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XLIX. *An Account of some neutral Salts made with vegetable Acids, and with the Salt of Amber; which shews that vegetable Acids differ from one another; and that the Salt of Amber is an Acid of a particular kind, and not the same with that of Sea Salt, or of Vitriol, as alledged by many chemical authors.* By Donald Monro, M. D. Physician to His Majesty's Army, and to Saint George's Hospital. F. R. S.

Title read December 17, 1767.

Read January 14, 21,
and 28, 1768.

THOUGH no substances have been more generally used, both for the preservation of health, and the cure of diseases, than vegetable acids, yet hitherto they have been examined with so little care, that it has been the common received opinion, that they were all nearly of the same nature, at least as to their chemical properties, and possessed nearly of the same virtues; but the following account of neutral salts, made with these acids, and the fossil or mineral alkali, shews that they differ materially from one another.

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Previous, however, to entering into the account of these salts, it will be proper to mention some few things relative to salts in general.

Simple salts are commonly divided into *acid* and *alkaline*.

The *acid* are reckoned four in number.

1. The vitriolic.
2. The nitrous.
3. The marine, or muriatic.
4. And the vegetable.

The *alkaline* three.

1. The vegetable, or that which is got from the ashes of most vegetable substances.

2. The fossil, or mineral, called likewise soda and natrum, which is got either by burning certain marine plants; or from sea salt; or in the bowels of the earth.

3. The volatile, which is got either by putrefaction, or by the force of fire, from most animal substances; or by distillation from mustard seed, and some other particular vegetables.

The *acid* are distinguished from each other, by their taste, smell, and other properties, but principally by their forming different neutral salts with the same alkali.

And the *alkaline* are known likewise from one another, by their forming different neutral salts, when joined with the same acid.

Hence when we find *acid*, or *alkaline* salts, in different bodies, if we saturate each with the same alkali, or

with the same acid, according as the original salt is of an acid, or of an alkaline nature, and find upon dissolving, evaporating, and crystallising the neutral salts, that they are all of the same kind, we conclude, that the original acid, or alkali, was the same in all; but if we obtain different neutral salts from each, we conclude that the original acid, or alkali, was different in each.

If there are no more alkaline salts in nature, than the three already mentioned; and if there were no more acids than four; then the number of neutral salts would be confined to the twelve marked in Dr. Cullen's Table; but it will appear from the following experiments, that instead of one, there are many vegetable acids; and that, therefore, the number of true neutral salts must be greatly multiplied*.

* Dr. Cullen's Table of neutral Salts.

Acid	Alkaline	Neutral Salt	Acid	Alkaline	Neutral Salt
Vitriolic	Vegetable	Vitriolic Tartar	Marine or Muriatic	Vegetable	Sal. digest. Sylvii
	Fossil	Glauber Salt		Fossil	Common Salt
	Volatile	Vitriol. Ammoniac		Volatile	Common Ammoniac
Nitrous	Vegetable	Common Nitre	Vegetable	Vegetable	Regenerated Tartar
	Fossil	Cubic Nitre		Fossil	Rochelle Salt
	Volatile	Nitrous Ammoniac		Volatile	Spiritus Mindereri

Dr. Vogel, Professor of chemistry in the university of Göttingen, in his *Institutiones Chimiæ*, published in 1752, gives a table of neutral salts, which comprehends the twelve mentioned by Dr. Cullen, with the addition of three or four more. He seems to believe, that the acid of vitriol forms a different neutral salt with the pot-ash, and with the alkali procured from nitre. He mentions three salts, made with the vegetable alkali

Many chemists have affirmed, that the vitriolic is the only original acid in nature; and that the nitrous and marine are only this acid changed into different forms by foreign mixtures; and Dr. Boerhaave *, Vogel †, Macquer ‡, and most late chemists, seem to think, that as all trees, plants, and other vegetable substances, receive their nourishment from the bowels of the earth, therefore their acids are only some of the mineral changed into a different form by the vegetative process; and that they all approached in their nature either to the vitriolic, the nitrous, or the marine: and as the neutral salts, produced from the mixture of the vegetable alkali, with vinegar, cream of tartar, and other common vegetable acids, have a good deal of the same external appearance, most chemists have concluded, that all vegetable acids were nearly of the same nature; though some few have suspected, that they might be found to differ from one another, and to have different degrees of affinity, if they were examined with care; and to confirm this, Dr. Vogel § tells us, that if some of the Rochelle salts be thrown into a decoction of tamarinds, the alkaline basis of the Rochelle salt will unite with the acid of the tamarinds, and the cream of tartar will be precipitated.

and vegetable acids; to wit, with vinegar, crystals of tartar, and lemon; and one with the native acid salt (as he calls it) of urine, and the volatile alkali, and one with the acid of tartar, and the volatile alkali.

* Boerhavi Element. Chemiæ, vol. I. 804.

† Vogel, Institut. Chemiæ, p. 215. sect. 468. Ed. II.

‡ Macquer, Elemens de Chymie Theorique, chap. xvi.

p. 240.

§ Vogel, Institut. Chemiæ, p. 216. sect. 469.

As I always suspected, from the taste and smell that vegetable acids differed materially from one another, and was the more confirmed in this opinion by the above experiment mentioned by Dr. Vogel, I began to consider whether some method might not be fallen upon to determine this question; and, on recollecting, that the Rochelle salt * con- creted into large solid crystals, which preserved their figure long, even in the open air, though the tartarus tartarificatus † always appeared in the form of a powdery foliated salt, and run very soon *per deli- quium*, when exposed to the air, I imagined, that if we were to unite the fossil, or mineral alkali, with different vegetable acids, we should be able to obtain true neutral salts in form of regular crystals; which would shew how far these acids differed or approached to each other in their nature and proper- ties; and, upon trial, found that I had judged right; for each particular acid almost yielded a neutral salt pecauliar to itself, of which I shall now give a parti- cular account, and shall range these salts under the following heads.

1. Of neutral salts formed with native vegetable acids.

2. Of neutral salts formed with fermented vege- table acids.

* The Rochelle salt is made with the crystals of tartar, and the fossil alkali.

† The tartarus tartarificatus, with the crystals of tartar, and the salt of tartar; so that the only difference between these two salts is, that the one is made with the fossil, and the other with the vegetable alkali.

3. Of neutral salts formed with distilled vegetable acids.

4. Of neutral salts formed with flowers of benzoin and salt of amber.

S E C T. I.

Of neutral salts formed with native vegetable acids, and the fossil or mineral alkali.

EXPERIMENT I.

With the acid of lemons.

The first experiment I made was with the acid of lemons; six ounces of the juice saturated rather more than three drams of the fossil alkali; and upon evaporating the liquor to a pellicle, and letting it stand for some days, I obtained a salt composed of a number of small crystals of irregular figures; some appeared to be irregular squares, or rhomboidal; others irregular pentagons; others to have more sides; but this general appearance was nearly what is represented at *a. a. a.* &c. in **TAB. XXIII.** fig. 1. They were mostly flat, and not above $\frac{1}{8}$ or $\frac{1}{10}$ of an inch thick; though some few were somewhat of an oblong irregular cubical shape, if I may be allowed to use the expression.

