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A PHARMACOLOGICAL STUDY OF BIBLICAL 'GOURDS'

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Two Hebrew words are rendered 'gourd' in the Authorized Version, and both of these are of great pharmacological interest from an historical point of view. In Jonah 4. 6–10 the word 'ḳiḳayon' is translated 'gourd'. This word, according to many authorities, is the name of *Ricinus communis* or the castor-oil plant. In 2 Kings 4. 39 the Hebrew word 'paḳḳu'ot' is rendered 'wild gourds', and this plant is of even greater interest from the pharmacological and toxicological points of view. The writer has been interested in the latter passage, and has carried out some investigations on the subject, of which it is proposed to give a brief outline in this place.

The particular passage to which we are referring describes the accidental poisoning of a band of prophets and the means employed by their leader, the prophet Elisha, in combating it. The narrative reads as follows:

'And Elisha returned to Gilgal; and there was a famine in the land; and the sons of the prophets were sitting before him; and he said unto his servant, "Set on the large pot, and seethe pottage for the sons of the prophets."

'And one went out into the field to gather herbs, and found a wild vine, and gathered thereof paḳḳu'ot his lapful, and came and shred them into the pottage; for they knew them not.

'So they poured for the men to eat. And it came to

pass as they were eating of the pottage, that they cried out, and said, "O thou man of God, there is death in the pot!" and they could not eat thereof.

'But he said, "Then bring meal." And he cast it into the pot; and he said, "Pour out for the people that they may eat." And there was no harm in the pot.' (2 Kings 4. 38–41.)

The points of query suggested by the above passage and calling for elucidation are, first, what is meant by 'paḳḳu'ot'; secondly, what are its pharmacological properties; and thirdly, the most interesting of all, what can we say of the antidote here employed in the light of modern science? In order to shed light on these questions, it was necessary not only to gather, sift, and analyse a good deal of historical, philological, archaeological, and botanical data, but also to perform a number of original pharmacological and toxicological experiments. The results of these inquiries and experiments we shall now proceed to describe.

On the Meaning of Paḳḳu'ot.

The Hebrew word 'paḳḳu'ot' is rendered in the Authorized Version 'wild gourds', which, of course may mean anything or nothing. All biblical scholars and students of comparative philology, however, are agreed that the word 'paḳḳu'ot' must mean either the *colocynth* or the *elaterium* fruit. The etymology of the word, from the root 'paḳa'', to burst or to break open, may apply appropriately to either one. *Ecballium Elaterium*, or the 'squirting cucumber', owes its name to the peculiar character of its fruit which bursts open when ripe, ejecting the seeds mixed with a mucilaginous liquid. The *colocynth* fruit, when ripe and dry, is also easily burst open at the slightest touch.

Professor Haupt suggests that the root 'paḳa' ', to burst or break through or open, may also refer to the drastic effects of the drugs, both of which, as is well known, are violent purgatives and may produce vomiting (cf. the German word *brechen*, to vomit). The Septuagintal rendering τολύπη refers to the round fruit of *Citrullus Colocynthis*. The Vulgate has *Colocynthides* (cf. Pliny, xx. 14).

While the term 'paḳḳu'ot' may from the etymological point of view denote equally well the colocynth or elaterium fruit, there is other evidence, botanical and archaeological, which seems to point to the colocynth as the correct translation. *Ecballium Elaterium* (in Arabic, *kitha el-himar*) is a common plant in Mediterranean countries, but it could not with any propriety, as pointed out by Post,[1] be called a vine, for it is destitute of tendrils. According to Baillon, it is 'une herbe couchée sans vrilles'—a decumbent herb, without tendrils.[2] The *Citrullus Colocynthis*, on the other hand, is a true vine growing prostrate on the ground, but trailing by means of its powerful tendrils over shrubs and herbs. This plant is also common in the Jordan Valley, but is rare in the hill-country of Ephraim; so that the men who gathered it mistook it for another plant of the same family, the *Cucumis Prophetarum*, or globe cucumber, common in Samaria.

Still further evidence, suggesting that 'paḳḳu'ot', or wild gourds, denotes the *Colocynth*, is the fact that we find the same term applied to the architectural ornaments mentioned in the Bible in connexion with the Temple. In 1 Kings 6. 18 the word 'p'ḳa'im', or colocynths, is mentioned as an ornamental design in the interior woodwork of King

[1] Post, in Hastings' *Dictionary of the Bible*, vol. II, p. 250 a.

[2] Baillon, *Dictionnaire de Botanique*, 1886, t. 2, p. 493.

