SODIUM IN FOODS AND BEVERAGES[1]

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Abstract

Sodium in the human dietary is derived from many sources, some of which are obvious, while others might be termed "hidden." Table salt and other compounds used in food processing and preparation contribute large quantities of sodium to the day's total intake. Numerous additives commonly used by the food industry are contributing a larger and larger proportion of the sodium content in the usual dietary.

Chronic ingestion of increasing intakes of sodium can have serious consequences in susceptible persons. A second look at all sources of dietary sodium may be in order, particularly in view of the introduction of newer convenience-type foods into the retail and institutional markets.

Salt, and other sources of sodium, have played a vital role in man's physiological environment. Life began in the salty environment of the sea and it is not surprising that salt should be a necessary component of all protoplasmic systems.

Salt has been used in cooking and preservation of foods since prehistoric times. Although sodium and chloride are necessary constituents of the extracellular fluids in the body of man, the appetite for salt and many other sodium-containing additives seems to be an acquired habit rather than a reflection of need.

Physiologic Role of Sodium

Salt is dissociated in aqueous solution to form sodium and chloride. Therefore the constituent ions are considered separately in respect to their effects on the total organism.

Because sodium and chloride constitute the principal ions in the extracellular fluid of the body, their major role in the body is to maintain osmotic pressure of body fluid compartments. Concentration of these ions directly affects control of the volume of interstitial fluid, control of the water content of the tissues, and control of the volume and pressure of circulating blood.

Sodium also affects irritability of cells but in this role it is directly related to other ions which must be present in fixed ratios in order to promote normal physiologic activity. Relative concentrations of potassium, magnesium, calcium, and hydrogen affect the ability of sodium to maintain normal cell irritability. This relationship is sometimes observed clinically in the review of electrocardiograms. The well known effects of low levels of serum potassium on the electrocardiogram may not be seen in the presence of elevated serum sodium levels, or reduced levels of calcium and magnesium *(4)*.

Sodium in the body has the additional role of helping to maintain normal acid-base balance by the stabilizing action of the sodium buffer systems which are present in the extracellular fluid. Sodium exchanges for potassium and for hydrogen in the distal tubule of the kidney. The quantity of sodium in the tubular fluid determines the rate of excretion of both potassium and hydrogen ions. This relationship is responsible for the potassium losing effect following ingestion of large amounts of sodium salts and the accentuation of an existing potassium deficiency when a diet high in sodium content is eaten.

Conversely, when sodium-induced hypertension occurs in animals, potassium has a protective effect *(6)*. Regulation of the sodium content of body fluids and tissues is maintained normally by the balance between intake and excretion. Under usual circumstances the excretion of sodium is controlled by the kidney. If sodium intake is reduced, the kidney has the capacity to reduce sodium excretion to very low levels, a capacity which does not exist for potassium. Therefore, with normal kidney function and in the absence of unusual losses of sodium through the skin or bowel, a severe sodium restriction in the diet does not result in serious sodium deficiency.

Usual Intake of Salt and Sodium

Salt and sodium intakes vary considerably among individuals in the United States and throughout the world. French chefs, for example, are said to add 3% of salt in their baking while in many areas of England, very little salt is used for this purpose *(4)*.

It is common in medical and dietetic practice to express total sodium consumption in terms of grams, milligrams, or milliequivalents. Frequently the person who is advised to adhere to some level of sodium restriction because of a disease condition must learn what this terminology means and how to interpret it in respect to his daily consumption of an advised

[1]Contribution from the College of Agricultural and Life Sciences.

amount of sodium.

