Practical Methods for Preparing Diets Low in Sodium and High in Protein

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IT IS generally recognized that the restriction of sodium in the diet is beneficial in many cases of hypertension and heart disease. A slight or moderate diminution in the salt intake is, however, seldom effective, a fact which accounts for much of the contradictory evidence in this field. Therefore, the attainment of a diet markedly low in sodium, but without diminution of other dietary factors, is of considerable importance to the physician and to the dietitian, as well as to the patient.

In a little-known manual by one of the pioneers in this field, Allen[1] gave detailed directions for preparing a diet low in salt. These included boiling some vegetables "in three changes of water, using abundant water and discarding it after each boiling . . . . To a limited extent the process can be applied to meat." Even though the sodium content of the various foods was not known, and the efficiency of the thrice-boiling procedure was not controlled, the results, according to this investigator, were quite good.[2] The subject of salt-restricted diets, however, remained a controversial one. With the advent of the Kempner rice diet,[3] the question arose as to the explanation for its effects. The most commonly accepted explanation was that this diet owed its efficacy to its low sodium content. The Kempner diet consists of rice, fruit, fruit juices, sugar, vitamins, and iron. Fluid is restricted. The diet furnishes about 2000 calories and about 15 to 25 grams of protein. The sodium content is estimated at about 100 to 150 mg.[4] It is thus seen to be low in protein, water, and calories, as well as in sodium.

The Kempner rice-fruit diet is quite difficult to maintain because of its monotony, but it does appear to be effective in many cases, if carried out rigorously.[3,4,5] Another objection to it is its low content of protein, far below the Sherman standard of 1 gram of protein per kilogram of body weight, which is usually considered a suitable mark at which to aim. An intake much less than this may lead to protein starvation, with unfortunate consequences. The Kempner diet, providing 15 to 25 grams, is certainly low in protein, and more than one investigator has remarked on the danger of continuing such a ration for a considerable length of time. Dole and his group[6] have shown that, "The reduction of blood pressure following restriction of dietary sodium was found to be independent of tenfold variations in the ration of dietary protein." In their patients, a restriction of dietary sodium was found to reduce the systolic and diastolic blood pressures by 12 ± 7.4 per cent. Some of the diets of their patients contained large amounts of protein, as much as 70, 90, or 100 grams per day for several weeks.

Our studies were stimulated by the success of Dr. George G. Ornstein in formulating and producing a diet extremely low in sodium, with a satisfactory protein content, and possessing variety and palatability.[7] Ornstein's plan comprised the selection of foods low in sodium and the removal of much of the sodium from other foods by repeated extraction by boiling them in three changes of water. Later he found that extraction with a large volume of cold water for several hours was apparently just as effective as boiling. The most effective procedure for accomplishing this remained

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This work was supported by a grant-in-aid from the Ornstein Physiological Research Fund donated by Joe Lowe, Inc.

to be determined, that is, the optimum extraction period, the optimum temperature, and other technical conditions. The present experiments were undertaken to attempt to answer these questions. In this work we have had the constant support and advice of Dr. Ornstein, which we gratefully acknowledge.

METHODS[8]

Sampling and Treatment of Samples

In all experiments, direct contact of the material with the hands was avoided.

(*a*) *Beef, steaks, chops, liver, veal cutlet, fish, and cheese:* In general, a two- to four-pound sample was utilized as starting material. Alternate slices were taken from the bulk and used as samples, the remainder as control. Fat, where present, was separated as completely as possible and all bones were removed prior to treatment. The samples were placed in ten times their weight of distilled water and allowed to soak in the refrigerator at 5° C for a period of 18 to 24 hours (Table I).

(*b*) *Legs and breast of fowl:* One whole, intact leg of a pair from the same fowl was used as sample, the other leg as control. Breast meat was cut in half—one piece for sample, the other as control. Treatment was the same as for (a).

(*c*) *Cream, milk, and eggs:* Samples of homogenized, bottled milk were pooled and thoroughly mixed; aliquots were taken for experimental treatment. Cream was dialyzed in Visking casing against ten times its weight of 3 per cent lactose; milk was dialyzed against distilled water. Stirring of the solutions did not alter the results significantly. Eggs, after mixing until homogeneous, were treated similarly, dialyzing them against distilled water.[9]

Analysis

Following soaking (or dialysis), samples and controls of the solid materials were homogenized in a Waring Blender, dried to constant weight at 105°C. and defatted for 48 hours by extraction with anhydrous ether. The residue was ground and re-dried, and a 750-mg portion was extracted with 25 ml of 0.75 *N* nitric acid.[10] After an extraction period of five days, aliquots were taken and determinations of sodium and potassium made on the Janke flame photometer. Naturally, the liquid foods did not require the preliminary treatment.

