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VITAMINS IN OUR FOOD[1]

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MY appearance on this program, I wish to assure you, is not of my choice. I am the object of a well-established punishment to those who have been "honored" due to previous servitude and an annual or perennial display of the older folks for the amusement or encouragement of the younger generation.

The particular subject, however, is of my selection in order to fit into the general program of "Nutrition —Some Current Views." Vitamins must have gained an alarming popularity, when a non-specialist, like myself, desires to discuss them before a group of assorted specialists. Plants and vitamins, however, are so closely linked that, as a horticulturist and plant physiologist, I, too, have been obliged to deal with them more intimately—the "little things" in nutrition that now count so much. If in this discussion I may be unduly critical, kindly forgive me by ascribing it to no greater fault than that due to emotional simplification, personal prejudice or perchance conservatism come with age. In agreement with Thorstein Veblen, I do not wish to criticize but merely to understand. If disparagement is involved in this quest for certainty, I hope for your graciousness.

[1] Address of the retiring vice-president and chairman of Section O (Agriculture), read before the joint meeting of Sections O and G (Botany) of the American Association for the Advancement of Science, Cleveland, Ohio, September 14, 1944.

DEMONSTRATION AND DISTRIBUTION OF VITAMINS

According to an older definition, a vitamin is a catalytic substance indispensable in animal or human nutrition. It can not be synthesized in their organisms but must be obtained from plants. Now we know that all plants, likewise, require certain vitamins and that many of them are heterotrophic, must obtain their vitamins from an external source. This certainly is

true of most cryptogams. In this metabolic relationship to the higher plants, fungi and bacteria show a striking similarity to animals. A most recent authoritative definition of a food factor of vitamin nature would be then something like this: "An organic substance, the need for which results from the loss of the capacity for its synthesis, whose action is catalytic, quantitative and markedly specific."[2] This excludes the many inorganic biocatalysts such as Fe, Cu, Mn, Zn, Mo, etc., the action of which is quite similar.

It is interesting indeed to speculate why and how this loss has occurred in the evolution of many organisms and whether it could be sometimes regained. It is assumed that the capacity for synthesis in plants and animals of all required substances degenerated during very early stages of evolution. From this complete biochemical independence have evolved, probably through mutations, changes of an adaptive or symbiotic character, leading organisms and organs to heterotrophism, saprophytism or parasitism. We are inclined to believe that this is a kind of economy in organic life and not merely variability. Some think that the general autotrophism of the green plants shows a tendency to decline, as is testified by the disappearance of certain substances in the higher phyla.

Of the numerous vitamins discovered so far almost all are found in the higher plants, though some are synthesized by animal cells also. Their exact and varied functions are still to be disclosed, though the present evidence points to a close connection with the activity of enzymes. They may have, however, many other biochemical roles in the organism.[3] As regulators of metabolism, these organic catalysts may serve in the chemical relation of tissues and organs of a plant or animal.

While a partial heterotrophism may exist in certain organs of green plants, requiring an external supply of particular vitamins, many of the lower plants are completely heterotrophic for one or several of these growth factors. For their best development specific vitamins have to be given in the culture medium. Certain fungi (*Phycomyces, Mucor, Ustilago, Phytium,* etc.), yeasts (*Saccharomyces*) and bacteria (*Rhizobium, Staphylococcus, B. lactis acidi,* etc.), therefore, are widely used to demonstrate the presence or necessity of vitamins in plant and animal nutrition.

Because of the relatively limited nutrient and general environmental requirements in their culture, microorganisms are now utilized extensively also for the study of biosynthesis of particular growth substances. Other avenues of approach (root, embryo and tissue cultures) have also been explored for this purpose. A very complete summary of the whole subject of relationship of vitamins to plants has been recently prepared by Schopfer (*loc. cit.*).

