CERTAIN FEATURES OF THE NUTRITIONAL VALUE OF MILK: A TRIBUTE TO GAIL BORDEN

Borden Award Address

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[In presenting the Borden Award to Dr. Weech, Dr. Harry Bakwin, President of the Academy read the following citation: “for his fundamental contributions in major fields of pediatric investigation. His studies in rickets, nutritional edema and physiologic hyperbilirubinemia stimulated newer lines of thought of the pathogenesis of these conditions. He characterized nutritional edema as a disturbance resulting from inadequate dietary protein. As the concentration of albumin in serum represents a practical means of recognizing protein deprivation in the pre-edema stages, he undertook studies of the effect of many basic dietary substances on the synthesis of this blood component. His comprehensive investigation of the causation of jaundice of the newborn established its relationship to liver immaturity. Dr. Weech is also being honored for his inspirational qualities as a teacher and a leader of research in numerous aspects of child health and welfare.”]

ON THE ANNUAL OCCASION OF THE PRESENTATION OF THE BORDEN AWARD OF THE AMERICAN ACADEMY OF PEDIATRICS IT IS PRECEDENT THAT THE RECIPIENT REVIEW THOSE ASPECTS OF HIS PERSONAL INVESTIGATIONS AS HAVE BEEN CITED BY THE AWARDS COMMITTEE IN JUSTIFICATION OF ITS DECISION. IN THE FACE OF SUCH TRADITION I WAS AT FIRST PERPLEXED. THE CITATION BEGINS BY AVERRING THAT SELECTION HAS RESTED ON “FUNDAMENTAL CONTRIBUTIONS IN MAJOR FIELDS OF PEDIATRIC INVESTIGATION.” THE STATEMENT IS BROAD, TOO BROAD TO SERVE THE PURPOSE OF CONCISE REVIEW. THE CITATION GOES ON TO MENTION STUDIES IN RICKETS, BILI-RUBINEMIA, NUTRITIONAL EDEMA AND BASIC DIETARY SUBSTANCES ESSENTIAL FOR THE SYNTHESIS OF SERUM ALBUMIN. THE BROAD RANGE OF INVESTIGATIONS STILL DEFIES TERE RETROSPEC-

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tion of nutritional edema or even with eradicating the milder signs of dietary deficits of protein. Nevertheless, history reveals that the term “nutritional edema” is synonymous with many nosologic expressions born of human adversity. Among the expressions we find such words as “war edema,” “camp edema,” “prison edema,” etc. Within a few years of the start of commercial production of evaporated milk our country was to become engulfed in a tragic civil war. It is a matter of record that during the strife the product was described as being of “greatest value” to the troops of the Union Army. In my own mind there is no doubt that the wide use of evaporated milk by the Army mitigated to some extent the otherwise devastating consequences of dietary protein privation. This is a dogmatic statement. We shall try to support it with evidence. To present evidence adequately there is first required a method. Over a number of years my colleagues and I had studied, in dogs, the consequences of inadequate dietary protein, that is, of maintenance on a diet yielding a negative nitrogen balance. Two of the consequences immediately concern us here: (a) maintenance on the diet is accompanied by a steady decline in the serum concentration of albumin; (b) an association exists between the serum albumin concentration and the presence or absence of edema. I might add that although mul-

Fig. 1.
Fig. 2. The average trends of albumin, globulin, and total protein during maintenance on the low protein diet. The dotted lines above and below the unbroken lines for albumin and total protein are placed at a distance of one standard deviation from the average values. (From the Journal of Experimental Medicine.)

Multiple factors are concerned in the accumulation of tissue fluid that leads to edema, there is little doubt that depleted serum albumin is a major cause of edema.

Figure 2 depicts the average course of the serum proteins in a group of dogs subsisting on a diet which permitted a daily loss of nitrogen of 1.15 gm. It is apparent that the steady decline in total serum protein concentration is due almost exclusively to depletion of the albumin moiety. It is further apparent that the charted pathway of depletion is not linear, that losses in concentration are greater during the early days and weeks than later in the experiment. The slowing in the rate of decline with the passage of time has been shown in metabolism studies to be associated with a progressive diminution in the nitrogen lost by the body. There is thus portrayed an adaptive ability of the body in adjusting its metabolic processes so as to spare protein.

Figure 3 shows the association in these animals between plasma protein concentrations and edema. The black dots represent analyses of plasma made when edema was present and the open circles refer to estimations before edema had developed or in a few instances after it had disappeared. Edema rarely appeared before the albumin was below 2%; it was more often present than absent when the albumin was between...
1 and 2%; below 1% edema was always present. Between globulin and edema no correlation can be discerned.

The foregoing association between deficits in serum albumin and the existence of edema led naturally to attempts to discover which dietary proteins would be most effective in promoting albumin synthesis and thereby relieving edema. The dog rendered hypoalbuminemic by dietary deprivation could obviously be used as a test animal for assessing the potency of specific food proteins in bringing about increases in serum albumin concentrations. An additional observation brought greater confidence in the validity of an assessment of this type. This observation was that the path of replenishment of serum albumin concentration from a depleted level and on a standardized intake of test-food protein is linear until the deficit has been obliterated, that is, replenishment does not simply reverse the path of depletion. Figure 4 illustrates the linear nature of the regeneration gradient and will help in understanding why the slope of the gradient can be used as a measure of the synthesizing value of a food protein undergoing test. Apparently the value obtained from an assay will be independent of the initial degree of depletion.

