The Aboriginal Eskimo Diet in Modern Perspective

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The aboriginal diet of the Arctic Eskimo, which consisted mainly of land and sea mammals and fish, is analyzed with respect to its capacity to provide the nutrients now regarded as essential for nutritional health. It is concluded that, despite its remarkably restricted composition, the native diet is capable of furnishing all the essential nutritional elements when prepared and consumed according to traditional customs. However, its low carbohydrate and high protein content necessitated major metabolic adaptations in energy and nitrogen metabolism. Erosion of the traditional diet culture and life style has been accompanied by a decline in nutritional status. [Eskimo, diet, nutrition]

AS A FORMULA for nutritional health modern nutritionists recommend a mixed diet of fruit, vegetables, cereals, meat, and dairy products. The assumption underlying this recommendation is that no single food or food group can be depended upon to provide all the essential nutrients required for health and well-being. Yet for centuries Eskimos residing at latitudes above the Arctic Circle maintained a vigorous life style on a diet consisting almost entirely of meat and fish. This paradox long has held a fascination for nutritionists.

It may be contended that the Eskimo diet was not fundamentally different from that of numerous other hunting societies which once populated the earth. But most other societies had the additional nutritional benefits of indigenous fruits, berries, seeds, nuts, leaves, and roots. Although plant foods were available to Eskimos residing at subarctic latitudes, they were virtually absent from the diet of Eskimos inhabiting the Arctic region. The remarkably restrictive character of their aboriginal diet has raised the question whether Eskimos possess unique metabolic capabilities which enabled them to adapt to their native regimen.

Modern nutritional science has identified most, if not all, of the essential nutrients required to sustain life and normal physiological performance. With certain reservations (mainly of a technical nature) the essential nutritional needs of man can be defined in terms of certain discrete biochemical entities which cannot be synthesized in the body. This accomplishment makes it possible to evaluate the Eskimo diet in terms of its capacity to supply the needs of the body for these essential entities. Viewed in this context, it can be concluded that the native diet, despite its remarkably restricted composition, is capable of furnishing all the nutrients essential for nutritional health, provided it is available in adequate amounts and is prepared according to traditional methods. In the following sections this proposition is examined with respect to specific nutrients.

VITAMINS

A natural association between the "B complex" vitamins and proteins in the enzyme systems of animal tissues provides strong assurance against a deficiency of these vitamins in a diet high in animal protein. There is no history among Eskimos of the epidemic vitamin deficiency diseases which afflicted some cereal-based food cultures. The oils of fish and

marine mammals are rich in the fat-soluble vitamin A and D. A high meat diet also provides adequate amounts of vitamin K. The vitamin E nutriture of Eskimos is of particular interest, since this vitamin is ordinarily derived mainly from cereal oils. A recent investigation of the vitamin E status of Alaskan Eskimos revealed that their blood levels are fully comparable to those of populations consuming a mixed diet (Wo and Draper 1975). This finding is attributable to the fact that nearly all of the vitamin E in animal tissues is present in its most active form (α-tocopherol), whereas in cereals it is present primarily as a less active isomer (γ-tocopherol).

The nutrition of the Eskimo with respect to ascorbic acid (a vitamin generally associated with fresh fruits and vegetables) has been a subject of much speculation. In south and central Alaska berries and green plants traditionally are harvested in the summer, and where permafrost is present berries are preserved in seal oil for use during the winter. In the northern coastal regions, however, berries and edible plants are not available in sufficient amounts to satisfy the requirement for vitamin C, especially in winter. The rumen contents of caribou have been cited as a possible source of ascorbic acid, but studies with cattle indicate that this compound is rapidly destroyed (probably as an energy substrate) by rumen microorganisms. The expeditions of early Arctic and Antarctic explorers foundered on scurvy, sometimes in spite of strict adherence to contemporary medical advice on methods of prevention. The Arctic expeditions of Stefansson were a notable exception. The fact that Eskimos were unaffected by the disease prompted Stefansson to condition his men to the native regimen before embarking on their explorations. Subsequently, in a celebrated experiment, he and his associate Karsten Andersen sustained themselves in good health under medical supervision for a year with a diet of fresh meat and fat. Stefansson's appraisal of the ascorbic acid nutriture of the Eskimo has successfully withstood 40 years of critical evaluation, namely "... that if you have some fresh meat in your diet every day, and don't overcook it, there will be enough C from that source alone to prevent scurvy" (Stefansson 1935-36). The Eskimo practice of eating their food in the raw, frozen, or lightly cooked state was a critical factor in preserving the small amounts of vitamin C necessary to prevent scurvy (less than 10 milligrams per day).