Though formerly particular organs or tissues of plants and animals were the chief source of vitamins, now, as a result of the establishment of their identity and structure, many of them are synthesized *in vitro* and available on the market under appropriate chemical names. Eventually others will come, in their pristine purity, from the laboratory and the factory.

Vitamins in Human Nutrition

Our first ideas about and interest in vitamins began with man and are of greatest importance at present in relation to human nutrition. The recognition and necessity of these accessory substances in our food are based on the commonly observed fact that when a "purified diet" is supplied avitaminosis (vitamin deficiency) symptoms set in, which can be removed by adding to the food the appropriate vitamin either in a crude or refined state. Small animals are conveniently used for the demonstration and assay of necessary accessory food substances.

As a result of a one-sided diet, particularly of processed foods, vitamin deficiency symptoms have been observed repeatedly in humans, though deaths from this cause are not so common, as judged from mortality statistics in the United States. Current appraisals of the nutritional states, especially those made by H. K. Stiebeling and associates,[4] based on dietary surveys in this country and Canada, show that the prevalence of malnutrition, due to vitamin shortage, is quite high, if pre-clinical methods of recognition are employed.[5] It has been reiterated by political and sociological authorities that one third of our population is "ill fed" and that better nutrition should be a major national policy.

As a result of such activity, and vitamin assays of foods commonly used by large groups of people, recommended dietary allowances or norms, as to optimal vitamin requirements, have been established by the Food and Nutrition Board of the National Research Council, some federal and other agencies. Certainly we have become extremely vitamin conscious, when judged by the interest displayed. Some believe that the evidence does not justify this alarm, that our diets are not impairing our health to the extent many nutritionists would have us believe, and that vitamins have become highly emotional words.[6] We do not know as yet to what extent the intestinal flora syn-

[2] "Plants and Vitamins." W. H. Schopfer, Chronica Botanica Co., Waltham, Mass., 1943.

[3] H. H. Mitchell, "The Chemical and Physiological Relationship Between Vitamins and Amino Acids," in "Vitamins and Hormones," Vol. 1. Academic Press, N. Y., 1943.

[4] H. K. Stiebeling *et al.*, U. S. Department of Agriculture Circular 507, 1939, and *Misc. Bulletin,* 405, 1941.

[5] N. Joliffe and R. M. Most, "The Appraisal of Nutritional States," in "Vitamins and Hormones," Vol. I. Academic Press, N. Y., 1943.

[6] L. Clendening, *Jour. Am. Med. Asn.,* 117: 1035, 1941.

thesizes many vitamins, some of them conceivably in quantities sufficient to support a normal nutritional state.[7] Neither are we certain of the capacity for storage and economy of the human body for these nutritional factors.[8] Moreover, some vitamins may have a sparing action on others.[9] The rat, on which many food assays are being made in the laboratory, is thought by some to be an unsatisfactory animal for this purpose because of its scavenger habits. This animal may be far more heterotrophic for many accessory food substances than man is. But above all, it has been pointed out that the relationship between health, vitamin deficiency syndromes and vitamin content of foods and diets has not been determined carefully enough for a basis of definite recommendations or strict rules in human nutrition.

VITAMIN CONTENT OF FOODS

Great diligence having been displayed in vitamin assays of the major foods used in human diets, an impressive array of data is extant on the content of these substances in many raw and prepared products.[10] One has the feeling that such records have accumulated faster than it has been possible to digest them. The information, however, seems to point to the general facts that foods of the same kind vary greatly as to their vitamin values and that several factors contribute to this variation: (a) There is a natural inherent (genetic) variability in this, as in many other respects, among species, varieties and strains of food-producing plants and animals. (b) The time of harvesting or slaughter and the methods of transportation and marketing of food materials is of great importance.[11] (c) Processing or refining in the manufacture of our modern foods, above all, has frequently played havoc with many vitamins, though it has made such products more appealing and convenient otherwise. I shall attempt to discuss in somewhat greater detail this situation in our food supply, using fruits and vegetables as examples.

