THE INFLUENCE ON GOUT OF THE MINERAL CONSTITUENTS OF VARIOUS VEGETABLES

BY

ARTHUR P. LUFF, M.D., B.Sc., F.R.C.P.

PHYSICIAN IN CHARGE OF OUT-PATIENTS IN ST. MARY'S HOSPITAL

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IN the Goulstonian Lectures of last year, whilst discussing the relative effects on the gouty process of animal and vegetable diets, I stated that, in my opinion, it was of little importance, as regards the production of uric acid from proteid matter, whether the proteid be of animal or vegetable origin, and that the same harm may result from an excessive consumption of either form of proteid.

But although animal and vegetable proteids may react alike with regard to the production of uric acid, yet it is well known that different articles of diet exercise different influences on the precipitation of sodium biurate, and on the solution and removal of uratic deposits. In connection with this subject, I was able to demonstrate that the saline constituents of animal and vegetable foods exercise very different solvent effects on sodium biurate. From the results of these experiments it appeared probable that if the mineral constituents of vegetables were

present in sufficient quantities in the fluids of a gouty person, they would not only delay the advent of an attack of gout by increasing the solubility of the sodium biurate present in these fluids, but would also by their increased solvent effects on uratic deposits, facilitate the removal of the latter.

Since the delivery of the Goulstonian Lectures I have carried out a long series of experiments with the mineral constituents of all the vegetables in ordinary use, in order to elucidate the two following points :—(1) the relative effects exerted by the mineral constituents of various vegetables on the solubility of sodium biurate at the temperature of the human body, and therefore presumably on uratic deposits; and (2) the influence, if any, exerted by these constituents in retarding the conversion of the sodium quadriurate, which is present in the fluids of the body in gout, into the sodium biurate. Obviously the elucidation of these points would have a material bearing on the treatment of gout.

EXPERIMENTAL INQUIRY TO ASCERTAIN THE SOLVENT EFFECTS
EXERTED BY THE MINERAL CONSTITUENTS OF VARIOUS
VEGETABLES ON SODIUM BIURATE.

The method of carrying out these experiments was as follows :—In each batch of experiments seven bottles, each containing 100 c.c. of distilled water mixed with a known quantity of the vegetable ash, were placed in the warm chamber until their contents were at a temperature of 100° F., when an excess of pure sodium biurate was added to each. The bottles were kept at 100° F. for five hours, during which period they were frequently agitated. At the end of that time the contents of the bottles were filtered, and if necessary re-filtered, through double filters until perfectly clear filtrates were obtained. The amount of uric acid in each of the filtrates was then estimated by adding an excess of strong

sulphuric acid and titrating with a standard potassium permanganate solution; the quantity of uric acid found was subsequently calculated into terms of sodium biurate. The results thus obtained are shown in the following sixteen tables, which are arranged in the order of the average solvent effect exerted by the mineral constituents of the various vegetables, commencing with those exercising the greatest influence.

The solubility of sodium biurate in distilled water is placed at the head of each table for comparison.

TABLE I.—*Showing the influence of the mineral constituents of spinach on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1.10 per 1000.
Water containing—	
1.0 per cent. of spinach ash	. 3.36 „
0.5 „ „ „	. 2.76 „
0.2 „ „ „	. 2.12 „
0.1 „ „ „	. 1.90 „
0.05 „ „ „	. 1.52 „
0.02 „ „ „	. 1.21 „
0.01 „ „ „	. 1.18 „

TABLE II.—*Showing the influence of the mineral constituents of Brussels sprouts on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1.10 per 1000.
Water containing—	
1.0 per cent. of Brussels sprouts ash	. 3.06 „
0.5 „ „ „	. 2.21 „
0.2 „ „ „	. 1.68 „
0.1 „ „ „	. 1.62 „
0.05 „ „ „	. 1.52 „
0.02 „ „ „	. 1.30 „
0.01 „ „ „	. 1.23 „

TABLE III.—*Showing the influence of the mineral constituents of potato on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1·10 per 1000.
Water containing—	
1·0 per cent. of potato ash	. 2·49 ”
0·5 ” ” ”	. 2·17 ”
0·2 ” ” ”	. 1·92 ”
0·1 ” ” ”	. 1·47 ”
0·05 ” ” ”	. 1·36 ”
0·02 ” ” ”	. 1·12 ”
0·01 ” ” ”	. 1·10 ”

TABLE IV.—*Showing the influence of the mineral constituents of asparagus on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1·10 per 1000.
Water containing—	
1·0 per cent. of asparagus ash	. 2·77 ”
0·5 ” ” ”	. 2·09 ”
0·2 ” ” ”	. 1·58 ”
0·1 ” ” ”	. 1·45 ”
0·05 ” ” ”	. 1·33 ”
0·02 ” ” ”	. 1·12 ”
0·01 ” ” ”	. 1·10 ”