Having observed that the figure of neutral salts, made with vegetable acids, varied sometimes, according as they were crystallised in larger or less quantity, I got a quart of lemon juice, and saturated it with about two ounces, and two drams of the fossil

fossil alkali. Before adding the alkaline salt in this experiment, I tried the temperature of the lemon juice with one of Fahrenheit's thermometers, and found that the quicksilver stood in the tube at 54; upon removing the thermometer, I immediately added the alkaline salt; and as the solution was begun, I again put the thermometer into the liquor, and let it remain for above a minute, and the quicksilver sunk above one degree; so that this acid generates cold in the time of its uniting with the fossil alkali, though the neutral salt, produced from their union, does not affect the thermometer in the time of its solution in water.

The appearance of the salt obtained in this crystallisation was very different from what it was in the former. The whole was made up of an infinite number of crystals, so small that one at first could scarce distinguish their figure; but on examination part seemed to be of the same shape as the larger ones, got in the former process; the others were very small oblong parallelograms, and they were every where interspersed with a number of small longish crystals, which in many places lay across each other, and formed a kind of lattice work. The general appearance of this crystallisation is represented by *b. b.* &c. in Tab. XXIII. fig. 1. and that of some of the particular crystals by *c. c. c.*

The taste of this salt is very mild, and rather pleasant, approaching a little to that of a very weak sea salt.

EXPERIMENT II.

With the acid of limes.

The lime is a fruit of the same genus as the lemon; its acid is sharper, and has a more agreeable flavour. From the near resemblance of these two fruits, one should have suspected that the neutral salt of both would have been almost the same; but their appearance is somewhat different, though perhaps upon more accurate trials they may be found to have nearly the same virtues, and chemical properties.

The first experiment I made was with the juice of a dozen and a half of small limes; and the neutral salt, produced from thence, was of the same shape, figure, and appearance, as the larger crystals obtained in the first experiment with the lemons; only the crystals were much smaller, and such as represented by *a. a.* &c. fig. 2. But having afterwards procured three dozen of larger and finer limes, I got from them near three times the quantity of juice I had in the former process; and having saturated this with the alkali, evaporated and crystallised it, I obtained a salt very different in its appearance from the former; though, in other respects, it seemed to be intirely of the same nature. Its crystals were of the size, and somewhat of the appearance, of barley corns, or grains of wheat, as at *c. c. c.*; some larger, some smaller; and laid in an irregular manner, but so as to form a beautiful crystallisation, which is represented by *b. b. b.* fig. 2. They appeared,

peared, at a little distance, to be roundish, but on examining narrowly, their sides were found to be made up of five or six flat surfaces; and generally one end of each crystal was made up of two flattish sides, which rose like a wedge which did not come quite to a point, but left a small narrow surface between.

These crystals, in the mouth, impress at first a very slight saltish, and somewhat sweetish cool taste; which is by no means unpleasant, and resembles a good deal that of the salt of lemons. They did not affect the thermometer in the time of their solution in water.

EXPERIMENTS III. and IV.

With the acid of Seville oranges, and of peaches.

It being late in the summer before I made any experiment with the juice of the Seville oranges, I could get none of this fruit but what had been long kept and was shrivelled, in so much that a dozen and a half of the oranges did not yield more than half a pint of juice, which had lost a great deal of its acidity, and saturated but a very small quantity of the alkali; and on crystallising I could obtain no other salt but a few very small cubical or square crystals, such as are represented by fig. 3. and similar to the salt got in an experiment I made with peaches, as may be seen in fig. 4. A saponaceous or mucous matter, with which these saturated juices abounded, seemed to prevent the crystallisation of the salts.

As both the juice of the orange, and of the peaches, was in small quantity, and not in the most proper state for yielding a neutral salt, these experiments ought to be repeated, before we can say what is the natural figure and appearance of the salts, that may be got by saturating the juices of these fruits with an alkali.

EXPERIMENT V.

With the acid of currants.

A quart of the juice of white currants, after being saturated with about nine drams of the fossil alkali, and purified by repeated filtrations, was evaporated till a pellicle appeared; being put into a cool place, and allowed to stand for two or three days, it yielded a number of small square flattish crystals, such as are represented by fig. 5. Many of them seemed to be exact squares, and in general they approached nearer to this figure, than the crystals of any of the other neutral salts I have hitherto met with.

This salt approached in its taste to that of the limes; its crystals were hard and firm, and did not run *per deliquium*.

EXPERIMENT VI.

With the acid of gooseberries.

A quart of the juice of gooseberries, being treated in the same way, as that of the currants, yielded a neutral

neutral salt very different in its appearance, from any of those hitherto mentioned. Its basis, or what adhered to the tea-cup, was made up of a number of very small roundish or squarish crystals; which formed an incrustation thicker than a shilling; from which grew up a number of very fine, thin, transparent plates, of irregular shapes; they were narrower at the basis than above; and in some measure might be compared to the scales of a small fish, or the wings of flies, set on their edges at a little distance from one another; in some places the plates arose from the sides of others; and in others they appeared somewhat like the fine leaves of very small plants. In fig. 6. we have different views of this salt; *a. a.* represents a piece of crystallised salt viewed from above; *b. b.* a profile view of the thin plates standing on their basis; *c. c.* the basis itself; and the letters *d.* a view of the thin plates laid on their flat sides.

EXPERIMENT VII.

With the acid of apples.

Having got two dozen of codling apples, I cut them to pieces, put them into a large earthen vessel, and poured three quarts of water upon them; and then dissolved above two ounces of the fossil alkaline salt in the water, and let them stand for six days; on examining, I found the water to be nearly in a neutral state; it did not ferment on the addition either of an acid or of an alkali. I then filtered the liquor through paper, and evaporated it,

till it was reduced to about five or six ounces, when it became thick, and a pellicle began to form on the surface. I then set it in a cool place, to allow the salts to concrete. After two days were elapsed, it was covered with a blueish variegated saline crust; immediately below which was a clay coloured saline matter, which resembled wet earth or sand, that had been raised by small worms; and this was interspersed every where with small flattish globules of the same sort of matter; below this was a purplish jelly, interspersed with a whitish or ash coloured saline matter, formed into irregular longish flat plates, which looked more like a composition of salt and earth than a pure salt. The appearance of this saline matter made me suspect, that it was mixed with some sort of oil, which the alkaline salt had extracted from the skins of the apples, which I had forgot to peel off before infusing them in water; I therefore got a fresh parcel of codling apples, which I caused to be carefully peeled, and then treated them in the same manner as the former, and obtained the beautiful salt painted in fig. 7. which resembled a good deal the salt of the gooseberries; being composed of a number of small roundish very delicate transparent plates, standing on one edge, on a fine saline crust, which adhered every where to the sides of the china basin; and were interspersed with a grey coloured saline matter. The crystals of this salt were in general rather smaller, rounder, and more of a size, than those of the gooseberry; and I did not observe any rising from the sides of others as in it; and they seemed to be disposed in a more regular uniform manner.

The letters *a. a.* &c. represent pieces of this crystallisation viewed from above; *b. b.* &c. some of the fine plates laid on their side; *c. c.* and *e* some of the ash coloured plates obtained in the first operation; *d. d.* some of the brown clay coloured saline matter; *f.* the flattish globules, which beset every where the inside of the pellicle, that was on the top.

After the crystallisation of the salt in this second process, the liquor which remained was poured into another small china basin; and, on being evaporated, exhibited nearly the same appearances as had been observed in the first process.

EXPERIMENT VIII.

With the acid of wild sorrel.

