THE STORY OF THE PAPAW

(ILLUSTRATED)

BY FRED B. KILMER

GATHERING THE MILK OF THE PAPAW.

THE BRUNSWICK PHARMACAL CO.
New Brunswick, N. J., U. S. A.
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INTRODUCTION.

The "Story of the Papaw" is a unique and valuable contribution to the literature on this famous plant. The author speaks from authority, for he devoted some ten years of almost continuous study and research on the Carica papaya and its peculiar digestive ferment. His investigations extend from the plant in its habitat to the most thorough study in the laboratory.

The basis of this publication was originally an address given at a pharmaceutical meeting of the Philadelphia College of Pharmacy, May 31, 1901. It was later published in the *Journal of Pharmacy* and is here reproduced in shortened form with the consent of the author.

It is with pleasure and confidence that we present to the medical profession this most entertaining story of the papaw. On the last pages of the pamphlet we have added a statement giving the physiological and therapeutic action of Papoid, the true ferment of the papaw. We believe that this publication will clear up many of the misstatements which have appeared in reference to this plant, and will establish the great value of Papoid as a vegetable digestive ferment, placing it among the standard drugs of modern medicine.

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"The slim papaya ripens its yellow fruits for thee."—Bryant.

Grant Allen tells us that no plant can be properly understood apart from its native place, so we begin our study of the Carica papaya in its tropical home. The Carica papaya is accredited as indigenous in Central America. Observations and correspondence lead me to conclude that it has become acclimated in the hot regions of three continents. The zone of most abundant growth seems to lie between the isothermal lines of 77 degrees wherever soil and rainfall are favorable, but it is grown by cultivation north and south of these lines.

THE ZONE OF THE PAPAW.

The carica papaya grows prolifically between isothermal lines of 77°; is grown by cultivation between the lines 70°.

In these tropical lands, where every tree or plant has its peculiar legends and myths, the views of the natives upon plant life are considered unscientific and valueless, but I have found that, when stripped of the terms of superstition, some of their observations, compared with our scientific knowledge, are not far apart. Their apparent veneration for trees and plants is based upon intimate association, wherein they have come to a knowledge that plants eat, drink, marry, propagate, care for their offspring and bestow blessings or curses upon all living things, including man. This is about all that anybody can know about them.

Many trees are famous in these lands, none more so than the papaw. Conflicting stories as to its powers and properties are due somewhat largely to the fact that different species, or variations in species possessing varying characteristics, are found in these localities.

Quite universal is the knowledge of the unique property that has given to this tree its world-wide fame, viz.: the power of its milky juice to soften and dissolve tough meat. The statement has passed current in our journals that the emanations from this tree will dissolve and digest albumin, and that it is the custom of the natives to hang meat and chickens in the branches of a tree to render them tender and edible. The natives often go further than this; they state that if male animals browse under the papaw tree, they become emasculated. If we compare this statement with the alleged property of the roots as a generative tonic, we shall have a marvelous combination of an aphrodisiac and an anaphrodisiac in the same plant. It is needless to urge that such stories are exaggerations of the pepsin-like properties of the fruit.

The native uses of the papaw are numerous and varied. The bark is used in the manufacture of ropes; the fruit is edible, and, according to local conditions, may be sweet, refreshing and agreeable, or in other localities it is sickly, sweet and insipid. The fruits find a large consumption by the natives, and are considered very nutritious. At the corner of a sugar-cane field, where the ragged canes bend over in a wild green, brown and yellow tangle, there will be standing a papaw tree, and if the time of the papaw has quite come, beneath the tree will be assembled a half-dozen negroes.

The natives enjoy its flavor, while the stranger has to acquire the liking. Excellent preserves are made of the ripe fruit, which, for this purpose, is boiled down in sugar and candied (like citron). It is also eaten as we eat melons. Salt enhances the flavor, and some users add sugar. The melons must be perfectly ripe when eaten raw, as the green fruit contains a strongly marked acrid principle. The color of the ripe fruit is more or less that of our very yellow muskmelon. The sweetness of its resinous, pulpy juice clings to the tongue and remains prevalent for some hours.

Just before ripening, the fruit is peeled and sliced, macerated in cold water, with frequent changes of the water for some hours, and then dropped into boiling water, boiled sharply and then served as a vegetable. At the sugarhouses slices of the papaw are often seen seething in hot syrup. The slices of melon combined with some acid fruit are made into native tarts, which articles correspond more or less to what we call "pies." The fruit is also stewed and served on the table. The green fruit is made into plain and spiced pickles, which are highly esteemed. In every tropical village one will find a market place set apart where the native products are bought and sold, and in

Selling papaw fruit in the market.

such a place by the roadside, under the shade, are the market women. In their quaint baskets or bowls, the traveler finds an astonishing and puzzling variety of green and yellow-colored fruits and vegetables. The papaw is always there in abundance, and a most frequent cry of the sellers is "Aqui estan las Mameo," or "Ca qui vle, papaya, ca qui vle."