TABLE V.—*Showing the influence of the mineral constituents of Savoy cabbage on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1·10 per 1000.
Water containing—	
1·0 per cent. of Savoy cabbage ash	. 2·32 ”
0·5 ” ” ”	. 1·92 ”
0·2 ” ” ”	. 1·77 ”
0·1 ” ” ”	. 1·57 ”
0·05 ” ” ”	. 1·34 ”
0·02 ” ” ”	. 1·13 ”
0·01 ” ” ”	. 1·10 ”

TABLE VI.—*Showing the influence of the mineral constituents of French beans on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1.10 per 1000.
Water containing—	
1.0 per cent. of French beans ash .	. 2.48 „
0.5 „ „ .	. 1.87 „
0.2 „ „ .	. 1.68 „
0.1 „ „ .	. 1.56 „
0.05 „ „ .	. 1.28 „
0.02 „ „ .	. 1.16 „
0.01 „ „ .	. 1.10 „

TABLE VII.—*Showing the influence of the mineral constituents of lettuce on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1.10 per 1000.
Water containing—	
1.0 per cent. of lettuce ash .	. 2.72 „
0.5 „ „ .	. 1.92 „
0.2 „ „ .	. 1.57 „
0.1 „ „ .	. 1.53 „
0.05 „ „ .	. 1.21 „
0.02 „ „ .	. 1.10 „
0.01 „ „ .	. 1.09 „

TABLE VIII.—*Showing the influence of the mineral constituents of beetroot on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1.10 per 1000.
Water containing—	
1.0 per cent. of beetroot ash .	. 2.46 „
0.5 „ „ .	. 1.82 „
0.2 „ „ .	. 1.60 „
0.1 „ „ .	. 1.45 „
0.05 „ „ .	. 1.34 „
0.02 „ „ .	. 1.15 „
0.01 „ „ .	. 1.10 „

TABLE IX.—*Showing the influence of the mineral constituents of winter cabbage on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1·10 per 1000.
Water containing—	
1·0 per cent. of cabbage ash .	. 2·30 "
0·5 " " .	. 2·14 "
0·2 " " .	. 1·63 "
0·1 " " .	. 1·31 "
0·05 " " .	. 1·23 "
0·02 " " .	. 1·10 "
0·01 " " .	. 1·10 "

TABLE X.—*Showing the influence of the mineral constituents of celery on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1·10 per 1000.
Water containing—	
1·0 per cent. of celery ash .	. 2·20 "
0·5 " " .	. 1·84 "
0·2 " " .	. 1·53 "
0·1 " " .	. 1·44 "
0·05 " " .	. 1·30 "
0·02 " " .	. 1·10 "
0·01 " " .	. 1·06 "

TABLE XI.—*Showing the influence of the mineral constituents of turnip-tops on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1·10 per 1000.
Water containing—	
1·0 per cent. of turnip-tops ash .	. 2·16 "
0·5 " " .	. 1·82 "
0·2 " " .	. 1·58 "
0·1 " " .	. 1·42 "
0·05 " " .	. 1·20 "
0·02 " " .	. 1·13 "
0·01 " " .	. 1·11 "

TABLE XII.—*Showing the influence of the mineral constituents of turnips on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1·10 per 1000.
Water containing—	
1·0 per cent. of turnip ash	. 2·04 „
0·5 „ „	. 1·78 „
0·2 „ „	. 1·50 „
0·1 „ „	. 1·42 „
0·05 „ „	. 1·32 „
0·02 „ „	. 1·14 „
0·01 „ „	. 1·10 „

TABLE XIII.—*Showing the influence of the mineral constituents of carrot on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1·10 per 1000.
Water containing—	
1·0 per cent. of carrot ash	. 1·63 „
0·5 „ „	. 1·53 „
0·2 „ „	. 1·47 „
0·1 „ „	. 1·45 „
0·05 „ „	. 1·33 „
0·02 „ „	. 1·13 „
0·01 „ „	. 1·11 „

TABLE XIV.—*Showing the influence of the mineral constituents of cauliflower on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1·10 per 1000.
Water containing—	
1·0 per cent. of cauliflower ash	. 1·52 „
0·5 „ „	. 1·50 „
0·2 „ „	. 1·42 „
0·1 „ „	. 1·34 „
0·05 „ „	. 1·28 „
0·02 „ „	. 1·09 „
0·01 „ „	. 1·09 „

TABLE XV.—*Showing the influence of the mineral constituents of sea-kale on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1·10 per 1000.
Water containing—	
1·0 per cent. of sea-kale ash	. 1·49 „
0·5 „ „	. 1·47 „
0·2 „ „	. 1·35 „
0·1 „ „	. 1·23 „
0·05 „ „	. 1·10 „
0·02 „ „	. 1·10 „
0·01 „ „	. 1·10 „