TABLE I

The Effect of Duration of Soaking* on Sodium Removal from Beef

Time	Average per cent removal
hr	
6	43
8	55
12	58
24	63

* All samples were approximately 100 g and were soaked in ten times their weight of distilled water.

RESULTS

The results obtained by the procedure outlined above are listed in Table II.

The values listed under the heading Sodium Control are those which were found by analysis of our control material. These are, in several cases, different from values listed in earlier reports.[11] We attribute this variation, in part, at least, to the source of the foods analyzed. For instance, eggs obtained from different regions showed a variation of nearly 100 mg sodium per 100 g egg. Such variations were noted in a great diversity of foods. Even samples of beef taken from different parts of the same piece varied to some degree.

The handling of samples was essentially quantitative, but *minimal removal* values are also listed. These minimal values represent sodium removals which can be expected even when allowance is made for touching of food with hands, the use of tap water in extractions, etc. This might occur when untrained persons are following the outlined procedure. Preliminary investigations revealed that maximal removal of sodium could not be obtained unless samples were soaked for a period of eighteen to twenty-four hours (Table I). *Maximal removal* is here an operational term which includes considerations of the limitations imposed on the housewife by the lack of laboratory facilities, and, further, considerations with regard to palatability, appearance, etc. In this connection, it was found that grinding of the meat before soaking would effect as much

TABLE II

Removal of Sodium from Foods

Sample	Time of soaking	Sodium control	Removal			Aver. amount of Na remaining
			Max.	Min.	Aver.	
	hr	(mg/100 g)	%	%	%	mg/100 g
		Meat—Fowl				
Calf liver	18	51	48	33	40	31
Chicken leg (skin intact)	24	66	41	5	27	48
Chicken breast	24	56	70	40	55	23
Chicken liver	24	78	51	6	26	58
Lamb chop	18	75	91	61	78	17
Pork chop	18	40	44	19	28	29
Steak—top round	24	43	73	52	63	15
Turkey leg						
Skin removed	18	115	—	—	45	63
Skin slit	18	97	—	—	20	78
Skin intact	18	94	—	—	16	79
Veal cutlet	18	77	73	67	73	21
		Fish				
Cod fillet	24	59	67	56	59	24
Halibut steak	18	52	43	30	38	32
Salmon steak (frozen)	18	39	23	18	29	28
		Dairy				
Cream cheese (Philadelphia)	18	321	94	92	93	22
Eggs—hard boiled						
Without shell	18	146	55	52	54	67
Shell intact	18	142		(No removal)		
Milk	6 (dialysis)	48	—	—	52	23
	18 (dialysis)	42	—	—	71	12
Cream	18 (dialysis)	32	—	—	80	6

as 90 per cent removal, but in view of the loss of palatability and the difficulty of handling such material for further cooking, the high removal rate was sacrificed in favor of increased esthetic appeal.

Alternate and auxiliary treatments, such as freezing and thawing or exposure to ion-exchange resins, for example, were discarded, since these methods only slightly increased removal of sodium and were found impractical and tedious. It should be noted that physical factors influence the rate of removal to a considerable extent. Thus, the skin over the leg of the turkey presents a barrier to sodium extraction. If it is slit or removed, a larger amount of sodium is removed than if left intact. Lamb and veal permit the highest removal of sodium among the muscle meats, as might be expected from the tenderness of the meat of young animals. The average sodium removal from cod, halibut, and salmon was 59, 38, and 29 per cent, respectively. Whether this is related to their initial sodium content, 59, 52, and 39 per cent, to their fat content, 0, 5, and 15 per cent, to their water content, 83, 75, and 65 per cent, respectively, or to texture, is a question which awaits further experimentation.