The seeds are reputed as anthelmintic and emmenagogue; they are also used as a thirst quencher, form component parts of a drink used in fevers, as well as being used as a carminative. Syrups, wines and elixirs made from the ripe fruit are expectorant, sedative and tonic. They are also eaten as a delicacy, leaving an agreeable taste, something on the order of the water-cress and a piquancy slightly suggestive of the mustard family. Macerated in vinegar, they are served as a condiment.

A malady which the natives call the " cocoa bag " is a troublesome tropical disease, reputed to be hereditary and contagious; at all events, it seems to lurk in the blood of persons of otherwise apparently good health and habits. Suddenly the victim becomes a mass of offensive sores, debilitated, etc. The native doctors add the papaw fruit to the diet drinks used in this disease, and succeed in moderating its violence, at least. To the sores a paste, made with the papaw milk as one of the constitutents, is also applied.

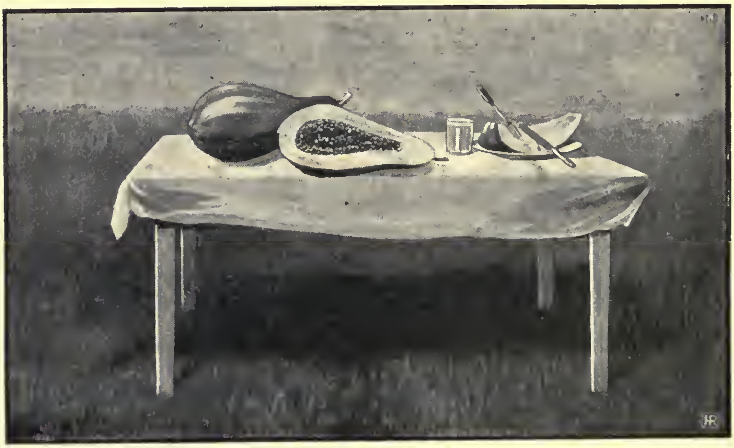
The slight pimples accompanying the first stages of the yaws soon spread into ulcerous sores that cover the entire body. Here, too, the claim is made that a slice of the papaw rubbed over the pimples will abort them. It is also claimed that the ulcers may be cleaned in a similar fashion.

I witnessed a most striking cleansing of a black foot in which the chiga had bored and laid its eggs, producing a mass of foulness beyond description. Here a paste of the papaw milk was pushed into the seething mass and kept there for forty-eight hours. It was then flushed, cureted and antiseptics were applied. A clean wound which readily healed, resulted.

The green leaves or slices of the green fruit of the papaw are rubbed over soiled and spotted clothes, and by its power of dissolving stains, papaw has acquired the name of " melon bleach." The leaves or a portion of the fruit are steeped in water and the treated water is used in washing colored clothing, especially black; the colors are cleaned up and held fast.

The strange and beautiful races of the Antilles astonish the eyes of the traveller who sees them for the first time. It has been said that they have taken their black, brown and olive and yellow skin tints from the satiny and bright-hued rinds of the fruits which surround them. If they are to be believed, the mystery of their clear, clean complexion and exquisite, pulp-like flesh arises from the use of the papaw fruit as a cosmetic. A slice of the ripe fruit is rubbed over the skin and is said to dissolve spare flesh and remove every blemish. It is a toilet requisite by the young and old, producing, according to the words of a French writer, "the most beautiful specimens of the human race."

The papaw has been brought to America as a cure for the national disease, dyspepsia. In its tropical home there are no dyspeptics, but its use along similar lines is by no means unknown. The meat in these countries is tough and tasteless; beef, mutton, pork or fowl have the same flavor, and are as tough as hickory wood; boiling until they fall to pieces does not render them more edible; they simply change from solid wood to fine, tough splinters. One reason for this is that in this climate meat must be eaten immediately after slaughter. (It often reaches the pot in an hour after killing.) The papaw helps to over-



A tropical desert of ripe papaw melons.

come this. Rubbed over tough meat it will render it soft and change a piece of apparent leather to a tender, juicy steak. It is put into the pot with meat, enters into the cereals, soups, stews and other dishes, and they are made at least more edible and digestible.

Most of the half-breeds of Indian extraction upon the South American continent and adjacent islands are particularly given to meat diet; many of them eat it raw: sometimes in a state of partial decay, and here the papaw is brought into use, being eaten with the flesh rubbed over it before it is eaten. Some of these people are great gluttons; they gorge themselves until the skin on their distended stomach is stretched to its utmost. It is certain that no human being could digest the kind of food and the enormous amounts they consume without the kindly aid of the papaw fruit to assist digestion.

The botanical characteristics of this family having been more or less completely described by various authors, need not here be repeated. Of the many species the following are edible: Carica cauliflora, C. pyriformis, C. microcarpa, C. integrifolia, C. papaya, and C. quercifolia.