TABLE XVI.—*Showing the influence of the mineral constituents of green peas on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	. 1·10 per 1000.
Water containing—	
1·0 per cent. of green peas ash	. 0·99 „
0·5 „ „	. 1·01 „
0·2 „ „	. 1·04 „
0·1 „ „	. 1·10 „
0·05 „ „	. 1·10 „
0·02 „ „	. 1·10 „
0·01 „ „	. 1·10 „

From the results detailed in these tables it is evident that 0·05 per cent. and over of the mineral constituents of nearly all the vegetables, very appreciably increase the solubility of sodium biurate. The solitary exception is in the case of the mineral constituents of green peas, which practically exert no influence whatever on the solubility of the biurate.

As I considered that these solvent effects of the mineral constituents of most vegetables on the biurate might have an important bearing on the treatment of gout, I next endeavoured to ascertain whether these effects were due to the alkalinity of the vegetable ashes, or whether they could be referred to any one saline constituent of the vegetables.

EXPERIMENTAL PROOF THAT THE SOLVENT EFFECTS OF THE MINERAL CONSTITUENTS OF VEGETABLES ON SODIUM BIURATE ARE NOT DUE TO THEIR DEGREE OF ALKALINITY.

That the solvent effect exerted respectively by the mineral constituents of each vegetable on the sodium biurate was not proportional to the alkalinity of the ash was very easily determined. I made estimations of the alkalinities of the different vegetable ashes, and calculated the percentages of alkalinity in terms of sodium carbonate. The alkalinity of the ashes was due to potassium and sodium carbonates; none of the ashes contained either potassium or sodium hydrate. The following table shows a comparison of the solubility exerted by the mineral constituents of vegetables on sodium biurate, and the alkalinity of those constituents.

TABLE XVII.—*Showing that the solvent effect on sodium biurate of the mineral constituents of vegetables is not dependent on the alkalinity of those constituents.*

Vegetables arranged in order of solvent effect of their mineral constituents on sodium biurate, commencing with those exerting the greatest effect.		Vegetables arranged in order of the alkalinity of their ashes, and showing percentages of alkalinity, reckoned as sodium carbonate, commencing with the most alkaline.	
Spinach	...	Spinach	. . 26·00
Brussels sprouts	...	Celery	. . 20·80
Potato	...	Turnip	. . 20·80
Asparagus	...	Potato	. . 17·55
Savoy cabbage	...	Beetroot	. . 15·60
French beans	...	Cauliflower	. . 13·20
Lettuce	...	Carrot	. . 13·00
Beetroot	...	Brussels sprouts	. . 12·35
Cabbage	...	French beans	. . 12·35
Celery	...	Turnip-tops	. . 11·70
Turnip-tops	...	Lettuce	. . 11·05
Turnip	...	Asparagus	. . 8·45
Carrot	...	Cabbage	. . 5·85
Cauliflower	...	Green peas	. . 5·20
Sea-kale	...	Savoy cabbage	. . 4·55
Green peas	...	Sea-kale	. . 1·95

It is evident from a glance at this table that the solvent effect of a vegetable ash on sodium biurate, with the exception of spinach ash, bears no relationship, either of a direct or an inverse ratio, to the alkalinity of the ash. For instance, it can be seen that the solvent effect on the biurate of the ash of Brussels sprouts is high, while its alkalinity is low; on the other hand, the solvent effect on the biurate of the ash of celery is low, while its alkalinity is high.

In other words, it is evident that the order in which the vegetables are arranged as regards the solvent effect of the mineral constituents on the biurate, is neither the order nor the inverse order of their relative alkalinities. These results support the conclusions I arrived at from some experiments made with blood serum, and described in the Goulstonian Lectures of last year. I then showed that a diminution in the alkalinity of blood-serum did not cause a diminution in the solvent power of the serum for biurate, and, conversely, that an increase in the alkalinity of the serum did not increase its solvent power for the biurate.

EXPERIMENTAL PROOF THAT THE SOLVENT EFFECTS OF THE
MINERAL CONSTITUENTS OF VEGETABLES ON SODIUM
BIURATE ARE NOT DUE TO ANY SINGLE CONSTITUENT.

The next problem to solve was whether the effect exerted by the mineral constituents of vegetables in increasing the solubility of sodium biurate is due to any one constituent. With regard to this point it appeared probable beforehand that such would not prove to be the case, since Sir W. Roberts has shown that sodium, calcium, and magnesium salts diminish the solvent power of water on sodium biurate, and that potassium salts exercise no influence, either for or against, on the solubility of the biurate.