Solomon's temple; and in 1 Kings 7. 24 the same word is used to designate the ornaments encircling the molten sea or great brazen cistern in the Holy Temple. The elegant orange-shaped fruit of the colocynth plant lends itself well for ornamental purposes, whereas the small olive-shaped fruit of the *Ecballium Elaterium* is by no means so beautiful or attractive.[3] [5]

What do we know in regard to the poisonous properties of either the colocynth or elaterium? Before proceeding to discuss the toxicology of these plants, it may be well to describe briefly their physical and chemical characters.

Pharmacognosy.

Both the colocynth and the elaterium plants belong to the family of the Cucurbitaceae or the pumpkin family. The colocynth fruit, *Fructus Colocynthidis*, or the English *bitter apple*, and German *Koloquinte*, is the fruit of the plant *Citrullus Colocynthis*, a slender scabrous plant with a perennial root, a native of warm and dry regions in the Old World. It is found in the Mediterranean regions, in Arabia, Syria, and some of the Greek Islands. It grows in immense quantities in Upper Egypt and Morocco, and is also found in some parts of Spain and Portugal. The plant bears yellow monoecious flowers, deeply lobed leaves and well-developed tendrils which enable it to trail over other plants. The fruit, which is globular in shape, resembles an orange and has a smooth, marbled-green surface, being from 5 to 10 cm. or from 2 to 4 inches in diameter. For medicinal purposes, the colocynth fruit

[3] *Jewish Encyclopedia*, vol. III, p. 357.

[4] Nowack, *Lehrbuch der hebräischen Archaeologie*, 1894, II, p. 42.

[5] Benzinger, *Archaeologie*, 1894, p. 252.

is dried in the sun, then peeled, and is sold in this form in the market. The pulp is white, very light and spongy, and is readily separable longitudinally into three carpels, each containing numerous flat, ovate, white or light brown seeds. It is the pulp which is purgative in its nature. The seeds are not laxative at all and are said to be used in some parts of Africa for food.[6] The active constituents of the colocynth fruits are at least two: one being the glucosid colocynthin, having the empirical formula, $C_{56}H_{84}O_{23}$, from which colocynthein may be obtained by hydrolysis; the other is a closely related body named colocynthitin. Both of these principles are drastic purgatives.[7]

The elaterium fruit comes from the *Ecballium Elaterium, Rich.* (*Momordica Elaterium, L.*), a coarse, hispid, fleshy decumbent plant without tendrils, having a thick white perennial root. It is also common throughout the Mediterranean region, extending eastward as far as southern Russia and Persia, and westward to Portugal. The fruit is ovoid and oblong and nodding, about 1·5 to 3 cm. long with numerous short prickles terminating in white elongated points. It is attached by a long scabrous peduncle, is fleshy and green while young, becoming slightly yellowish when matured. It is three-celled and contains numerous oblong seeds lodged in a very bitter succulent pulp. The fruit when ripe separates suddenly from the stalk on the slightest jarring, and at the same moment, the seeds and juice are forcibly expelled from the aperture left by the detached peduncle. Hence the name 'squirting cucumber'.

Several active principles have been isolated from the elaterium, the principal one, *elaterin*, being a crystalline

[6] Pickering, *History of Plants*, 1879, p. 249.

[7] Husemann und Hilger, *Pflanzenstoffe*, Berlin, 1889, p. 1347.

body with a formula, $C_{20}H_{28}O_5$. Other constituents described are hydroelaterin, prophetin, and ecballin or elateric acid.[8] Both the colocynth and elaterium plants have been known from remote antiquity, and are mentioned by ancient writers—Pliny, Dioscorides, Theophrastus, and others.[9-12]

Toxicology.

Colycynth and elaterium are well known in therapeutics as powerful or drastic purgatives, and even small doses of these drugs sometimes produce great irritation of the intestines. Slightly larger doses of the crude drugs, as well as of their active principles, produce a dangerous enteritis, and still larger doses act as violent poisons, leading to death.

The poisonous nature of these drugs was well known in the Orient. C. M. Doughty (*Travels in Arabia Deserta*, Cambridge, 1888, vol. I, p. 132) says of the *Citrullus Colocynthis*: 'To human nature it is of so mortal bitterness that little indeed, and even the leaf, is a most vehement purgative. They say it will leave a man half-dead, and he may only recover his strength by eating flesh meat'.[13] Cases of poisoning with these drugs are described by the present writer elsewhere.[14]

Poisoning with colocynth has, on the whole, been reported more frequently than with elaterin, possibly

[8] Husemann und Hilger, *Pflanzenstoffe*, Berlin, 1888, p. 1350.
[9] Flüchiger und Hanbury, *Pharmacographia*, 1879.
[10] Kramer, *Pharmacognosy*, 1917.
[11] *United States Dispensatory*, 1917.
[12] *National Dispensatory*, 1917.
[13] Hastings, *Dictionary of the Bible*, vol. II, p. 286.
[14] Macht, *Johns Hopkins Hospital Bulletin*, February, 1919.

because the bitter apple has been employed to produce abortion.

