DR. FRANCISCO REDI A PIONEER IN PLANT ASH STUDIES.*

BY LYMAN F. KEBLER.[1]

INTRODUCTORY OBSERVATIONS.

During my researches in connection with the History of Federal Food and Drug Legislation, in which I have been engaged for a number of years, as time permitted, I came across a very interesting statement, in A. W. Blyth's book on "Foods," page 33 (1882), it reads:

Francesco Redi of Florence, published in 1660, on the amount of Mineral Substances in pepper, ginger, and black hellebore. He burnt 100 lbs. of each and weighed the ash: Black pepper yielded 5 lbs. 2 ozs. 4 drs. of ash, ginger 5 lbs. 3 ozs. 2 drs., while black hellebore burnt in the same quantity gave 4 lbs. of ash. These ash percentages, as we know are accurate. He treated the ash with water, and noticed that all of the salts lixiviated, had a peculiar and definite figure, which they kept although they were often resolved and afterwards congealed.

The same statement appears in Blyth's 7th, edition on "Foods," 1927.

The questions that would naturally arise in anyone's mind, in connection with the above statements, are the following:

1. Why did Redi make the determinations? 2. Why did he use 100 pounds for each plant substance? 3. How did he incinerate such large amounts? 4. Are the substances enumerated by Blyth, the only ones ashed by Redi? 5. How do Redi's ash percentages accord with modern determinations? 6. What was the purpose of lixiviating the ashes?

The reference to Redi's work was not clear, as a consequence it was several years before I came across the article in the *Philosophical Transactions*, Vol. 20, page 281 (1698), published a year after Redi's death.

FRANCISCO REDI AND HIS ENVIRONMENTS.

"Who was this pioneer, that made these ash investigations and what were his environments? Redi (1626–1697), a physician and iatro-chemist, was born a year before the distinguished Robert Boyle. He was a contemporary of Glauber, Hooke, Leeuwenhoek, Malpighi, Newton, Sydenham and John Winthrop, Jr. He lived in an era of great scientific activity. An era in which the influential Royal Society of London was organized. At a time when there were a dozen universities functioning in Italy. Alchemy had practically run its course. Iatro- or medical chemistry was to the fore. The teachings and influence of Paracelsus and his followers were still potent forces. Redi lived in Florence of Italy, a city of great influence in commerce, politics, medicine, the sciences and the arts. It was the seat of the great Florence University, founded in 1349. It was the apothecaries of Florence who requested the medical college to compile a pharmacopœia, which was done and published in 1498. Florence was at the time the name of a city and a state. This accounts in part for characterizing the 1498 pharmacopœia as the first city—state pharmacopœia. This pharmacopœia is by common accord, recognized as the first of the modern pharmacopœias."—E. KREMERS, JOUR. A. PH. A., 23, 46 (1934).

ROMANCE OF PLANT ASHES AND THEIR USES.

The fact that plants are made up in part of ashes, dates back into the remote mist of the ages. Indeed ashes have been known since the advent of the use of fire by mankind, the time of which is not recorded in history. Ashes are referred to the "Old Testament," Genesis, 18, 27, about 1898 B.C. Other references appear

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in the same publication. Some are rather interesting. Particularly those referring to the eating of ashes. "I have eaten ashes like bread," Psalms, 102, 9: "He feedeth on ashes," Isaiah, 44, 20.

An empirical knowledge of the nature of wood ashes is reflected by various writers. Jeremiah, "Old Testament," 2, 22, about 629, B.C., refers to soap, resulting from the interaction of fatty substances and alkalies. Pliny (23–79) A.D., in his immense repository, records the preparation of soap from animal fat and ashes. Pliny furthermore observes that ashes were strengthened for the making of soap, by the addition of lime. The same author notes that wood ashes were preferred to the dung of beasts. In fact the dung itself, he avers, was even burned and the ashes used in preference to the dung.