The Carica digitata is credited with poisonous emanations, and its juice is actively poisonous, causing pustulation when applied to the flesh.

The Carica papaya is designated by different names in the various localities where found. For instance, in Mexico, " lechoco ; " in Brazil, " papai," " mameo " and " mamerio ; " in Paraguay, " mamon." Here, too, the term " jacarata " (chakarateca) is applied to the Carica papaya, as well as to several trees of the same natural order.

In Yucatan the native uncultivated variety is designated as " chick put," or little papaya, while the cultivated is simply "put." The Spaniards designated the original species as " papaya los pajaros," or " bird papaya." The term " papaw," though sometimes applied to several species, almost universally means the Carica papaya.

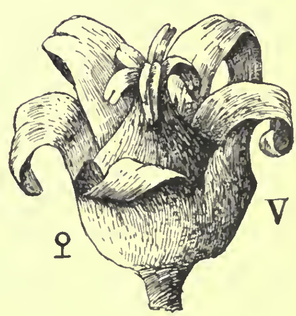
The Carica papaya may, in brief, be described as follows :

A single, supple, slim, straight stalk, terminating in a group of large leaves which are arranged in the form of an umbrella. Cultivated plants attain a height of from ten to thirty feet ; wild varieties push up to sixty or even to one hundred feet. Near the base of mature trees the diameter ranges from six inches to one foot.

A large turnip-shaped tap-root reaches down to seek nourishment and to give stability to the tree. The leaves are large palmlobed, dark green on the upper and light green on the under side.

The locality where grown, as well as the effects of cultivation, modify the character of this plant, causing many varieties, among which are the green and violet plants. In the latter species the stalk and limb portion of the leaves are violet color. The fruit is large, often weighing as high as twenty pounds, and when ripe is very sweet. By cultivation a dwarfed variety (" lechoso enana ") is produced. The green Carica grows to a greater height than the purple ; its fruits are smaller and possess a less agreeable flavor.

The three forms of flower present in the papaw are, according to the native description, classified as varieties. The so-called female trees bear only fruiting flowers and produce the largest fruit and the



I—Carica papaya, branch of male or hanging papaw.

III—Male flower of papaw.

IV—Pistillate or fruiting flower.

V—Young fruit.

greatest numbers. The fruit development is so rapid that buds, flowers, green and ripe fruit are often seen at the same time. The male flowers are borne on hanging stems, ranging from six inches to one foot or more in length (hence the "hanging papaw"). The hanging stems in older trees bear fruiting flowers and present a somewhat curious sight. The fruits vary considerably in form as well as in size. They are orange-shaped, squash-like, or quite resembling the cocoa pod; again, they resemble muskmelons, and in the highly cultivated variety watermelon shapes are seen.

The flesh of the green fruit is white, tough and watery. As the fruit ripens it turns to a muskmelon yellow, with a thickness of about one and a half inches, the central cavity being filled with seeds, which, when dried, resemble pepper.

CULTIVATION AND GROWTH.

There are no forests of papaw, because the plants need sun and room. They are seldom seen among dense growths. They do not propagate in clusters. For the most part they are the product of cultivation, and near every hut are carefully guarded groups from two to six in number.

They present a striking appearance with their straight, slim, shiny stalk; their bright green umbrella tops towering above a wilderness of flower-sprinkled verdure. Most beautiful specimens are seen in such a place, their base covered with a tangled undergrowth of trailing, climbing vines. Under these conditions fruiting is generally abundant. The young plants are exceedingly sensitive and tender, exhibiting somewhat the characteristics of the melon tribe.

A place where it never rains but always pours seems best suited to the papaw. It grows at the edge of the sea with the waves washing the roots, luxuriates in the high mountain plateaus, in all of the windward and leeward islands: it flourishes, but does not attain to any great height on the bare coral rocks of Yucatan. In parts of Peru it grows prolifically without much cultivation or care, and it is reported that in the Transandine regions it reaches a height of over one hundred feet.

In some localities the plant begins to grow fruit in seven months; in others, eighteen to twenty months from the seed. Usually its life is rather short, two to three years being the maximum fruit-bearing period. The fruiting of the papaw is abundant. From two to three hundred have been gathered in a season from a wild tree in size varying from an inch in diameter to that of a baseball. The cultivated plants yield from twelve to sixty fruits, weighing from five to twenty pounds each.

It is reported that in Brazil, in the French colonies, in Algiers, and in the island of Reunion, successful and extensive cultivations have been carried on. In the island of Jamaica, under government patronage and the care of William Fawcett, director of the botanical gardens, several attempts at the cultivation of this plant were undertaken on a large scale, but the results were not encouraging. Plots consisting of five acres in the first instance, and ten acres in the second, were pre-

Carica papaya "wild."

pared by clearing, seeds were carefully selected, one portion of the seed being sown directly in the ground, other portions sown in bamboo pots, and the young plants transplanted. In the first instance a rather fair proportion of the trees came to maturity and began fruiting, but at this stage disease set in, insects attacked the plants and the whole field was exterminated. The wild plants do not seem to be attacked by disease except after injury, but the cultivated plants seem very susceptible to every sort of malady. After fruiting, and especially if the fruits are bled, the tree will take on a general debility and become the prey of every adverse circumstance.