CLINICAL FEATURES

The clinical effects of such a dietary regimen are illustrated in Table III, which lists results with several typical patients and reveals the striking clinical benefits of a dietary restricted to foods which have been lowered in sodium content or are naturally low in that element. That is, in addition to the selection of foods low in sodium, some of their foods were either extracted with water or were dialyzed. No medication was used. Thus far, the appearance of none of the ill effects commonly attributed to the Kempner regimen has been detected;

TABLE III

Electrolyte and Nitrogen Excretion in the (24-Hour) Urine Following the Use of Very Low Sodium Diets, and Their Effect upon Blood-Pressure

No. and sex	Weights* kg			Na		K		Cl		Total N	Blood pressure*	
	Before		After	mg	meq	mg	meq	mg	meq	g	Before	After
1M	69.5	69.5	70.0	92	4.0	2693	68.9	207	5.8	9.41	—	—
1M	69.1	70.4	69.1	83	3.7	3695	94.5	826	23.3	12.38	240/140	160/100
2F	70.7	71.6	70.7	214	9.3	1784	45.6	930	26.2	6.05	—	—
2F	70.7	—	72.7	255	11.1	1867	47.6	1130	31.9	7.27	234/130	161/96
3M	72.8	70.9	71.8	190	8.3	—	—	1490	42.0	—	—	—
3M	71.8	72.9	—	240	10.4	3686	94.3	334	9.4	14.27	169/118	148/106
4F	52.9	53.0	56.8	344	15.0	—	—	970	27.4	7.81	250/111	230/101
5M	68.3	68.7	66.7	353	15.4	3190	81.6	613	17.3	12.33	215/146	201/122
6M	82.3	83.2	84.3	475	20.7	1503	38.4	574	16.2	11.97	201/123	136/92
7F	77.0	76.0	75.7	1679	73.0	3052	78.1	2912	82.1	9.80	236/119	164/92
8F	66.4	66.6	—	177	7.7	2965	75.8	216	6.1	9.80	172/94	174/93
9M	62.5	64.8	64.1	171	7.4	2457	62.9	1634	46.1	8.86	226/133	145/105
10M	67.8	67.8	69.1	91	4.0	2548	65.2	396	11.2	10.72	190/120	110/80
11M	56.9	58.1	59.0	288	12.5	1088	27.8	466	13.1	8.24	212/132	145/108
12M	66.7	66.6	65.4	501	21.8	3351	85.7	1365	38.5	12.11	231/142	209/140

* Weights and blood pressure measurements are from the records of Drs. G. G. Ornstein and L. Lercher. The middle weight column refers to weights at the time analyses were made, the "before" and "after" columns record weights on the preceding and following visit, respectively, and vary considerably as to time elapsed.

rather, patients have reported a gradual disinclination toward foods with a high sodium content and finally, a distaste for untreated foods. In all cases reported, the maintained high dietary nitrogen did not hinder the lowering of blood pressure and shrinkage of heart size, but tended toward establishment of a feeling of well-being and a general lessening of tension which parallels a diverse food intake.

It is assumed that the excretion of sodium, most of which is by way of the urine, is very nearly equal to the intake, i.e., that these patients were in approximate sodium balance. This assumption is based on the observations that (1) normally, and even in partial starvation, the body's ability to store salt is very limited and sodium balance rapidly occurs,[12] and (2) these patients showed no edema or marked gain or loss of weight. It is common knowledge that a gain in weight, with or without edema, accompanies retention of salt; and usually a loss of weight occurs with a deficit of salt. However, edema may also occur in the "sodium depletion syndrome" as a result of decrease in urine volume when kidney function is affected. None of these patients had renal involvement. It is, therefore, fair to conclude that, in these cases, the 24-hour urinary output of sodium is very nearly a measure of the intake. In this study the range of the 24-hour sodium output was 85 to 1679 mg of sodium per day, with three values below 100 and all, except one, 501 mg or less. The usual output of sodium on a mixed diet is of the order of 2000 to 4000 mg; therefore, this is indeed a marked diminution in the sodium excretion. The atypical output of sodium of Patient 7F (1679 mg) might have been caused by an inadvertent deviation from instructions.*

It is generally recognized that normal adult individuals on mixed diets, with but slight daily variation in the protein content, are in nitrogen equilibrium. Negative balances may occur in starvation, wasting diseases, or on diets having an imbalance in the essential amino acids. When any of these occurs there is usually a loss of weight. These patients consumed about 2500 calories per day and their weights remained fairly stable (Tables III and IV); hence the assumption of approximate

* These 15 24-hour samples were requested from 12 patients without any regard to the duration of the low sodium diet prior to collection. One factor which might have accounted for an occasionally high figure was the convenience, for the patient, of collecting the sample over the week-end when temptations are somewhat greater than usual.

TABLE IV

Typical Example of a Week's Estimated Intake for One of These Patients

	Carbohydrate	Protein	Fat	Total calories
	g	g	g	
Monday	401	81	129	3176
Tuesday	275	71	120	2535
Wednesday	263	55	78	2029
Thursday	298	60	112	2509
Friday	213	59	87	1924
Saturday	230	53	115	2230
Sunday	279	87	107	2496

nitrogen balance, i.e., that the urinary nitrogen in these cases is an index of protein intake.