This usually means the patient will need to find sodium contents of food products readily available on the food label. For ease in converting milligrams of sodium to milliequivalents, the milligram weight is divided by the atomic weight of the monovalent sodium ion. For example a diet (or a single food) which contains 2300 mg of sodium would contain 100 milliequivalents (meq) of sodium. Label statements about the milligram and milliequivalent weights of sodium in a given portion would be exceedingly useful for the many people who must adhere to a sodium-restricted diet. The daily sodium intake of Americans has, for some years, been estimated as ranging between 2.3 and 7.0 g (2300 - 7000 mg or 100 - 304 meq of sodium). A part of this is derived from salt per se, a part from the sodium naturally present in foods and waters, and a part from the sodium containing substances added in food processing and preparation. It is probable that the sodium intake of many Americans now lies high above this upper range of estimate because of increased use of sodium-containing additives in food processing.

Sodium ingested via the salt route is then only one of many sources of sodium intake. Naturally, the use of baking soda, baking powder, monosodium glutamate, and other commonly used additives in food preparation also add to the sodium content of the usual dietary.

Many common foods in their natural state contain sodium in amounts that can be significant when dietary restriction is indicated because of disease. Unprocessed foods of animal origin, which contain protein, have significant natural contents of sodium. They include milk and other dairy products, meats, fish, eggs and variations thereof (Table 1). Non-fat milk solids contribute sodium as well as protein and other nutrients. Increasing use of milk-base convenience foods by the public probably is an important source of sodium for many individuals. Added to this, the salt and/or other additions used in processing or preparation of foods already fairly high in sodium, can make for very significant quantities of sodium in the day's total intake *(9)*. Fruits and vegetables, in their natural form, are generally low in sodium.

Analysis of foods used in hospital menu planning at the University of Wisconsin clearly showed the effects of sodium containing additives on final composition of foods which, in their usual state, contribute sodium *(2)*. American cheese has been thought to contain roughly 1,100 mg of sodium per 100 g of cheese. In the study mentioned, the content of sodium in 100 g of one brand of American cheese was close to 1,800 mg. The increase in sodium content of this one newer food item apparently resulted from addition of sodium aluminum phosphate which was added as an emulsifier. Commercially prepared stew may contain up to 9,000 mg of sodium per 10 oz can *(5)*.

TABLE 1. SOME EXAMPLES OF SODIUM CONTENTS OF FOODS AND BEVERAGES

Food	Amount	Approximate mg sodium
Foods from animal sources		
Butter, salted	1 tsp	50
Cheese, cottage	1 oz	130
Egg	1	60
Fish, fresh, unsalted (as walleye pike)	1 oz	80
Meat, fresh, unsalted	1 oz	20
Milk, buttermilk	1 cup	315
Milk, whole fresh	1 cup	120
Other common foods		
Bread, regular	1 slice	135
Fruit	1 serving	2
Low sodium vegetables as lettuce, sliced tomato	1 serving	5-10
Vegetables	1 serving	varies widely
Taste teasers		
Bacon	3 slices	300
Baking powder (tartrate type)	1 tsp	350
Baking soda	1 tsp	1000
Bologna	1 slice (1 oz)	390
Bouillon cube	1 (for 1 cup liquid)	1050
Canadian bacon	1 serving (2 oz)	1530
Cheddar cheese	1 slice (1 oz)	210
Corned beef	1 serving (2 oz)	1040
Cornflakes	3/4 cup	220
Dill pickle	1/4 medium	270
Monosodium glutamate	1 tsp	765
Prepared yellow mustard	1 tsp	60
Soda crackers	4	130
Soy sauce	1 tsp	365
Table salt	1/4 tsp	580
Wines		
Dessert (U.S. origin)	1 qt	75- 510
Red (U.S. origin)	1 qt	48-1210
Rosé (U.S. origin)	1 qt	115-1100
White (U.S. origin)	1 qt	32-1175

To list the contribution of various sodium containing additives to individual foods in the course of food preservation and processing would be an almost endless task. Brine solutions used in vegetable processing; mold retardants used in breads; and salted, corned, and pickled meat products are several examples of methods of introducing sodium into commonly consumed foods. In the latter connection, some highly spiced, highly salted sausage and other meat products have been known to produce "taste fatigue," the result of an over abundance of flavor in the product. New uses for sodium containing additives are constantly being discovered *(8)*. A new use will probably be found for precooked and reheated meats, now commonly used in institutional food service *(7)*. Undesirable organoleptic changes caused by oxygen and moisture can apparently be prevented by certain additives, some of which contain sodium. What these additives will do to sodium contents of foods, particularly for hospital food services, remains to be seen.