Varietal differences in vitamin content: In our search for desirable varieties of food plants, attention has not always been paid to quality of the crops they produce and, till lately, not at all to the vitamin content. Size, appearance, carrying or storage properties, together with yield and regional adaptability, have commonly played the major role in varietal selection of fruits and vegetables. Many choice varieties and strains, formerly grown in our gardens and orchards or for local trade, have disappeared or become of minor importance, because the product was not of a desirable appearance or too tender for distant transportation or prolonged storage. One may search in vain on most markets to-day for a carrot that tastes like a carrot, sweet corn as delicious as the old Golden Bantam, lettuce that is less crisp but has more flavor, plums spicy like those of the Gage or Americana types, apples sweet and delicious like some of the old yellow and russet varieties. This is not a nostalgic longing for the "good old days," but a mere statement of facts and in full awareness that many varieties of food plants have been improved lately. By catering to the "eye-appeal" we have, in our choice, often lost "food value," including undoubtedly a large amount of vitamins, both known and unknown. Thus economics and style, not nutrition and health, unfortunately have guided most parties concerned in food production and distribution.

Realizing the present situation, many plant breeders are engaged now in improvement of the food plants in the direction of higher vitamin content and other properties that make them more valuable for human consumption.[12] In this activity to obtain more nutritious varieties, wild plants may play an important role as breeding materials. Frequently they are much higher in vitamin content than cultivated ones and may be of value also because of disease resistance and other desirable characteristics.

Present evidence points to the fact that climate to some extent affects the vitamin content of plants grown for food, but, surprisingly enough, soil fertility seems to be of minor importance in this respect.[13] Effects of nitrogenous fertilizers on ascorbic acid (Vitamin C) formation has been observed in some fruits and vegetables, but this may be associated with the relative yields, the amount of foliage and extent of shading of the fruit. Light seems to have an important function in the formation of Vitamins C and A (carotene) and possibly others. Very little is known as yet on the effects of temperature. In general, however, the genetic constitution of the plant apparently is of far greater importance than the environment, both adaphic and aerial, in which the plant is grown as regards vitamin production.

Effects of modern distribution and marketing on nutritive value of foods: Commercial production of fruits and vegetables is confined at present largely to regions of most favorable soil and climate. These are often distant from many city markets, requiring lengthy transportation and complex marketing for the

[7] A. G. Hogan, *Mo. Agr. Exp. Sta. Bul.*, 446, 1942.
[8] C. A. Elvehjem, *Jour. Am. Diet. Asn.*, 19: 743, 1943.
[9] K. C. D. Hickman *et al.*, *Jour. Biol. Chem.*, 152: 321, 1944.
[10] L. E. Booher *et al.*, U. S. Department of Agriculture Circular 638, 1942. Also, "Tables of Food Composition." Committee on Food Composition, National Research Council, 1944.
[11] G. Adams and S. L. Smith, U. S. Department of Agriculture Misc. Publication, 536, 1944.
[12] R. J. Garber, "Plant Breeding in Relation to Human Nutrition," 1944 (unpublished paper).
[13] L. A. Maynard and K. C. Beeson, *Nutr. Abstr. and Rev.*, 16: 155, 1943.

transfer of the products to consumers. If sold in the fresh state, this frequently necessitates harvesting the crop in an immature condition, thus lowering the food value, including vitamin content. Growers and dealers are fully aware of the situation but find it difficult to remedy. Peaches, cantaloupes, plums, strawberries and many other fruits are often harvested in so "green" a state that a very low quality is realized no matter how they are subsequently handled. This has been so disturbing a factor in marketing that stringent maturity regulations have been promulgated and are enforced in states where fresh produce is grown extensively.