Now it can easily be demonstrated that the solvent effect is not due to the potassium salts. The following table contains a comparison of the solvent powers exerted by the mineral constituents of vegetables on sodium biurate, and the proportions of potassium salts present.

TABLE XVIII.—*Showing that the solvent effect on sodium biurate of the mineral constituents of vegetables is not dependent on the amounts of potassium salts present.*

Vegetables arranged in order of solvent effect of their mineral constituents on sodium biurate, commencing with those exerting the greatest effect.

Vegetables arranged in order of the proportions of potassium salts present, and showing the percentages of potassium salts present in the ashes, reckoned as potassium oxide, commencing with those richest in potassium salts.

Spinach	...	Potato	.	56.03
Brussels sprouts	...	Turnip	.	54.05
Potato	...	Carrot	.	53.36
Asparagus	...	Lettuce	.	48.01
Savoy cabbage	...	French beans	.	46.50
French beans	...	Asparagus	.	39.21
Lettuce	...	Green peas	.	38.96
Beetroot	...	Beetroot	.	38.33
Cabbage	...	Cabbage	.	37.71
Celery	...	Brussels sprouts	.	35.00
Turnip-tops	...	Celery	.	33.14
Turnip	...	Turnip-tops	.	30.55
Carrot	...	Savoy cabbage	.	26.82
Cauliflower	...	Cauliflower	.	23.46
Sea-kale	...	Spinach	.	23.43
Green peas	...	Sea-kale	.	2.59

It is also evident from this table that the solvent effect of the mineral constituents of vegetables on sodium biurate bears no relationship, either of a direct or an inverse ratio, to the proportions of potassium salts present. For instance, it can be seen that the solvent effect on the biurate of the ash of spinach is high, while the proportion of potassium salts is low; on the other hand, the solvent effect on the biurate of the ash of turnips is low, while the proportion of potassium salts is high.

It can also be demonstrated that the increased solubility of the biurate effected by the mineral constituents of vegetables is not due to the sodium salts. The following table contains a comparison of the solvent powers exerted by the mineral constituents of vegetables on sodium biurate, and the proportions of sodium salts present.

TABLE XIX.—*Showing that the solvent effect on sodium biurate of the mineral constituents of vegetables is not dependent on the amounts of sodium salts present.*

Vegetables arranged in order of solvent effect of their mineral constituents on sodium biurate, commencing with those exerting the greatest effect.

Spinach	...
Brussels sprouts	...
Potato	...
Asparagus	...
Savoy cabbage	...
French beans	...
Lettuce	...
Beetroot	...
Cabbage	...
Celery	...
Turnip-tops	...
Turnip	...
Carrot	...
Cauliflower	...
Sea-kale	...
Green peas	...

Vegetables arranged in order of the proportions of sodium salts present, and showing the percentages of sodium salts present in the ashes, reckoned as sodium oxide, commencing with those richest in sodium salts.

Sea-kale	. .	33·84
Spinach	. .	31·42
Beetroot	. .	31·17
French beans	. .	30·50
Celery	. .	19·33
Asparagus	. .	16·79
Carrot	. .	14·17
Savoy cabbage	. .	13·86
Brussels sprouts	. .	12·60
Lettuce	. .	11·80
Cauliflower	. .	10·87
Turnip	. .	6·37
Green peas	. .	5·20
Turnip-tops	. .	4·19
Cabbage	. .	2·39
Potato	. .	2·18

It is evident from this table that the solvent effect of the mineral constituents of vegetables on sodium biurate bears no relationship, either of a direct or an inverse ratio, to the proportions of sodium salts present. For instance, it can be seen that the solvent effect on the biurate of the ash of potato is high, while the proportion of sodium salts is low ; on the other hand, the solvent effect on the biurate

of the ash of sea-kale is low, while the proportion of sodium salts is high.

In like manner it can be demonstrated that the increased solubility of the biurate effected by the mineral constituents of vegetables is not due to the calcium salts. The following table contains a comparison of the solvent powers exerted by the mineral constituents of vegetables on sodium biurate, and the proportions of calcium salts present.

