Panel Discussion

Food Composition and Availability of Nutrients in Foods

ROBERT S. HARRIS, PH.D. (*Moderator*) AND SESSION SPEAKERS

Dr. HARRIS (*Cambridge, Mass.*): First I will ask each speaker if he has any comments on what has been said by other speakers, then we will discuss several topics that really belong in this session but were not covered by the speakers and, finally, we will try to answer some of the questions which have been submitted.

It is fortunate that Dr. Campbell from the Food and Drug Directorate of Canada was with us to act as Chairman. I will ask him to be the first to comment on the formal papers presented.

DR. J. A. CAMPBELL (*Ottawa, Ont.*): I was interested in Dr. Harper's mention of the use of amino acid levels in determining availability of amino acids. We have used this approach and found that it is possible to feed test diets to rats for about three days, determine the amino acid levels and calculate availability. We obtained values that compare quite favorably with those obtained by the growth methods that Dr. Harper discussed in some detail.

More recently we also applied a micro-modification of amino acid microbiologic methods to blood obtained from finger puncture of human subjects in our own laboratory whom we use as "guinea pigs." They fast overnight, do without breakfast and receive the test meal at about 9 A.M.

We started out using halibut steaks which furnished an acceptable meal and we tested several levels of steak, supplying 19, 39 and 66 gm. of protein. We obtained typical amino acid response curves for lysine, methionine, threonine and tryptophan, which are the only ones we have investigated so far.

The response, which was proportional to the dose, reached a peak in one to two hours and returned to fasting level at four to six hours. The general procedure was similar to that used by Longenecker and Hause. Our experience indicates that the method can be applied to human beings consuming practical amounts of food and that it can be used to study responses to different proteins. We have not yet applied it to the study of the availability of amino acids, but I think this is another possibility. It has the advantages that it can be used directly on human subjects, the amounts of food that have to be consumed are quite practical and only 0.5 ml. of blood is required to study four amino acids.

DR. HARRIS: Dr. Asenjo, would you like to comment on any of the papers?

DR. CONRADO F. ASENJO (*San Juan, Puerto Rico*): I was particularly interested in the presentation made by Dr. Harper on proteins and amino acids. In Puerto Rico, although great progress has been made toward improving the nutritional status of the population, much has still to be accomplished before an acceptable protein quality could be established in the average diet. Some work in this direction has been carried out by our group and we have encountered some of the difficulties pointed out by Dr. Harper. For example, Torula yeast protein once seemed to be the ideal answer to our protein tribulations. Torula yeast is not only a rich source of protein, about 50 per cent on a dry basis, but also, more important, it could be produced locally by using black strap molasses, a by-product of our sugar industry, as raw material.

Work in animals, however, promptly indicated that Torula protein does not supplement, to any significant extent, our local diet which contains mainly legume proteins. This observation was later confirmed when nitrogen-balance trials were carried out in human subjects. Not only did Torula protein prove to be low in methionine, the first limiting

amino acid in our local diet, but in addition the methionine present in it was not efficiently utilized. Organoleptically, our Torula yeast was highly acceptable, but physiologically our human volunteer subjects were seldom able to tolerate more than 15 gm. of Torula yeast per day without having gastrointestinal disturbances.

In regard to Dr. Krehl's topic, I liked the didactic approach used in which it was pointed out briefly, but clearly, how blocks can occur at different levels in the processes of digestion, absorption and metabolism and may result in different states of malnutrition.

In regard to your presentation, Dr. Harris, I am sure everyone here will agree that the methods of proximate analysis in current use are archaic. Despite all its limitations, however, it has served a useful purpose in the routine description of foodstuffs since it was conceived nearly a hundred years ago at the Weede Experiment Station in Germany. It is time to revamp this method or perhaps radically change the whole approach to what we call proximate analysis. However, in order for any new scheme to be successful it will have to preserve the expediency and simplicity of the Weede scheme and at the same time overcome its uncertainties.

DR. WILLARD A. KREHL (*Iowa City, Iowa*): I would like to ask Dr. Asenjo whether or not he has considered the results observed in areas in which lime-treated corn is used—that a rather low incidence of pellagra exists—and whether in his area coffee, which is also a good supplier of niacin, has an effect.

In 1947 we carried out an investigation by making a tortilla meal in the traditional method; we were unable to observe that this treatment increased the utilization of niacin or tryptophan in the diet. There have been pros and cons since then, but, as far as human beings are concerned, I believe the matter is not yet settled.

DR. ASENJO: Whatever I have said about this topic is not the result of any personal experience for we seldom encounter pellagra in Puerto Rico, probably because of the generous consumption of legumes which are a rich source of free niacin.