In order to save the trouble of a tedious evaporation, by saturating this acid mixed with the other juices of the plant, I procured some of the essential salt of the wild sorrel, from Mr. Heineken, apothecary in Duke-street; which I dissolved in boiling water, and saturated with the alkali; and by evaporating obtained a beautiful pure white neutral salt, which is represented by fig. 8; *a. a.* shews a part of the crystallisation where the salt shot into longish crystals, resembling somewhat the small ones of nitre; none of them exceeded the length of half an inch; *b. b.* other pieces of the crystallisation, which had a different appearance; *c. c.* a piece where it appeared like a small granulated salt; *d. d.* some small roundish or square crystals, which adhered like

a crust to the sides of the tea-cup; *e. e. e.* detached crystals.

EXPERIMENT IX.

With the acid of tamarinds.

Having had a present of some tamarinds in pods, from Mr. Arch. Gloster, practitioner in physick in Antigua, I took out the pulp, and put about two pound of it into three quarts of water; and then saturated its acid with the alkali, and, after filtrating the liquor, I evaporated it to the consistence of a syrup, and then put it into a cool place for 24 hours; when I found that a crystallisation had actually taken place, I separated the salt from a thick sweetish liquor of the consistence of a syrup; after it was dried, it had the appearance of a piece of common moss, made up of a number of small crystals disposed in an irregular manner, and mixed with viscid or saccharine juices. The letters *a. a.* &c. of fig. 9. shew some pieces of this salt while it remained in this form.

As I suspected this salt to be still mixed with a viscid matter, I dissolved some of it in warm water, and crystallised it anew, when it had a very different appearance, for it had shot into an infinite number of very small crystals, which came every where from centres. The length of these crystals did not exceed half an inch at most; they were no thicker than horsehairs, or common white thread. How many crystals shot from each centre I could not determine; but, in many places, the crystallisation

fation rose into small oblong, oval, or roundish tufts, made up of an infinite number of the small crystals that shot from the centre towards the circumference.

Some of the concentrated liquor having been accidentally left in a saucer, and on the sides of a tea cup at night, next morning the liquor in both vessels had shot every where into small fine crystals, that came like radii from a centre; in some places they had completed the circle, in others only half, and in others only the two opposite quarters.

I treated three pound of East-India tamarinds, which I bought in a shop in Castle-Street, in the same manner; only, after they were saturated with the alkali, and the liquor filtrated, it was set by for some weeks, and then filtered again before it was evaporated. The people of whom I bought these tamarinds told me, that there was no sugar mixed with them; and I believe what they said was true, for I obtained easily a very pure and fine salt from them. Having at first carried the evaporation too far, as soon as the liquor was removed from the fire, it immediately began to concrete in form of a number of small circles on the surface of the liquor, which were successively succeeded by others, till the whole became one solid mass; but on dissolving this mass in water, and evaporating only a little, and setting the liquor in a cool place to allow the salts to concrete, the crystallisation began on the surface of the liquor, in form of small circles or stars, and I obtained a salt in every respect similar to the former.

The general appearance of this salt is represented by *b, b*, in fig. 9, and the different appearances in different parts of the crystallisation by *c, c*.

EXPERIMENT X.

With the acid of plums.

Having got a quantity of the larger sort of the green plums, I caused the stones to be picked out, and the plums to be bruised and put into a large china bowl; I then poured about two quarts of water over them, and saturated their acid with the fossil alkali; after they had stood 24 hours, I strained off the liquor, filtered, and evaporated it, till there remained only a few ounces, when it was set in a cool place for four days, at the end of which time I found that a crystallisation had taken place; but, upon pouring off the superfluous liquor, I could not observe any general form of crystallisation; the whole was made up of a number of very thin, flat, longish crystals, from about $\frac{1}{12}$ to $\frac{1}{4}$ of an inch long, and from $\frac{1}{12}$ to $\frac{1}{8}$ or $\frac{1}{5}$ of an inch broad, of an irregular figure, laid without any particular form, and mixed every where with a mucous and black oily matter; when dry, the whole appeared like a confused mass, where however the form of some of the crystals was to be observed, as is to be seen at *a, a*, in fig. 10; in some places the crystals seemed to be laid with their edges uppermost, and in others in a different manner, as at *b, b*, &c.

In order to know the regular and true form of the crystallisation of this salt, I separated a quantity of the purest from the large mass, dissolved it in boiling water, filtered it through paper, and crystallised it a second time in a tea cup. It now appeared in a more regular form; the crystallisation

tion was divided into four roundish clumps, or clusters, which were separated or distinguished from each other by a furrow. Each clump was made up of a number of very fine delicate plates laid edgeways, in somewhat of a regular manner; and between them a number of others, where part of the flat sides were to be seen, and amongst them an infinite number of small rhomboidal or roundish crystals; the clumps appeared, in miniature, in the sun, somewhat like to the lower part of the spread tail of a peacock. The letters *c, c, c, c*, shew the general form of the crystallisation, *d, d, d*, the form and shape of some of the separate crystals.

I treated another parcel of plums of the same kind in a different manner; I saturated part of the liquor when fresh, and let it stand till a fermentation had taken place before I evaporated it; and I let the other half stand till the fermentation was over before saturating it; but the salt obtained from both, appeared nearly in the same form, though the number of clumps in this second crystallisation was only three: and in a third experiment the appearances were exactly similar, only the salt did not divide into clumps.

This salt tastes coolish on the tongue, but does not affect the thermometer, in the time of its solution in water.

In the present hard frost * some of the salt of plums, which had been dissolved in three or four times its own weight of water, and set by in a closet, crystallised anew. The crystals were flat, thicker than a shilling, and most of them had six sides of unequal

* N. B. The account of this last part of the experiment was given in to the Royal Society in the beginning of January 1768.
lengths,

lengths, as represented by *b, b*, in the figure marked large crystals of neutral salt of plums: where they were run together, their figures were most irregular as at *i, i*; some few small ones were squares, as at *k, k*. Hence we see what a variety the different methods of crystallisation make in the figures of these salts.

EXPERIMENT XI.

With the acid of mulberries.

Three quarts of the pure juice of the mulberry being saturated with four ounces of the fossil alkali, filtered, clarified with the whites of eggs and evaporated, yielded a saline matter, mixed with a quantity of a mucus and oil; which, on being purified as much as possible, by lying on a spongy brown paper, exhibited a very fine granulated salt almost like sea sand, in which no regular-formed crystals were to be observed.

Some of this salt being again dissolved in water, evaporated and crystallised a second time, appeared in the tea cup like a cake made up of the same sort of fine granulated salt as represented at *a, a*, fig. 11;— and another parcel *b, b*, which was treated in the same manner, though it at first appeared rougher, and more of a crystalline form, yet on examination was found to be made up of the same sort of saline matter.—On taking out the cake, there were a few thin very small square crystals, such as those marked *c, c, c*, adhering to the bottom of the tea cup.

A small quantity of the saturated juice of the mulberries having been left by accident for ten or twelve

twelve days in different tea cups and china basons, there formed in each a number of figures, or sort of crystals, resembling somewhat the alphabet of the Chinese language, interspersed with a few small, oblong, parallelogram-shaped crystals, as at *d, d, d*.

Three quarts more being saturated with the alkali, were allowed to stand for five or six weeks, and then filtered and evaporated to about seven or eight ounces; the greater part of which was put into a stone basin, and about half an ounce into a small china bowl; after ten days, the liquor in the bowl had shot into a number of small thin crystals, such as represented at *e, e, e*;—and that in the stone basin into a fine pure salt made up of similar crystals, but thicker and larger, such as those at *f, f, f*.—These last are certainly the true last crystals of this salt.

EXPERIMENT XII.

With the acid of grapes.