TABLE XX.—*Showing that the solvent effect on sodium biurate of the mineral constituents of vegetables is not dependent on the amounts of calcium salts present.*

Vegetables arranged in order of solvent effect of their mineral constituents on sodium biurate, commencing with those exerting the greatest effect.		Vegetables arranged in order of the proportions of calcium salts present, and showing the percentages of calcium salts present in the ashes, reckoned as calcium oxide, commencing with those richest in calcium salts.	
Spinach	...	Turnip-tops	. 37.15
Brussels sprouts	...	Sea-kale	. 27.56
Potato	...	Cauliflower	. 23.33
Asparagus	...	French beans	. 17.48
Savoy cabbage	...	Cabbage	. 17.14
French beans	...	Lettuce	. 15.02
Lettuce	...	Savoy cabbage	. 14.83
Beetroot	...	Turnip	. 13.38
Cabbage	...	Celery	. 13.06
Celery	...	Spinach	. 10.64
Turnip-tops	...	Carrot	. 6.88
Turnip	...	Brussels sprouts	. 6.16
Carrot	...	Potato	. 5.46
Cauliflower	..	Asparagus	. 5.05
Sea-kale	...	Green peas	. 4.98
Green peas	...	Beetroot	. 2.58

It is also evident from this table that the solvent effect of the mineral constituents of vegetables on sodium biurate bears no relationship, either of a direct or an inverse ratio, to the proportions of calcium salts present. For instance, it can be seen that the solvent effect on the biurate of the ash of potato is high, while the proportion

of calcium salts is low; on the other hand, the solvent effect on the biurate of the ash of sea-kale is low, while the proportion of calcium salts is high.

Similarly it can be shown that the increased solvent effect on the biurate exerted by the mineral constituents of vegetables is not due to either the magnesium or iron salts present.

It can also be demonstrated that the increased solubility of the biurate is not due to the phosphates present in the vegetables. The following table contains a comparison of the solvent powers exerted by the mineral constituents of vegetables on sodium biurate, and the proportions of phosphates present.

TABLE XXI.—*Showing that the solvent effect on sodium biurate of the mineral constituents of vegetables is not dependent on the amounts of phosphates present.*

Vegetables arranged in order of solvent effect of their mineral constituents on sodium biurate, commencing with those exerting the greatest effect.

Spinach	...
Brussels sprouts	...
Potato	...
Asparagus	...
Savoy cabbage	...
French beans	...
Lettuce	...
Beetroot	...
Cabbage	...
Celery	...
Turnip-tops	...
Turnip	...
Carrot	...
Cauliflower	...
Sea-kale	...
Green peas	...

Vegetables arranged in order of the proportions of phosphates present, and showing the percentages of phosphates present in the ashes, reckoned as phosphoric anhydride, commencing with those richest in phosphates.

Green peas	. 35.62
Cauliflower	. 22.14
Asparagus	. 21.93
Potato	. 15.99
Carrot	. 15.02
Celery	. 14.39
Brussels sprouts	. 14.20
Savoy cabbage	. 13.19
French beans	. 12.21
Cabbage	. 11.99
Lettuce	. 9.62
Turnip	. 9.26
Spinach	. 8.56
Beetroot	. 8.25
Sea-kale	. 8.00
Turnip-tops	. 6.15

It is also evident from this table that the solvent effect of the mineral constituents of vegetables on sodium bi-

urate bears no relationship, either of a direct or an inverse ratio, to the proportions of phosphates present. For instance, it can be seen that the solvent effect on the biurate of the ash of spinach is high, while the proportion of phosphates is low; on the other hand, the solvent effect on the biurate of the ash of green peas is low, while the proportion of phosphates is high.

It can also be demonstrated that the increased solubility of the biurate is not due to the sulphates present in the vegetables. The following table contains a comparison of the solvent powers exerted by the mineral constituents of vegetables on sodium biurate, and the proportions of sulphates present.

TABLE XXII.—*Showing that the solvent effect on sodium biurate of the mineral constituents of vegetables is not dependent on the amounts of sulphates present.*

Vegetables arranged in order of solvent effect of their mineral constituents on sodium biurate, commencing with those exerting the greatest effect.		Vegetables arranged in order of the proportions of sulphates present, and showing the percentages of sulphates present in the ashes, reckoned as sulphuric anhydride, commencing with those richest in sulphates.	
Spinach	...	Sea-kale .	19·78
Brussels sprouts	...	Turnip-tops .	15·27
Potato	...	Cauliflower .	14·16
Asparagus	...	Savoy cabbage .	12·85
Savoy cabbage	...	Turnip .	12·47
French beans	...	Brussels sprouts .	8·31
Lettuce	...	Cabbage .	7·28
Beetroot	...	French beans .	6·82
Cabbage	...	Potato .	5·60
Celery	...	Asparagus .	5·40
Turnip-tops	...	Carrot .	5·20
Turnip	...	Spinach .	4·44
Carrot	...	Green peas .	4·36
Cauliflower	...	Lettuce .	3·92
Sea-kale	...	Beetroot .	2·41
Green peas	...	Celery .	1·10

It is also evident from this table that the solvent effect of the mineral constituents of vegetables on sodium bi-

urate bears no relationship, either of a direct or an inverse ratio, to the proportions of sulphates present. For instance, it can be seen that the solvent effect on the biurate of the ash of spinach is high, while the proportion of sulphates is low; on the other hand, the solvent effect on the biurate of the ash of sea-kale is low, while the proportion of sulphates is high.