The early users of ashes knew their good effects on growing crops, but it remained for the gifted technical French chemist, Bernard Palissy (1499–1589), to point out the reason. Ashes are made up in good part of soluble salts. It was Palissy who announced the value of soluble salts in manures. This is considered the beginning of rational agricultural chemistry.[1]

Geogius Agricola (1494–1555), a noted physician-chemist, devoted a good part of his time to the study of mineralogy and metallurgy, in both of which he became a world-renowned authority. In his classic book entitled, "De re Metallica," 1556, he discusses the use of ashes derived from reeds, rushes, musk ivy, hemlock and various oaks. This interesting book has been translated into English by the former President Herbert C. Hoover and Lou H. Hoover and published in 1912.

THE RESEARCHES OF FRANCISCO REDI ON PLANT ASHES.

"Remarks Concerning Factitious Salts:[2] Drawn from a discourse written by Sen. Francisco Redi. Seignior Francisco Redi has been induced to collect divers Writings and Observations made some years past in Florence, about Vegetable Salts; which being not ready to be published, you will here receive an Extract of them, for the Satisfaction of the Curious, and Improvement of Natural Knowledge, being hereby conducted into the Manner of Extracting the Salts, their Quantity and different Figures, as likewise their Virtues and Purgative Qualities, Preparation and Circumstances."

Various sorts of flowers, fruits, herbs, woods and whatnot were burned, to make the ashes; the ashes then extracted with pure water, at the natural temperature, to make a lye, which was filtered as clear as possible. The clear lye was then put into a glass vessel, the greater part of the water evaporated, "in Balneo Marinæ," to the point that had been shown by experience to give the most satisfactory results. Redi found that five pounds of water would extract all of the soluble matter from two pounds of ashes.

"Not all herbs, nor Flowers, nor Fruits, nor Woods when they are burnt, render equally the same Quantity of Salt, but according to the Diversity of their Species, the Quantity of Salt which is drawn from the Ashes, is found different. The Seasons wherein the Plants are gathered make a Diversity, as also does the Country, whether Mountanous or Champaine or Sea-Coast or Marshy or Moist.

"All matters burnt give not the same Quantity of Ashes, but there is great Diversity which you may see by the following Proofs, the great Part in the year 1660, in the Time of the Most Serene Great Duke Ferdinand II, of Glorious Memory."

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[1] "History of Chemistry," Ernst von Meyer, translated by George McGown, page 96 (1906).

[2] *Phil. Trans.*, 20, 281 (1698).

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Pounds. Vegetables.	Ashes. lb ℥ ʒ	Salts. lb ℥ ʒ
100 Of dryed Flowers of Oranges	4 06 00	00 00 05
800 Of Gourds new gathered which dryed in the Oven were 36 lb	4 00 00	00 10 00
400 Red Onions (being 720) roafted, the Coals turn'd to 16 lb to the Coals new added 4¾ of Sulphur.	1 06 00	00 02 02
150 Eyebright freſh, and afterwards ſtilled and burnt	5 00 00	00 04 00
120 Diſtill'd Roſes	4 00 01	
100 Of Maidenhair	9 00 00	00 00 04
150 Roots of Black Hellebore, which dryed came to 50 lb.	6 00 00	00 01 00
150 Roots of White Hellebore freſh, which dryed came to 50 lb	2 00 00	00 04 00
96 Roots dryed and burnt of freſh Eſula	3 00 00	00 02 00
30 Roots of Liquoriſh	2 00 00	00 01 04
20 Pellitory	1 00 00	00 00 06
100 Green Endive	2 00 00	00 02 00
90 Green Bindweed	1 00 00	00 02 00
2000 Leaves of Lawrel	33 00 04	00 00 00
500 Leaves of Lawrel	6 00 00	00 10 00
1000 Water Mellons well ripe, the Seeds being taken	25 00 01	00 09 00
2400 Cucumbers	18 00 00	00 00 00
300 Wood of Ivy	9 00 00	00 00 00
50 Scorzonera dryed	8 00 00	00 00 00
300 Pine Apples, the Nuts taken out	3 00 00	00 00 00
150 Mugwort dryed	8 00 00	00 00 00
130 Leaves of *Cyprus*	6 00 00	00 00 00
10 Peele of Pomgranates dryed	08 00	00 00 00
2 Saſſafras	00 00	00 00 00
12 *Lignum Sanctum*	2 06 00	00 00 00
4 Yellow Sanders	01 04	00 00 00
4 Black Pepper	02 04	00 00 00
30 Ginger	1 07 00	00 00 00
12 Turbith	1 00 00	00 00 00
Wood of Firr	3 00 00	00 03 00
Scopæ	16 00 01	00 04 00
Scopæ	16 00 01	00 06 00

Heads.