In another series of planting conducted with still more careful preparation of the ground and selection of seeds, coupled with care for the young plants, there was a record of a small portion of the plants coming to maturity, and of these only a meagre part bore fruit. None of the plants or their fruits were as large as those of the parent stock.

Carica papaya, cultivated.

The papaw is likewise very prone to variation. Seeds selected with extreme care from flourishing trees, the fruit of which would weigh fifteen pounds, upon being planted would in part follow the parent stock; other portions would revert to the wild prototype and yield fruit the size of a hen's egg. In some of the fruits of the papaw the seeds number five, in others prodigal nature supplies over five hundred; apparently only a few of these seeds are fertile.

THE MILK OF THE PAPAW.

Trees that give milk are plentiful in the tropics. The native name for the papaw is "lechoso" (a producer of milk). When an incision is made in the bark of any part of the tree or the fruit rind, a limpid, milk-like liquid exudes very freely. It is slightly more dense than water, and in contact with the air quickly coagulates and closes the incision. This coagulation is a rather notable phenomenon. For the fraction of a minute the milk flows as though a milk bottle were uncorked, and one supposes that gallons will flow without stopping, but it suddenly ceases. On examination it is found that the milk is coagulated for a considerable distance within the glands. I am quite firmly convinced that this action is due to the presence of a clotting enzyme.

Hanging papaw.

Some of the difficulties of gathering the milk can be imagined by the recollection that in some cases the fruits are from twenty to thirty feet from the ground. The coagulation allows only a small yield, requiring constant climbing to make fresh incisions

This milk seems to be secreted for the most part from fairly large vessels (readily observable by a pocket lens), which lie just under the epidermis in every part of the plant. In the ripened fruit it seems to permeate to all parts of the fleshy portion of the fruit (somewhat changed in character). The dried milk of the papaw is an article of commerce, and its character is dependent upon the method of preparation. The main source is the crude methods of the natives.

The latex, when allowed to dry on the fruit, becomes discolored and dark. The lighter-colored and best products are produced when the coagulated juice is removed as fast as it exudes, spread out thin and quickly dried.

OFFICE OF THE MILK AND ENZYME.

The office of this milk in the economy of the papaw is not easy to explain. Parkin states: "The most important function of such a latex is that of holding water in reserve." This seems hardly possible in respect to this plant, because all tissues of the plant are filled with a watery fluid, so much so that they flow upon cutting, and it is possible that the tree is dependent upon the milky juice for a supply of moisture. The native observers suggest that the milk has to do solely with the ripening of the fruit, and it is true that as the fruit ripens it is in all parts permeated with the milk, and as a consequence the starch compounds are changed to sugar; the proteids are peptonized, and the flavor mellowed. But it would seem to be a prodigious waste of energy if this ripening action was the only action of the milk and its enzyme contents.

Assuming that there is at the lowest estimate one hundred ounces of latex in a tree, we would have twenty ounces of dried material capable of converting about three thousand pounds of proteids.

We do know, however, that this latex is the carrier of enzymes, and that in plant life certain enzymes play an important part in incorporating material for the growth of the living substance or of preparing material brought to it, so that it may be capable of such incorporation. Again, they bring about compositions which supply the energy needed for the maintainence of vital processes. In other words, these enzymes digest and prepare food for the plant life and growth.

J. Reynolds Green has shown that in the process of nutrition in plants, when the construction processes are active, an excess of material is elaborated and deposited in temporary reservoirs. This material is utilized by a process of digestion brought about by the agents of enzymes or ferments which are formed to digest these deposited materials. From many plants we have been able to separate diastasic, proteolytic, glucosidal, emulsifying and other ferments.

The papaw is a plant of quick growth. It rapidly appropriates and converts decaying vegetation Its best fertilizers have been found to be dead vegetable and animal matter, house waste, etc. This suggests that the presence of this abundance of enzymic power is necessary for the digestion and conversion of plant-food material, and that the material is prepared for incorporation in the living plant by the enzymes present in the latex.

Native method of drying papaw milk.

The milky juice of the papaw can therefore be imagined as quite akin to the gastric or pancreatic juice of the animal organisms. The ducts through which this latex flows are possibly digestive tracts; their contents, an emulsion of partially digested proteid and other material, under transformation preparatory to ultimate assimilation.

CORROSIVE PROPERTIES OF THE LATEX.

The corrosive action of the later has been recorded; all species have this property in some degree; in fact, a caustic property is not unusual in many tropical plants. Persons who handle the green fruit in the preparation of pickles are troubled with raw and bleeding fingers and are forced to abandon the work. The fresh latex will irritate the mucous membrane and its continuous use is very caustic; in some instances, very escharotic.