Finally, as disposing of all the mineral constituents of any importance in vegetables, it can be demonstrated that the increased solubility of the biurate is not due to the chlorides present in the vegetables. The following table contains a comparison of the solvent powers exerted by the mineral constituents of vegetables on sodium biurate, and the proportions of chlorides present.

TABLE XXIII.—*Showing that the solvent effect on sodium biurate of the mineral constituents of vegetables is not dependent on the amounts of chlorides present.*

Vegetables arranged in order of solvent effect of their mineral constituents on sodium biurate, commencing with those exerting the greatest effect.		Vegetables arranged in order of the proportions of chlorides present, and showing the percentages of chlorides present in the ashes, reckoned as chlorine, commencing with those richest in chlorides.	
Spinach	...	Celery	22.14
Brussels sprouts	...	Beetroot	18.13
Potato	...	Sea-kale	15.46
Asparagus	...	Cabbage	9.09
Savoy cabbage	...	Lettuce	8.80
French beans	...	Spinach	7.78
Lettuce	...	Savoy cabbage	7.53
Beetroot	...	Turnip-tops	7.33
Cabbage	...	Asparagus	6.62
Celery	...	Turnip	5.06
Turnip-tops	...	Cauliflower	4.83
Turnip	...	Carrot	3.70
Carrot	...	Brussels sprouts	3.00
Cauliflower	...	Potato	2.50
Sea-kale	...	French beans	2.50
Green peas	...	Green peas	2.10

It is also evident from this table that the solvent effect of the mineral constituents of vegetables on sodium biurate

bears no relationship, either of a direct or an inverse ratio, to the proportions of chlorides present. For instance, it can be seen that the solvent effect on the biurate of the ash of Brussels sprouts is high, while the proportion of chlorides is low; on the other hand, the solvent effect on the biurate of the ash of sea-kale is low, while the proportion of chlorides is high.

These results show that the solvent effect exerted on sodium biurate by the mineral constituents of vegetables is not due to any one constituent.

EXPERIMENTAL PROOF THAT AN ARTIFICIALLY PREPARED
ASH DOES NOT REACT TO SODIUM BIURATE IN THE
SAME MANNER AS A NATURAL VEGETABLE ASH.

I next endeavoured to ascertain whether an artificially prepared ash of the same composition as the natural ash of one of the vegetables would exercise a similar effect in increasing the solubility of the sodium biurate as that possessed by the natural ash. For this purpose I selected the spinach ash, which has the greatest solvent effect on the biurate. An artificial ash was prepared which was made with the same proportions of potassium, sodium, calcium, sulphates, phosphates, and chlorides, as those present in the natural spinach ash, and also of precisely the same degree of alkalinity. Experiments were carried out with this artificial ash and the biurate in a similar manner to that employed in working with the natural vegetable ashes. The following table shows the results of these experiments.

TABLE XXIV.—*Showing the influence of the artificial spinach ash on the solubility of sodium biurate at 100° F.*

Solvent.	Sodium biurate dissolved.
Water	1.10 per 1000.
Water containing—	
1.0 per cent. of artificial spinach ash	0.20 "
0.5 " " "	0.34 "
0.2 " " "	0.62 "
0.1 " " "	0.86 "
0.05 " " "	0.96 "
0.02 " " "	1.04 "
0.01 " " "	1.06 "

These results are very remarkable, as they indicate that the artificial ash exercises in all proportions a deterrent effect on the solubility of the biurate. This deterrent effect is well seen by contrasting the results with those of the natural ash, which show the marked solvent effect exerted by the latter on the biurate.

TABLE XXV.—*Showing the different influences exerted by the artificial and natural spinach ashes on the solvency of the biurate at 100° F.*

Solvent.	Sodium biurate dissolved in 1000 parts.	
Water	1.10	
Water containing—	Artificial spinach ash.	Natural spinach ash.
1.0 per cent. of ash	0.20 ...	3.36
0.5 " "	0.34 ...	2.76
0.2 " "	0.62 ...	2.12
0.1 " "	0.86 ...	1.90
0.05 " "	0.96 ...	1.52
0.02 " "	1.04 ...	1.21
0.01 " "	1.06 ...	1.18

The only explanation that I can offer of these remarkable results is that in the natural ash there is some combination of the mineral constituents which cannot be artificially imitated, and that upon this natural combination of the salts is dependent the increased solvent effect

exerted on the biurate by the mineral constituents of most vegetables. If this view be correct, then modern science is but confirming the correctness of the practice of those ancients who employed vegetable ashes in the treatment of gout.