MINERALS

Little specific information is available about the mineral content of the native diet, but it appears to contain adequate amounts of the essential inorganic elements with the possible exception of calcium. Meat is notably low in this element, and dairy products (the main source of dietary calcium in industrialized countries) were unavailable to Eskimos until recent times. Explorers' accounts indicate that calcium was derived mainly from the soft bones of fish and the spongy portion of the bones of land and sea mammals. Recent biochemical research has elucidated a vitamin D-dependent mechanism which enables the body to adapt to a range of calcium intakes by modifying the efficiency of absorption, and this mechanism undoubtedly enabled the Eskimo to adapt to the limited quantity of calcium supplied by his diet. There is no evidence, however, that Eskimos have an unusual capacity for such adaptation and, indeed, the calcium content of their traditional diet is not notably different from that of many cereal-based food cultures.

The low calcium content of the meat regimen may be of lesser significance than its exceptionally high content of phosphorus. Adult animals and humans fed a high phosphorus diet, particularly one in which the calcium content is low, exhibit mild hypocalcemia, secondary hyperparathyroidism, and an increased rate of bone resorption. It is of interest, therefore, that Mazess and Mather (1974:916-925) and Pawson (1974:369-380) observed an unusually high rate of aging bone loss among Eskimos of northern Alaska. Further, a high protein intake is known to produce calciuria. To what extent, if any, the accelerated rate of

bone resorption observed in aging Eskimos is attributable to their high protein, high phosphorus, low calcium diet is unknown.

ENERGY AND PROTEIN

The predominant feature of the Eskimo native diet from an adaptational standpoint is its remarkably low carbohydrate content. The all-meat diet typically provides about 10 grams of glucose in the form of glycogen per 2,500 calories. The adult brain alone is estimated to consume about 100 grams of glucose, or its equivalent, per day. The central problem in adaptational bioenergetics for the aboriginal Eskimo therefore was to maintain glucose homeostasis in the face of a paucity of carbohydrate in the diet. In Table I the sources of calories in the Eskimo native diet are compared with those in the modern U.S. diet and in the contemporary diet in two northern Alaskan Eskimo villages.

TABLE I. DIETARY SOURCES OF METABOLIC FUEL*

Population	Gm. per Day			% of Kcal.		
	CHO	Fat	Protein	CHO	Fat	Protein
Wainwright Adults	200	120	156	32	43	25
Wainwright Children	269	108	113	43	39	18
Point Hope Adults	269	97	138	43	35	22
Point Hope Children	294	105	94	47	38	15
Premodern Arctic Eskimo	10	185	200	2	66	32
Modern U.S. Mixed	287	117	75	46	42	12

*Basis 2500 Kcal. per day. Wainwright and Point Hope data from 1971-72 survey. Premodern Eskimo data are illustrative. U.S. data from current statistics.

Since glucose cannot be synthesized from fatty acids (the main components of fat), when the diet is low in carbohydrate blood glucose levels must be maintained primarily by synthesis from amino acids released by the digestion of dietary protein. The biochemistry of these conversions has been well established. Because of its low carbohydrate content, a high concentration of protein therefore was an essential feature of the Eskimo diet, since extra protein was necessary to furnish the amino acids required for glucose synthesis beyond those required for body protein synthesis.

The low carbohydrate, high fat content of the native regimen is also noteworthy with respect to its influence on the composition of body fat. A high carbohydrate diet provides more glucose than can be immediately utilized by the tissues or stored as glycogen; consequently there is an active conversion of glucose to fatty acids which are stored in the adipose tissues as fat. These fatty acids, which are saturated and mono-unsaturated, constitute the main components of body fat. In the Eskimo, on the other hand, lipogenesis was inhibited by a surfeit of fatty acids supplied by the diet. Dietary fatty acids, somewhat modified during metabolism and diluted by fatty acids synthesized *de novo*, had a major influence on the composition of body fat. The long-chain polyunsaturated fatty acids typical of marine oils were prevalent in the adipose tissues of Eskimos, as well as in the lipids of the blood and body organs. Dyerberg, Bang, and Hjorne (1975:958-966) recently have documented the occurrence of these acids in the blood lipids of Greenland Eskimos and have discussed their possible relationship to the low serum cholesterol levels which are characteristic of Eskimos consuming the native diet.

