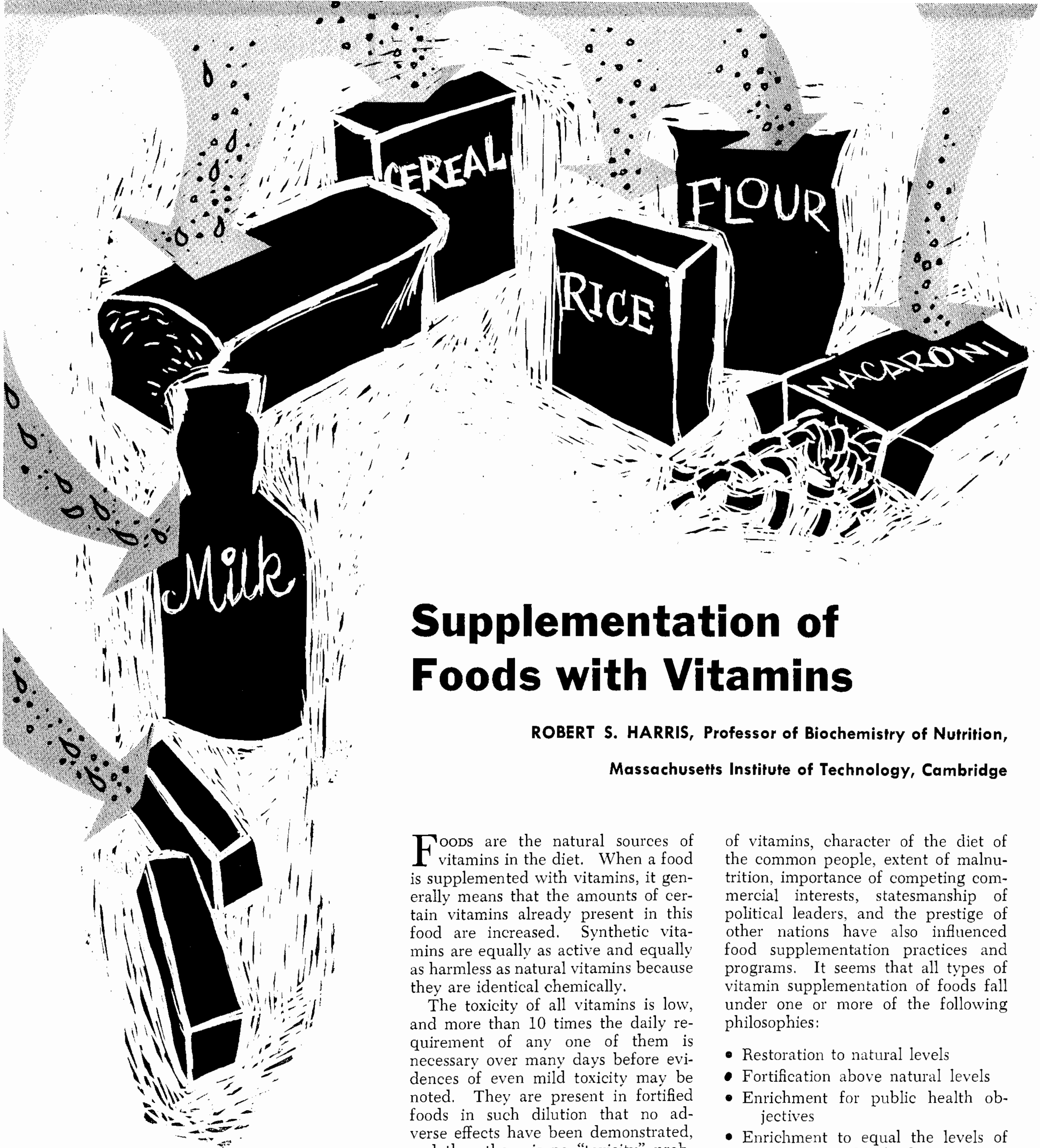


Supplementation of Foods with Vitamins

ROBERT S. HARRIS, Professor of Biochemistry of Nutrition,

Massachusetts Institute of Technology, Cambridge

FOODS are the natural sources of vitamins in the diet. When a food is supplemented with vitamins, it generally means that the amounts of certain vitamins already present in this food are increased. Synthetic vitamins are equally as active and equally as harmless as natural vitamins because they are identical chemically.

The toxicity of all vitamins is low, and more than 10 times the daily requirement of any one of them is necessary over many days before evidences of even mild toxicity may be noted. They are present in fortified foods in such dilution that no adverse effects have been demonstrated, and thus there is no "toxicity" problem in relation to the vitamin supplementation of foods.

Philosophy of Vitamin Supplementation

Vitamin supplementation of foods in different countries has been carried out for so many different reasons that the kinds and amounts of vitamins added to any particular type of food are seldom the same. Influence of food scientists on national policy, cost of vitamins, character of the diet of the common people, extent of malnutrition, importance of competing commercial interests, statesmanship of political leaders, and the prestige of other nations have also influenced food supplementation practices and programs. It seems that all types of vitamin supplementation of foods fall under one or more of the following philosophies:

- Restoration to natural levels
- Fortification above natural levels
- Enrichment for public health objectives
- Enrichment to equal the levels of interchangeable foods
- Fortification to make a food nutritionally self-sufficient
- Addition for non-nutritional reasons

Restoration to Natural Levels

Significant quantities of vitamins may be removed when foodstuffs are milled, or may be destroyed during dehydration, heating, treatment with radiant energy, or storage. These

Nearly 90% of all white bread sold in the U. S. is vitamin enriched

processing procedures are necessary if urban populations remote from their sources of food supply are to be fed. Many food processors are therefore restoring some of the vitamins lost during manufacture of their products. The vitamins selected for restoration are those which are destroyed in significant amounts, which tend to be present in limited quantities in the diets of the people, and which are inexpensive. Usually the amount added is sufficient to raise the vitamin to the level present in the food before processing.

The restoration philosophy may be criticized on the ground that the vitamin content of an unprocessed food has no relation to human nutrition. The vitamin content of whole wheat is related to the biological needs of the sprouting seed next season and not to the needs of man; that of cow's milk is related to the needs of the very young calf and not of children and adults; and that of spinach is related to metabolic functions of the growing plant and not to needs of human beings. Thus, restoration of a vitamin to the pre-processing level is not necessarily useful to the consumer.

On the other hand, restoration to natural vitamin levels may be praised as an attempt to repair damage done during processing and storage. Table I shows that several vitamins are sensitive to pH, oxygen, light, and heat, and that losses in preparation may be large. Table II reveals that important amounts of nutrients are removed during the milling of wheat. Similarly, significant amounts of vitamins and other nutrients are lost when foods are blanched, canned, dehydrated, pasteurized, and stored (*25*).

Fortification Above Natural Levels

Some food products (such as infant or geriatric foods) are designed to carry the burden of the nutrition of an individual. These products may supply all the required nutrients or they may be designed to complement the nutrients of milk with which they are to be compounded. Such special purpose foods or food combinations should contain optimum levels of all vitamins in a daily portion. These levels are governed by the needs of the person to be fed, rather than by the composition of the foodstuffs from which the product is prepared.

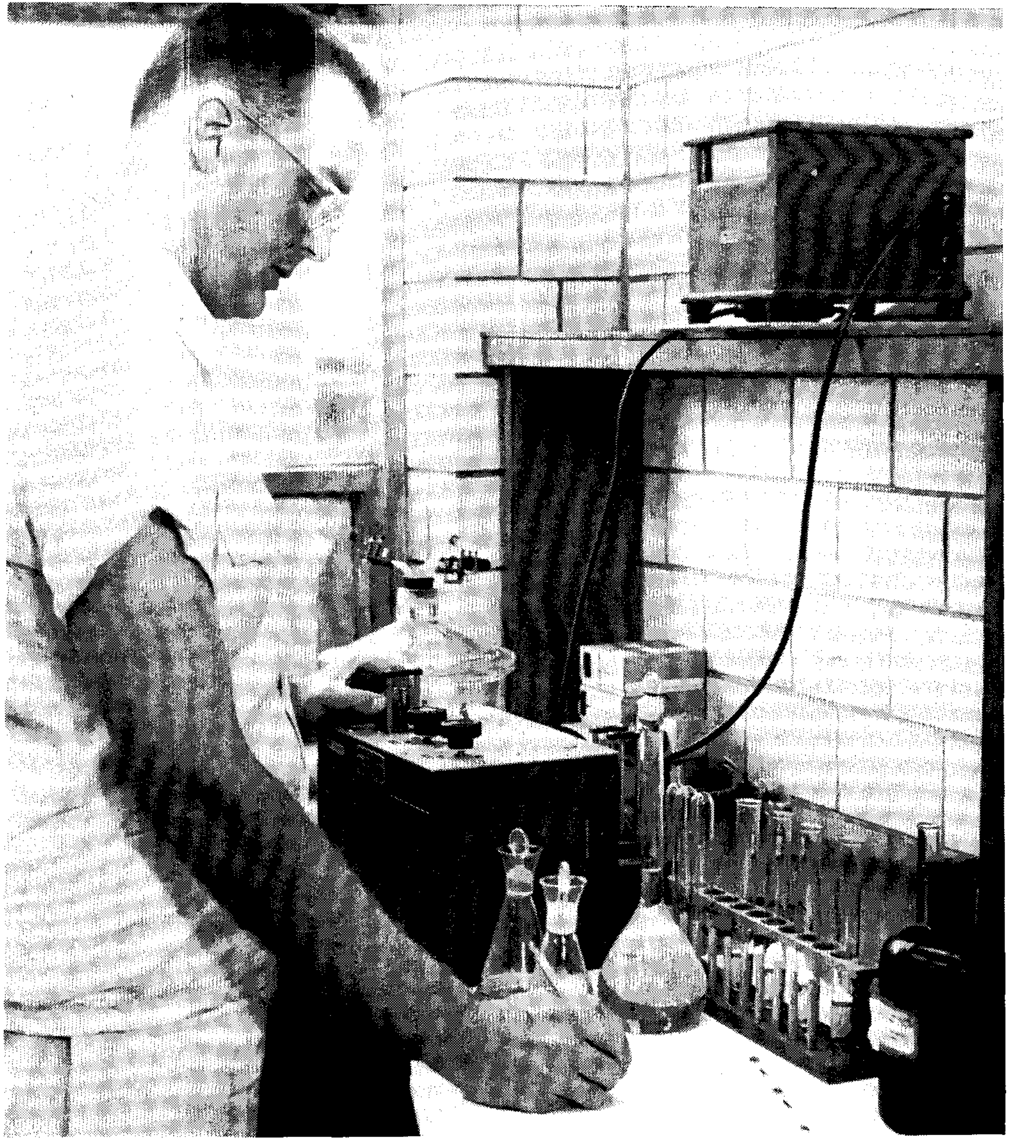
By virtue of their being excellent carriers for certain vitamins, some foods are used to provide a major part of the day's requirement to the consumer. Vitamin D milk and vitamin C enriched fruit juices for the nutrition of infants and young children are typical of foods in this category.