In assaying the various food proteins we used a standardized regeneration diet furnishing 5 gm of protein per kilogram of body weight. An assay value was defined as the gain in grams per cent of serum albumin concentration over a period of 7 days plus

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**Fig. 3.** The relation between plasma protein concentration and edema in dogs. Open circles indicate estimations when no edema was present; black circles refer to determinations when edema was present; vertical lines in the middle of each column indicate the range of normal variation. (From the *Journal of Clinical Investigation*.)
0.15, a figure corresponding to the average expected loss during the 7-day period if no test protein were being fed. Recorded potency values for each food protein represent the average of a number of assay values.

Table 1 summarizes the food proteins that have been so characterized. They are arranged in descending order of effectiveness in promoting the synthesis of serum albumin. It is perhaps not surprising that serum itself should be in the highest category of potency but it was a surprise to us that the whey protein of milk, soluble lactalbumin, did not differ significantly in potency from serum. It is worthy of note that the soluble lactalbumin used in these experiments was prepared without cost by Dr. George C. Supplee in the laboratories of the Borden Milk Company in Bainbridge, New York. The other milk protein, casein, acts effectively in stimulating the synthesis and belongs in the same grouping as liver and muscle.

There is no doubt then that the proteins of milk constituting part of a diet can be highly efficient deterrents to the development of depleted serum albumin and nutritional edema. The evidence has been presented and constitutes a reason for believing that evaporated milk, the discovery of Gail Borden, was of genuine value in maintaining a positive nitrogen balance in the soldiers of the Army of the Republic.

In quite another way, by necessity unforeseen at the time of invention, evaporated milk was destined to play a leading role in the ultimate conquest of a then rampant nutritional disease. I bring the subject up because the citation accompanying this Borden Award mentions contributions once made by the recipient to the knowledge of rickets. Back in the middle Twenties
investigators in many places became interested in the potentialities of milk as a vehicle for vitamin D. I was among the many. My share of the over-all problem involved daily visits to the maternity ward at Johns Hopkins and the attempt to persuade a reasonable number of young Negro mothers to imbibe cod-liver oil during the period when they would be nursing their babies. At this time the incidence of active rickets among breast-fed Negro infants in Baltimore was extremely high. The lot of having to persuade adults of the human race to drink fish oil “is not a happy one.” I was favored in the ill-conceived experiment (a) by the constant support of visiting nurses from the city’s well-baby clinics, (b) by the fact that we were dealing largely with young mothers keenly interested in the welfare of first babies, and (c) by the circumstance that I was too young to know better. As it turned out the amounts of cod-liver oil consumed by the 47 mothers included in the study varied widely. Nevertheless, when the infants were studied at the age of 6 months, it was possible to demonstrate that the quantity of cod-liver oil taken by the mother did have an effect on the degree of rickets exhibited by the infant.

The demonstration was made both by roentgenography and by analysis of serum for calcium and inorganic phosphorus. In Figure 5 the roentgenographic findings are

![Figure 5](https://example.com/figure5.png)

**Fig. 5.** Analysis of roentgenograms of 47 patients whose mothers took varying amounts of cod-liver oil in a 6 months’ test period. (From the Bulletin of the Johns Hopkins Hospital.)
summarized. In interpreting the films criteria were used that made it possible to classify each infant numerically with respect to the degree of rickets present. The chart shows only the average findings which are represented on the ordinate both by the numerals that were averaged to give each point and also by the degree of rickets corresponding to each numeral. Successive points along the abscissa correspond to groups of infants whose mothers received increasing amounts of cod-liver oil over the 6-month period. The declining curve with respect to severity of rickets suggests strongly that some of the vitamin D present in cod-liver oil was finding its way into the breast milk.

The chemical findings presented in Figure 6 are even more impressive. Here the degree of rickets is represented on the ordinate by the Ca X P product. Again from left to right along the abscissa we have the findings in groups of babies whose mothers received increasing quantities of cod-liver oil. We can see clearly that a high maternal intake of vitamin D was associated with a high level of lime salts in the sera of the infants. Again there is evidence of vitamin D being excreted in the milk.

These studies to which I have referred were of course only a tiny part of mass investigations of milk as a vehicle for vitamin D. And in turn the studies with milk are only a small part of the total of work on vitamin D. Out of it all a miracle has been wrought. Today we find it difficult to locate an occasional case of privational rickets for teaching purposes and most of our graduating residents have never seen a case of rachitic tetany. Gone are the days when Ethelbert Nevin's immortal song, "The Rosary," had a personal implication.

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![Graph showing the relationship between cod-liver oil intake and rickets](image-url)
for more than 50% of the childhood population. Gone are the days when the minds of medical students need be clogged with such phrases as hot-cross-bun head, caput quadratum, Harrison's groove, string-of-pearl deformity or even the saber shin. I am aware that vitamin D is now available on the market in hundreds of different forms. Under the circumstances it is perhaps brash to attribute the miracle of the disappearance of rickets to any single commodity. I am not alone, however, in holding the belief that the widespread practice of fortifying milk with vitamin D has been the most important factor. This viewpoint has been ably supported by the Council on Foods and Nutrition of the American Medical Association. Dr. Eugene H. Stevenson, acting secretary of the Council, informed me recently that at the time of last tabulation in February, 1955, there were listed 340 different brands of evaporated milk in this country, all of them fortified with vitamin D. The opinion seems justified that this almost universal fortification of evaporated milk has done more than has anything else to eradicate rickets in the very segments of the population least liable to avail itself of what we may call the newer knowledge of nutrition.

I wish now to conclude this speech of acceptance by dedicating it to the memory of Gail Borden on the centennial of the issuing of the patent on his process for producing evaporated milk.

REFERENCES
CERTAIN FEATURES OF THE NUTRITIONAL VALUE OF MILK: A TRIBUTE
TO GAIL BORDEN: Borden Award Address
A. A. Weech
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