A basket of grapes, which were brought to market for ripe, though many of them were still hard and sour, and not come to their full perfection, yielded three quarts of juice, which I filtered and saturated with two ounces and a dram of the fossil alkali:—after it had stood for a month to depurate, it was again filtered, and then clarified with the whites of eggs, and evaporated to about five ounces, when it became of the consistence of a syrup, and had somewhat of a sweetish taste.

It was then set in a cool place for two days to crystallise; but, instead of forming any regular crystals, it concreted in form of a saline matter,

resembling coarse loaf sugar, when it first concretes in a thick syrup; some of which being dried on brown spongy paper, became very white, and seemed to be made up of long, very small crystals, no thicker than human hairs, and a saccharine matter.

From this appearance, I judged that the salt was still mixed with a quantity of viscid juices; and therefore I diluted the whole with a quart of New River water, depurated it again with the whites of eggs, and evaporated it to four ounces, which I set in a cool place for eight days; and then, on examining, I found that a crystallisation had taken place, and I obtained above a dram of a pure neutral salt, made up of small, square, and cubic, and small narrow oblong parallelogram crystals, resembling somewhat in appearance those got from the juice of the mulberry, only the crystals were less, as may be seen in fig. 12.

After separating this salt, I set the remaining liquor again in a sand heat, and evaporated about half an ounce of it, and then put it for some days into a cool place; and there formed a saline saccharine-like concretion, exactly similar to what was got in the first trial.

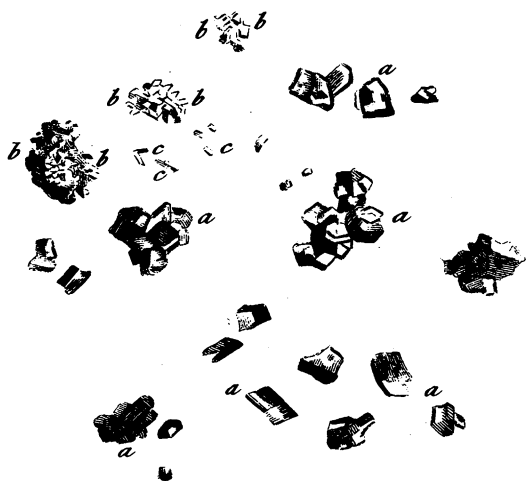
S E C T I O N II.

Of neutral Salts formed with fermented vegetable Acids, and the fossil Alkali.

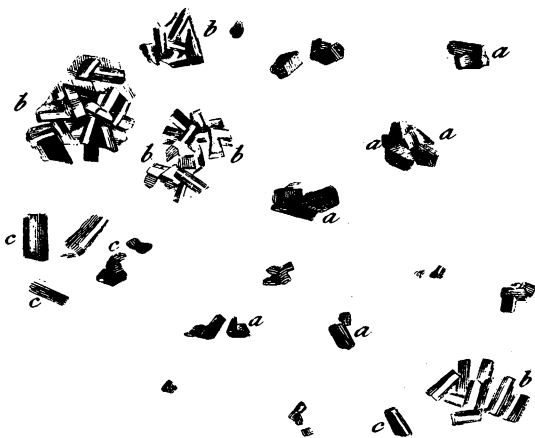
Having shewn a variety of neutral salts made with native vegetable acids, we come next to take a view of those made with fermented acids, and shall begin with that produced from vinegar.

E X P E -

N. Salt of Lemons.
Fig. 1.

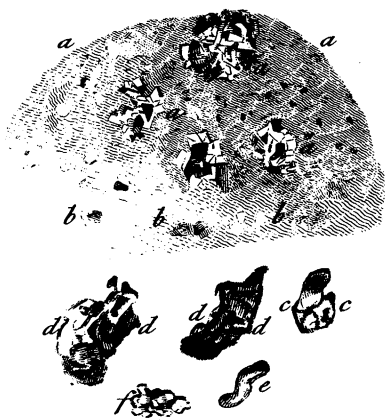


N. Salt of Limes.
Fig. 2.

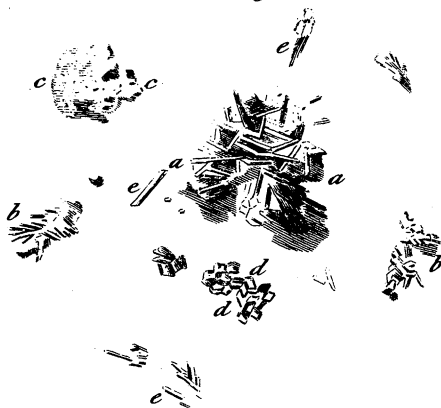


N. Salt of

N. Salt of Apples.
Fig. 7.



N. Salt of Wild Sorrel.
Fig. 8.



N.



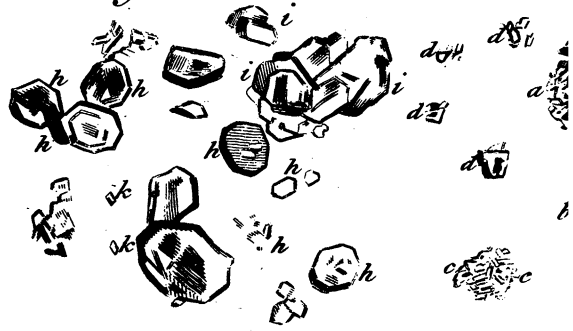
N. Salt of Sevil Orange.
Fig. 3.



N. Salt of Peaches.
Fig. 4.



Large Crystals of N. Salt of Plums.
Fig. 10. 2.



N. Salt of C...
Fig. 1.

N. Salt of Currants.
Fig. 5.

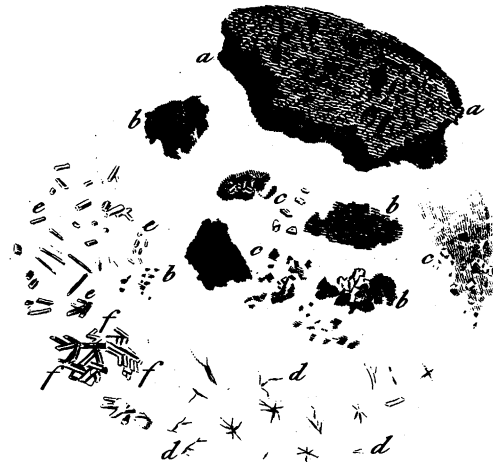


N. Salt of Plum
Fig. 10.

N. Salt of Tamarinds.
Fig. 9.



N. Salt of G...
Fig. 12.



N. Salt of Mulberries.
Fig. 11.

alt of Gooseberries.
Fig. 6.



Plums.

?

lt of Grapes.
Fig. 12.



f
es.

EXPERIMENTS I. and II.

With common wine and distilled vinegar*.

The plain vinegar used, was said to be the best white wine vinegar that could be got; and the distilled was said to be prepared from wine vinegar likewise.

I saturated a pint of each of these vinegars, with the pure alkali, evaporated them to a pellicle, and let them stand to crystallise.

From the distilled vinegar I obtained the salt represented by *a, a, a*, fig. 14, Plate XXIV. which in the evaporating glass appeared as you see it, resembling the figure of a sun in a fire-work. Its crystals were a little twisted; and upon taking them out, and examining them separately, they appeared like so many small crystals of glauber salt, as are represented by *b, b, b*.—On laying the evaporating glass on one side to allow the liquor to drain away, some thin flat square crystals, such as are represented by *c, c, c*, formed on the sides of the glass.