Enrichment for Public Health Objectives

A fine example of enrichment for public health objectives is the enriched flour and bread of the United States. In 1942, Lane, Johnson, and Williams

At its San Francisco Meeting in 1958, the ACS Division of Agricultural and Food Chemistry presented a major symposium on food additives. During the next several months, AG AND FOOD will publish a number of papers from that symposium, covering in particular the scientific evidence for nutritional improvements of food through supplementation with vitamins, minerals, essential fatty acids, and amino acids.

The intentional addition of chemicals to improve foods has been practiced for centuries. It started with the addition of salt. Where it will go is a matter for conjecture, but numerous guideposts have already been erected. Significant milestones from the past and guideposts for the future are outlined in this article and those that will appear in our next several issues. —THE EDITORS.



Vitamin determination with a photoelectric colorimeter

(*33*) reported that the thiamine content of the diet of the middle two-thirds to three-fourths of the U. S. population was about 0.8 mg. per 2500 calories. They calculated that it would be increased to 1.3 mg. by the use of enriched flour and bread. The National Research Council recommended 1.25 mg. per 2500 calories (*18*). The riboflavin content of the diet was 1.4 mg. per 2500 calories instead of the recommended 1.8 mg.; and the niacin content was 11 mg., rather than 12 mg. per 2500 calories (*18*). Thus, prior to enrichment the U. S. dietary was deficient in thiamine, riboflavin, and niacin. At that time a National Research Council committee concluded (*32*) that "The evidence from numerous surveys over the past ten years among people of all ages in many localities is in agreement that inadequate diets are widespread in the nation. . . . It would seem advisable to give further consideration to the program of judicious enrichment of appropriate foods since that would add much to the guarantee of successful nutrition."

On the basis of the Recommended Dietary Allowance, and data on the average per capita intake of flour and bread, and the average daily intake of thiamine, riboflavin, and niacin in the diet, it was possible to calculate the amounts needed to make the average U. S. dietary adequate in these three vitamins. It was reasoned that flour and bread enriched with these quantities of vitamins and consumed in average amounts (6 slices) would raise the nutritive value of the average diet to desirable levels and eliminate malnutrition due to deficiencies of these vitamins.

This public health approach is attractive because it permits improvement of diets without requiring any change in stubborn food habits, it is inexpensive, and it is effective.

But this philosophy may be criticized because the enrichment formula is transient and requires continual resurvey and revision to make certain that enrichment is adequate on the one hand, and is not wasteful on the other. In the U. S. A. the enrichment formula of cereal products has not been revised year by year to make it conform with changes in dietary patterns. Certainly there have been shifts since 1941 in the amounts of thiamine, riboflavin, niacin, iron, and other nutrients supplied by foods other than bread and flour to the average consumer. Furthermore, no improvements have been made by the addition of other nutrients to the enrichment formula.

This approach to flour and bread enrichment in the United States has unwittingly delayed the adoption of similar measures in other countries. The U. S. enrichment formula was based on the needs of the U. S. population and certainly has no meaning for a country such as Venezuela. To accord with this philosophy each country must determine by survey the per capita deficiencies of its own population, and thereby determine what vitamins and minerals should make up its own enrichment formula and what amounts of each nutrient should be used. This survey is expensive and complicated, and it requires trained personnel. But all this is necessary if the public health approach to enrichment of staple foods is to be used properly.

It is a fact that the enrichment formula in the U. S. A. is in need of revision, having been developed 18 years ago. Since the inception of the enrichment program "dietary surveys made in this country show a great increase in the thiamine, riboflavin, niacin, and iron intake. Clinicians interested in nutritional deficiency diseases report almost virtual disappearance of beriberi and pellagra" (*2*). Though the enrichment of flour and bread is partly responsible for this improvement, it is due also to a better selection of foods.

It is evident that the enrichment of staple foods in terms of the dietary deficiencies of the population is not a completely satisfactory approach.

Enrichment to Equal Vitamin Levels in Interchangeable Foods

This approach is being used in Great Britain in the enrichment of low extraction flour and bread. Enriched 70% extraction flour in Britain contains essentially the same amount of thiamine, niacin, and iron as 80% National flour. Riboflavin is not added because the government policy links riboflavin to milk rather than to bread (*21*). Apparently this more conservative philosophy of enrichment was adopted in Britain to keep the bread made with enriched white flour comparable in vitamin content to that made from the National flour. The latter bread was recommended as a wartime economy measure.

Another example of the equal-level

approach is enriched margarine. In the U. S. A. margarine is fortified to 15,000 U.S.P. units of vitamin A activity per pound, the average yearly potency of butter. Because butter may fluctuate between 5,000 and 24,000 I.U. of vitamin A during the year, margarine is a more reliable source of vitamin A activity.

A third example of this philosophy of enrichment is the addition of ascorbic acid to fruit juices (apple, tomato, pineapple, orange, e.g.) to standardize them at 30 mg. per serving. This is advocated because these juices are commonly taken at breakfast and the consumer has come to expect them to supply significant amounts of ascorbic acid to his diet. The adjustment of all types of fruit juice, even orange juice, to the same significant level of ascorbic acid is laudable.

Fortification to Make a Food Nutritionally Self-Sufficient

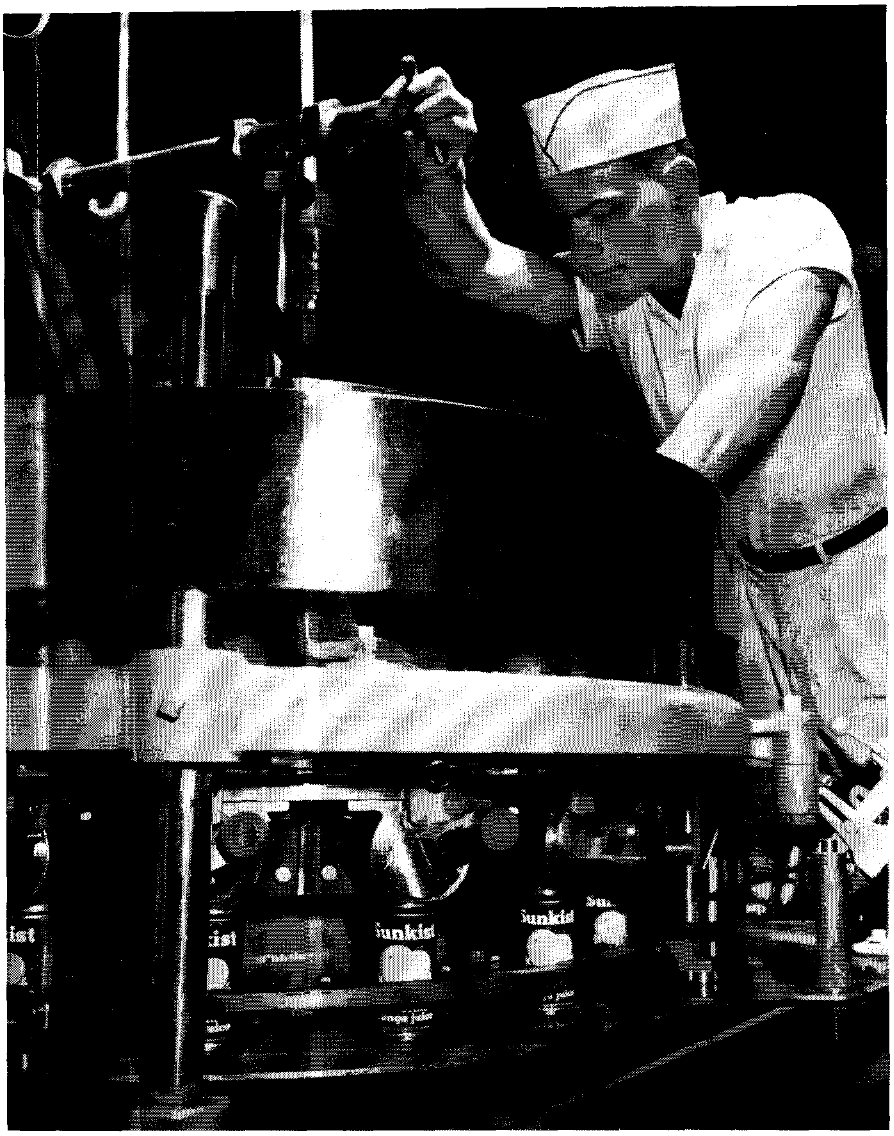
Vitamins are involved in the metabolism of carbohydrates, fats, and proteins. It is more meaningful to express the requirement of certain vitamins in terms of calories (and even in terms of carbohydrate calories, fat calories, and protein calories) than in relation to age, sex, weight, and activity. The approximate number of milligrams of some vitamins required to metabolize a food can be calculated from its proximate analysis. Soon it will be possible to do this with precision. On the basis of these data a food may then be fortified with those nutrients in which it is deficient, and as a result it will become metabolically self-sufficient.

At present most foods lean on other foods in the diet to make up for their deficiencies. In sophisticated diets these other foods are often not sufficiently endowed with extra amounts of these nutrients so that they may adequately contribute to the metabolism of other foods. Furthermore, these supplementary sources of vitamins are often not taken concurrently with the foods which they might assist in metabolism.

