has reported that the enrichment of white bread in the United States today costs only 1 cent for 67 loaves, or about $\frac{1}{70}$ of 1 cent per loaf. Evidently much is being accomplished at a very low cost.

ENRICHMENT OF SWEET BREADS, CAKES, AND PASTRIES

It has been estimated that at the present time nearly 95% of the white bread in the United States is being enriched, even though approximately 30 out of 50 states have laws which require white bread enrichment.

The public does not realize that these enrichment regulations do not apply to cakes, pies, pastries, and similar sweet goods. Le Bovit (1968) reports that there has been a 65% increase in the consumption of sweet goods in this country in the past 10 years. Undoubtedly this has resulted from the increased popularity of the coffee break.

Unfortunately, sweet goods were exempted when the standards of identity for enriched flour and white bread were set up over 25 years ago. Standards of identity for enriched sweet goods should be promulgated to protect those who habitually consume significant amounts of these foods.

ENRICHMENT OF SUGAR AND SUGAR PRODUCTS

With the advent of inexpensive synthetic vitamins more than 25 years ago, nutrition scientists in this country debated whether vitamins and minerals should be added to white flour and white bread in a mass effort to improve the nutrition of the population. Those who objected contended that the people should be educated to eat unrefined types of bread. The majority were of the opinion that since the people persist in eating bland white bread, they should be protected from their folly by providing white bread enriched with selected vitamins and minerals.

Nutrition scientists have not given similar support to suggestions that sugar and sugar products be supplemented with vitamins and minerals in a manner similar to white flour and bread. Sweet sugar appears to be irresistible to many, especially children and the elderly. Consid-

eration should be given to supplementing table sugar, candies, and other foods rich in sugar content with amounts of vitamins and minerals sufficient to make these foods self-sufficient metabolically. Sugar is most in need of enrichment because it is a "naked-calorie" food and must therefore depend on other foods in the diet to supply the nutrients needed to catalyze its metabolism.

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