And what is very particular with regard to this salt is, that, on dissolving some of the crystals, resembling those of glauber salt, in pure water, and fully saturating the water with the salt, in some days there formed a number of crystals very different in figure and appearance from the former; be-

* The neutral salt with vinegar I find mentioned, but not described, in a chemical dictionary published at Paris in the year 1766.—All that is said of it is, that it is a salt which crystallises easily, but is little known. See the articles ALKALI MINERAL, SEL NEUTRE, and VINAIGRE.

ing some of them squares, others longish parallelograms, others irregular pentagons, and some with six sides; some were flat, and from $\frac{1}{4}$ to $\frac{1}{5}$, or $\frac{1}{4}$ of an inch thick; others appeared somewhat roundish, or oval, but the sides were made up of flat surfaces, as are represented by the letters *d*, *d*, *d*, &c.

I do not remember to have seen such a variety of shapes and figures in any other salt; and I cannot account for the great difference of appearance in the first and second crystallisation in any other way, than from the liquor in the first crystallisation having been evaporated to a pellicle, and being very highly impregnated with the salt, the crystals began to shoot at once in every part of it, so that they had not room to extend in breadth, and to form themselves into various shapes, as in the second process, where the liquor was not so highly concentrated, and where each crystal was formed separate, and at a distance from another.

2. The plain wine vinegar, treated in the same way, but in a narrower vessel, yielded a salt which had a different appearance from the former; for on pouring off the superfluous liquor which remained after the crystallisation was completed, it seemed to be composed of a number of small, thin, broad crystalline, square plates, standing up from about half an inch to an inch above the surface, as represented by *a*, *a*, *a*, in fig. 13; on separating them, each crystal appeared at the basis like a small crystal of glauber salt, which terminated at the top in the thin broad plate already mentioned, as represented by the letters *b*, *b*, *b*, &c.

On dissolving some of this salt in water, and letting it stand for 18 or 20 days, there formed a
number

number of crystals of different shapes, as in the distilled vinegar; some such as them, others resembling exactly the figure of the Rochelle salts, but smaller as those at *c x*; some squares, others of different shapes and figures, as at *c, c, c, &c.* and one large one marked *d, d.*

Both the salts from the distilled and from the plain wine vinegar, have a pleasant cool taste, without any disagreeable bitter; and generate cold in the time of their solution in water, for the quicksilver in the thermometer, which stood at 63 in New River water, sunk to 62, as soon as some of this salt, which was put into it, began to dissolve.

From the figure and shape of some of the crystals of the salt of the wine vinegar coming so near to that of the Rochelle salt, I think we may reasonably conclude that the acid of vinegar approaches near to that of tartar, but is not entirely the same.

The salt of the distilled vinegar can be made with great ease and very pure; but the common vinegar contains such a large proportion of oil as to require some care to purify it after it is made.

EXPERIMENT III.

With the crystals of tartar.

The Rochelle salt, made with the acid of tartar, and the fossil alkali, is so common a purging salt, that I shall not enter into any description of it, and I have only given a figure of some of its crystals at fig. 15, that we might be able to compare it
with

with the other neutral salts made with vegetable acids.

EXPERIMENT IV.

With the acid of verjuice of Apples.

I made two trials with the verjuice; the first was with a quart of what was old and tart, and took rather above an ounce of the alkali to saturate it; the other, which was newer, not so tart, and was saturated with about seven drams of the alkali.

The first was evaporated to a few ounces, when an oily or mucous pellicle appeared on the top; after letting it stand for some days, no salt was likely to crystallise; I therefore diluted it with water, filtered it, clarified it with the white of an egg, and evaporated it a second time; and after it had stood for some days the salt concreted into the form represented by fig. 16. It was composed of a number of small long crystals, which branched out from centres somewhat like the sticks of a fan, or the fibres in the leaf of a tree, such as at *a, a, a*.

The second or new verjuice, after being saturated, was allowed to stand for four or five weeks, then filtered, purified with the white of an egg, and evaporated; and after standing some days in a cool place, a crystallisation was formed, which approached very near in its appearance to the salt of apples, though somewhat different; it was composed of a number of very fine delicate small, flat square or rhomboidal plates set upon their edges, near to one another, without any certain regular order

order that I could observe, but so as on the whole to make a very beautiful appearance; in this crystallisation the salt seemed to form in clumps, two of which are to be seen at *b, b*, &c. and a profile view of a small piece at *c, c*, and a figure of some of the plates laid on their flat sides at *d, d*.

Did the difference of the age of the verjuice employed in these two experiments, or the difference of the processes they underwent, make the difference in the appearance of the salts obtained in the different crystallisations? The salt of the old verjuice approached to that of vinegar; of the new to that of apples.

EXPERIMENT V.

With the acid of perry.

At the time I gave in this paper, in the beginning of November, I had made several attempts to obtain a neutral salt from perry (or the fermented juice of pears) but without success, owing to the large quantity of saccharine juice with which this liquor abounds. But having accidentally left some of the concentrated liquor in a small china basin, on examining it some days after the present hard frost had begun,* I found that a crystallisation had taken place.

The crystals were flat, long, narrow, very thin transparent plates, such as represented in fig. 17; they were from a quarter of an inch to near an

* The account of this experiment was given to the Royal Society about the middle of January 1768.

inch long; they were mostly fixed to the sides of the basin by one end, many stood almost upright, and others lay across each other. One end was commonly made up of two short sides, which met at a point.

They remained some days exposed to the air in a cold room, and preserved their transparency and figure; but after they had stood for about a quarter of an hour in a warm room, while the painter was drawing the figure, they lost their transparency, and became white and mealy. They tasted cool, and somewhat bitter in the mouth.

S E C T I O N III.

Of neutral Salts, formed with distilled vegetable Acids, and the fossil Alkali.

Acids distilled from wood, and other vegetable substances, have been mentioned as a distinct species, but no proof has been brought of their differing from the other vegetable acids; on the contrary, in the tables of neutral salts given by chemists, no notice is taken of any neutral salts made with these acids; and therefore it is to be presumed that they imagined them to be nearly of the same nature with the others.

In order to know if these acids differed from one another, and from the native and other acids, I had some guaiac wood, some fir wood, and some honey distilled, and procured some of the acid of each, which I saturated, filtered, evaporated, and crystallised.

EXPERIMENT I.

With the acid of guaiac wood.

The crystals of the neutral salt of guaiac wood were long and small, and shot like the rays of the sun from a centre, and appeared as represented in fig. 18.

EXPERIMENT II.

With the acid of fir wood.

The neutral salt of fir had a very different appearance; there were no such distinct crystals as in the other; what were to be observed seemed to be long and small, to come in many places from points, and to go in somewhat of a circular manner, or to describe a curve, and appeared as represented by fig. 19.

EXPERIMENT III.

With the acid of honey.

It has been a doubt among naturalists, whether honey should be ranked among the vegetable or the animal substances. Most chemists seem to think it should be ranked among the vegetable, and look upon it as made up principally of the juices of plants collected by the bees; but, however that matter may be, the following is an exact account of

the neutral salt made with the acid obtained from this substance by distillation.