Although ruminant fats are generally characterized as being highly saturated, analysis of the fatty acids of caribou meat consumed by northern Alaskan Eskimos revealed a much

higher content of polyunsaturated fatty acids (21%) than is found in the meat of modern beef animals (approximately 3%) (Wo and Draper 1975). This discrepancy is attributable to the "marbling" of beef with saturated fat, a property which has been encouraged in breeding practices as an asset to flavor and palatability. The general association between saturated fatty acids and animal fat therefore does not apply in the case of the Eskimo native diet of land and sea mammals and fish.

Under ordinary conditions fatty acids are utilized for energy by a process involving degradation to small fragments ("acetate") which are combined with products of glucose metabolism and further oxidized to carbon dioxide and water (hence the biochemical adage that fats burn in a flame of carbohydrates). Under conditions of glucose shortage, however, these fragments accumulate and condense in the liver to form the so-called ketone bodies. These substances are transported by the blood to the extrahepatic tissues which are capable of enzymatic adaptation to their use as a major source of energy, thereby conserving the body's supply of glucose. Recent evidence indicates that under conditions of severe glucose shortage the brain is also capable of adapting extensively to the use of ketone bodies to meet its energy requirements.

A subject of frequent speculation concerning the energy metabolism of Eskimos is whether they relied on ketone bodies as a significant source of metabolic fuel. It is difficult to estimate how frequently conditions conducive to ketogenesis prevailed in Eskimo dietary experience, but it seems likely that there were times when the supply of protein was inadequate to meet the amino acid requirements for glucose synthesis as well as for protein synthesis. Further, it has been estimated that the capacity of the liver to convert amino acids to glucose is limited to about half the total energy requirement. Four of the 20 amino acids supplied by dietary protein are ketogenic as well as glycogenic and another (leucine) is specifically ketogenic. An abrupt change from a mixed diet to a meat diet leads to asymptomatic ketosis and ketonuria, but these conditions gradually diminish as a result of biochemical adaptation to the use of ketone bodies for energy. Whether Eskimos have unusual adaptational capabilities in this regard is unknown.

Their high-protein diet imposed on Eskimos a need to dispose of an unusually large metabolic load of urea, a potentially toxic nitrogenous compound formed during the conversion of amino acids to glucose. Animals fed high-protein diets exhibit diuresis and an increase in water consumption, and it is of interest that early explorers commented on the high water intake of Eskimos. A feedback mechanism acts to prevent uremia under conditions of high protein intake by stimulating water consumption and thereby enhancing the dilution and excretion of urea. The need for efficient urea clearance implies that renal disease in Eskimos consuming the native diet has unusually serious clinical implications.

The all-meat diet is also distinctive with respect to its lack of "fiber," a composite of plant materials which is resistant to digestion and therefore passes relatively unchanged into the feces. Such materials normally exert several physiological effects, including an enhancement of food transit through the gut, an increase in fecal bulk, alterations in bacterial activity, and a sequestering of cholesterol and bile salts. The decline in the fiber content of the general U.S. dietary in recent decades has been implicated as a factor in the incidence of a number of intestinal diseases (constipation, diverticulosis, colonic cancer) which may be increased by food stasis and putrefaction in the lower intestine. Medical records are too fragmentary to indicate whether these diseases are unusually prevalent in Eskimos habituated to the native diet.

LACTOSE TOLERANCE

Eskimos resemble other cultures lacking a long history of dairying in having a limited capacity for lactose digestion, and this physiological constraint places a limit on the amount

of milk and other dairy products which can be tolerated. Lactose intolerance, manifested in abdominal cramps, flatulence, and diarrhea, is due to a decrease with age in the synthesis of lactase by the intestinal mucosa. Sahi and co-workers (1973:823-826) have shown that lactose intolerance in Lapps is due to a single recessive autosomal gene. Duncan and Scott (1973:867-868) observed that 80% of a mixed sample of adult Alaskan Eskimos and Indians were intolerant to a 50-gram lactose load (an amount equivalent to that present in a liter of milk), and Bell, Draper, and Bergan (1973:1185-1190) found a 56%-70% incidence of intolerance to a similar dose in school children. However, studies on both children and adults revealed that they were capable of tolerating nutritionally significant amounts of dairy foods. Use of graduated lactose loads indicated that nearly all Eskimo adults are asymptomatic after a 10-gram load (equivalent to 1 cup of milk) and that about half are tolerant to a 20-gram load (Bell, Draper, and Bergan 1973:1185-1190). Most adults, as well as children, therefore appear to be tolerant of at least one cup of milk (or its equivalent in other dairy products) at a time. If this quantity is ingested two or three times per day at intervals of several hours, the recommended consumption of dairy foods can be achieved by most children, adult males, and nonpregnant females. Many Eskimo women, however, will experience difficulty in consuming the additional amounts of dairy products commonly recommended during pregnancy and lactation. In the modern diet dairy products are an important source of calcium and protein as well as riboflavin (one of the nutrients most likely to be inadequate in the diet of children of low economic status).