My remarks relating to the "lime-treated corn" controversy, a topic of special interest to nutritionists in Mexico and some of the Central American countries, were made with the express purpose of precipitating a discussion on this subject, considering that there are several persons possessing first hand knowledge of this topic in the audience as well as on this panel.

DR. KREHL: You do find that the coffee of Puerto Rico contains niacin?

DR. ASENJO: Yes, we have carried out some work on the niacin content of Puerto Rican coffees. Our coffee beans are roasted more than they are in the Continental U. S. With a rich roast, as it is known, values as high as 30 mg. of niacin per 100 gm. of roasted coffee beans are not uncommon. The coffee beverage as prepared in Puerto Rico supplies approximately 4 mg. of niacin per cup. But in Puerto Rico we do not drink as much coffee as in Central America or Colombia, for example.

DR. HARRIS: Dr. Arroyave, do you wish to comment on lime-treated corn?

DR. GUILLERMO ARROYAVE (*Guatemala City, Guatemala*): Yes, I think the evidence points to the fact that lime-treated corn fed to rats produces better growth. There are two schools of thought as to the reason for this: (1) that it is due to the release of niacin, and the evidence in favor is quite convincing, (2) that there is a better balance of amino acids in the corn after the lime treatment. This also is supported by good evidence. I am inclined to believe that both are right, but question whether in quantitative terms either explains the presence or absence of pellagra in our region. I think corn becomes better balanced after the lime treatment but the importance of this in terms of human nutrition should be evaluated carefully before we try to associate it with the presence or absence of good nutrition in an area.

DR. A. E. HARPER (*Cambridge, Mass.*): Dr. Arroyave had summed up the controversy very well, but Dr. Scrimshaw tempts me. I think it is important to distinguish between the significance of lime-treated corn for human subjects and the experimental findings obtained in studies of rats. Three groups of workers

have isolated from cereal grains niacin-containing compounds in which the niacin does not become available until the compounds are heated with sodium hydroxide. I think this is adequate evidence that the niacin in some cereal products is not available, at least to some species of animals.

One point which has become very obvious during this discussion is that nutritionists are entering a controversy, waged by biologists for years, as to the relative significance of genetics and environment. I wonder if Dr. Krehl would comment a little further on the extent to which genetic factors may influence vitamin requirements or the availability of vitamins to animals and human subjects.

DR. KREHL: Actually there is little evidence concerning the effect of genetics on vitamin needs if such factors as the lack of intrinsic factors in the development of pernicious anemia are excluded. There is supposed to be a trait, but no genetic block has been delineated. There is some evidence in the literature that small children who have convulsive seizures respond to pyridoxine therapy (5 to 10 mg. a day). This is significant because convulsive seizures in children are very common; perhaps they are not due to pyridoxine deficiency, but again I think we should take a close look to see if there is a latent nutritional deficiency or so-called pyridoxine deficiency in these children. Of course, there are the well known diseases which have important genetic effects that are not related to vitamins *per se*. When these diseases are treated rather unusual and bizarre diets are used which may be nutritionally deficient unless watched for.

DR. HARRIS: I wish to comment on the point raised by Dr. Asenjo relating to the effect of genetics on composition. Many years ago we collected samples of the Barbados cherry in Mexico and found it contained only about 17 mg. per cent of ascorbic acid. Several years later Dr. Asenjo reported a very high vitamin value in the Barbados cherry. We investigated and found that two strains of the same plant were involved. We planted seeds of the Guatemalan strain in Cuba and the fruits they produced were also low in ascorbic acid content. This indicated that the difference was of genetic origin and not due to agronomic practices.

As one travels to different parts of the world, one often sees the same plants; it is logical to assume that they produce foods of the same nutritive value. The acerola (Barbados cherry) of Puerto Rico is about one hundred times richer in vitamin C content than a similar cherry indigenous to Guatemala. I have objected to the publication of world food tables because significant differences in the nutritional values of the same food grown in different areas may be swallowed up when data from all over the world are averaged. Regional tables, reporting the content of local and indigenous strains, are more useful and less misleading.

For somewhat the same reason, I object to reports which give the average dietary intakes of population groups. Information on the *incidence* of deficient intakes is much more important. People can be starving in a country in which the average intake calculates to be adequate.