In order to procure this acid, I prevailed with Mr. Winter, brother-in-law to Mr. Heineken, apothecary, to distil four or five pounds of honey in a retort; at first he imagined that I only wanted the watry phlegm, which has been called by the name of the spirit of honey, and stopped the distillation before the acid came over; but having distilled a second quantity, he procured me about six ounces of a very acid liquor, which I mixed with the phlegm or spirit which he first brought me; I then saturated the whole with the fossil alkali, filtered and evaporated the liquor to a pellicle. After it had stood all night in a cool place, I found the pellicle to be composed of a yellow, bitter, salish, mucous and oily matter; below which was a dark purplish liquor, which I poured into a tea cup, and there remained at the bottom of the stone gallypot, in which the evaporation had been performed, a yellow concreted matter, somewhat of the appearance of yellow wax, mixed with a little honey; on the surface of which was to be observed a number of globules of the same sort of matter, of the size of mustard seeds, and interspersed with a black very bitter stuff. Next day, on examining the dark coloured purplish liquor which I had put into the tea cup, I found that a great part of it had concreted into a very beautiful salt, which is represented by fig. 20. *a, a, a*, shews the general form of the crystallisation; *b, b, b, b*, the shape, figure, and size of some of the crystals. The crystals were almost all flat, and seemed in general to assume the form of long,

long, narrow parallelograms, or longish squares, if I may be allowed to use the expression; *c, c*, some of the yellow saline matter.

This salt is pleasant to the taste, and evidently generates cold in the mouth in the time of its solution; but I had not quantity enough to try with a thermometer what degree of cold it generated in the time of its solution in water.

S E C T I O N IV.

Of neutral Salts formed with Flowers of Benzoin, and Salt of Amber.

EXPERIMENTS I. and II.

With the flowers of benzoin.

Most modern chemists have looked upon the gum benzoin as a resinous substance, which bears the same analogy to the vegetable resins, as the succinum or amber does to the fossil bitumens; and they have esteemed the flowers of benzoin to be an acid salt, mixed with an oily and a small proportion of an earthy matter; but have brought no proof of its being so.

1. In order to ascertain this fact, I put two drams and a half of the flowers of benzoin into some water, and then dropped into it by degrees a solution of the fossil alkali; every drop raised an ebullition or effervescence, in the same manner as when any common alkaline salt is thrown into an

acid liquor. I continued adding the alkaline lye till all ebullition ceased, and the flowers were fully saturated and dissolved; after which I filtered the liquor, and evaporated it till a pellicle began to appear, and then set it in a cool place all night, and next morning I had a fine pure transparent neutral salt, such as is represented by figure 21. It adhered to the china basin in form of a saline crust, which I removed; and on looking thorough it in the light, it seemed to be composed of an infinite number of very small crystals; above this lay, in many places, a number of crystals of the figure of small oblong parallelograms, as those at *b, b*. But from the greater part of the surface of the crust there arose a number of very fine thin delicate plates of irregular figures, standing on one edge; some were squares, others parallelograms, and others had more sides, the general appearance of which was such as is to be seen at the letters *a, a, a*, &c.

This salt, when first made, appeared as transparent and clear as glauber salt, or nitre; but on being exposed to the air, became very soon white and mealy.

In the time of the evaporation of this salt, a saline white mealy crust rose every where on the sides of the china basin in which the operation was performed, and even came over so far, as to cover its whole outside. What rose in this manner had a sweetish taste, and was not so sharp in the mouth as what appeared in a transparent saline form.

The superfluous liquor, which remained after the crystallisation was compleated, being put into a

tea

tea cup, concreted in a very uncommon manner. In the middle of the tea cup it arose something like a plant, or a fountain, where the water is discharged from a number of pipes, and spread from the bottom of this, so as to cover both the inside and outside of the cup, with a sweetish, white, mealy, saline crust, which in many places seemed disposed like the fine fibres of plants, or of the leaves of trees.

2. As a further proof of the flowers of benzoin being an acid of a particular kind, I saturated some of them with the sal volatile ammoniacum, evaporated and crystallised; and obtained an ammoniacal salt, which had a very singular appearance. It was covered on the top with a very white saline pellicle, below which were a number of thin, flat, white transparent crystals, the greater number of which seemed to be exact squares, some few, oblong parallelograms, such as are represented in fig. 22.

The flowers of benzoin generated a considerable degree of cold in the time of their saturation with the volatile alkali; they sunk the quicksilver in the thermometer from 52 to 46.

EXPERIMENTS III. and IV.

With the salt of amber.

The salt of amber is now generally known to be of an acid nature; but from what Mons. Bourdelin has said of it, in the Memoirs of the French Academy of sciences for the year 1742, its acid has

been looked upon by many chemists *, to be exactly of the same nature as the spirit of sea salt, only mixed with a little of the oleum succini;—though some have imagined it to be an acid of the vitriolic kind.

1st, When I first mixed this acid with the fossil alkali, I began to believe that what *Monf. Bourdelin* had alledged was true; for the liquor tasted saltish, like to a weak solution of sea salt in common water, but I was soon convinced of my error; for on evaporating and crystallising, I had a salt very different in its nature and properties from that of sea salt, or of *glauber salt*, one of which salts it must have been †, had the acid been the marine or the vitriolic. This agrees with what *Dr. Stockar de Neuforn* ‡, has said of this being a particular acid.

* *Macqner* seems to be thoroughly convinced of the acid of *succinum*, or amber, being the same with that of sea salt; for in mentioning the proofs which *Monf. Bourdelin* has brought of its being so, he says, “C’est ce point qui est l’objet principal de *memoire de Monf. Bourdelin*; & cette decouverte est sans contredit une des plus belles, & en même temps des plus difficiles, qu’il y eût à faire sur ce Bitume.” See his *Elemens de Chymie pratique*, tom. ii. p. 213.

† Sea salt is a neutral salt made of the fossil alkali, and marine acid, or spirit of sea salt; and *glauber salt*, of the same alkali and the spirit of vitriol.

‡ In the year 1760, *Dr. Jo. Geo. Stockar de Neuforn*, in his inaugural Dissertation de *Succino*, published at *Leyden* the 7th of July, 1760, proves by a number of experiments, that the acid of *succinum* is neither that of vitriol nor of sea salt; and he mentions two neutral salts made with this acid, the one with the common vegetable alkali, and the other with the volatile.

He says that the crystals of the one, made with the vegetable alkali, are clear and pellucid, and of the same figure as the

The

The crystals, I obtained in the first experiment I made, were large and flat; and such as are to be seen at the letters *a, a, &c.* fig. 23; they were of no certain shape or figure; some were roundish with a number of sides, others appeared somewhat triangular, and others of different figures; and in some parts the crystallisation appeared like a piece of rock work. I dissolved some of this salt in water, and crystallised it a second time, but the crystals were in general smaller than in the first operation; and the crystallisation appeared as represented by *b, b, b.* In order to shew the difference between this and sea salt, I made Mr. Paul draw the figure of some beautiful crystals of sea salt, near to those of this neutral salt of amber.

This salt is extremely different in its taste from that of sea salt, and certainly likewise in its virtues and properties.

2. In order to ascertain more fully that the sal succini is an acid *sui generis*, I saturated some of it with the volatile ammoniac salt, crystallised it, and obtained a neutral ammoniacal salt very different from that of the common sal ammoniacum; it was composed of a number of small long narrow flattish crystals, whose sides were made up of four flat surfaces, such as those represented in fig. 24, and laid

crystals of the salt of amber itself; that it has a particular taste, and dissolves easily in water, which the tartarus vitriolatus does not; and when thrown on the fire, or put on a red hot iron, crackles and melts, but yet remains fixed and neuter. Acids make no change on it, nor is aqua fortis converted into an aqua regia by its mixture; it does not precipitate silver from spirit of nitre, though it precipitates lead from vinegar, in form of a white calx, which, however, cannot be changed into a saturnus corneus.

in an irregular order, some lying across others, and some standing on one end *.