SUCROSE TOLERANCE

A novel racial-ethnic form of primary sucrase deficiency has been identified in Greenland and Alaskan Eskimos (McNair, Gudmand-Hoyer, Jarnum, and Orrild 1972:19-21; Bell, Draper, and Bergan 1973:1185-1190). The symptoms are similar to those of lactase deficiency. Typically they appear after consumption of a piece of cake, an ice cream cone, or a bottle of carbonated beverage. In contrast to normal subjects, intolerant individuals given a 50-gram oral sucrose load exhibit no plasma glucose response, indicating a lack of sucrose digestion in the intestine. There is a distinct familial pattern to the occurrence of sucrose intolerance.

The incidence of sucrase deficiency in Eskimos is not yet well documented and may vary with geography. McNair and associates (1972:19-21) found an incidence of 10.5% in a sample of Greenland Eskimos which included patients with a history of chronic diarrhea. In the whole population of Wainwright, Alaska, the incidence was estimated at 2%-3% (Bell, Draper, and Bergan 1973:1185-1190). No evidence of intolerance was found at Kasigluk or Nunapitchuk in southwest Alaska, where berries contributed significant amounts of sucrose to the aboriginal diet. It is possible that sucrase deficiency is confined to the Arctic region where sucrose has been virtually absent from the diet for many centuries. Under these conditions a tolerance for sucrose presumably was a negligible factor in natural selection.

Sucrose intolerance differs from lactose intolerance with respect to its prevalence, mode of inheritance, and nutritional significance. Whereas lactase production declines gradually during the growing period, sucrase deficiency is present from birth. Sucrose intolerance is considerably less prevalent than lactose intolerance, but its nutritional implications for those affected are more serious. Whereas lactose intolerance generally can be managed by moderating the consumption of a limited number of foods, sucrose intolerance imposes many restrictions on the selection of foods from the modern diet.

THE IMPACT OF ACCULTURATION

In the course of nutritional studies carried out under the International Biological

TABLE II. PERCENT OF NUTRIENTS OBTAINED FROM NATIVE FOODS

	N	Calories	Protein	Fat	CHO
Wainwright—Summer 1971					
Men	9	43	79	48	0.5
Women	7	52	83	63	0.6
Children	16	23	56	30	0.1
Wainwright—Winter 1972					
Men	17	33	68	45	0.5
Women	15	46	73	60	0.9
Children	21	25	56	42	0.5
Point Hope—Winter 1972					
Men	16	24	62	26	0.5
Women	16	20	52	22	0.4
Children	12	8	22	13	0.1

Programme, diet surveys were conducted in 1971 and 1972 on residents of the northern Alaskan villages of Wainwright and Pt. Hope (Bell and Heller 1974). The results confirm previous evidence of the erosion of the traditional diet culture, especially among children.

Table II shows the percent of major nutrients derived from native foods at each village in 1971-72. Wainwright adults obtained nearly half of their calories from native sources and about three-quarters of their protein. At Point Hope, where dietary acculturation is more extensive, less than one-quarter of the calories in the adult diet were obtained from indigenous foods, which nevertheless provided over half of dietary protein. The proportion of native foods in the diet of children, on the average, was about half that in the diet of adults. The difference between generations in the composition of the diet is striking. This difference is further illustrated in Tables I and III. The diet of adults in both villages is still high in protein, but the diet of children at Point Hope is now not substantially higher in protein than that of the general U.S. population (recently estimated at 12% of calories).