This philosophy of enrichment will rapidly develop as more precise data on the vitamin-calorie relationship become available. This is the most sound and scientific approach to food enrichment.

Addition for Nonnutritional Reasons

Ascorbic acid and the tocopherols are more than vitamins for they also protect other unstable compounds in foods from destruction. Ascorbic acid is an active detoxifier, also.



Fruit juices are fortified with vitamin C to a level of about 30 mg. per 4 oz.

These vitamins may be added to foods, therefore, primarily because of their non-vitamin activities. These uses will be discussed later.

Policy of FDA Relating to Enrichment of Foods

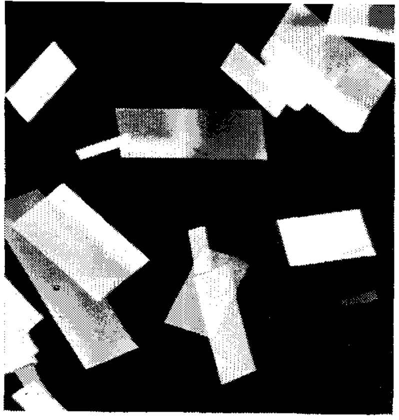
In the recently proposed Standards of Identity for Frozen Desserts (*15*), addition of carotene and vitamin A as optional ingredients was not approved. The following statement of policy was given in justification for this stand:

"To avoid confusing and misleading consumers, the fortification of food with vitamins should be restricted to a few staple foods that are effective carriers of the particular vitamins deficient in the diet of a significant segment of the population that regularly consumes the foods to be fortified."

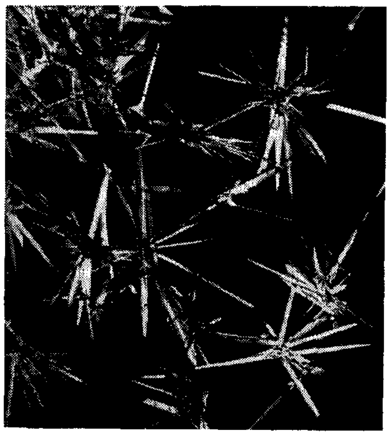
This general policy has been applied to those foods for which Standards of Identity have been established. While this policy is administratively convenient, it puts a freeze on the present nutritional quality of a food and retards improvement. The tendency in recent years has been for people to consume a wider variety of foods, other than staple foods. It is true today that enriched white bread is so good nutritionally that a person becomes less well fed as he consumes less bread.

When staple foods are singled out for enrichment, and when the enrichment of other processed foods is frowned upon, the problem of nutrition becomes increasingly difficult as a person decreases his intake of staple foods. Significant enrichment of all processed foods should be permitted, not required, not prevented.

The Swiss Federal Department of the Interior issued a decree on March 7, 1957, giving guiding principles for food enrichment (*39*). Article 3 of this decree states that "the addition of vitamins should be made primarily in those cases where foodstuffs suffer vitamin losses during processing (restoration of original vitamin contents)." A food product labeled "rich in vitamins X and Y" should contain at least the daily requirements of vitamin X and Y; to justify a declaration "contains vitamins X and Y" it must contribute one third the daily require-



Beta-naphthoate



Palmitate

Phenylether

Pure Vitamin A Preparations . . .

ments of these vitamins. No product may contain more than three times the daily requirement in a daily portion. In principle, all foodstuffs except alcoholic beverages and tobacco may be vitaminized. The vitamin "requirements" are in accord with the NRC Recommended Dietary Allowances.

However, unlike NRC, the Swiss have established daily requirements for the following: vitamin B_6 1.6 mg., pantothenic acid 10 mg., vitamin B_{12} 1 γ, vitamin K 3 mg., vitamin E 10 mg., vitamin P (rutin) 20 mg. The daily portions of the most important foodstuffs have been fixed by the decree. Also, it has defined the promotional arguments for vitamins which are permitted in the marketing of food products. Foods such as milk which show wide seasonal variations in natural vitamin content must be supplemented with vitamins to a standard level if these foods are to be sold with a vitamin declaration.

This decree has sufficient flexibility to control the enrichment of basic foods and special purpose foods and yet permit significant nutritional improvement of all important foodstuffs.

Special Purpose Foods

"If a food purports to be or is represented for special dietary use by reason of its use for treating any disease resulting from a dietary deficiency in man, its label shall bear . . . a statement of the proportion of the minimum daily requirement for such vitamin supplied by such food when consumed in a specified quantity during a period of one day. . . . The quantity specified as above shall be the quantity customarily or usually consumed during a period of one day. . . . If the need in human nutrition for such a vitamin has not been established, the label shall also bear the statement 'The need for ___ in human nutrition has not been established'" (*13*).

For purposes of the regulation, the FDA has established the following minimum daily requirements (MDR):

	Infant	Child under 6 yr.	Child over 6 yr.	Adult
Vitamin A	15000 USP	3000 USP	3000 USP	4000 USP
Vitamin D	400 USP	400 USP	400 USP	400 USP
Thiamine	0.25 mg.	0.50 mg.	0.75 mg.	1.0 mg.
Riboflavin	0.6 mg.	0.9 mg.	0.9 mg.	1.2 mg.
Niacin		5.0 mg.	7.5 mg.	10.0 mg.
Ascorbic acid	10.0 mg.	20.0 mg.	20.0 mg.	30.0 mg.

In this way FDA controls the labeling of special purpose foods with respect to vitamin content. A food should contain at least 10% of the MDR in a daily serving in order to be considered a significant source of that vitamin.

Enrichable Foods

Enrichment is an effective way of correcting inherent deficiencies in a food because it places no responsibility on consumers and avoids the long and expensive efforts needed to change food habits through education.

The decision as to whether a food is enrichable is influenced by the philosophy of the individual. Certain foods have been preferred for enrichment because they suffer serious nutritional damage during processing or because they are satisfactory vehicles for the nutrients needed by the population.

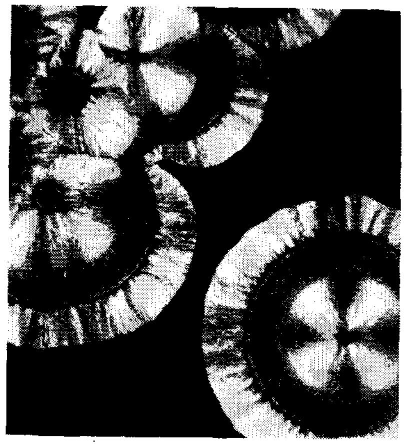
Wheat Flour and Bread

The germ and outer bran layers are removed during the milling of wheat. Various flours derived by this process are referred to in terms of "extraction" rate. A 70% extraction flour is what remains of the endosperm when 30% of the wheat kernel has been removed. Since the bran and germ layers are richer in nutrient content, the flours of lower extraction rate are relatively lower in nutrient content (Table III). Thus, a 72% extraction flour contains approximately five-sixths as much protein, one-fifth as much thiamine, one-fourth as much riboflavin, and one-eighth as much niacin as whole wheat meal.

Because these losses are great, because wheat products are an important part of the U. S. diet, and because these nutrients are present in limited amounts in diets, it was logical that the enrichment of white flour and bread was given serious consideration.

The enrichment of wheat flour and bread has been carried on for years in many countries either on a voluntary or compulsory basis. In the U. S. it was compulsory from 1941 to 1946 under War Food Order No. 1. Since the repeal of this order, 27 states have passed flour and bread enrichment legislation. Even though the enrich-

Methylether



Stearate

p-Phenyl-asobenzoate

ment of flour and bread is carried out on a voluntary basis in the remaining states, it is estimated nearly 90% of all white bread sold today in the U. S. is enriched.

The history of flour and bread enrichment in Britain has been fraught with controversy and the war emergency. In 1940 the government approved addition of thiamine to 72% extraction flour and soon 60% of all white flour was enriched. That same year the food shortage compelled the government to raise the extraction level to 85%, in 1944 it was reduced to 82%, and in 1945 a near-white 82% extraction flour with reasonable proportions of vitamins was produced. However, during the first quarter of 1946, the extraction rate was raised to 90%, during the next four months it dropped to 85%, then to 80%, where it has remained.

Beginning in 1945, the British government required that all flour contain a minimum of 0.24 mg. thiamine, 1.6 mg. niacin, and 1.65 mg. iron per 100 gm. These nutrient levels approximate the amounts in 80% extraction flour. Cereals were controlled and bread was subsidized from the end of the war until 1953. For the first time in 13 years flours with extraction rates below 80% were permitted, but only if they contained the three token nutrients at levels above the specified minima. To discourage the use of these flours, however, bread made from white flour for a time was given a lower subsidy.

The nutritive value of the British National Flour has decreased since decontrol because the extraction rate has dropped from 80% to about 74%. Its quality is poor and it is said to be unpopular with millers, bakers, biscuit makers, and the public (*31*).

The recommended or required levels of vitamin and mineral enrichment of white flour according to countries are given in Table IV. In certain countries (e.g. Sweden) some calcium is added to the vitamin mixture to enhance its handling characteristics rather than for its nutritional value. The type of calcium used in flour enrichment is not of nutritional importance, for Bronner et al (*10*) have shown by radio-calcium studies that the commonly used calcium salts are equally effective in the nutrition of children.

Bread enrichment is permitted or required in several Australian states and in Belgium, Brazil, Canada, Chile, Costa Rica, Denmark, Germany, Guatemala, Israel, Panama, Peru, the Philippines, Salvador, Switzerland, United Kingdom, Uraguay, and Venezuela.

Enrichment materials may be added directly to the flour at the mill. This is often done by preparing a homogeneous premix of vitamins and minerals with an aliquot of flour and then blending the premix into the entire batch of flour. Usually the enrichment in the form of a premix is continuously added by mechanical feeders to the flour at the mill. Further agitation and handling ensures uniform distribution of the vitamins in the flour.