The sal succini generates a great degree of cold in the time of its saturation with the volatile alkali, for it sunk the quicksilver in the thermometer from 52 to 40; in this it agrees with the common sal ammoniacum.

The Conclusion.

From the experiments above related, it is evident that physicians have hitherto been in a great mistake, in believing that all vegetable acids were nearly of the same nature; for from them it should seem that almost each of the acids, called vegetable, has something peculiar to itself, and upon future trials may be found to have different virtues and properties †.

The different appearance of the neutral salts above mentioned, from that of those produced by the union of the fossil alkali with any of the mineral acids, seems to make it doubtful whether the vegetable acids derive their origin from the mine-

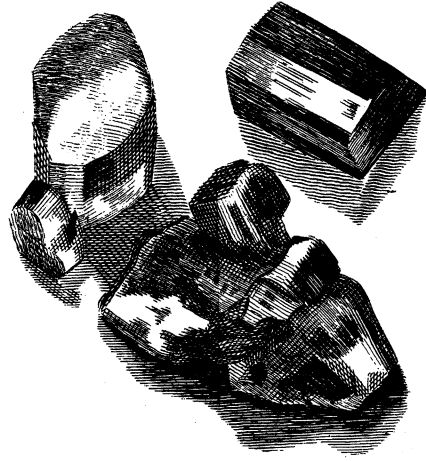
* Dr. Stockar de Neuforn says, that this ammoniacal salt does not precipitate silver from aqua fortis, nor change aqua fortis into aqua regia; and when put in a silver spoon, and set over the fire, it melts and flies off in form of a vapour.

† However, it ought to be remarked, that when any of the concentrated saturated liquors stood for ten or twelve days before they crystallised, for the most part some crystals of a flat, square, or of a narrow oblong parallelogram figure, were found adhering to the sides of the cup or basin in which the liquor stood; but whether this was owing to the alkaline basis of these salts, or to the acids approaching to each other in their nature, is what can only be determined by future experiments.

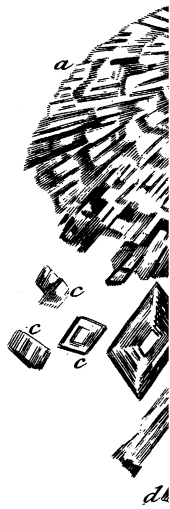
N. Salt of Verjuice.
Fig. 16.



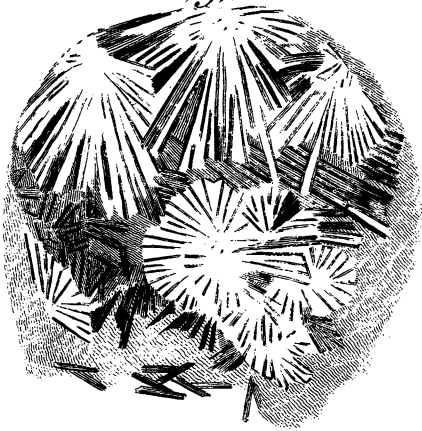
Rochelle Salt.
Fig. 15.



N. S.



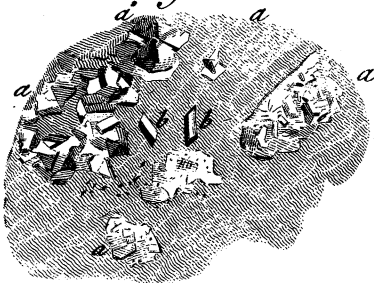
N. Salt of Guaiac Wood.
Fig. 18.



N. Salt of Fir.
Fig. 19.



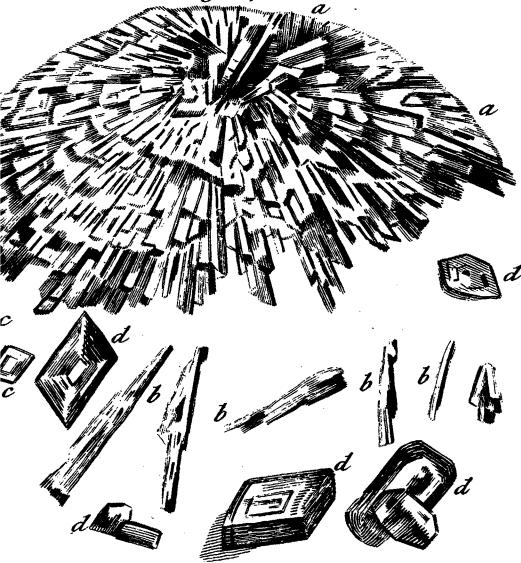
N. Salt of Benzoin.
Fig. 21.



Ammoniacal Salt of Amber.
Fig. 24.



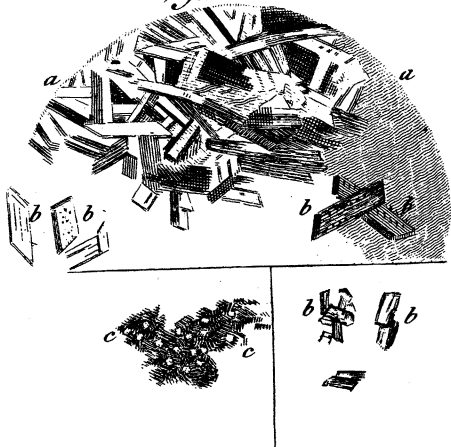
N. Salt of Distill'd Vinegar.
Fig. 14.



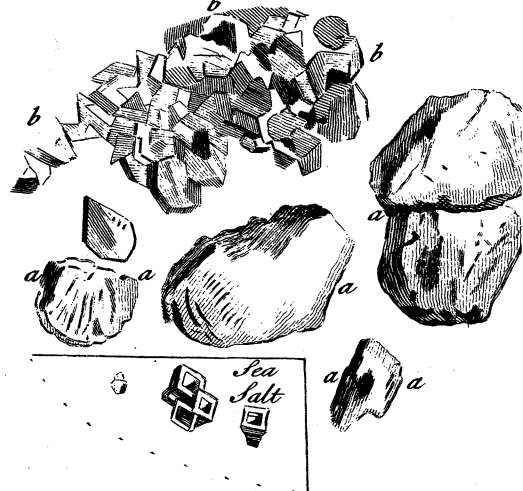
N. Salt of Common Wine Vinegar.
Fig. 13.



N. Salt of Honey.
Fig. 20.

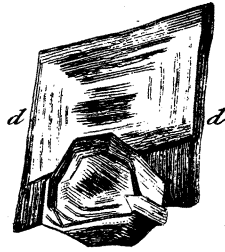


N. Salt of Amber.
Fig. 23.



Ammoniackal Salt of Benzoin.
Fig. 22.





N. Salt of Perry.
Fig. 17.



ral; or whether they are not new substances, generated either in the vessels of plants by means of the vegetative process, or by fermentation, or by the force of fire. If they owe their origin to the mineral acids, they are certainly so much changed in their virtues, and properties by the combination of new particles, and by the processes they have undergone, that they may be looked upon as distinct bodies in many respects.

From what has been said, it is evident that the number of true neutral salts* is infinitely greater than what has been supposed, of late, by chemists; and it is probable that many of the neutral salts, above described, may prove to be excellent remedies in the cure of diseases, as well as useful in many manufactories.