TABLE III. SOURCES OF DIET CALORIES (MARCH 1972)

	Protein	Fat	CHO
Wainwright Adults	25	43	32
Wainwright Children	18	39	43
Point Hope Adults	22	35	43
Point Hope Children	15	38	47

Extension of these studies to the southwestern Alaskan sister villages of Kasigluk and Nunapitchuk revealed a latitudinal gradient in obesity, hypercholesterolemia, and hypertension which was correlated with the increased use of processed foods and the decay of the traditional life-style. Whereas the incidence of high plasma cholesterol levels at Wainwright and Point Hope was still below the national average, 42% of the adults and 19% of the children in the southern villages had clinical hypercholesterolemia (Table IV). A corresponding gradient was observed in blood pressures, especially among women (Table V). Obviously the historic pictogram of low cholesterol levels and blood pressures is no longer valid for most Alaskan Eskimos.

In many respects the changes in the nutritional status of the Eskimo which have occurred in recent years as a result of acculturation parallel the changes which have taken place in the rest of the U.S. population over a longer time frame. They also provide a commentary on the

TABLE IV. PLASMA CHOLESTEROL LEVELS IN ESKIMOS LIVING IN THREE ALASKAN VILLAGES (1971-74)

Site	Total N	Total Cholesterol (Mean ± S.D.) Males	Females	Both	% Hypercholesterolemia* Males	Females	Both
Children (7-16 yr.)							
Wainwright	63	145±21	151±29	149±46	0	2.4	1.6
Point Hope	56	164±22	168±27	166±24	0	0	0
Nunapitchuk	83	201±25	205±30	202±27	14.9	25.0	19.3
Adults (18-74 yr.)							
Wainwright	66	187±41	205±57	197±51	6.7	13.8	10.6
Point Hope	82	212±39	210±38	211±38	10.3	14.0	12.2
Kasigluk-Nunapitchuk	79	247±36	260±48	256±45	38.9	42.6	41.8

*Defined as $\geq$230 mg./100 ml. in children and $\geq$260 mg./100 ml. in adults.

modern mixed diet. Industrialized societies have (at least for the time being) removed the danger of starvation which was a constant threat to most primitive societies. Science and technology have greatly enhanced the efficiency of food production and preservation and have increased the number of nutritious foodstuffs available. Concomitantly, however, there has been a marked increase in the production of foods of low nutritional quality. Moreover, these foods have been made attractive and appetizing with the result that their consumption has increased at the expense of better quality foods. In order to assure an adequate intake of essential nutrients, it has become necessary to divide foodstuffs into groups according to their distinctive nutritional qualities, and to formulate dietary rules designed to assure a balanced intake of foods from each of these groups. A massive educational program has been necessary to inform consumers of the merits of each food group and of the rules of food selection which must be followed in order to maintain nutritional health. To be assured of a balanced diet the modern consumer must be sufficiently knowledgeable about the principles of good nutrition to be able to evaluate the quality of each food item in the marketplace. This task has been made more difficult by the presence of many "conglomerate" foods that do not fall clearly into any one food group. The consumer is required to develop a more sophisticated knowledge of nutrition than of any other health science. Such a knowledge may be beyond reasonable expectations.

While the primitive Eskimo was beset by serious nutritional crises, these problems arose not from deficiencies in the quality of his native diet but from periodic breakdowns in his food supply as a result of natural forces. He required no knowledge of nutritional principles in order to be well nourished. He ate a balanced diet for one simple reason: there was little else to eat.

TABLE V. % of ESKIMOS AGED 18-74 YEARS WITH B. P. $\geq$160 SYSTOLIC OR $\geq$95 DIASTOLIC

	Male		Female		Both	
	N	%	N	%	N	%
Wainwright	39	5.1	43	4.6	82	4.9
Point Hope	41	12.2	42	14.3	83	13.3
Kasigluk and Nunapitchuk	20	10.0	66	27.3	86	23.3
U.S. National Health Survey (1960-62)		15.0		16.7		15.9

The modern Eskimo has for the first time the opportunity to make significant food choices. Presented with an array of exotic new foods which he is not equipped by personal experience or education to evaluate, he tends to choose badly. In general, the items he selects are below the average quality of the U.S. mixed diet and of the foods they replace in his native diet. His nutritional status is deteriorating, in terms of both undernutrition and overnutrition, in direct relation to the proportion of processed foods in his total diet. In the subarctic, where dietary acculturation is extensive, the Eskimo has the full complement of diet-related diseases that are characteristic of other segments of the U.S. population of low socioeconomic status: obesity, cardiovascular disease, hypertension, and tooth decay.

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