TABLE 2. SOME EXAMPLES OF SODIUM CONTAINING CHEMICALS USED IN FOOD PROCESSING

Preservatives	
	Sodium acetate, diacetate, benzoate, hypochlorite
	Sodium propionate, chloride, sorbate
Antioxidants	
	Sodium ascorbate, thiosulfate, sulfite, bisulfite, metasulfite
Sequestrants	
	Sodium diacetate, citrate, gluconate metaphosphate, aluminum phosphate, tartrate, thiosulfate, calcium disodium salt of EDTA.
Surface active agents	
	Sodium sulfoacetate glycerides, monosodium glycerides, stearate, taurocholate
Stabilizers, thickeners	
	Sodium alginate, methyl sulfate, pectinate
Bleaching and maturing agents	
	Sodium chloramine, chlorite, hypochlorite, tri-metaphosphate
Buffers, acids, alkalis	
	Sodium acetate, carbonate, bicarbonate, citrate, aluminum phosphate, acid pyrophosphat, hydroxide, potassium tartrate
Non-nutritive sweeteners	
	Sodium saccharin
Flavoring agents	
	Synthetic flavors
	Spices, herbs
Miscellaneous—Firming agents, texturizers, binders, anti-caking agents	
	Sodium sulfate, sulfide

Frequency of use of individual food items must be considered in evaluating the sodium contribution of a given food in the dietary. When an individual eats large quantities of bread, for example, the use of salted bread as a single type of food in the diet will soon increase sodium intakes. Breads prepared without added salt contain some sodium depending on the kind and proportion of ingredients and on the local water supply. One product developed in cooperation with a bakery in the Madison area averages 5 mg sodium for a 1-oz slice, whereas in the same area, a 23-g slice of salted bread contains 200 mg or more of sodium.

Drinking waters vary in sodium content but often are a significant additional source of sodium intake. A study conducted by the U. S. Public Health Service indicated that in samples derived from 2,100 municipalities in the United States, the sodium ion varied considerably, with highest sodium concentrations found consistently in the waters of the Far West and Midwest areas of the United States. All areas of the country had some municipal water supplies showing a high sodium content *(10)*. Here again, the significance of sodium contents of drinking waters becomes most important when dietary sodium must be restricted. A sodium content of more than 20 mg per liter could be of much importance when sodium restriction on the order of 500 mg a day is indicated in disease conditions. A 500 mg sodium intake is less frequently advised now than it has been formerly, in part because of the development of more effective medications which promote body sodium loss. However, a dietary prescription of 1,000 mg of sodium is not at all uncommon in the food services of most hospitals and in the home care of the patient for whom sodium intake must be restricted and controlled. The water and syrup in which foods are packed may in themselves contain large amounts of sodium. Like drinking waters, wines in the diet may also be an additional unexpected source of sodium (Table 1).

Ingestion of sodium from foods and liquids can be further increased by use of sodium containing toothpastes and medications such as cough remedies, laxatives, antibiotics, and sedatives.

The introduction of new food items, especially the convenience type food item, into the retail and institutional markets has posed problems for the physician, patient, and dietitian. Although various tables of sodium composition of foods commonly used in American households have been available in past years, the lack of information regarding sodium composition of newer food products has made dietary planning for the patient difficult.