Fig. 1.—Redi's tabulated results of plant ashes and the soluble salts contained therein.

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Heads of Old Garlick 32 lb were dryed in a Furnace and burnt, from the Aſhes there was hardly any Salt to be gathered.

Thirty Pounds of Wheat-Flower burnt in a Furnace with a little Sulphur, and burnt a new in a Potter's Oven, give 8 ℥ of very black Aſhes, the which being Baked again for Eight Days continually in a Brick Furnace, after the Lye was made, there could not be a Grain of Salt drawn. The like happen'd in 10 ℥ of Aſhes drawn from a Stare and a half of Bran, burnt firſt in the Furnace with Sulphur, and afterwards baked in a Potter's Oven, and in one of Bricks.

Fig. 2.—Soluble salts in the ashes of garlic, wheat and bran.

16. All the Salts whatever drawn from the Aſhes of Vegetables, taken by the Mouth, ſays he, have a Purging Faculty, and a great Meaſure more than what by ſome is believed in common Salt, which taken by the Mouth has little or none at all, or if it have any betwixt that of common Salt and Vegetables, the Proportion is but as Two to Eight.

17. This Solutive Faculty is of equal Energy in all the Salts in ſuch Manner that the Salt of Sumack, Peeles of Pomgranates, Mirtle Berries, or Maſtick Purges as much as the Salt of Rubarb, Sena Turbith, Mechoacan, and all other like purgative Drugs.

18. The Doſe to be uſed is the ſame in all the Salts, to wit, from Two Drachms and an half to half an Ounce, diſſolved in Six Ounces of common Water; and Broth he has obſerved by infinite Experiments, that half an Ounce uſes to Purge Three Pounds and a half, or Four, or thereabouts, of Matter more or leſs, according to the Complexions, and according to the Fulneſs of the Bodies.

19. In Purging he has found no difference betwixt theſe Salts that have ſharp Points, and thoſe that are obtuſe and blunt or cubical; he has made Proof very often in divers Perſons, cauſing the like cubical Stones of Cucum-

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bers, Ginger, Colewort, and of Liquoriſh to be picked out, and he has ſeen that they have worked with the ſame Energy as the moſt acute Hexagone Stones of the Salt of Pepper, of Cirnation Roſes, of Mechoacan, of Coleworts, of Cucumbers, &c.

20. From the aforeſaid Obſervations, tho' you cannot eſtabliſh a certain Rule, you may nevertheleſs conjecture, not without ſome Reaſon, *Firſt*, That the Salt drawn from the Aſhes of Herbs, Flowers, and of Fruits, &c. do not conſerve the Virtue, and that Faculty which Phyſicians believe the Herbs, Flowers, Fruits, &c. are endowed with. *Secondly*, You may very near be certain of the Proportion of Aſhes riſing from each Species of Vegetables, and of the Quantity of Salt which is afterward to be drawn from them; and it will not be ungrateful to the Reader that I put here the Differences by me computed (of the Aſhes, after the rate of 100 Pounds of Vegetables, and of the Salts after the Rate of One Pound of Aſhes) and depoſed according to the Order of the Exceſſes.

Fig. 3.—The purging or laxative properties of certain plants are not due to the soluble salts extracted from the ashes.

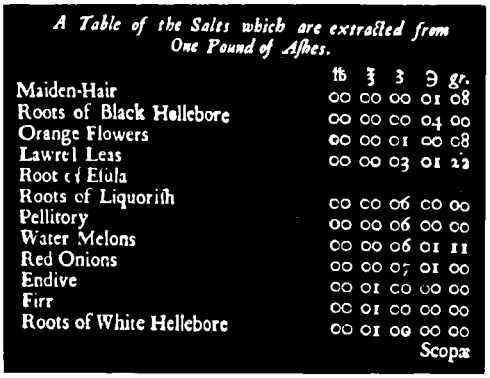
These interesting observations, on the ash content of plants, varying with the species, the condition under which they are grown, and the time of collection, made over two centuries ago, are the earliest recorded and hold good to this very day.