The nitrogen output in this study indicates an optimal protein intake or nearly so, i.e., a close approximation to the Sherman standard of 1 gram of protein per kilogram of body weight per day. This would be evidenced by a urinary nitrogen of about 0.16 g per kilogram. This value is reached or exceeded in five of the fourteen urines analyzed. The others ranged from 0.08 to 0.15 gram of nitrogen per kilogram. The average of all fourteen is 0.147 g of nitrogen per kg per day. The protein equivalent, therefore, ranges from 0.53 to 1.25 grams of protein, with an average of 0.92 g per kilogram body weight. It is possible, then, to have a diet which conforms closely to the recommended protein intake and at the same time is extremely low in sodium.

It is seen that satisfactory reductions in blood pressure occurred in every case except one. Number 8, with a blood pressure of 172/94 mm Hg, showed no effect, but all of the others reacted with reduction of both systolic and diastolic pressures. In some instances this effect was a substantial one.

This series comprises only a small number of individuals treated similarly with equally good results. No symptoms of sodium depletion were ever observed. However, it should be emphasized that the very low sodium diet was never prescribed for patients being treated with mercurial diuretics. None of these patients had renal complications. Chemical analyses of the blood urea, nitrogen, and creatinine were frequently performed, and no evidence of marked nitrogen retention was observed. The clinical details of some of these cases are discussed elsewhere[13] and a further report will appear soon.

DISCUSSION

Our experiments show that simple extraction of various foods with water (or dialysis) for 24 hours will remove from 26 to 93 per cent of the sodium. Longer periods of time are of little value, and the time may be shortened to some extent by changing the extracting fluid at intervals. Many experiments were performed in which variations in the technique were employed, but none yielded sufficiently better results without impairing palatability to warrant further study.

It is self-evident that the simple extraction of a foodstuff with water will leach out not only the more soluble inorganic salts but also other water-soluble substances. In the case of the salts, since the greater proportion of sodium salts is extracellular, it was expected that this element would be removed more completely than potassium. This was not the case, and the removal of both was more or less parallel. However, since only those foods richest in sodium in the diet are subjected to extraction, and most foods have a considerable amount of potassium, there is no danger of a deficiency in potassium. This is clearly seen from Table III, where the potassium output in the urine exceeds the sodium output many times.

The loss of protein in the aqueous extract must be negligible. No determinations were made, but from the urinary nitrogen output it would seem that an adequate protein residue was available. This is important, since an intake of sufficient amounts of the indispensable amino acids is essential for good nutrition.

The loss of water-soluble vitamins was replenished in the clinical trials by the administration of a multivitamin supplement, but no attempt was made to supply trace elements. No doubt sufficient amounts of these were supplied in those foods which had not been extracted.

The method described is clearly of practical use and can be employed by any housewife. It is very simple to add approximately 10 volumes of water to a piece of meat or fish or a supply of vegetables and set it in the refrigerator overnight, pour off the water just before mealtime and cook it. Spices, which are extremely low in sodium,[14] may be added as well as salt substitutes, notably ammonium glutamate. Dialysis of milk, cream, and eggs is not difficult, but probably will require a little practice. A Visking membrane (sausage skin) is moistened. One end is slipped under a rubber band which encircles the top of a large jar or beaker. Into the beaker is previously placed the required volume of water or 3 per cent lactose solution. The milk, cream, or eggs are then poured into the membrane through a glass funnel, and the open end of the membrane is slipped under the rubber band opposite the first end. If necessary, the main bulk of the filled sausage skin is gently pushed into place below the level of the fluid with a spoon. The jar is then placed in the refrigerator overnight. After emptying the dialysis tube, it may be washed and used again. The dialysis fluid at first used for milk and cream was a 3 per cent lactose solution, to avoid the loss of this sugar by dialysis. However, it was soon realized that this meant using and discarding a large amount of milk sugar, and that it was much simpler and more economical to add the sugar to the milk or cream after dialysis. The purpose of this is not only to provide the calories lost but especially to restore the flavor of the milk.