In most countries, and at small bakeries in the U. S., it is more practical to use flour which has been enriched at the mill. In large bakeries, especially in the U. S., it has been found more convenient and economical to add the enrichment at the dough stage in bread making. When certain ingredients (i.e. milk, yeast, yeast food) of the bread formula contribute significant amounts of vitamins and minerals to the final loaf of bread, it is an economic advantage to add smaller amounts of these nutrients via the enrichment mix. By this economy the baker can also avoid exceeding the maxima permitted by the regulations. Bakers can purchase enrichment tablets or powders which they disperse in water and work into calculated amounts of dough to produce a bread which conforms with local regulations relating to nutrient content. At least two types of enrichment tablet or powder are available: one for use in bread formulas containing less than 4 lb., and the other for bread formulas containing more than 4 lb. of nonfat milk solids per 100 lb. of flour.

During the 20th century there has been a growing preference for low extraction flour and white bread. White bread is easier to digest than whole wheat bread, its calcium and iron are more available, and its protein (because of added milk) is of higher nutritional value.

The contribution of enriched white bread to the diet of the U. S. population has been presented in several ways by USDA. Five cents' worth of bread (6 slices, 23 gm. each, $.172 per pound loaf) was calculated (*43*) to contribute the following percentages of the NRC Dietary Allowance (*19*) of a young man: thiamine 20%, riboflavin 12%, niacin 18%, calcium 13%, iron 19%, protein 17%, and calories 11%. A survey showed that in 1955 only 4% of the food budget was used to buy enriched white bread. This 4% bought the following percentages of nutrients (*43*) in the diet: thiamine 14%, riboflavin 10%, niacin 13%, calcium 7%, iron 12%, protein 10%, and calories 10%. Thus, enriched bread supplied an average of 16% of the daily allowance of these essential nutrients for 5 cents, about 10% of the daily intake of these nutrients for only 4% of the food budget, and more nutrition per calorie than the average food in the diet. These data show that enriched white bread makes a significant contribution of thiamine, riboflavin, iron, and niacin to the diet. It is fortunate that these vitamins and minerals can be added to foods without the public's knowing it; but also unfortunate, for what the people cannot see or taste, they cannot easily believe.

There are some who refuse to be convinced that enriched bread is good solely on the basis of its composition or the results which are obtained when it is fed in the diets of rats. They insist that its values be demonstrated in human beings. One study to which the disbelievers point is that conducted by McCance and Widdowson in Germany, on starving children (*49*). This report confounded both the naturalists and the synthesists in concluding that there were no differences in the growth and development of children fed bread made from either whole wheat, 80% extraction flour, 70% extraction flour, or 70% extraction flour enriched with thiamine, niacin, and iron to the level of 80% extraction flour. "All the breads were equally satisfactory and the nutritional state of the children improved greatly."

This experiment has been variously interpreted and misinterpreted. The following points should be made regarding it:

- The analysis of the 70% extraction flour showed it to resemble 80% extraction flour.
- The enriched flour contained relatively low levels of thiamine, niacin, and iron enrichment, and no riboflavin additions.
- The period was relatively short for this type of study.
- The composition of the soups liberally consumed by the children was not known.
- Since starving children respond to any food, they were poor subjects to use to detect moderate differences between breads.

For these reasons, the claim that the McCance and Widdowson report proves that unrefined, refined, and enriched breads are equal in human nutrition when fed as part of ordinary diets is to be disputed.

A more meaningful demonstration of the values of enriched white bread is to be found in the study in Newfoundland begun in 1944. After the nutritional status of the people was determined, the bread and flour of a large area were replaced by flour and bread enriched to U. S. standards. A resurvey in 1948 showed that signs of malnutrition had been reduced, and apathy and listlessness had disappeared from the population (*5*). By 1950 the crude death rate had fallen from 12.1 to 9.6 per 1000, stillbirths from 43 to 33 per 1000, infant mortality from 111 to 53.4 per 1000, tuberculosis from 136 to 65 per 100,000. Decreases were noted only in those signs of malnutrition which could have been affected by the enrichment program (deficiencies in thiamine, riboflavin, niacin, iron, calcium). There was no indication in

Table I. Stability and Lability of Vitamins[a]

Nutrient	Hydrogen Ion Conc. Neutral	<pH7	>pH7	O_2	Light	Heat	Cooking Loss (%)
Vitamin A	S	...	...	L	L	S	10–30
Ascorbic acid	L	S	L	L	L	L	20–80
Biotin	S	S	S	S	S	S	0–72
Choline	S	S	S	L	S	S	...
Cobalamin	S	S	S	L	L	S	...
Vitamin D_2	S	...	L	L	L	L	some
Vitamin E	S	S	S	L	L	S	50
Folic acid group	L	L	S	L	L	S	0–97
Inositol	S	S	S	S	S	S	0–95
Vitamin K	S	S	L	S	L	S	...
Niacin	S	S	S	S	S	S	0–72
Pantothenic acid	S	L	L	S	S	L	0–44
p-Amino-benzoic acid	S	S	S	L	S	S	...
Pyridoxine group	S	S	S	S	L	S	...
Riboflavin	S	S	L	S	L	S	0–48
Thiamine	L	S	L	L	S	L	25–45
Unsaturated fatty acids	S	S	L	L	L	S	10

S = stable; L = labile

[a] Adapted from Albritton (*1*).

Table II. Nutrient Content of Wheat Flours (U.S.A.)

Flour	Thiamine	Riboflavin	Niacin (Mg./100 Gm. Flour)	Calcium	Iron	Pyridoxine
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 III. Composition of British Flours According to Extraction Rate[a]

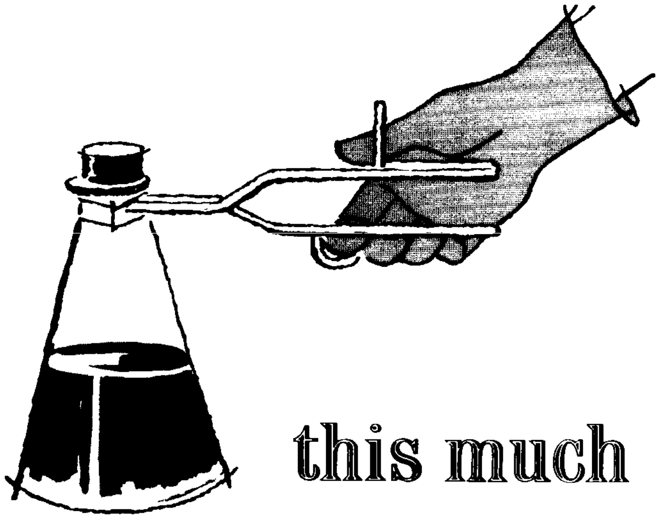
Extraction Rate	Protein (%)	Thiamine (mg.%)	Riboflavin (mg.%)	Niacin (mg.%)
100% whole meal	12.0	0.40	0.12	6.00
85%	11.6	0.30	0.07	1.70
80%	11.4	0.24	0.05	1.40
75%	11.2	0.15	0.04	0.77
72%	11.0	0.10	0.035	0.72
50%	10.0	0.08	0.03	0.70

[a] From Kent-Jones (*37*)

Table IV. Vitamin and Mineral Supplementation of White Wheat Flour According to Nation

Country	Thiamine (mg./lb.)	Riboflavin (mg./lb.)	Niacin (mg./lb.)	Calcium (mg./lb.)	Iron (mg./lb.)	Vitamin D (I.U./lb.)
Brazil	2.1	1.1	0	1100[a]	14[b]	0
Canada	1.9	1.1	14	565[c]	12–16	0
Chile	2.0	0.6	6	5[a]	6[b]	0
Denmark	2.3	2.3	0	900[d]	14[b]	0
England	0.9	0	4	550[h]	3	0
Sweden[i]	1.2–1.8	0.5	10–18	0	14[e]	0
United States	2.0–2.5	1.2–1.5	16–20	500–625[f,g]	13–16.5[e]	250–1000[f]

[a] $Ca_3(PO_4)_2$; [b] ferrum reductum; [c] $CaCO_3$ or bone meal; [d] $CaCO_3$; [e] $FeSO_4$; [f] optional; [g] $CaHPO_4 \cdot 2H_2O$, $CaSO_4$ or $CaCO_3$; [h] creta praeparata; [i] according to extraction rate.



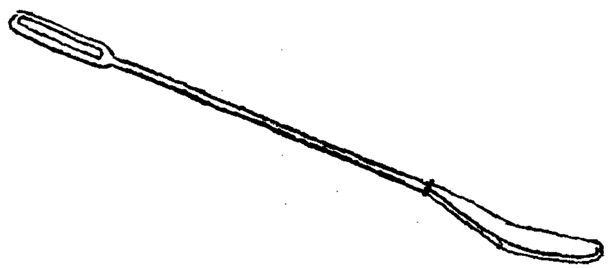
this much Methyl Parathion...

A little Victor methyl parathion puts the *cide* into those pesticides that knock boll weevils and other cotton pickin' pests for a loop.

Cotton farmers and pesticide formulators both bank on the fatal charm of Victor methyl parathion – whether used as a dust, a wettable powder, or an emulsifiable concentrate.

Perhaps you'd like to unload some of your problems . . . make your product more marketable, more economical to produce. You're in the driver's seat, of course, but selecting Victor phosphates, formates, and oxalates can pay dividends—as they have for many others in more than 40 industries. Write on your letterhead for literature of the chemical you are interested in. We'll have data on your desk before you can say, "It *pays* to see Victor."

Victor Chemical Works, Box 271, Chicago 90.