IMPLICATIONS OF HIGH SODIUM INTAKE IN HEALTH AND DISEASE

Because of the healthy kidney's capacity to excrete excess sodium, the assumption has been made by many that a liberal intake of sodium is not injurious to the healthy adult. This assumption has been refuted by some. There appears to be growing support for the thesis that excessive sodium intake over a period of time might precipitate hypertension and atherosclerosis in susceptible individuals *(1)*. The food industry is alerted to the withdrawal of monosodium glutamate from foods processed for babies. It is known, of course, that the infant's renal excretory mechanisms are not mature and do not function with the same efficiency as the healthy adult kidney.

The implications of high sodium intake in certain disease conditions are profound and serious. Sodium retention occurs in a number of clinical conditions. Congestive heart failure, hypertension, kidney diseases, cirrhosis of the liver with fluid retention, severe malnutrition, and toxemia of pregnancy are among the more common. Sometimes medications, in themselves, cause sodium retention and therefore must be used in conjunction with a sodium-restricted diet. Certain steroids, for example, can cause this situation to occur.

In many hospitals a temporary loss of normal kidney function is sometimes noted post-operatively in patients of all ages, and excessive sodium (and solute) intake at this time can be injurious. Elderly persons often have a change in kidney efficiency which may or may not be reflected in the way the kidney can handle sodium.

When sodium restriction is obviously indicated as often happens in congestive heart failure and various forms of kidney failure, strict adherence to a regimen of diet and medications is often a life or death proposition. As mentioned previously, sodium restriction of the order of 1,000 mg a day is not uncommon nor are prescriptions for less or more than this amount of sodium.

In recent months and years medical attention has focused also upon the total osmolality of a diet, since it is known that diets with high osmolalities (derived from ionic constituents and dissolved substances, notably sugars) can provoke diarrheas in some sick persons and increase serum osmolality levels in others.

Depending upon the total composition of a special diet, a diet high in sodium may have a high osmolality. The osmolality effects of processed convenience type liquid diets and mixtures consisting of liquified foods have received attention. Reports of deaths in persons fed liquid diets via nasogastric tube have been attributed to the effects of the osmolality of the feeding unaccompanied by adequate fluid intake.

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GE INTRODUCES NEW HIGH-TEMPERATURE VORTEX I VORCINERATOR SYSTEM TO CUT POLLUTION-IN SOLID WASTE DISPOSAL

The General Electric Industrial Heating Department announces Vortex I, a new high-temperature modular Vorcinerator system affording high-speed elimination of industrial solid waste materials without violating air and water pollution regulations.

The Vortex I system, which meets Federal air pollution control standards, was especially designed for industrial manufacturing plants, warehouses, institutions and food processors who have solid waste disposal requirements in the range of 5- to 20-tons daily.

Vortex I provides 10- to 20-times the hourly combustion rate of conventional incinerators. The new Vorcinerator system uses a horizontal vortex combustion chamber measuring 7-feet wide by 11-feet long, and has an operating temperature range of 1800 to 2000 F.

The cylindrical combustion chamber can handle up to 1-1/2-tons-per-hour of industrial waste materials, such as highly combustible paper, cardboard, wood boxes and plastics. The waste can contain up to 10 percent non-combustible materials, and small rubber items from commercial and industrial sources.

The new modular Vorcinerator system is comprised of the Vortex combustion chamber with automatically regulated secondary air system, primary air/feed blower and material feed rate control system, exhaust stack assembly, control, panel, and ash separation system.

The automatic control system contains two separate overtemperature control systems which monitor the exhaust gas temperatures through thermocouples and meter-relays to provide double protection by shutting down the electrical power system and secondary air supply in case the pre-selected maximum temperature limits are exceeded. The entire unit will shut down to the preheat condition automatically after its last load if left unattended.

The cylindrical combustion chamber receives waste material blown in from a high-capacity shredder. The

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recommended action so will be listed together. *Problem 10*: Recommend a change in the bacteriological procedure for the determination of bacterial counts of both Grade A raw and pasteurized milk.

Problem 11: Evaluate the significance of current bacterial standards that are applied to raw and pasteurized milk.