Speedier transportation and better refrigeration to certain extent may overcome this difficulty. It is highly probable that air transportation of fresh produce, which is surely coming, will bring us fruits and vegetables from distant regions in immeasurably better eating quality and of higher vitamin value. Very probably then we shall see the return to favor of some of the choicer tender varieties. Let us hope so anyway. Many "victory gardeners" undoubtedly have at least an inkling now how delicious and healthy peas, sweet corn, tomatoes and many other vegetables and some fruits can be when harvested at the peak of perfection and consumed immediately. There is ample evidence that the vitamin content decreases on delay in the use of fresh produce.

Vitamins in processed foods: Commercial processing of food and living in the modern city have advanced hand in hand. By and large it is nothing more than a factory scale extension of food preservation in the home, which of course has declined greatly. There are certain aspects to this method of food preparation, both good and bad, that have a profound bearing on human nutrition. Buying conserved or prepared foods is usually economical, more convenient and often absolutely necessary for the average housekeeper in a modern city. A large-scale establishment can preserve food by drying, smoking, canning or freezing at infinitely less cost than one may do it individually in one's household. Unfortunately, because of competition or desire for more profit, as a result of what Lin Yutang calls a "swine-and-slop" economics of the avaricious, foods are often prepared hastily and improperly, resulting in a loss of their nutritive qualities. Often enough they are so "denaturalized" of vitamins and other food factors that their use in volume or continuously has resulted in malnutrition and impaired health. Many food processors undoubtedly look with envy at sugar refiners, who have managed to attain the ultimate in food refining. Said E. E. Slosson: "Common sugar is an almost ideal food—cheap, clean, white, portable, imperishable, unadulterable, germ free, highly nutritious, completely soluble, altogether digestible, requires no cooking and leaves no residue. Its only fault is its perfection. It is so pure that man can not live on it." Sugar consumption has increased in the United States from about 9 to 100 pounds per capita during the past hundred years. The total production of this, most voluminous pure organic compound, was over 13 billion pounds in 1939.

In practically all grocery stores there are at present a bewildering array of ultra-modern food preparations. The spongy "starch paste" that is commonly sold as bread, the sweet "goo" that goes into the making of some cereals and many bakery goods, the artificial cheese and other mixtures, synthetic sweets and beverages and many other products are well known to every one. Federal laws do require the listing of ingredients making up such preparations, but the relative quantities of each invariably are not given. And, after all, very few purchasers read this information usually given in small print. One can not help admiring the ingenuity used in preparation of processed foods, the beauty of their appearance, the convenience of their merchandising and the artistry and psychology with which they are presented to the buyer. Manufacturers and dealers study not only consumer demand for certain types of products but sales possibilities and resistance to their most profitable preparations. Modern advertising and mass production of prepared foods have run on parallel tracks.

Some processed foods are so refined that hundreds of thousands of people would develop scurvy and other deficiency diseases were they not eating also many natural "protective foods," especially fruits, vegetables and dairy products. Selected largely by instinct, they compensate for vitamin shortages in other foods. Tomatoes, citrus fruits and the green leaf vegetables are considered by nutritionists of particular value for this purpose and their increased use is being advocated widely.

As a result of the present food situation, a program of fortification or enrichment of flour, bread and a few other cereal food materials and products has been inaugurated. Being to some extent alarmed, and finding it not too inconvenient, the industries have cooperated rather well in this partial restoration of the vitamin content at least of the "staff of life"—bread. Moreover, a Nutritional Foundation has been established to aid the food industry, through research, in solving its problems as related to nutrition and public health and to do this by "lawful and effective means."

VITAMIN PILLS

No sooner was it found that much of our food and some diets are short of the optimal vitamin content

and that many pure vitamins can be bought wholesale at a reasonable price, vitamin pills and tablets appeared on the market and became popular almost overnight. Recently the supply and demand for them has increased tremendously. In some cities there are even special "vitamin shops" or "bars." The vitamin fad has become an epidemic. While most people have only a vague idea what vitamins are, excepting that they are connected with the alphabet, still that does not prevent them from becoming enthusiasts, even faddists. Says H. L. Kretschmer, president of the American Medical Association, according to press reports: "The people of the United States are spending a quarter of a billion dollars annually on vitamin pills and tablets. This means that every morning hundreds of thousands of potent little pellets travel eagerly down as many anxious esophagi into the systems of people, most of whom do not need them." Evidently it keeps them happy.