It may be well to make here a brief reference to the experiments that I described in the Goulstonian Lectures of last year, which showed that the mineral constituents of meat exercise a marked deterrent effect on the solubility of sodium biurate, and that this effect is most marked by proportions of the mineral constituents which may certainly be present in the blood after eating a few ounces of meat. The following table shows in contrast the effects exercised respectively by the mineral constituents of lean beef and spinach on the solubility of the biurate.

TABLE XXVI.—*Showing the respective effects exercised by the mineral constituents of beef and spinach on the solubility of sodium biurate at 100° F.*

Solvent.		Sodium biurate dissolved in 1000 parts.		
Water			1.10	
Water containing—		Beef ash.		Spinach ash.
1.0 per cent. of ash		0.93	...	3.36
0.5 " " " "		0.76	...	2.76
0.2 " " " "		0.56	...	2.12
0.1 " " " "		0.32	...	1.90
0.05 " " " "		0.15	...	1.52
0.02 " " " "		0.11	...	1.21
0.01 " " " "		0.85	...	1.18

EXPERIMENTAL INQUIRY TO ASCERTAIN THE EFFECT EXERTED
BY THE MINERAL CONSTITUENTS OF VARIOUS VEGETABLES
ON THE CONVERSION OF SODIUM QUADRIURATE INTO
SODIUM BIURATE.

It is well known from the researches of Dr. Bence Jones and of Sir W. Roberts that sodium quadriurate, which is the form in which uric acid first appears in the

blood in gout, is an unstable body, and is gradually converted by combination with the sodium carbonate of the blood into sodium biurate, which latter body, on account of its comparative insolubility, is deposited in the tissues and constitutes the gouty uratic deposit. This gradual conversion of the quadriurate into biurate is known as the *maturation process*.

It is obviously of therapeutical importance to know whether the mineral constituents of any of the vegetables, in addition to exerting an increased solvent effect on the biurate, possess the power of delaying this maturation process; or, in other words, of inhibiting the conversion of the quadriurate into the biurate. In order to ascertain this I conducted a series of experiments. In all these experiments I employed Sir W. Roberts's standard solution, as being a more convenient medium to work with than blood serum. This standard solution contains 0.5 per cent. of sodium chloride and 0.2 per cent. of sodium bicarbonate dissolved in distilled water. Sir W. Roberts found that this solution is a fairly exact representation of blood serum, in so far as its saline ingredients are concerned, and that it reacted with uric acid and the urates in the same manner as blood serum itself, and in the same manner as a solution comprising all the salines of the serum in their due proportions.

The experiments were conducted in the following way: Ten milligrammes of pure sodium quadriurate were well rubbed with ten drops of the standard solution, and the mixture placed in a small corked bottle in the warm chamber and kept at 100° F. Every half hour a small quantity of the mixture was examined under a high power of the microscope, and the time at which crystals of sodium biurate first appeared was noted. This represented the time occupied by the maturation process when the standard solution was saturated with sodium quadriurate. Similar experiments were conducted with the same amount of sodium quadriurate in the same quantity of standard solution, containing respectively 0.1 per cent.

of the mineral constituents of each of the vegetables in ordinary use. The results are shown in the following table:

TABLE XXVII.—*Showing the effects exerted by the mineral constituents of vegetables on the conversion of sodium quadriurate into sodium biurate.*

Solvent.	Crystals of sodium biurate first appeared in
Standard solution . . .	2 hours.
Standard solution containing—	
0·1 per cent. of potato ash . . .	2 „
„ cauliflower ash . . .	2 „
„ lettuce ash . . .	2 „
„ carrot ash . . .	2 „
„ asparagus ash . . .	2½ „
„ beetroot ash . . .	3 „
„ green peas ash . . .	3½ „
„ celery ash . . .	3½ „
„ Brussels sprouts ash . . .	4 „
„ cabbage ash . . .	4 „
„ turnip-tops ash . . .	4 „
„ turnip ash . . .	4 „
„ Savoy cabbage ash . . .	4 „
„ sea-kale ash . . .	4 „
„ French beans ash . . .	4½ „
„ spinach ash . . .	5 „

These results show that the mineral constituents of some of the vegetables, notably spinach, Brussels sprouts, French beans, cabbage, turnip-tops, and turnips, very considerably delay the conversion of sodium quadriurate into sodium biurate. The inference is that if such mineral constituents were present in suitable proportions in the blood of gouty subjects, and if, at the same time, proper measures were adopted for promoting excretion of the quadriurate by the kidneys, the elimination of that body might be secured without the occurrence of any precipitation of the biurate in the tissues. Moreover, it must be borne in mind that these experiments were conducted under very stringent conditions, in that they were all

carried out with a saturated solution of the quadriurate, and it is extremely unlikely that the fluids of the body are ever, in gouty subjects, saturated with so soluble a compound as the sodium quadriurate; therefore it is but fair to infer that with smaller proportions of the quadriurate in solution the inhibitory effects of the mineral constituents of vegetables would extend over much longer periods than actually occurred in the carrying out of these experiments.