The information is now available to answer the questions propounded in connection with the statement quoted from Blyth.

A Table of the Aſhes which 100 ℔ *give.*

	℔	℥	ʒ	℈	gr.
Red Onions	00	04	04	00	00
Gourds	00	06	00	00	00
Cucumbers	00	09	00	00	00
Pine Nut-Shells	01	00	00	00	00
Yellow Sanders	01	00	04	00	00
Bindweeds	01	01	02	02	00
Laurel Leaves	01	02	00	00	00
Roots of White Hellebore	01	04	00	00	00
Other Leaves of Laurel	01	07	04	02	10
Endive	02	00	00	00	00
Wheat Flower	02	02	05	01	00
Water Melons	02	06	00	00	00
Ivy	03	00	00	00	00
Roots of Eſula	03	01	04	00	00
Saſſafras	03	01	04	00	00
Eyebright	03	04	00	00	00
Diſtill'd Roſes	03	04	00	00	00
Roots of Black Hellebore	04	00	00	00	00
Orange Flowers	04	06	00	00	00
Leaves of Cyprus	04	07	03	05	00
Pellitory	05	00	00	00	00
Black Pepper	05	02	04	00	00
Ginger	05	03	02	02	00
Mugwort	05	04	00	00	00
Pomgranate Bark	06	08	00	00	00
Roots of Liquoriſh	06	08	00	00	00
Turbith	08	04	00	00	00
Maiden-Hair diſtill'd	09	00	00	00	00
Scorzonera	16	00	00	00	00
Lignum Sanctum	20	10	00	00	00

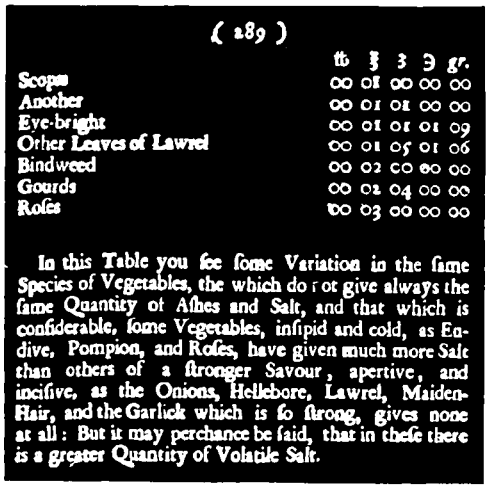
Fig. 4.—See title, top of plate. Second part 4 top of next column.



A Table of the Salts which are extracted from One Pound of Aſhes.

	℔	℥	ʒ	℈	gr.
Maiden-Hair	00	00	00	01	08
Roots of Black Hellebore	00	00	00	04	00
Orange Flowers	00	00	01	00	08
Lawrel Leas	00	00	03	01	23
Root of Eſula					
Roots of Liquoriſh	00	00	06	00	00
Pellitory	00	00	06	00	00
Water Melons	00	00	06	01	11
Red Onions	00	00	07	01	00
Endive	00	01	00	00	00
Firr	00	01	00	00	00
Roots of White Hellebore	00	01	00	00	00
					Scopæ

Fig. 4.—Second part. See legend at top.



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	℔	℥	ʒ	℈	gr.
Scopæ	00	01	00	00	00
Another	00	01	01	00	00
Eye-bright	00	01	01	01	09
Other Leaves of Lawrel	00	01	05	01	06
Bindweed	00	02	00	00	00
Gourds	00	02	04	00	00
Roſes	00	03	00	00	00

In this Table you ſee ſome Variation in the ſame Species of Vegetables, the which do not give always the ſame Quantity of Aſhes and Salt, and that which is conſiderable, ſome Vegetables, inſipid and cold, as Endive, Pompion, and Roſes, have given much more Salt than others of a ſtronger Savour, apertive, and inciſive, as the Onions, Hellebore, Lawrel, Maiden-Hair, and the Garlick which is ſo ſtrong, gives none at all: But it may perchance be ſaid, that in theſe there is a greater Quantity of Volatile Salt.