Vitamin advertisements have increased by leaps and bounds, have gone on the air in volume, invading our ears almost every hour day and night. They have reached even the war front. In a relatively recent dispatch from the Italian Front, Ernie Pyle, popular reporter of the daily press, says: "One night a colonel was talking offhandedly about the war, and how people felt and everything and he said—'The whole trouble with everything is vitamins. We got along all right before everybody had to have so many vitamins a day.'"

The Instinct for Good Food

In animals as well as man nutritional needs seem to have been, and we trust still are, determined largely by instinct. Selection of the proper food has been chiefly by trial and error. Establishment of traditional diets was based on experience and natural taste. With food limited as to variety, the older simpler civilization produced people of splendid physical development. Although an infinitely greater variety of foods is available now, the nutritional condition and stamina of the American people do not seem so good. In less industrialized countries even to-day members of many communities, particularly rural, have certain traditional food combinations or habits. Though they may appear sometimes strange and unreasonable, a mere habit, to the unfamiliar, critical examination almost invariably has disclosed that they were based on fairly sound judgment and often scientifically correct. Facts could be marshalled from observations in many countries, especially among groups of people living on restricted varieties of foods. Before advocating a change in their dietary habits strict attention should be paid to the usually wise composition in vogue.

In a country of a high technical culture, such as ours, old traditional food materials are largely gone. Moreover, new unhealthy habits have been imposed upon many people. Milled grain products, for example, were formerly so prepared that most of the vitamins were retained. Now, because of extreme refining, they have contributed to poor nutrition among large numbers of people, who still cling to traditional habits, using the new refined product in the old way in their diet. Not knowing what has really happened to their flour, meal or grits, they are bewildered and in trouble. The same situation often exists as regards changes in other foods, significantly so in the making of which formerly prolonged fermentation or ageing was an essential step in their preparation. Yeast certainly has the capacity to produce a host of known and unknown dietary factors of vitamin nature.

There is an unjustifiable hope of a simple solution of our nutritional difficulties by an over-emphasis on the value of vitamins, which, under the present circumstances, after all are only a "first aid" and not a fundamental solution of the problem.

Nutritionists, particularly the home economics group, have been paying a great deal of attention lately to the effects of food preparation, mainly cooking, on vitamin retention. It has been reiterated that the housewife or cook, if not on guard, can peel away, soak away, drain away and cook away 50 per cent. or more of the original vitamin content of the food material. Emphasis is placed on the fact that the longer the cooking the more vitamins may be lost. Very little water is to be used in cooking vegetables and fruits, for example, and none discarded.

To get a full dose of vitamins it looks very much as if we will have to eat most of our garden products raw. For all we know the time may eventually come when hubby will be tethered in the vegetable patch to forage his supper of high vitamin and mineral content there. Not all hope for a continuous use of the kitchen stove and the dining room table has faded, however. It is said (L. Clendening) that the fine food in New Orleans, for instance, is due to the fact that it is cooked and often recooked several times. A French chef is supposed to start boiling his Sunday soup on Friday. New Orleans may be making the last stand against vitamins, for preparation of a meal there seems to be based on taste, not on the recognition of the presence of accessory food factors. Vitamins evidently avoid New Orleans and other places where very good well-prepared food is still obtainable, for if they show up, they will be cooked to death. One wonders how people survive and are even healthy on such meals.