It seems to us that adherence to a diet incorporating moderate amounts of normally high sodium foods, treated as described above, will overcome most of the shortcomings of previous low sodium diets. When mixed with vegetables and fruits of naturally low sodium content,[11] such as potatoes, rice, cabbage, tomatoes, onions, peas, squash, beans, apples, lemons, oranges, pears, bananas, grapes, and grapefruit, these foods will provide an extremely varied and palatable diet with an adequate nitrogen intake. There are also on the market many low sodium foods, including bread, cake, matzoths, canned meats and vegetables, which add to the variety of such a diet. Most of these commercial foods are reliable, but some purchasers do not realize that "low salt" does not always mean low sodium, since other sodium salts are sometimes used for technical reasons. A government regulation to control this would be welcome.

It should be noted that all hypertensives do not require the same degree of sodium restriction. We believe it is wise to begin with as strict a regimen as possible, and gradually allow more and more sodium until the optimum is reached. In some regions the drinking water contains relatively high concentrations of sodium.[11] To meet this problem there are two possible recourses. The first is to drink distilled water. If aerated and chilled, this is quite palatable. The second is to use a de-ionizer. The de-ionizer* is a plastic bottle with an attachment, containing de-ionizing resins, through which tap water in the plastic bottle may be forced by inverting and squeezing the bottle. This has the advantage of being easily portable for use when the patient travels. Of course, low sodium water should be used in cooking as well as for drinking by these patients.

SUMMARY

Methods for removing much of the sodium from various foods, by extraction and by dialysis, have been described. These are simple and may be employed by the average housewife. Maximum, minimum, and average removal values of sodium from various foods are tabulated.

A dietary containing as little as 100 to 500 milligrams of sodium with a satisfactory protein content may be made up of such foods, combined with other low sodium foods. It is palatable and variable, and aids in reducing blood pressure in many instances of hypertension.

REFERENCES

1. Allen, F. M.: *Treatment of Kidney Diseases and High Blood Pressure*, Part I, Practical Manual for Physicians and Patients, The Physiatric Institute, Morristown, N. J., 1925.
2. Allen, F. M.: Arterial hypertension. *J.A.M.A.* 74: 652, 1920; Treatment of arterial hypertension. *M. Clin. North America* 6: 475, 1922.
3. Kempner, W.: Some effects of the rice diet treat-

* The de-ionizer is made by Deeminac, Hartford, Conn.

ment of kidney disease and hypertension. *Bull. New York Acad. Med.* 22: 358, 1946.
4. Flipse, M. E., and Flipse, M. J.: Observations in treatment of hypertension with rice-fruit diet. *South. M. J.* 40: 721, 1947.
5. Contratto, A., and Rogers, M.: The use of the rice diet in the treatment of hypertension in non-hospitalized patients. *New England J. Med.* 239: 531, 1948.
6. Dole, V. P., Dahl, L. K., Schwartz, I. L., Cotzias, G. C., Thaysen, J. H., and Harris, C.: Dietary treatment of hypertension. III. The effect of protein on appetite and weight. *J. Clin. Investigation* 32: 185, 1953.
7. Ornstein, G. G.: A very low sodium diet both palatable and variable. *J. M. Soc. New Jersey* 48: 145, 1951.
8. A preliminary report of parts of this work was made to the XIX International Physiological Congress, Montreal, 1953. Table III was shown there but did not appear in the abstract.
9. Kleiner, I. S., Ornstein, G. G., Baron, H., Katchman, A., Batzdorf, U., and Ajemian, E. P.: Studies on the establishment of a low-sodium-high protein dietary regime: A simple method for the removal of sodium from eggs. *Bull. New York M. Coll.* 15: 91, 1952.
10. Lowry, O. H., and Hastings, A. B.: Histochemical changes associated with aging. I Methods and calculations. *J. Biol. Chem.* 143: 257, 1942.
11. Bills, C. E., McDonald, F. G., Niedermeier, W., and Schwartz, M. C.: Sodium and potassium in foods and waters. *J. Am. Dietet. A.* 25: 304, 1949.
12. Keys, A., Brožek, J., Henschel, A., Mickelsen, O., and Taylor, H. L.: *The Biology of Human Starvation*, Univ. of Minnesota Press, Minneapolis, 1950, p. 526.
13. Ornstein, G. G., and Lercher, L.: The effect of sodium depletion on the cardiac silhouette in essential hypertension and asthma. *Quart. Bull. Sea View Hosp.*, 1953, p. 97.
14. Elvehjem, C. A., and Burns, C. H.: Sodium content of commercial spices. *J. A. M. A.* 148: 1032, 1952.

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—J. A. Shannon. *J. A. M. A.* 160: 1030, 1956.

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—J. Bronowski. *Bull. Atomic Scientists* 12: 11, 1956.