The symptoms of poisoning by both colocynth and elaterium described by various authors are those arising chiefly from irritation of the gastro-intestinal canal. Vomiting, bloody stools, severe colic, collapse and convulsions, followed by death, constitute the general course of the intoxication. In some cases, symptoms referable to intense irritation of the kidneys are encountered.

The pathological findings reported describe an intense congestion of the stomach and intestines with ecchymoses and bloody serofibrinous exudates with adhesions. In more protracted cases, more or less extensive peritonitis with matting of the intestines and congestion of the kidneys, liver, and spleen, have been noted. The lumen of the intestines may actually be obliterated by the fibrinous exudate and adhesions of the intestinal walls.

Toxicological Experiments.

In order to study the symptoms of colocynth and elaterium poisoning more in detail, and in order to visualize more exactly what took place in the case of poisoning which we are discussing, and especially in order to determine the value of the antidote employed in that case the author has performed a number of toxicological experiments on dogs. In connexion with these experiments, it was interesting to note a toxic symptom, which is not mentioned by most authors on the subject and not emphasized sufficiently by those who have noted it, and which is especially interesting in connexion with the passage before us. In my experiments I made use of infusions of either colocynth

apples or the crude elaterium which can be bought in the market. The drugs were roughly cut up or ground up, and infusions were made by boiling them in ordinary tap water in a casserole with or without the addition of a little common table salt. This corresponded roughly to the conditions obtained in the case of the prophets. After the mixture had been boiled for half-an-hour or longer, the resulting infusion was strained through coarse cheese-cloth and was administered cold to the dogs through a stomach-tube. The symptoms following the administration may be divided into two groups, the primary and the secondary. The most striking primary symptom consisted of a profuse salivation which occurred even when the drugs were introduced through the stomach-tube, enough of the infusion coming in contact with the mucous membranes of the mouth when the stomach-tube was withdrawn to produce this irritation. The salivation was very intense; the animals foaming at the mouth more than after a dose of pilocarpin. This primary symptom, so little emphasized by other writers, is quite sufficient to account for the exclamation of the victims, 'There is death in the pot!' Vomiting was occasionally noted soon after administration of the infusions of colocynth.

An almost precisely similar primary salivation followed the introduction of an elaterium infusion into the animal's stomach. Following the primary salivation and occasional vomiting, the secondary or later symptoms of colocynth or elaterium poisoning did not come on until an hour or two later. These began with violent purging, soon followed by bloody stools, collapse, and depression. After large doses of either drug (the quantities described below), the animals were generally found dead on the following day. At

autopsy, the anatomical findings were: intense inflammation of the stomach and especially the intestines, with bloody exudate and adhesions, occasional peritonitis, and intense congestion of the liver and the kidneys.

In view of the marked irritation and destructive lesions just described, it is especially interesting to turn our attention now to the most perplexing feature of our narrative, namely, the antidote administered or employed by the prophet Elisha to antagonize the effects of the poison.

On Flour as an Antidote.

In order to ascertain whether the method employed by Elisha can be explained on a natural basis, the author in a purely scientific and impersonal manner carried out two series of experiments. In the one series, a number of dogs were given colocynth or elaterium infusions straight, that is, without the admixture of any other substance. In the other series exactly the same quantities of the infusions in proportion to the animal's weight or even larger doses of the poisons were administered after previous admixture with ordinary corn and wheat flour. The results of these experiments are very interesting and enlightening and may be best illustrated by the following protocols:

Exp. V, October 7. White dog weighing 7·1 kilos.

Five colocynth apples, weighing together 40 gm., were cut up and boiled with 750 cc. of tap-water. The mixture was boiled until the volume was reduced to 500 cc. It was then strained through coarse cheese-cloth and one-half of the infusion, or 250 cc., were given to the animal through the stomach-tube, about 2 p. m. Immediately after the

removal of the stomach-tube the dog became most violently salivated, foaming and frothing at the mouth so that the whole cage was bespattered with saliva. A little of the infusion plus stomach contents was vomited out. Two hours later, the animal was violently and repeatedly purged, the stools being fluid and tinged with blood. During the night, the frequent stools continued and assumed a much more bloody character. On the following morning the animal was found dead. The autopsy revealed a violent congestion of the stomach, especially of the small intestine. The intestines were filled with a bloody exudate, and, in some places, were stuck together by fibrinous adhesions. The liver also was congested and the kidneys to a very marked degree.