Conclusion

Now that "hollow hunger" has been largely eliminated in countries of modern technical culture, we are preoccupied with "hidden hunger." In the search for

its causes, deficiencies in vitamins and minerals in our foods have so far been ascertained as the chief reasons. A large number of vitamins necessary or of value in the human diet have been found. Their list runs through the full length of our alphabet if the fractional parts of those letters that the nutritionists have been obliged to "split" are taken into consideration. Improper selection of food-producing plants, modern methods of handling the crop and faulty preparation by cooking and other means has resulted in a diet of subnormal vitamin content for many people. Refining and processing of foods has devitaminized still further our modern products. Profit has been often the motivating force in present food technology, the dollar sign the guiding star, setting styles, fostering sales and creating eating "habits" for the use, in volume, of certain products.

Having become conscious of the present undesirable food situation, the factors involved are being studied diligently by nutritionists, chemists, plant breeders and food processors. Counter measures are being advocated and promulgated for the breeding of plants of higher vitamin content, for better handling and storage of food materials and for the enrichment or restoration of devitalized food products. The popularity of vitamin pills has reached an epidemic stage, sales being fostered through modern ads wildly by dealers.

In this excitement the scientists hope to create or at least wait for sanity in the attitude of the average man and emotional nutritionists towards vitamins. The instinct for a healthy diet has not been destroyed in most people, though social and economic forces undoubtedly have modified it. We trust that in the future the "common man" will be nourished more properly to the benefit of his gastro-intestinal flora, his health and serenity of his mind. In the meanwhile, let us have the fortitude to hope that "freedom from want" will eventually mean also freedom from unhealthy food. Good health is not only desired by every American citizen, he is also entitled to have it. If we believe that "science goes from strength to strength to dominate the lives of men," to use words by E. W. Sinnott,[14] let us not forget that, in its application, "science has the power to work us infinite good or ill. The mastery it gives of energy and material things may send our race careening to its doom unless we gain the wisdom and the sanity to control our course."

OBITUARY

THOMAS MIDGLEY, JR.

An Appreciation

IN the passing of Thomas Midgley, Jr., on November 2, the American Chemical Society lost its president and the long-time chairman of its board of directors, and the nation lost one of its most creative men. Also those of us who were fortunate enough to know him personally lost a friend who held the highest place in our affection and esteem. Although only fifty-five when he died, Midgley had crowded into his lifetime an immense amount of accomplishment, and the achievements he left behind are an important legacy to the world.

Among the several contributions of Midgley and his associates, these four are particularly noteworthy:

He discovered the chemical antiknock agents. Tetraethyl lead, the principal one of these, is added to most automobile gasoline and it is also an essential ingredient of all high-octane aviation gasoline, so vital to-day.

As bromine in large amount is a necessary complement to lead in gasoline, he conceived and demonstrated the possibility of extracting it from the ocean, although it is present there in concentration so minute as to be measured in parts per million.

He made an altogether new series of refrigerating gases, based upon the unpromising element, fluorine, which are at once nontoxic and noninflammable.

He conducted intensive researches on rubber which extended the knowledge of the chemistry of vulcanization and of the composition of natural and synthetic rubbers.

How it happened that Thomas Midgley, Jr., a man trained not in chemistry but in mechanical engineering, came to make all these important advances in chemistry, is one of the unusual stories in modern research.

Midgley was born in Beaver Falls, Pa., on May 18, 1889. He attended high school in Columbus, Ohio, and at Betts Academy, Stamford, Connecticut. Then in 1911 he graduated from Cornell University with the degree of mechanical engineer. Out of college, he was employed at the National Cash Register Company. There he served as a draftsman in Inventions Department Number Three, the same department which I myself had left only two years before to develop a system of battery ignition and the self-starter for automobiles. After about a year at the National Cash Register Company, he left there, first to do some research on tires, and then to be successively chief engineer and superintendent of the Midgley Tire and Rubber Company, of which his father, Thomas Midgley, Sr., was general manager. In 1916, Midgley, desiring to go into research, applied for a position in our Dayton Engineering Laboratories Company. And thus began an association between us which lasted for nearly thirty years.

[14] E. W. Sinnott, *Am. Scientist*, 32: 205, 1944.