RESULTS OF THE EXPERIMENTAL INQUIRY.

The net results of all the experiments described indicate that the mineral constituents of most vegetables increase the solubility of sodium biurate, and also, in several cases, delay for considerable periods the conversion of the sodium quadriurate into the biurate. On the other hand, the mineral constituents of meat diminish the solubility of sodium biurate, and, as I have shown elsewhere, exercise but little effect in delaying the conversion of the quadriurate into the biurate.

I wish it to be clearly understood that I do not attribute the different effects of animal and vegetable diets on gouty subjects to the saline constituents alone. I think, however, that the results of these experiments clearly show that it is to the different mineral constituents of animal and vegetable foods and to the different physical effects they exercise on the quadriurate and biurate that we must look for a partial and perhaps a main explanation of the known facts that an excessive diet of the one tends to produce gout, and of the other tends to retard it.

A reference to some of the tables previously given will show that certain vegetables stand out prominently with regard to the effect exercised by their mineral constituents in both retarding the conversion of the sodium quadriurate into the biurate, and in increasing the solubility of the

latter. These vegetables are spinach, Brussels sprouts, French beans, winter cabbage, Savoy cabbage, turnip-tops, turnips, and celery. These are the vegetables which I consider are likely to prove most beneficial to gouty subjects. Of these, in so far as the effects produced by their mineral constituents are concerned, spinach occupies the first place both as regards inhibiting the decomposition of the quadriurate and increasing the solubility of the biurate. Spinach has the further advantage of being extremely rich in mineral constituents, since it contains 16.27 per cent. of mineral matter as compared with 8.50, which is the average percentage of the mineral constituents of all the vegetables experimented with. It may be argued that a drawback to the employment of spinach is that it cannot be obtained fresh throughout the year. Very excellent spinach is, however, now obtainable in the desiccated and compressed state, and when cooked makes a dish which is practically indistinguishable from the fresh vegetable.

Owing to the undoubted action which I have shown the mineral constituents of several vegetables possess in delaying the conversion of sodium quadriurate into biurate and in increasing the solubility of the latter, it has occurred to me that the free use of a table salt composed of the ashes of certain of the vegetables, in place of common salt, might prove advantageous to the gouty. Sir W. Roberts has shown that small quantities of sodium chloride introduced into blood-serum containing quadriurate in solution always appreciably hastened the formation and precipitation of the biurate. In addition sodium chloride very considerably diminishes the solubility of sodium biurate, while the mineral constituents of vegetables increase it. This is well shown in the following table, which represents the comparative effects of 0.1 per cent. solutions respectively of sodium chloride and of the mineral constituents of vegetables on the solubility of sodium biurate.

TABLE XXVIII.—*Showing the comparative effects of 0·1 per cent. solutions respectively of sodium chloride and of the mineral constituents of various vegetables on the solubility of sodium biurate.*

Solvent.	Sodium biurate dissolved.
Water	. 1·10 per 1000.
Water containing—	
0·1 per cent. of sodium chloride	. 0·45 „
„ spinach ash	. 1·90 „
„ Brussels sprouts ash	. 1·62 „
„ Savoy cabbage ash	. 1·57 „
„ French beans ash	. 1·56 „
„ lettuce ash	. 1·53 „
„ potato ash	. 1·47 „
„ beetroot ash	. 1·45 „
„ carrot ash	. 1·45 „
„ asparagus ash	. 1·45 „
„ celery ash	. 1·44 „
„ turnip ash	. 1·42 „
„ turnip-tops ash	. 1·42 „
„ cauliflower ash	. 1·34 „
„ cabbage ash	. 1·31 „
„ sea-kale ash	. 1·23 „
„ green peas ash	. 1·10 „

This table shows the great advantage that the mineral constituents of vegetables possess over common salt as regards their solvent effect on sodium biurate. I have been able to calculate that with the moderately free use of vegetables, especially if supplemented by the use of a table salt prepared from vegetables, it is quite possible to introduce more than 0·1 per cent. of the mineral constituents of vegetables into the fluids of the body. I have therefore suggested to Messrs. Savory and Moore the desirability of preparing such a vegetable table salt for the use of persons suffering from or addicted to gout. At present they are engaged in the preparation of different mixtures of the mineral constituents of various vegetables, with which I propose to experiment in order

to ascertain which combination is likely to prove the most efficient to gouty subjects. I hope to be able shortly to publish the results of my experiments with these vegetable table salts.

(For report of the discussion on this paper, see 'Proceedings of the Royal Medical and Chirurgical Society,' Third Series, vol. x, p. 154.)