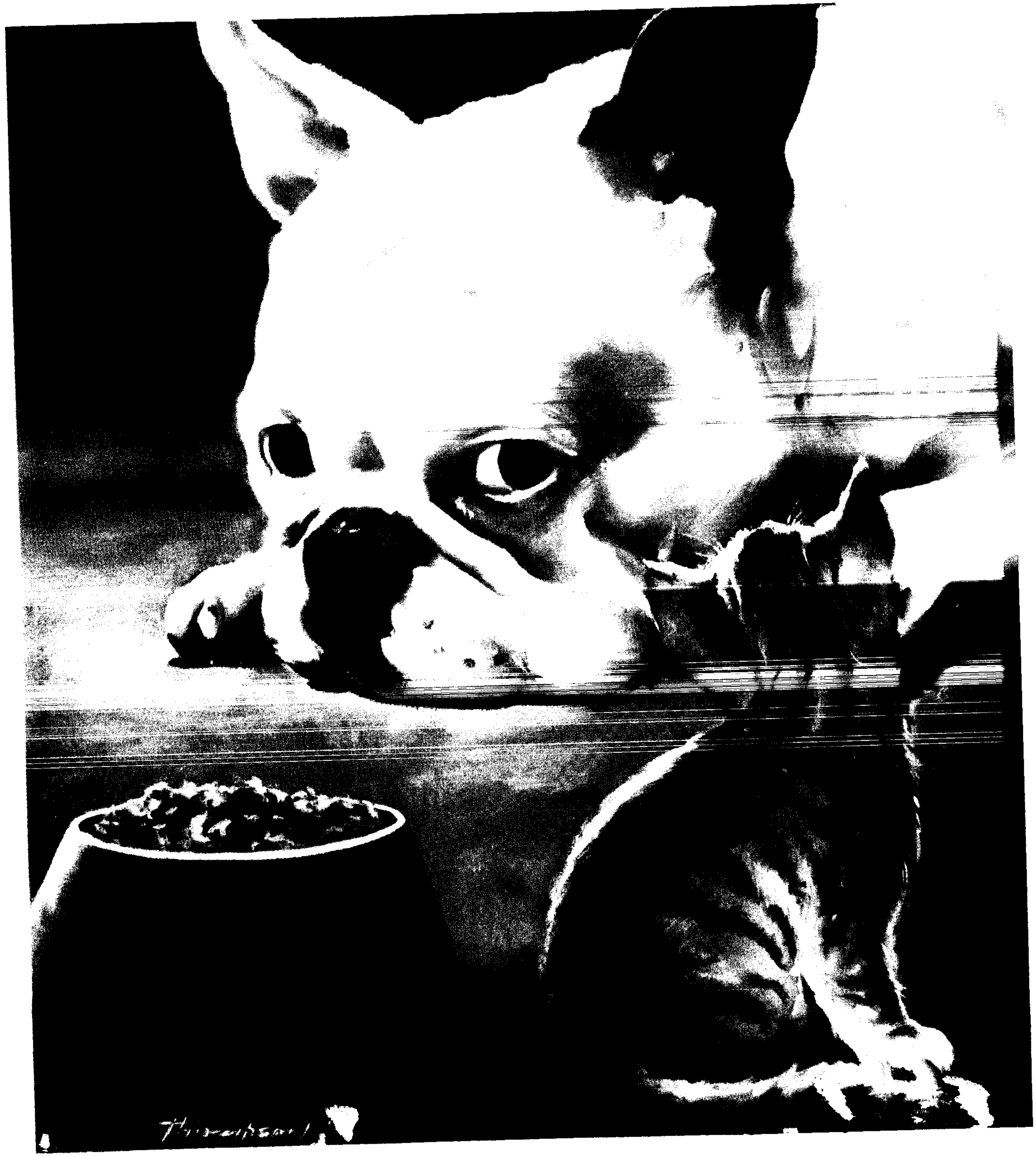
this much SIPP...

A single "pinch" of Victor SIPP *(Sodium Iron Pyrophosphate)* in pet food provides the iron enrichment animals need to stay healthy.

Victor SIPP doesn't "go to the dogs" exclusively, however. Because it is the safest form of iron for foods susceptible to rancidity, Victor SIPP is a popular source for iron enrichment in wheat flour, baby foods, candy, milk drink additives, vitamin tablets, and health preparations.

Why not take a long look at some of *your* products? We don't have any pet theories on how to solve production problems, but we're not letting the cat out of the bag when we tell you Victor phosphates, formates and oxalates have become real favorites for more than 40 industries. A sample of the chemical you'd like will be in your hands before you can say, "It pays to see Victor"—if you'll write on your company letterhead to:
Victor Chemical Works, Box 271, Chicago 90.

VICTOR
Dependable Name in Chemicals for 60 Years



his careful and extensive test that an important nutrient was missing from this bread.

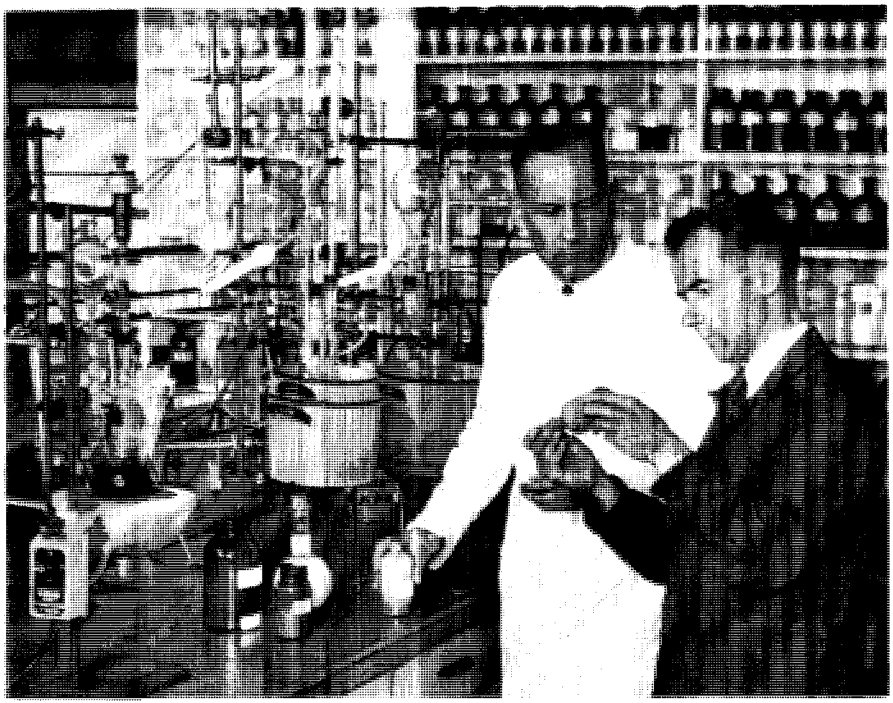
Rice

Rice is the chief cereal of mankind, nd is eaten mostly as white rice. During milling the bran layers and germ are removed and the nutritive value is greatly reduced. Beriberi is endemic wherever white rice is a major component of the diet of man. Attempts to induce populations to consume brown or parboiled rice in place of white rice have met with little success. Since deficiency disease in rice-eating populations can be largely eliminated by enrichment, there are many who believe enrichment to be the cheapest and most satisfactory solution of the white rice problem.

The value of the enrichment of polished rice with thiamine, niacin, and iron was studied in Bataan Province of the Philippines in 1947. After an initial survey, enriched rice was used exclusively by a population of 63,000. As a result of enrichment, the thiamine content of the average diet was raised from 0.7 mg. to nearly 2 mg. By 1950, the incidence of beriberi had declined by 93% in 7 municipalities and the mortality rate from beriberi had fallen from 263 in 1947–48 to 28 in 1949–50. There was a noticeable improvement in the alertness and general appearance of the people. There was complete absence of frank or suspected cases of beriberi where in the former survey there were numerous cases of both types (*11*, *38*). A population of 29,000 in an adjacent area showed an increase in beriberi during the same period.

Programs of rice enrichment have been developed in Colombia, Formosa, Hawaii, Japan, United States, and Venezuela, and a rice premix plant is in operation in Thailand. White rice enrichment is required by law in Puerto Rico, and in the Philippine provinces, and according to U. S. standards (see Table V).

In most areas rice is washed and rinsed before cooking. In the U. S. consumer packages of enriched rice can be enriched with a powdered premix which adheres to the surface of the rice. These packages must be labeled "Do not rinse before or drain after cooking." Because of traditional food habits in the major rice consuming areas, it is important to protect the enrichment ingredients against rinsing and not to rely on no-rinse labeling. In one satisfactory procedure, a premix is prepared by impregnating rice grains with 200 times the required level of vitamins and minerals. The impregnated grains



Ottolsler and assistant, of Hoffman-LaRoche, examine a sample of vitamin A

are then coated with a water resistant edible coating. This coating does not dissolve in cold water and therefore prevents the loss of nutrients during rinsing (*20*). It is solubilized during cooking and the nutrients are released. When 1 part of this premix is blended with 199 parts of unenriched rice, the resulting enriched rice contains the required levels of the specified nutrients.

In some countries riboflavin is omitted because the consumer objects to the yellow color it imparts to the rice. This is especially true of the grains of rice enriched by the premix method, for they contain 200 times as much riboflavin as the unenriched grains. Consumers have been observed to pick out and discard these yellow grains as undesirable. These people should be educated to appreciate the golden goodness of enriched rice. In the U. S. riboflavin has been listed as an optional ingredient until a public hearing can be held to determine whether it should be made a required ingredient (*14*), from the nutritional viewpoint. The inclusion of riboflavin is necessary.

Enrichment of Corn

In parts of the world whole corn is used in the preparation of tortillas, breads, or meals. It is milled and bolted to remove much of the bran, germ, and oil, and about half the corn consumed by human beings is degerminated. The meal and flour prepared from this bolted corn are nutritionally inferior to whole corn. Whole corn is deficient in niacin and in tryptophan, which is considered to be a precursor of niacin. This deficiency can be compensated for by the addition of niacin alone. Enrichment with tryptophan would be impractical because of cost, and because the body's conversion of it into niacin is only 2% efficient.

Standards of identity of enriched corn products were established in the U. S. in 1947 (Table V) and five states (Alabama, Georgia, Mississippi, and the Carolinas) have passed laws requiring enrichment of corn meal and grits. Different enrichment formulas are desirable for degerminated and non-degerminated corn, and the latter is definitely improved by supplementation. Egypt, Mexico, Yugoslavia, and other countries are experimenting with enriched corn.

Corn enrichment has presented difficult problems because, unlike wheat, much of it is processed in small mills which serve local populations. In large mills corn enrichment is handled as in the enrichment of flour.