Exp. VI, October 7. Brown dog weighing 6 kilos.

Forty grammes of colocynth apples were cut up and mixed with 60 gm. of flour (equal parts of wheat and corn) and 1000 cc. of tap-water. The mixture was boiled until the total volume was reduced to 500 cc. It was then strained, in order to remove the seeds and debris, through a coarse cheese-cloth, and 250 cc. of the broth were administered to the dog through a stomach-tube exactly as in the preceding experiment, about 2.15 p.m. On removal of the stomach-tube, there was no vomiting and practically no salivation noted. About two hours later, the animal passed several normal stools, but no blood was noted in them, neither was there any blood noted in the stools passed during the night. On the 8th, the animal was lying slightly depressed and still had diarrhoea, but ate the food offered it. On the 9th, the animal was apparently completely recovered, running about in a lively fashion.

On comparing the two experiments described above, it will be see that in the case of the dog to which the pure infusion of colocynth was administered, both the primary

and the later symptoms of colocynth poisoning were very markedly developed, and in this respect differed from those noted in the other animal. The white dog was very profoundly salivated ; indeed, the salivation was more marked than that noted by the author after any other poison. Violent irritation of the bowels very early manifested itself as indicated by the bloody stool, and the animal died within eighteen hours.

In the dog to which the infusion of colocynth was administered together with flour, the symptoms were not at all so striking. There was practically no salivation at all and no vomiting, nor did the stools indicate any violent irritation of the intestinal mucosa, and the animal recovered completely within two days.

Exactly similar results were noted in experiments with elaterium.

Discussion.

To the superficial reader of the Bible and to a class of destructive critics who are prone to condemn any statement in that Book which does not accord with their own personal subjective views, as an impossibility or a figment of the imagination or as a perversion of the original text, the results of the above investigations may appear unexpected and possibly even disappointing. To the truly unbiased scientific mind, however, which does not condemn or disbelieve anything, but only demands facts and proofs, the above experiments are not altogether surprising, and the biblical narrative which we are discussing does not appear at all improbable. In fact, the results of the experiments just described well agree with the teachings of modern chemistry and pharmacology. Recent advances in those

sciences have revealed the very important *rôle* played in the physiological economy of animal organisms by the so-called 'colloid' substances. It has been shown that an admixture of colloidal and even of non-colloidal but inert and inactive matter to various foods and drugs may profoundly influence their absorption and their action. Thus, for instance, Mendel and Lewis[15] in a paper on 'The Rate of Elimination of Nitrogen as influenced by Diet and other Factors', have found that with a definite diet it is always possible to get a definite typical curve of nitrogen elimination. On the addition, however, of various inert or colloidal substances, such as minerals, vaseline, bone-ash, filter paper, cork, agar-agar, &c., to exactly the same diet, the curve is entirely changed, and the rate of nitrogen elimination in such cases is greatly delayed.

Again, Fantus[16] and others have found that admixture of kaolin and other inert matter may greatly modify the action of strychnin and other poisons. It is, therefore, not entirely surprising to find that flour or meal should profoundly modify the action of the infusions of colocynth or elaterium and render them innocuous, and the popular first aid maxim to give flour in many cases of poisoning has a real rational basis. What the exact mechanism of this antagonistic action is, is not quite clear, but undoubtedly several factors are involved in the phenomenon. The colloid broth, in the first place, hinders the absorption of the poison; secondly, the flour probably acts as a demulcent and protective to the intestinal walls; and thirdly, this substance must also exert some effect by

[15] Mendel and Lewis, *Journal of Biological Chemistry*, 1913, vol. XVI, p. 19.

[16] Fantus, *Journal A. M. A.*, 1913, vol. LXVII, p. 1838.

virtue of its adsorptive properties.[17] Whatever the exact mechanism of flour as an antidote may be, there can hardly be any doubt as to the plausibility of the biblical narrative before us, and in the light of the experiments performed, the story, if not a miraculous one, certainly attests to the wonderful insight and wisdom and practical experience of the seer Elisha.

[17] Bayliss, *General Physiology*, 1915 (chapter on Surface Action and Colloid Solutions).