The corrosive constituent is not volatile and remains in the dried juice. An examination of many of the preparations sold in our market under the name of "papain," etc., shows that this corrosive property had not been altogether removed.

ANALYSIS OF PAPAW LATEX.

This latex is an emulsion of fats and wax, containing also extractive matters, albumen and salts, as shown by the following:

Caraca Latex—Sun-dried.

Moisture	6.06
Soluble ash	2.64
Insoluble ash	4.78
Matters soluble in water (including ash)	82.74
" " " benzine	11.43
" " " ether	9.77
" " " chloroform	11.20
" " " acetone	5.98
" " " alcohol	7.16

Ash.

Total ash	7.42
Soluble ash	2.64
Insoluble ash	4.78
Calcium sulphate, insoluble ash	0.896
Calcium phosphate " "	3.72
Silica " "	0.164
Calcium sulphate, soluble ash	1,024
Potassium, sodium, lithium, chlorides and carbonates, soluble ash	1.616
Chlorine	0.22
Ferric oxide	trace

As a result of a rather hasty examination of these extractions, we may assume that they contain coloring matter: "vegetable extractive matter;" hard and soft waxes; hard and soft resins; a volatile resin; a substance of the nature of fat-free acids; pectose compounds.

Water Soluble Contents.

The dried latex extracted by repeated washings with water gives 82.74 per cent. of matter, soluble to a clear, greenish-yellow solution. This watery extract is of acid reaction and responds to the usual reactions for the presence of proteids.

Further researches indicate that we have in this substance a mixture of globulin, proto and deutero albumose with, possibly two or more forms of peptone.

ANALYSIS OF PAPAW PROTEIDS.

From the examination of the water soluble contents of the latex of the papaw, the conclusion was reached that the enzyme was associated with one or more of the soluble proteids. And analysis of these porteid bodies was therefore made as follows ·

For the purpose of anaylsis a portion of the air-dried latex was extracted with alcohol, benzine, and ether, to remove waxes, resins, etc., the residue consisting of the proteid matters and ash. This preparation is marked I in the accompanying table.

A second preparation was made by extraction of the milk, as above, the product dissolved in water and the proteids precipitated by sodium chloride, and the precipitate partly freed from excess of salts by dialysis.

This process was repeated with a view of obtaining an approximately pure preparation, and one representative of the enzyme of the latex. This preparation is marked II in the accompanying table.

Papaw Proteids.

	I	II
Air-dry.	Per Cent.	Per Cent.
Carbon	39.96	42.81
Hydrogen	6.57	6.77
Nitrogen	11.26	10.09
Ash, or mineral matter	9.88	6.51
Moisture (loss at 100-105 degrees C.)	10.83	7.90
Moisture free.		
Carbon	44.81	46.84
Hydrogen	6.00	6.39
Nitrogen	12.62	10.95
Ash	11.07	7.06
Moisture-free, ash-free.		
Carbon	50.38	50.01
Hydrogen	6.74	6.87
Nitrogen	14.19	11.78
Oxygen	28.69	31 34
Total	100.00	100.00

The large proportion of mineral ash in the purest preparation—II—is notable and seems to indicate that the proteid constituents and the ash are most closely associated. Otherwise, we may observe that the carbon stands in about the same proportion as in other vegetable proteids We have, however, a much smaller amount of nitrogen than of proteids; but this low content of nitrogen is quite in accord with the constitution of some of the enzymes which have been examined.

THE FERMENTS OF THE PAPAW.

The latex of the papaw is notable from the fact that it contains several soluble enzymes or ferments, or else (if such a thing is possible) a ferment body with a manifold power. The ferments so far noted as contained in the latex are:

(1) A proteolytic ferment which decomposes proteids.

(2) A coagulating (rennet-like) ferment which acts upon the casein of milk.

(3) An amylolytic ferment having the power to attack amylose, starch etc.

(4) A clotting ferment similar to pectase.

(5) A ferment possessing feeble powers of action upon fats.

The digestive action of the latex at the instant of its extraction from the green fruit is very marked. Placed in contact with such a substance as blood fibrin in a little water, the fibrin will be disintegrated before your eyes mixed with milk and warmed, the milk is instantly coagulated. Boiled starch paste is thinned, and the blue color produced upon starch by iodine is changed to a purple in a few minutes. Poured over lumps of beef and placed in a warm place, the meat is softened, its fibres disintegrated, finally becoming a partially transparent jelly. The action upon cooked egg albumen is not so marked.

The latex, when dried, retains these powers in a somewhat lesser degree. I am of the opinion that the ferments exist in the latex, and possibly in the cellular structure, as a zymogen (carizymogen).

The ferment may be extracted from the dried milk by water or glycerine (neutral, acid or alkaline), by very dilute alcohol (5-100), and from such a solution may be precipitated by any of the usual methods, such as an excess of full strength alcohol, saturation with alkaline salts, etc.