Fig. 5.—See explanation in plate.

1. Why did Redi make the determinations? Redi's objects were first to ascertain the degree of purgation present in the soluble salts of the ashes of the various plants tested; second, whether the laxative nature of the plants was due to the salts lixiviated from the ashes or not; and third, were the salts extracted from the various ashes the same, similar or different. It is quite apparent that the percentages of the ashes and the salts in the ashes recorded were largely incidental.

2. Why did Redi use 100 pounds for each plant substance ashed? The prime purpose for using large amounts was, apparently, to obtain sufficient ash, to make enough soluble salts, to enable him to test their physiological effects. A glance at the table shows that the amounts varied from 2 pounds in the case of sassafras to 2400 pounds in the case of cucumbers. Redi ashed 4 pounds of black pepper, 30 pounds of ginger and 150 pounds in the case of hellebore. From the results obtained, Redi did calculate the amount of ash, that would be present in 100 pounds, of thirty different products, but this is quite different from saying that Redi "burnt 100 pounds of each and weighed the ash."

3. How did he incinerate such large amounts? This is not clearly set forth in the article. Reference is made to the drying and burning and baking in a brick furnace, and in a potter's oven, but this is not as conclusive as it might be. One must take into consideration the large amounts ashed and the state of the developments of the arts.

4. Are the substances enumerated by Blyth, the only ones ashed by Redi? The answer is clearly no, but they probably served Blyth's purpose.

5. How do Redi's ash percentages agree with modern determinations? Blyth says: "These ash percentages as we know are accurate." It is well known that the ash content of the same part or parts of plants vary considerably, depending on a number of circumstances. Redi calls attention to several of them. The characters used in the article show that the author employed the apothecary system of weights in making his determinations, excepting the term "Stare" used in connection with the ashing of bran. This unit according to the "New English Dictionary" (Murray), appears to represent 220 pounds. The Doctor's data give the following percentages: Black hellebore 4%, black pepper 5.21% and ginger 5.27%. Modern determinations record the following: black hellebore 6.6%, black pepper 3.5–7% and ginger 5.25–7.5%. The latter percentages show that Redi's results agree well with the average of recent date. It may further be said, that his results, for some of the other plant substance ashed, are in good accord with the findings of modern investigators, in spite of the apparently crude method employed by him.

6. What was the purpose of lixiviating the ashes? The amounts of the water-soluble salts, are given in tabulated form, but it is quite evident that the chief purposes were, to ascertain the medicinal and crystalline natures of the salts extracted.

CONCLUDING OBSERVATIONS.

Redi's report on the study of ashes, stands by itself, in this field. It is one of the most interesting articles that it has been my privilege to study. To my mind it is a real classic. No important investigation, of any kind, on plant ashes, is reported for more than two centuries, following the studies of Redi in 1660. From this it must not be assumed that interest in plant ashes had ceased all this time. On the contrary it is reported that pot-ashes were made in Virginia and exported as early as 1608. In 1661, the exportation of potash, from the American Colonies, to any country, but England was prohibited by Parliament. The American forests continued to be burned, the ashes converted into pot and pearl ashes and exported for many years, thereafter.

It may be of interest to note that Samuel W. Johnson, professor of analytical and agricultural chemistry of Yale, compiled the trustworthy analytical data of the ashes of agricultural plants and products thereof, in print in 1867 and published the results in his book, entitled, "How Crops Grow," in 1868. The data are based largely on the work of Emil Wolff and his associates. Redi's work dealt largely with medicinal problems and was not referred to by any of the above workers.

GILES FIRMIN, SENIOR.[1]

BY WILL T. BRADLEY.[2]

In the fall of 1633, hands were imposed upon Giles Firmin, Senior, newly come from Sudbury in England to the colony settled about Massachusetts Bay, and he was thus made a deacon of the Boston church. A very godly man, upwards of forty years old, with some experience of public life in his youth, he proved a valued member of the community, was soon made a selectman, and served conscientiously; but during the hot months of the following summer he sickened, and by the time it was fall again he was dead. Very little else up to now has been known about him.

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