It is a practice in many areas to rinse corn grits with water before use. Such a procedure would remove water-soluble enrichment ingredients. This problem has been solved by a procedure similar to that described for rice.

Enrichment of Milk

Cow's milk is not an adequate food for the complete nourishment of an infant or young child. When it reaches the consumer it may be deficient in vitamin D, iron, and perhaps vitamin C, vitamin B_6, and vitamin A, because of seasonal variations and processing losses. Vitamin

D is the only enrichment nutrient of milk which has had extensive trial in most countries (Table VI).

Whole milk has been supplemented with vitamin D in three ways: (1) feeding dairy cows irradiated yeast, (2) direct irradiation of the milk with ultraviolet light, and (3) addition of vitamin D concentrates. The latter is now preferred in most countries because exact dosage is simple and reliable, and little equipment is required. Since milk is a good source of calcium and phosphorus, and vitamin D aids in their utilization in the body, this program of milk enrichment is logical.

Milk supplemented with several other vitamins is now distributed in some areas of the U. S. A typical milk of this sort contains the following additions per quart: vitamin A, 3-5000 U.S.P. units; vitamin D, 400 U.S.P. units; thiamine, 1 mg.; riboflavin, 2 mg.; niacin, 10 mg.; ascorbic acid, 30 mg.; and occasionally iodine, 0.1 mg. and iron, 10 mg. Iron is not often added because it destroys ascorbic acid. A market for this type of milk has been slow in developing, primarily because local regulations usually prevent the addition of any foreign matter (including nutrients other than vitamin D) to milk. Wisconsin has passed regulations which permit the sale of this type of milk (*50*).

Milk supplemented with as much as 4000 U.S.P. units of vitamin A per quart is extensively used in the U. S., and fluorine has been added in restricted areas of Switzerland as a prophylactic for dental caries.

Though evaporated, condensed, and powdered milks have been enriched with vitamin D in the past, there is a growing use of vitamin A in these milk products. Thiamine is also added to condensed milk for distribution in certain countries.

Because populations receiving reconstituted nonfat milk have shown a tendency to develop vitamin A deficiency, WHO and FAO (United Nations) recommended that both vitamin A and vitamin D be added to all milks which are used as fresh milk substitutes in underdeveloped countries (*51*).

In the United Kingdom the vitamin D content of National dried milk was recently reduced from a minimum of 280 I. U. per dry ounce to an average of 100 I. U. (*30*). The change was made because experts feared that an excessive intake of vitamin D might cause illness in young children. Manufacturers of proprietary dried milks and of infant cereals have been asked to adopt the same levels of fortification as those recommended for these welfare foods.

The poor stability of the vitamins in nonfat and full-fat milk powders has been a difficult problem to solve. Methods for producing a vitamin A–fortified nonfat dried milk with good vitamin A stability have reportedly been developed (*12*). Synthetic vitamin A acetate or palmitate in vegetable oil is dissolved in coconut oil to which tocopherols and lecithin are added. The coconut oil in this application adds only about 0.2% fat to the dry product. This is homogenized into pasteurized skim milk and added to skim milk concentrate before spray drying.

Enrichment of Butter

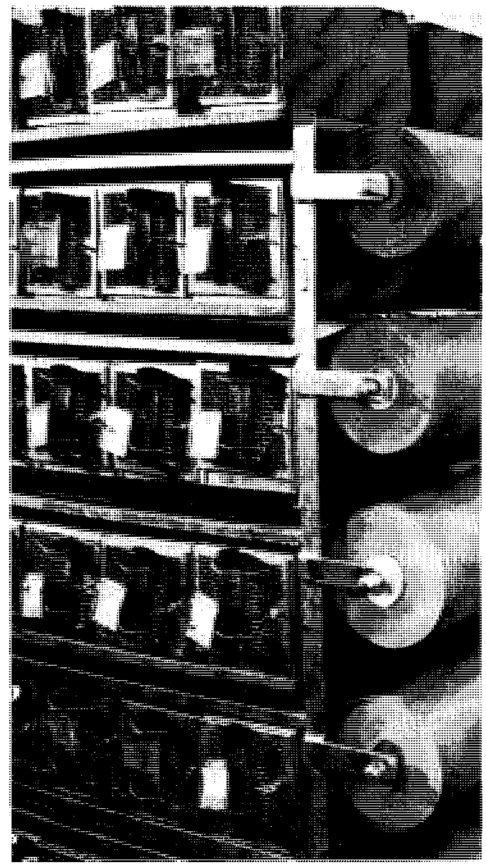
An extensive survey by USDA in 1947 (*44*) indicated that the β-carotene content of butter ranged between 1226 and 8020 U.S.P. units of vitamin A activity per pound and the vitamin A content ranged between 8320 and 22,907 U.S.P. units per pound; or an average of 15,000 U.S.P. units per pound during a 12-month period. β-Carotene and other vitamin A–active carotenoids are permitted colors for butter in the U.S.A. By adding β-carotene, pale winter butter may be made equal to summer butter in color and in vitamin A activity.

Fortification of Margarine

Margarine, commonly used as a spread interchangeable with butter, is generally fortified with vitamins A and D to equal or exceed the average levels of these nutrients in butter.

The fortification of margarine with vitamins A and D is at present mandatory in Denmark, United Kingdom, Israel, Norway, Sweden, and India ("vanaspati") (Table VII). It is enriched on a voluntary basis in Australia, Austria, Belgium, Brazil, Canada, Germany, Finland, Greece, Holland, Iran, Newfoundland, Pakistan, Portugal, Russia, South Africa, Switzerland, Turkey, and the U. S. (since 1941). It is estimated that 75% of the world's margarine production is fortified.

A vegetable oil concentrate of the vitamins is added to the margarine during processing. Measured amounts of α-tocopherol (vitamin E) are often added to assist in stabilization of the vitamin A and the fats. Coal tar colors were widely used for coloring until their harmlessness was questioned. A desirable color can be achieved by the use of β-carotene (provitamin A), a natural colored food constituent. A safe color, β-carotene can provide much of the required vitamin A activity.



Enrichment of Macaroni Products

Since macaroni products are made chiefly from refined wheat, durum, semolina, and other farinaceous material, FDA standards of identity have been promulgated for enriched macaroni and noodle products.

Though the average consumption of macaroni was only about 7 lb. per capita per year in 1952 and the consumption in urban areas was estimated to be 20 lb. per capita per year, as much as 82 lb. per capita per year was consumed by people of Italian origin. It is important that racial and cultural groups be considered when a food is assessed for enrichment.

The FDA has established minima and maxima for thiamine, riboflavin, niacin, and iron for enriched macaroni (Table V). These levels allow for 30% to 50% losses in preparation and cooking. Some macaroni is enriched during batch manufacture by the addition of an enrichment wafer or powder to each 100 lb. flour after dissolving it in water. Manufacturers who use the continuous press method prefer a powdered concentrate of vitamins and iron; this premix is fed in measured amounts into the semolina or flour stream. They may also purchase semolina or flour enriched at the flour mill.

Merck's vitamin research laboratory provides space for several thousand rats, each in an individual cage

The important effects of macaroni enrichment may be seen from the fact that 200 calories of enriched macaroni contains 0.2 mg. more thiamine, 1.0 mg. more niacin, and 0.1 mg. more riboflavin than 200 calories of unenriched macaroni, equivalent to 20%, 10%, and 8% of the minimum daily requirement of thiamine, niacin, and riboflavin, respectively.

Enriched Farina

Farina has essentially the same vitamin and mineral content as 72% extraction flour. It is consumed by people of all ages, especially by infants and young children. It is bland, highly digestible, and easily eaten.

Farina was perhaps the first cereal to be vitaminized. A standard of identity has been established by the FDA (Table V). Enriched farina is nutritionally superior to enriched white bread in content of iron, thiamine, riboflavin, and niacin, but lower in calcium, on a dry basis.

Enrichment of Breakfast Cereals

Cereals may lose significant amounts of thiamine, riboflavin, niacin, iron, vitamin B_6, and lysine during processing. Every practical effort should be made to retain all natural nutrients by improvements in processing procedures. However, when these losses are unavoidable and are important it is desirable to restore these nutrients to whole grain levels.

In a "statement of principle concerning breakfast food cereals and amounts of certain nutrients" the NRC food and nutrition board (*17*) advised a U. S. government agency in 1942 that cereal products be restored with the following amounts of thiamine, niacin, and iron in order to be "considered as acceptable compliance with the whole grain levels":

Product	Milligram per Lb. Thiamine	Niacin	Iron
Wheat	2–3	24–36	16–24
Oats	3–4	4–8	12–24
Rice	1.5–2.5	20–30	10–20
Corn	1.7–2.6	8–12	6–15

Recently in the United States there have been marketed several types of flake cereal product which contain higher levels of vitamins and minerals than are found in whole grain cereals. One ounce of one of these products supplies one third of the minimum daily adult requirements of thiamine, riboflavin, niacin, ascorbic acid, vitamin D, and iron; it supplies one tenth of the MDR of calcium and phosphorus; and this ounce also supplies a third of the daily allowance of vitamin B_6 and vitamin B_{12}. A similar product contains slightly larger amounts of six of these nutrients, an equal amount of one, lesser amounts of two, no added vitamin B_6, but some folic acid.

Fortification of cereal products to whole cereal levels or with amounts of a nutrient sufficient to make the product self-sufficient metabolically is laudable. Fortification beyond these levels is not generally advisable. A cereal product which is essentially a complete meal does not serve the best interests of the consumer who should consume a wide variety of foods.

Enrichment of Special Dietary Foods

In the U. S., a food intended for special dietary use by man is subject to FDA regulations. The label must state the proportion of the minimum daily requirement (MDR) of vitamins and minerals when consumed in a specified daily intake, according to the age groups for which it is intended.

FDA recognizes the requirement for only certain vitamins and minerals in human nutrition. Foods may be enriched not only with these vitamins and minerals, but others for which the MDR has not yet been established. However, if a claim is made for any nutrient, the amount and its nutritional contribution must be stated on the label.