DR. ASENJO: I would like to clarify some points in regard to your comments, Dr. Harris. As far as I know, no work on the chemical composition or nutritional value of the Barbados cherry appeared before 1945 when, by chance, we found this fruit had a very high ascorbic acid content. We have checked the literature on this subject very carefully and we are absolutely sure of this. The wild cherry from Mexico with a low ascorbic acid content, which you mistakenly believed to be Barbados cherry, was not a *Malpighia*, but *Prunus capuli*. Recently, in a private communication, Dr. Rene Cravioto informed us that he did not begin to work with Barbados cherries until 1951, that is five years after our original publication had appeared. He and his associates found that the Mexican Barbados cherry, the one botanically classified as *Malpighia punicifolia* was very high in ascorbic acid while the one classified as *Malpighia glabra* generally contained less ascorbic acid. However, the first report to appear on the Barbados cherry with a low ascorbic acid content, as far as I know, emanated from your own laboratory in 1950 when Dr. Hazel Munsell, then working

with you, reported that the ascorbic acid content of Barbados cherries from Guatemala was about 15 mg. per cent on a wet basis.

This interesting finding was later confirmed by members of INCAP. At the present time in my department, some of my associates are performing a comparative study of the metabolism of ascorbic acid in the Guatemalan Barbados cherry which has a low ascorbic acid content, and in the Puerto Rican Barbados cherry which has a high ascorbic acid content.

In regard to the precise botanical classification of the Barbados cherry, there seems to exist a great deal of uncertainty among botanists between these two species. The Barbados cherry from Puerto Rico, also known by the trivial names of acerola and West Indian cherry, generally has been classified as *Malpighia punicifolia*, while that from Central America as *Malpighia glabra*. It seems to be a difficult task for the average botanist who is not an expert in the family to which the *Malpighia* belong, to differentiate between these two species.

DR. HARRIS: Thank you for correcting my faulty memory. In trying to recall our work of about twelve years ago I referred to Mexico instead of Guatemala as the country in which we picked up the cherry low in vitamin C content.

DR. CAMPBELL: I have been asked to differentiate between chemical score and simplified chemical score. Dr. Harper prefaced his paper with some remarks on the regular chemical score. A few years ago we proposed the use of the simplified chemical score. For many foods consumed in Canada, including processed cereals and many other foods on the market, we found the simplified chemical score gave a good indication of the protein value of the food as indicated by the fact that we obtained a straight line relationship between the simplified chemical score and protein efficiency ratio. There is no doubt that simplified chemical score has some disadvantages as it is based on methionine, cystine and lysine content. If other amino acids are limiting, it will not of course give the value of the food.

DR. HARPER: I have another question that follows very logically from that. Why is the chemical score not calculated from wheat lysine over egg lysine times a hundred which gives the same value? This question is a result of my effort to condense. Actually, it is necessary to determine which of the amino acids is the most deficient in the test protein before making the calculation. The subtraction step, therefore, must be done for each indispensable amino acid to determine the difference between the value for egg protein and that for the experimental protein once the amino acid which is in lowest concentration with respect to egg protein has been determined, the final calculation can be made either way.

DR. KREHL: I have been asked the question: Are recommended dietary tables a good guide for nutritional adequacy or are these values unrealistic in a modern society?

I think they have served as a very useful guide in measuring nutritional status. As Dr. Scrimshaw quite properly pointed out, if one accepts these guides too literally and states that a person who does not come up to the measure is malnourished, or that he is perhaps overnourished, these guides are obviously being misused. Naturally, certain parts in these tables are subject to severe criticism. For example, I do not believe a twenty-five year old, moderately active man needs 3,000 calories a day. I think it is too much and that if he eats this amount he will have a phenomenal weight gain over twenty-five years. An excess of 25 calories a day over twenty-five years means a weight gain of 25 pounds, which is significant.

It is obvious these tables must be used with common sense. The best guide to whether you are eating too much or too little is the scale in your bathroom.

The particular item in the dietary allowance table which I think deserves mention here is iron. Iron deficiency in the female or in the growing child is manifest in the hospital where a number of patients are seen with hemoglobin values of 11 to 13 gm. per cent and are accepted as normal. These are not normal values. While some of these levels can be improved by giving the patient iron, others cannot for various reasons. I think the data presented

by Dr. Carl Moore indicating rather poor iron absorption and considerable loss through the skin, plus the fact that each 1 cc. of blood lost is equivalent to 0.55 mg. of iron a day, are strong evidence of a great drag on the body stores if extended over a significant period of time.

DR. ASENJO: The following question has been asked: When an environmental factor affects the composition of a plant, for example, increases the ascorbic acid content, does it increase the yield?

This question is impossible to answer categorically. First of all, the genetic make-up of the particular plant will determine the maximum level that can be attained by any plant component even under optimum environmental conditions. For example, the amount of sunlight to which a fruit is exposed will usually have a favorable effect on the ascorbic acid content, but it will never exceed the maximum value set by the genetic factors operating. Whether the total yield will increase, however, will depend on the concurrent effect of a variety of factors.