As there is such a variety of vegetable acids, and as each of them produces a distinct neutral salt with each of the three alkalies, I think it would be right to distinguish them from one another by particular names; the salts made with the vegetable alkali may be called *vegetable salts*, as both the acid and the alkali are vegetable substances; those made with the fossil alkali *neutral salts*; and those made with the volatile alkali *ammoniacal salts*, as all the neutral salts hitherto made with this alkali have gone by this name. Thus we may call the three neutral salts made with lemon juice: 1. Vegetable salt of lemons. 2. Neutral salt of lemons. 3. Ammoniacal salt of lemons.

* By true neutral salt is meant, a salt made with an acid and one of the three alkalies; the word *true* is added to these salts, to distinguish them from neutral salts, made with earths or metals, and acids.

By means of these neutral salts we may be enabled to discover many of the properties of vegetable acids, and particularly the different degrees of affinity or attraction between them and alkaline salts; thus, for example, if we dissolve in water some of the neutral salt of currants, and add some lime juice or some vinegar, and then evaporate and crystallize: if we obtain a neutral salt of currants, we conclude that the acid of currants has a greater affinity or attraction to the alkali than the acid of limes or of vinegar; but, if we get a neutral salt of limes, or of vinegar, we conclude that these acids have a greater affinity with the alkali than the juice of currants.

As I am sensible that this account of vegetable neutral salts is very incomplete, and that I have done little more than given a very superficial description of their external appearance; and as it will probably require a length of time, and the labours of many, to discover fully their virtues and properties, I shall recommend it to those who may prosecute this subject to endeavour to ascertain the following facts:

1. What degree of cold or of heat is generated on the mixture of each acid with the different alkaline salts; and likewise to try the same experiment with each neutral salt at the time of its solution in water.

2. What quantity of pure alkaline salt it takes to saturate any determined quantity of each of the vegetable acids.

3. What figure each neutral salt assumes when it is first crystallised, and likewise after it has been purified,

purified, and again dissolved in water and crystallised.

4. What quantity of water it takes to dissolve any determined quantity of each salt.

5. What effects these salts or their solutions in water have on oils, sulphur, ardent spirits, metals, earths, and other substances; what substances they mix easily with, and to what bodies they prove a menstruum, or assist in dissolving.

6. How far they agree in their virtues and properties with the neutral salts made with mineral acids, and with each other.

7. What effects they have on the human body; whether they promote more particularly the perspiration or the secretion by the kidneys, or whether they act more readily on the bowels, and promote the discharge by stool; and to ascertain the exact and proper doses of each.

8. And lastly, what effects fermentation and distillation have on native vegetable acids; and to observe and compare the appearances of the neutral salts made with these acids in their different states: viz. 1. In their native state. 2. When made into wine. And 3dly, when made into vinegar; and likewise when made with acids brought over by the force of fire, or distilled from the same juices in each of the three different states mentioned.

And in order to facilitate their labours, I shall conclude this long paper with observing,

1st, That all vegetable juices used for making neutral salts ought to be strained through a cloth, and then filtered through paper, before they are saturated with the alkaline salt; and that, after they

are saturated, they ought to be allowed to stand for some days, and some of them for weeks, and then be filtered again, before they are evaporated.

2dly, That it is of use to clarify many of these juices, after being saturated, with the whites of eggs.

3dly, That it is sometimes easier to obtain a neutral salt, by evaporating with a boiling heat, than with a slow or gentle fire; as the heat of boiling water coagulates, and throws up a quantity of viscid juices to the surface, which cannot be easily separated by any other means.

4thly, That the sweeter any fruit is, and the more it abounds with saccharine or viscid juices, the more difficult it is to obtain a neutral salt; and for this reason I have not hitherto been able to get any neutral salt from the saturated juices of pears, or of cherries.

5thly, That, in cases where we are obliged to employ water mixed with the fruits cut small, instead of their juices, it is right to peel off the skins before we attempt to saturate the acid; otherwise the alkaline salt is in danger of uniting with, and rendering soluble in water, the gross oils with which the skins generally abound, which afterwards prevent the crystallisation of the neutral salts.

N. Salt of Lemons.
Fig. 1.



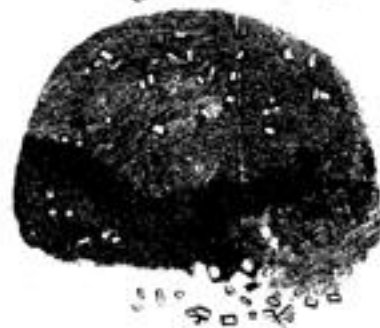
N. Salt of Limes.
Fig. 2.



N. Salt of Sevil Orange.
Fig. 3.



N. Salt of Peaches.
Fig. 4.



Large Crystals of N. Salt of Plums.
Fig. 10. 2

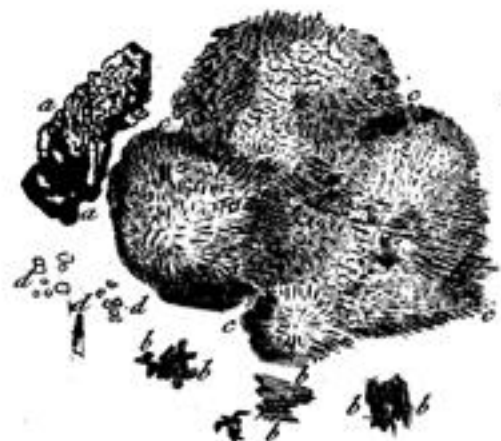


N. Salt of Gooseberries.
Fig. 6.

N. Salt of Currants.
Fig. 5.



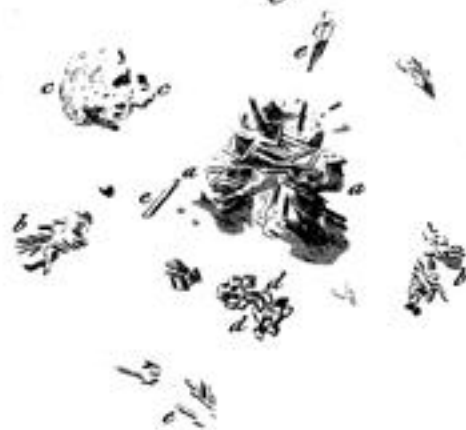
N. Salt of Plums.
Fig. 10.



N. Salt of Apples.
Fig. 7.



N. Salt of Wild Sorrel.
Fig. 8.



N. Salt of Tamarinds.
Fig. 9.



N. Salt of Grapes.
Fig. 12.



N. Salt of Mulberries.
Fig. 11.



N. Salt of Verjuice.
Fig. 16.



Rochelle Salt.
Fig. 15.



N. Salt of Distilled Vinegar.
Fig. 14.



N. Salt of Common Wine Vinegar.
Fig. 13.



N. Salt of Guaiac Wood.
Fig. 18.



N. Salt of Fir.
Fig. 19.



N. Salt of Perry.
Fig. 17.



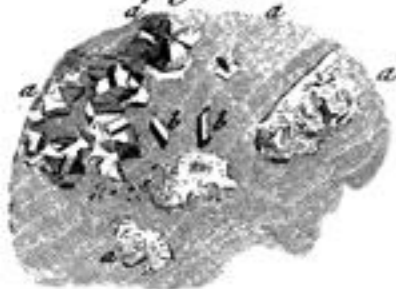
N. Salt of Honey.
Fig. 20.



N. Salt of Amber.
Fig. 23.



N. Salt of Benzoin.
Fig. 21.



Ammoniaccal Salt of Amber.
Fig. 24.



Ammoniaccal Salt of Benzoin.
Fig. 22.