Vitamin C Fortification of Fruit Juices

The vitamin C content of canned natural fruit juices is low for certain species of fruit, and variable for all species:

Canned Fruit Juice	Ascorbic Acid per 100 Gm.	
Apple	0.2–3.6 mg.	
Cranberry	7.5–10.5	(*16*)
Grape	0.0–4.7	
Grapefruit	10.0–49.0	
Orange	9.7–70.0	
Pineapple	5.4–18.0	
Raspberry	7.5–8.3	(*37*)
Tomato	1.8–29.3	(*3*)

Since these juices, and blends of these juices, are used interchangeably in breakfasts to supply dependable amounts of ascorbic acid, it is rational to fortify canned juices to about 30 mg. per 4 fl. oz. (118 cc.), a level of vitamin C which is considered good. In commercial processing and storage there is usually a loss of 5 to 15 mg. of ascorbic acid per 4 fl. oz. of canned product. Experience indicates that at least 30 mg. are present at the end of the shelf life of a product which contained 35 to 45 mg. per 4 fl. oz. before pasteurization. Sale (*40*) reported a 75% average retention of

Table V. Levels of Enrichment of U.S. Foods (Mg./lb.)

Enriched product	Thiamine		Riboflavin		Niacin		Vit. D[a] (U.S.P. units)		Iron		Calcium[a]	
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
Bread	1.1	1.8	0.7	1.6	10.0	15.0	150	750	8.0	12.5	300	800
Flour[b]	2.0	2.5	1.2	1.5	16.0	20.0	250	1000	13.0	16.5	500	625
Farina[c]	2.0	2.5	1.2	1.5	16.0	20.0	250	...	13.0	...	500	...
Macaroni[d]	4.0	5.0	1.7	2.2	27.0	34.0	250	1000	13.0	16.5	500	625
Noodles[a]	4.0	5.0	1.7	2.2	27.0	34.0	250	1000	13.0	16.5	500	625
Corn meal	2.0	3.0	1.2	1.8	16.0	24.0	250	1000	13.0	26.0	500	750
Corn grits[e]	2.0	3.0	1.2	1.8	16.0	24.0	250	1000	13.0	26.0	500	750
White rice	2.0	4.0	1.2[a]	2.4[a]	16.0	32.0	250	1000	13.0	26.0	...	...
Whole milk	...	...	...	...	...	...	150	400	...	...	...	...

[a] Enrichment is optional; [b] in enriched self rising flour, Ca 500–1500 mg./lb. required; [c] no maximum for iron; [d] levels allow for 30–50% losses in kitchen procedures; [e] levels must not fall below 85% after washing and rinsing.

ascorbic acid in citrus juice blends after 12 months' storage, while Atkinson and Strachen (*4*) found a 90% retention of added ascorbic acid in grapefruit after 10 months' storage. Lee et al. (*34*) observed good retention of ascorbic acid after storage of six juices or juice blends for 11 months at room temperature.

Other Vitamins for Food Enrichment

As the nutritional importance of certain vitamins became known and the extent of their losses in processing, storage, and preparation was recognized, food processors began to add these vitamins to certain foods. During recent years, nutritional and clinical data have indicated that mild pyridoxine deficiencies exist as a result of low intake of this vitamin. The report of Nisensen (*36*) seems to warrant further study of the extent of biotin deficiency, especially in prenatal and infant diets, since seborrheic dermatitis occasionally responds to biotin administration. Changing food habits and promiscuous medication with antibiotics and sulfa drugs may diminish intestinal synthesis of required biotin and other factors. Vitamin B_{12}, pantothenic acid, vitamin E, and other nutrition factors should also be considered if biochemical and clinical investigations indicate that foods should be supplemented by any of them.

During the milling of wheat the losses of vitamin B_6, pantothenic acid, biotin, and folic acid are similar to the loss of thiamine (Table VIII).

Vitamin B_6

The vitamin B_6 content of whole wheat is under genetic control. Because of this, and of the different effects of various milling practices, the vitamin B_6 content of different flours at any one extraction rate is not the same. Kent-Jones (*31*) has reported that whole wheat and 72% extraction flour contain 0.5 mg. and 0.1 mg. of vitamin B_6 per 100 g., respectively. Bradley recently reported (*9*) that (on an anhydrous basis) whole wheat contains 0.8 to 1.2 mg. %, 72% extraction flour contains 0.13 to 0.21 mg. %, and bread made with 72% extraction flour contains 0.11 to 0.16 mg. % vitamin B_6. Harris et al (*26*) found as much as 0.26 mg. % vitamin B_6 in breads made with high extraction flour, and only 0.10 mg. % in enriched or in unenriched white bread (anhydrous basis). These fragmentary data indicate that possibly 80 to 90% of the vitamin B_6 of wheat is lost during milling, and that white bread is a poor source of this vitamin. Since milk contains only about 0.6 mg. per quart it cannot be relied upon to overcome the B_6 deficiency of white bread.

The vitamin B_6 requirement of the human being has not been established. A value of 1.5 mg. per day has been suggested (*47*), but Greenberg has recently indicated (*22*) that the true requirement is about 4 mg. per day.

Is the U. S. dietary deficient in B_6 content? If it is, could it be that this is a contributing cause of heart disease? More thorough studies of the vitamin B_6 content of U. S. diets are warranted and a technique for the measurement of "available" vitamin B_6 is needed.

Recently in our laboratories we analyzed six dinner meals for vitamin B_6 content. The three restaurant meals contained 0.24 to 0.34 mg. (average 0.28 mg.) and the three home-cooked meals contained 0.07 to 0.27 mg. (average 0.19 mg.) vitamin B_6 (*24*). These typical dinners contained much less vitamin B_6 than expected. Apparently there are significant losses in B_6 during the processing and preparation of foods. There are other signs that the U. S. diet is not adequate in vitamin B_6 content. Boxer et al. (*8*) found more B_6 in the white blood cells of Cuban children than in those of U. S. children. This is evidence that there is significantly less vitamin B_6 in U. S. diets.

Hollingsworth et al. (*27*) have estimated that in 1952 the British diet contained 1.7 mg. of B_6 per day, and that 44% of it was supplied by flour and other cereals. Since that time there has been a rapid trend away from 80% extraction flour, so that today perhaps 80% of the flour consumed is of 70% extraction. A 70% extraction flour contains only 25% as much vitamin B_6 as an 80% extraction flour. He calculated that today the British diet contains about 75% as much vitamin B_6 as it did in 1952.

A similar, but perhaps less striking, drop in the vitamin B_6 content of the U. S. diet occurred in the 19th and 20th centuries when improved milling methods were developed, and significant amounts of vitamin B_6 were removed. No concerted attempt has been made to replace it.

Essential fatty acids have been shown to be effective in preventing and lowering high blood cholesterol values. They may be key compounds in the solution of the heart disease problem. Since linoleic acid is the chief essential fatty acid in dietary fats, and since vitamin B_6 is required to convert it to arachidonic acid (the active form), a liberal intake of vita-

Table VI. Vitamin D Supplementation of Milk According to Nation

Country	Type of Milk	Vitamin D/Quart
Germany[a]	Condensed	710–950 I.U.
England[b]	Powder	330
Sweden[b]	Fresh winter, and powder	425
United States[a]	Homogenized fresh, and condensed	135–400

[a] Irradiated or supplemented; [b] supplemented.

min B_6 is important. A careful study should be made to determine whether the vitamin B_6 intake of the U. S. population is sufficiently low to be of concern. If so, flour, bread, and cereal products as well as infants' foods should be considered as logical vehicles for vitamin B_6 enrichment.

Biotin

Biotin is present in at least small amounts in all cells of plants and animals. It is difficult to estimate the requirement by human beings because D-biotin is synthesized in appreciable amounts by the intestinal flora. Gyorgy (*45*), on the basis of relevant literature, suggested that the recommended minimal dose of biotin for man is 150 to 300 mg. per day. The synthesis of biotin by intestinal bacteria may be reduced by 50% when antibiotics or sulfonamides are taken. Seborrheic dermatitis and Leiner's disease have been observed in breast fed infants whose mothers were living on foods low in biotin. Nisenson (*36*) reported 17 patients cured with 5 mg. doses of biotin. Barker et al (*6*) reported four cases of seborrheic dermatitis, nine of Leiner's disease, and two with Pitter's disease, each type successfully treated with biotin.

Thus, biotin is required by human beings and clinical deficiencies are known to exist, but the incidence of subclinical deficiencies has not been established. Biotin is quite stable in foods during treatment, but significant amounts are removed during milling of cereals (Table VIII). More data are needed before a decision can be reached as to the value of the enrichment of foods, especially cereals, with biotin.

Folic Acid

From 50 to 95% of the folic acid content of foods may be destroyed during cooking (*41*). The folic acid content of canned foods, excepting spinach, is especially low (*29*). Incomplete evidence is available on the effect of milling upon folic acid in cereals. Kent-Jones (*31*) found 0.018 mg. % in 80% extraction flour and only 0.007 mg. % in 50% extraction flour, but he presented no data on the content of whole wheat.

Bethell (*46*) has estimated that the daily requirement of folic acid, and its analogs, may be equivalent to 1 to 2 mg. of the free vitamin, and that the daily dietary supply is probably less than 1 mg. owing to processing and cooking losses. However, until there is evidence that mild folic acid deficiency exists in population groups, it is not desirable to include it as an enrichment ingredient.

Vitamin A production

Vitamin B_{12}

Although it is an essential nutrient, normal nutrition can apparently be maintained in the almost complete absence of a dietary supply of vitamin B_{12}. Possibly the nutritional needs are met by the absorption of that produced in intestinal synthesis by bacteria. While large amounts of B_{12} are excreted in the feces, even in patients with pernicious anemia, the quantity present in the small intestine is limited. Only 1 γ per day is needed. Vitamin B_{12} deficiency is commonly due to impairment of intestinal absorption rather than deficient intake or deficient intestinal synthesis.

There is no valid evidence that the enrichment of staple foods with vitamin B_{12} would be useful.