Another question: Is it possible to increase the harvest as well as other characteristics by a particular fertilizer? It is well known that fertilizer generally increases harvest. In the case of corn, for example, it will increase the total amount of protein in the corn itself, although, on the other hand, the protein quality will usually be affected adversely. However, it is difficult to generalize as no two crop plants will behave exactly alike on the addition of fertilizer, except perhaps in the increased harvest observed.

DR. HARRIS: I have been asked: How do dietary calculations agree with dietary values with respect to nutrient content?

They seldom agree closely. Some years ago we studied the vitamin content of meals already prepared to eat in homes. We weighed and calculated the nutrient contents in each meal item using food tables, and compared the calculated amounts with the analysis amounts. In most cases the calculated value exceeded the analyzed value by 5 to 30 per cent. Only the mineral content ran higher by analysis. Possibly the iron content was higher because of the water used in cooking, and the calcium content was greater because milk was used in the recipes.

More recently we conducted a study of dinner meals with the same results. The ascorbic acid content of the prepared meals by analysis was about 60 per cent of the calculated value, the fat content was about 70 per cent of the calculated value, etc.

Thus, food tables tend to give values that are too high. It is not yet possible to prepare a food table in which the composition is expressed in terms of *available* nutrients. We found poor agreement between the true fat content of prepared foods as determined by analysis and calculated from the literature. Various food tables differ significantly from each other, especially in regard to prepared foods and mixed dishes.

DR. CAMPBELL: I have been asked to reply to two questions related to amino acid determinations: Which is the most satisfactory chemical or microbiological method, and how precise is the Moore-Stein column method?

We have used the microbiological method and believe it gives reliable results with fairly good precision. I would be interested in any comments on the Moore and Stein technic. As far as I know there has been relatively little published on the actual application of this method to natural materials. I think this is the area in which the greatest source of error lies.

DR. HARPER: I believe that in most of the studies utilizing the Moore and Stein method calculations have been made on figures obtained from analyses of mixtures of crystalline amino acids. Here the precision is as great as 2 to 3 per cent. When variability is estimated from several determinations on a single protein, the figures range higher, up to 5 or 6 per cent and occasionally higher. What is often overlooked in comparisons of the methods for amino acids is that large discrepancies arise due to losses occurring during hydrolysis. The amount of destruction of amino acids depends partly on the amount of carbohydrate present during hydrolysis. If destruction of amino acids occurs regardless of the method of analysis, the values will tend to be more variable.

Also, to add to Dr. Campbell's comments, two or three comparisons have been made between the Moore and Stein method and the microbiological method and agreement was good; both seemed equally applicable.

The column chromatographic method does not separate the D- and L-amino acids so the Moore and Stein method may give high values if the sample contains D-amino acids. On the other hand, if analysis is made microbiologically on materials containing peptides, the growth of the test microorganism may be stimulated by the peptides and the values will be high. This is seen clearly in some of the work in which analysis of amino acids in biological fluids has been carried out by both methods. The values obtained by the Moore-Stein method are much lower than those obtained by microbiological assay.

DR. KREHL: I have been asked to reply to a question: How do carbohydrates, fats and proteins affect the requirements for minerals?

Certainly stress experiments tell us that the biological response of the animal in terms of growth and lactation is altered significantly. I think much more research is needed relating to the effects of intestinal flora on human nutrition, particularly in view of the common use of antibiotics and the rather highly purified diets that might be used in human nutrition.

DR. CAMPBELL: This question is asked: Are there interrelationships in the balance and imbalance of fats similar to those with amino acids? We have found that a diet containing roughly 30 per cent saturated fatty acids produces maximum growth in rats. We have also been interested in the growth-retarding effect of rapeseed oil which contains a high proportion of erucic acid, and a low proportion of saturated fatty acids. Recently, we have obtained evidence that this effect can be eliminated by the addition of an oil, such as palm oil, containing a high proportion of saturated fatty acids.

DR. HARPER: I have been asked to clarify the difference between "theoretic" and "actual" efficiency of utilization of proteins. In using these two terms I was trying to say that from an amino acid analysis of a protein and from a knowledge of the amino acid requirements of a subject we can calculate what would theoretically be the maximum efficiency with which the protein could be used. When I used the term "actual" efficiency of protein utilization I was taking into account the many factors other than amino acid composition that influence the efficiency of utilization and generally tend to reduce it, such as a high level of protein in the diet.

DR. HARRIS: During this session we have discussed recent advances in relation to food composition, and the factors responsible for variations. Things are not quite as discouraging as they sometimes seem. We must admit that nutritional science is still in a state of considerable flux. Many interrelationships are not yet understood. It is not a simple subject now, and as time goes on it will become more complicated. If we understand the complications, we will be realistic in developing the science and in applying available knowledge to current problems.