Something like thirty methods for extraction have been tried in my researches, with the result that all methods where precipitation is involved tend to weaken the digestive power of the ferment. The methods used in the separation of pepsin whereby a purified and high power pepsin is produced do not seem to be applicable to the papaw.

It has been stated that the ferments of the papaw are chiefly associated with one of its proteid constituents. I have never been able to verify this statement. When any of the various forms of proteids are separated (except by the processes of heat or coagulation) the separated body will be found to possess ferment power. Even the peptone remaining after separation of the albumoses exhibits feeble powers. The ferment action seems to be the most marked when all of the proteids are associated together in their natural form.

GLUCOSIDE OF THE PAPAW.

The Carica papaya contains a glucosidal body, caricin. This I have never been able to obtain except from the seed, in which it is fairly abundant. A glucoside resembling sinegrin may also be extracted.

The seeds also contain the glucoside, splitting ferment myrosin. The glucoside resides within the hard inner coating of the seed, while the myrosin ferment is secreted in the gelatinous outer envelope.

ALKALOID

An alkaloid, carpaine, has been separated from the Carica papaya. The source so far noted has been the leaves.

In my experiments the yield was small. I have noted traces of alkaloidal reaction with Mayer's reagent from alkaline ether washings, from the latex, but it cannot be stated that the alkaloid is present in this product. It is soluble in absolute alcohol, amylic, alcohol, chloroform, benzine and in water acidulated with hydrochloric acid.

Its physiological action is quite similar to that of digitalis, a heart depressant.

MARKET PREPARATIONS OF THE PAPAW.

There are numerous preparations in our own and in the European markets claiming to be the ferment of the papaw. These are sold under various names.

From a somewhat extended examination I am quite satisfied that several of the preparations named are the papaw milk dried and powdered. In this case they bear the same relation to the true separated ferment, as the dried mucous membrane of the stomach might bear to purified pepsin. Some of these so-called papains retain the waxy, rubber-like constituents, and the acrid, irritating resins of the milk.

The application of such crude material of the term "papain," or any similar name which would imply the isolated ferment, is misleading and should be abandoned. The dried juice of the papaw, or a mixture of the dried juice with any other ferments, should be properly labelled. From these crude preparations the true ferment can be separated by extraction with water, and precipitation with alcohol. In a few experiments which I have tried, some of the crude preparations were found to contain only twenty per cent. of the ferment-bearing bodies (albuminous).

There are, however, preparations in the market which consist of the more or less purified and separate ferment, or, more accurately speaking, consisting of the separated proteids; with these proteids the ferments are associated.

I know of no standard by which these market preparations can be judged. They vary greatly in their proteolytic action. In such as may be prepared by simply drying of the milk, no two lots can be alike. These will be found to vary in color, to emit an offensive odor, and to have a marked acrid, disagreeable taste, producing, in several instances in my experience, quite a sharp, caustic action.

The dried papaw juice is usually the more energetic in the beginning of digestive action than is the purified ferment, but this energetic action of the dried juice apparently soon ceases, while the pure ferment, though slower in immediate action, continues its activity for many hours.

In the best of market preparations which I have examined I have found insoluble globulins and an appreciable amount of peptone, the latter not being precipitated by the foregoing methods.

DIGESTIVE ACTION.

The digestive action of the ferment of the papaw plant has been quite fully described. The actions which are here summarized have been made with one of the market ferments sold under the name of Papoid.

Papoid is a German production, and, according to the statement of the manufacturers, it is prepared by precipitation from a watery extract of the papaw juice or milk. It consists essentially of globulin and albumose, associated with the ferments, and, in addition, it contains a small amount of natural inorganic salts. This preparation was used by the writer in a previous communication, and by Chittenden. (See " Papoid Digestion " Transactions of Connecticut Academy, Vol. IX., 1892.)

The action of this ferment presents features which contrast peculiarly with those of the ordinary digestive ferments. Direct comparison of the enzyme of the papaw with any other ferment is practically impossible, and this is especially true as to their behavior in comparison with the animal ferments.

The action of most ferments is inhibited by the products of digestive action; such does not seem to be the effect in the case of the papaw enzyme. It acts in a concentrated solution, even when carrying products of its own action. Certain of my experiments tend to show, however, that this enzyme has a notable action in a stream of running water. In other words, its action seems to be continuous, and the ferment is not removed by washing or by the action of fluids in which it is soluble. One such experiment was as follows:

Two ounces of raw beef were cut into slices, over which was poured an alkaline solution of the papaw ferments. The beef was allowed to remain in this solution for half an hour, during which time the solution was fairly well absorbed and the beef somewhat softened. The whole was then wrapped in a filter paper, transferred to a fine muslin bag; this bag and contents were placed under a faucet of running water and allowed to remain for five hours. Upon opening the bag it was found that only a few shreds of meat remained. In order to demonstrate that the action was not that of a washing away-process due to force of the water, a check experiment was made without the ferment, and the loss in weight only amounted to about fifty per cent.