Problem 12: Develop statistically significant sampling, laboratory procedures, and standards that more truly reflect the degree of the sanitary production and quality of raw and pasteurized milk.

Problem 13: To undertake a study with the PHS to determine acceptable maximum number of bacteria in milk, determine acceptable maximum number of bacteria in raw milk determined by the coliform, psychrophilic, and laboratory pasteurized tests. The task force recommended that the laboratory committee review existing bacterial standards and procedures and if necessary work toward development of new standards and procedures for the examination of Grade A raw and pasteurized milk. The laboratory committee shall report back to the 1973 Conference on its findings. The delegates approved the recommendation.

After conclusion of the task force reports, Program Chairman Wright called for unfinished business. Since there was no unfinished business, the Conference moved on the consideration of new business. There being no new business, the Chairman called for election of new members of the Executive Board. The Nominating Committee recommendations were read for the second time. Delegate Boosinger, Florida, moved that the nominations be closed, and the Secretary be directed to cast a unanimous ballot for candidates. The motion was carried. The new members of the Executive Board were duly announced and the final general session of the 13th National Conference adjourned at 12:10 P.M. on Thursday, May 20.

Executive Board Meeting, May 20, 1971

Secretary-Treasurer J. C. McCaffrey convened the meeting of the new Executive Board at 12:25 p.m. on Thursday, May 20, 1971. All members with the exception of Carl Henderson were in attendance. Secretary-Treasurer McCaffrey introduced the new members of the Board from Region II, namely H. H. Vaux, Ken Van Patten, Burdett Heinemann and the three who were re-elected: John Schilling, Earl Wright, and J. C. McCaffrey.

Secretary-Treasurer McCaffrey called for the election of new officers. John Schilling was elected Chairman and J. C. McCaffrey was re-elected as Secretary-Treasurer.

Each member of the Board received a list showing the various hotels and cities which had submitted proposals to host the 1975 meeting. After considerable discussion the meeting was awarded to St. Louis, Missouri. The exact dates will be arranged later.

Chairman Schilling asked for a discussion of new business. Secretary McCaffrey mentioned that no particular recognition had ever been given to individuals who had served as Chairmen of the organization. He suggested that a suitable plaque be purchased and awarded to each of the past chairmen during the 1973 meeting in Des Moines, Iowa. Van Patten moved, seconded by Arledge that McCaffrey be authorized to make all arrangements for the purchasing of the plaques. There being no further new business, the meeting was adjourned at 2:10 p.m.

GE INTRODUCES

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shredded material is then suspended and whirled around the interior circumference of the combustion chamber wall by the circular motion of the vortex flame where it is burned to a sterile ash. Ash particles are then guided to a cyclone separator where they are collected for disposal.

Vortex I has been demonstrated through the joint efforts of GE, the City of Shelbyville, and the Environmental Health Service's Bureau of Solid Waste Management under Phase I of a two-year, $444,680 Federal program.

Benefits afforded by the new Vorcinerator system were found to include exhaust and ash removal systems which markedly reduce emission of noxious gases, smoke and ash particles to the atmosphere; low maintenance and operating costs; no moving parts in the high-temperature combustion chamber; modular unit construction for ease of portability and installation; and automatic controls for safety and efficiency.

In Phase II of the demonstration program a larger Vorcinerator system (6- to 7-ton per hour capacity) has been built by GE and installed in Shelbyville for further testing. Operation should begin by the end of the year.

The new Vorcinerator system reduces combustible waste materials to a fine ash suitable for industrial applications such as parking lot surfacing material. The inert ash also eliminates the need for large landfill areas and normally does not add to ground water pollution.

For more information on the new Vortex I modular Vorcinerator system, contact your local GE Industrial Sales Representative, or write the GENERAL ELECTRIC COMPANY, Waste Management Systems, 1 Progress Road, Shelbyville, Indiana 46176.