Essential Fatty Acids

Horder et al (*28*) reported that wheat contains 1% essential fatty acids. Wheat germ oil contains 57% linoleic acid and 9% linolenic acid (*23*), and the phosphatides of wheat germ are rich in these important unsaturated fatty acids.

Sinclair (*42*) has pointed out that 80% extraction flour contains 0.8%, while 72% extraction flour contains 0.53% linoleic acid. The essential fatty acids in white flour are contained in the phospholipid-gluten complex which binds the starch granules.

Table VII. Vitamin Supplementation of Margarine According to Nation

Country	Vitamin Supplement/Lb. Vitamin A (I.U.)	Vitamin D (I.U.)
Denmark[a]	11,300[b]	285
Germany	9,000	135
England[a]	13,600	1,300–1,600
Holland	10,000	450
India[a]	11,200[c]	0
Norway[a]	9,000	1,150
Sweden[a]	13,600	680
Switzerland	15,500	1,350[d]
United States	15,000	.....

[a] Mandatory; [b] 1/3 as β-carotene; [c] Vanaspati; [d] optional.

Tocopherols are highly effective in the protection of these fatty acids in flour, but chlorine dioxide destroys them. There is some evidence (23) that the chlorine adds to the double bonds to give a chlorinated stearic acid which acts as an antagonist and increases the requirements of essential fatty acids.

Essential fatty acids should not be included as optional ingredients of enriched flour and bread, but present evidence indicates that it may be nutritionally valuable if margarines and hydrogenated oils contain at least 8% of these fatty acids.

Vitamin E

Wheat contains about 1.6 mg. % of tocopherol, 22% of which is α-tocopherol (35). About 55% of it is in the embryo; the remainder is mainly in the surface endosperm layers of hard wheat, and is fairly uniformly distributed throughout the endosperm of durum wheat (7).

During the aging and bleaching of

Table VIII. Composition of British Flours According to Extraction Rate[a]

Extraction Rate	Vitamin B_6 (mg. %)	Pantothenic Acid (mg. %)	Biotin (mg. %)	Folic Acid (mg. %)
100%, whole meal	0.50	0.80	0.007	. . .
85%	0.30	0.42	. . .	. . .
80%	0.25	0.37	0.0023	0.018
75%	0.20	0.35	. . .	. . .
72%	0.15	0.34	0.0008	0.014
50%	0.10	0.33	0.0005	0.007

[a] From Kent-Jones (*31*)

flour with chlorine dioxide, 88 to 94% of the tocopherol is destroyed (*35*) and the remaining 0.02 mg. % α-tocopherol is further reduced by 50% during baking. Thus, 200 g. of wheat flour, which provides a third of the calorie intake, supplies only one-seven-hundreth of the 15 mg. or more of tocopherol required daily by human beings (*48*).

Tocopherols are distributed in foodstuffs in approximately the same proportions as linoleic acid. They protect this highly unstable compound from destruction not only in foods but also in the body tissues. While γ-tocopherol is much more active as an antioxidant than α-tocopherol, the alpha form is much better absorbed from the intestine than the gamma form.

These are some of the reasons why some people believe that tocopherols should be permitted as optional enrichment ingredients of flour and bread. Some consideration is being given this suggestion in Germany, Italy, and Great Britain. The evidence does not appear to be sufficiently strong to warrant supplementation of foods with tocopherols.

Literature Cited

(1) Albritton, E. C., "Standard Values in Nutrition and Metabolism," W. B. Saunders Co., Philadelphia, 1954.

(2) American Institute of Baking, Chicago, Ill., "Enriched Bread," p. 8, 1957.

(3) Anderson, E. E., Fagerson, I. S., Hayes, K. M., and Fellers, C. R., *J. Am. Dietet. Assoc.* **30,** 1250 (1954).

(4) Atkinson, F. E., and Strachen, C. C., Dominion Experimental Farm, Summerland, B. C., Canada, Tech. Bull. **68** (1949).

(5) Aykroyd, W. R., Jolliffe, N., Lowry, O. H., Moore, P. E., Sebrell, W. H., Shank, R. E., Tisdall, F. F., Wilder R. M., and Zamecnik, P. C., *Can. Med. Assoc. J.* **60,** 329–32 (1949).

(6) Barker, L. P., Gross, P., and McCarthy, J. T., *Arch. Dermatol. and Syphilol.* **77,** 201–9 (1958).

(7) Binnington, D. S., and Andrews, J. S., *Cereal Chem.* **18,** 678–86 (1941).

(8) Boxer, G., and Goodhart, R., *J. Nutrition* **63,** 623–36 (1957).

(9) Bradley, W. B., 1958, Personal communication.

(10) Bronner, F., Moor, J. R., Harris, R. S., and Benda, C. E., *Federation Proc.* **14,** 428 (1955).

(11) Burch, H. B., Salcedo J., (Jr), Carrasco, E. O., and Intengan, C. L., *J. Nutrition* **46,** 239–54 (1954).

(12) Conochie, J., and Wilkinson, R. A., *Intern. Dairy Cong., Proc. XIV Congr.*, 357–66 (1956).

(13) *Federal Register*, **22,** 3841, 1957 (amendment effective July 1, 1958).

(14) *Federal Register* **23,** Feb. 25, 1958.

(15) *Federal Register* **23,** 1991 (1958).

(16) Fellers, C. R., and Esselen, W. B., Mass. Agr. Exp. Sta., Bull. **481,** (1955).

(17) Food and Nutrition Board, Nat. Research Council, "Enrichment of Flour and Bread," Bull. **110,** pp. 101–2 (1944).

(18) Food and Nutrition Board (Committee on Cereals), Nat. Research Council, Washington, D. C., "The Facts About Enrichment of Flour and Bread; Enrichment of Flour and Bread. A History of the Movement," 1944.

(19) Food and Nutrition Board, Nat. Research Council, Washington, D. C., "Recommended Dietary Allowances." Publ. **302** (1953).

(20) Furter, M. F., Lauter, W. M., Rubin, S. H., and Siemers, G. F., *Trans. Am. Assoc. Cereal Chemists* **V,** 26 (1947).

(21) Great Britain, Parliament, "Report of the Panel on the Composition and Nutritive Value of Flour," Cmd. **9757,** H. M. Stationary Office, London, 1956.

(22) Greenberg, L. D., personal communication, 1958.

(23) Gunstone, F. D., and Hilditch, T. P. *J. Soc. Chem. Ind. (London)* **65,** 8–13 (1946).

(24) Harris, R. S., and Lopez, H., *J. Am. Dietet. Assoc.* (in press).

(25) Harris, R. S., and Von Loesecke, H., "Nutritional Evaluation of Food Processing," Wiley, New York (in press).

(26) Harris, R. S., Lopez, H., and Siemers, G., Proc. IV Internt. Nutrition Congr., p. 119 (1957).

(27) Hollingsworth, D. F., Vaughan, M. C., and Warnock, G. M., *Proc. Nutrition Soc. (Engl. and Scot.)* **15,** xvii (1956).

(28) Horder, Sir, Dodds, C., and Moran, T., "Bread," Constable, London, (1954).

(29) Ives, M., Pollard, A. E., Elvehjem, C. A., and Strong, F. M., *J. Nutrition* **31,** 347–53 (1946).

(30) *J. Am. Med. Assoc.* **165,** 2217 (1957).

(31) Kent-Jones, D. W., *Proc. Nutrition Soc. (Engl. and Scot.)* **17,** 38–43 (1958).

(32) Kruse, H. D., Bessey, O. A., McLester, J. S., Jolliffe, N., Tisdall, F. F., and Wilder, R. M., "Inadequate Diets and Nutritional Deficiencies in the United States", Bull. **109,** Nat. Research Council, Washington (1943).

(33) Lane, R. L., Johnson, E., and Williams, R. R., *J. Nutrition* **23,** 613–24 (1942).

(34) Lee, F. A., Robinson, W. B., Hening, J. C., and Pederson, C. S., N. Y. Agr. Exp. Sta., Bull. **743,** July (1950).

(35) Moore, T., Sharman, L. M., and Ward, R. J., *J. Sci. Food Agr.* **8,** 97–104 (1957).

(36) Nisenson, A., *J. Pedia.* **51,** 537 (1957).

(37) N. Y. Agr. Exp. Sta., Bull. **743,** (1950).

(38) Salcedo, J., Jr., Bamba, M. D., Carrasco, E. O., Chan, G. S., Concepcion, I., Jose, F. R., DeLeon, J. F., Oliveros, S. B., Pascual, C. R., Santiago, L. C., and Valenzuela, R. C., *J. Nutrition* **42,** 501–23 (1950).

(39) Schnyder, W., *Food* (February, 1958).

(40) Sale, J. W., *J. Assoc. Offic. Agr. Chemists* **30,** 673 (1947).

(41) Schweigert, B. S., Pollard, A. E., and Elvehjem, C. A., *Arch. Biochem.* **10,** 107–11 (1946)

(42) Sinclair, H. M., *Proc. Nutrition Soc. (Engl. and Scot.)* **17,** 28–37 (1958).

(43) U. S. Dep. Agr., "Bread Facts for Consumer Education," Agr. Inform. Bull. **142** (1955).

(44) U. S. Dep. Agr. Misc. Publ. **636** (1947).

(45) "The Vitamins I," (Sebrell, W. H., Jr., and Harris, R. S., editors), Academic Press, New York, p. 618, 1954.

(46) "The Vitamins III," (Sebrell, W. H., Jr., and Harris, R. S., editors), Academic Press, New York, p. 217, 1954.

(47) *Ibid.*, p. 298.

(48) *Ibid.*, p. 572–3.

(49) Widdowson, E. M., and McCance, R. A., "Studies on the Nutritive Value of bread and on the effect of variations in the extraction rate of flour on the growth of undernourished children," Med. Research Council (Brit.), Spec. Rep. Ser. **287,** H.M. Stationery Office, London, 1954.

(50) Wis. Dep. Agr., General Order **103,** *Milk Dealer* **32,** 34 (1943).

(51) World Health Organization, Tech. Rept. Ser. **97,** Joint FAO-WHO Expert Committee on Nutrition, Fourth Report (1955).