This experiment seems to show that the enzyme combined with and hydrated the fibres of the meat. The products of this combination are soluble, and are removed by the action of water or other fluids; furthermore, in the process of washing away the soluble products, the ferment is left behind to act upon a fresh portion of the fibre, in turn giving rise to soluble products or peptones.

This experiment was made in order to imitate certain known conditions present in the process of digestion, where there is a constant stream of fluid in the intestinal tract. Taken with other experiments, this result seems to show that ferments of the papaw act very energetically in a small amount of fluid, and will also act in a stream of water.

The influence of reaction upon the ferments of the papaw form an interesting comparison with those of the animal ferments. The power of pepsin is destroyed in alkaline solution, such as lime water, sodium bicarbonate, ammonia, etc.; on the other hand, the activity of pancreatin, pyatolin or diastase is inhibited in acid solution. The papaw enzyme is active in acid, neutral or alkaline solution; but pepsin and pancreatin cannot be mixed together in solution either acid, alkaline or neutral, and still preserve their characteristics; whereas, the ferments of the papaw can be mixed with other ferments in a solution of any reaction. Pepsin is inert in a neutral solution, and is destroyed in solutions containing traces of alkalinity. If an alkaline solution of pepsin be made acid, the pepsin action is not restored; pancreatin acts slowly in neutral solutions, and is destroyed in acid solution. If an acid solution of pancreatin be made alkaline, the pancreatin action will not be restored. The papaw ferments are active in neutral solutions; their activity is enhanced when such solution is made acid, and if such acid solution be in turn made alkaline, the ferment will still remain active. In fact, the changing of solution of the papaw ferments from acid to neutral, then to alkaline; then reversing the order to neutral, acid and alkaline, or, in fact, changing the order of reaction almost indefinitely, does not thereby destroy the ferment which seems to remain active under all reactions and conditions.

Certain physical changes in the proteid substances acted upon are characteristic of these enzymes of the papaw. For instance: when raw beef is acted upon with an alkaline solution of these ferments, there is an immediate softening to a jelly-like mass in which the fibres lose their individuality, this jelly gradually becoming thinner under the further action of the ferment.

This action in the case of blood fibrin is quite striking, and advantage is taken of this property in therapeutics where a solution of the ferments is used as a solvent for the false membrane of diphtheria, a substance quite analogous to blood fibrin.

In the case of cooked beef in either alkaline or acid solution, the action of the ferment of the papaw is quite different. There is a rapid disintegration of the fibres which separate into tiny fragments. Finally the undigested portion becomes a pultaceous residue.

It is notable that with meat proteids, both cooked and uncooked, in acid or alkaline solutions containing no ferment, there is a marked swelling of the fibre. In an alkaline solution this becomes a solid jelly, but this swelling seems to be entirely counteracted by the presence of the papaw ferment.

A most interesting feature of the papaw enzyme is its action at a wide range of temperature. With the animal ferments, especially pepsin and trypsin, digestion is very slow at room temperature, 68 to 70 F. While at this temperature the papaw enzyme acts as energetically as at 110 F., the anmal ferments act most energetically at body temperature (diastase at 130 F.).

With the animal ferments, if the temperature be raised to near 140 F., there is a diminution in the digestive action, and at about 158 F., pancreatin is destroyed; pepsin at about 160 F. Quite the reverse is the influence upon the papaw ferments. Here the action, beginning as low as 50 or 60 F., increases slightly with the rise of temperature until about bewteen 155-160 F., it reaches the maximum. The action is not entirely destroyed even at a few moments' exposure at the boiling point. A digestive ferment active at temperature ranging from 50 F. to the boiling point is notable.

PRODUCTS OF DIGESTION BY THE PAPAW FERMENT.

A peculiar phenomenon arises in the digestion of albumen by the papaw enzyme. It is particularly noticeable in the digestion of egg albumen in alkaline solution, but it is manifest in the digestion of raw flesh albumen in either acid, neutral or alkaline media. After every prolonged digestion there is found an undissolved residue, which many observers have characterized as an unchanged albumen, and which is usually measured as undigested residue. But such is not the case. This residue is an altered albumen; is soluble in 0.3 to 0.5 solution of sodium carbonate or 0.2 per cent. hydrochloric acid From such solution it is reprecipitated upon neutralization and re-dissolved by an excess of the precipitant. It is insoluble in salt solutions. Its solution in sodium carbonate upon dialysis becomes almost entirely soluble in water.

The dialized solution noted above gives a precipitate with acetic and potassium ferrocyanide, but nitric acid gives no precipitate. The solution gives the ordinary proteid reactions, and apparently the whole of the proteids are reprecipitated by the addition of a large quantity of alcohol. The body is further digested after washing and treatment with a fresh solution of the ferment, and also in an acid solution of pepsin; it is almost completely digested in an alkaline solution of trypsin, yielding (as shown at one trial) the ordinary products of digestion. This body corresponds quite closely to the antialbumid found in digestions by hydrochloric acid and by trypsin. A quite similar body is found in brometin digestion of albumen. (See Chittenden Journal of Physiology, No. 4, 1893). It is quite evident that this body would be readily converted into soluble, absorbable products in the digestive tract.

The products arising in the digestion of egg albumen, blood fibrin or beef albumen are quite alike, either in acid, alkaline or neutral solutions, with the exception of certain slight modifications, dependent upon the conditions of trial, reaction, etc. Hemialbumose (protoalbumose, deuteroalbumose, and, in some instances, heteroalbumose), hemi-peptone, peptone products, and the amid bodies, leucin and tyrosin, are all found in addition to the peculiar body above noted, which is present only in minute amounts. All these bodies seemingly make their appearance in the early stages of digestion, and each one is found at the end of prolonged digestion, although under ordinary circumstances deuteroalbumose and true peptone predominate to a high degree.

The close identity of the products of the action of the enzyme of the papaw and that of tryptic and pepsin digestion can be seen in the accompanying diagram:

Papaw Ferment Digestion.

Albumen.

P. Albumose	Hemialbumose
	Hemipeptone
	Leucin Tyrosin

Trypsin Digestion.

Albumen.

Antialbumose	Hemialbumose
Antipeptone	Hemipeptone
	Leucin Tyrosin

Pepsin Digestion.

Albumen.

Antialbumose	Hemialbumose
Antipeptone	Hemipeptone

NITROGEN IN DIGESTIVE PRODUCTS.

It is well known that hemialbumoses and peptones formed by pepsin or trypsin show an increase of nitrogen above that of the original proteids. In the case of ferments under consideration this is reversed: the proteid products show a decrease in the nitrogen contents. The following experiment illustrates this: The clear filtrate resulting from a prolonged digestion of egg albumin in a neutral solution was concentrated, filtered, precipitated with alcohol and extracted with hot alcohol; the resultant mass (consisting for the most part of peptones) was then subjected to analysis by the Kjeldahl process. The average result of three trials expressed in percentage was N. 14.14.

The following comparison with the nitrogen content of proteids will illustrate the point:

Egg albumen	N. 16.02 Hamerstein	1588
Hemialbumose	N. 16.55	Kuhne
Soluble (proteoses) (papaw ferments) ..	N. 14.14 3 trials	Kilmer

The action of the papaw ferments upon milk is quite identical to the action of pancreatin. There is first the act of curdling, in which the casein is separated into a soft, flocculent precipitate; this is followed by a digestion of the proteids, during which process they are converted into soluble and diffusible products. The curdling takes place at ordinary temperature in neutral or alkaline reaction; is delayed by increase of alkalinity, and hastened by increase of temperature. The digestive action proceeds independent of the act of curdling, and whether the reaction is neutral, acid or alkaline. (Best digestion is with 2 per cent. bicarbonate of soda or 25 per cent. lime water.)

In addition to the proteolytic and rennet ferments noted, and the probable presence of pectase, there is present in the papaw latex amylolytic ferment capable of acting upon cooked starch. The amount of this starch-converting ferment is not large, or else it is weak. The fresh latex acts promptly upon starch paste, thinning it, and converting a portion at least into soluble starch and dextrin. (The amount of reducing sugar produced is slight.)

The starch-converting action of the separated ferment (or dried latex) is not very pronounced. The most that can be said is that it is present.

The pronounced amylolytic action of some of the papaw ferments in the market is probably due to the addition of diastase.

Altogether, we are warranted in the statement that the digestive action of the ferments contained in the papaw latex, and the products formed in such, are quite identical with that of the animal and vegetable ferments in general.

PAPOID.

[Extracts from medical literature.]

The true and natural ferment of the Carica papaya or South American papaw is that enzyme derived directly from the reserve store of the plant, representing its manifold fermentative action and known to the medical world under the name of Papoid. It is distinctly different from all other ferments, such as pepsin, trypsin, steapsin or amylopsin, inasmuch as it is not a single ferment, but a mixture of ferments or a compound enzyme. A general survey of its physiological and therapeutic actions cannot fail to be of interest to all who are interested in the search for a perfect digester of food-stuff.

THE PHYSIOLOGICAL ACTION OF PAPOID.

In presenting the physiological action of Papoid we shall aim to be brief and clear in statement. From the many analyses made by Professor Chittenden and other eminent physiological chemists, Papoid is shown to be composed essentially of a mixture of globulin, albumoses and peptone, with which, of course, are associated the ferments characteristic of the preparation.

"The result of the simple reactions upon analysis is practically in full accord with our present knowledge concerning the vegetable ferments in general, including the animal ferments as well. The constituent element present in Papoid, in addition to the above, contains a small amount of indifferent matter, which the peptones, or other life bodies, have towards the accumulation of hygroscopic moisture." (Chittenden.)

The physiological action of Papoid is manifold. It is at once an energetic proteolytic, an efficient amylolytic and also an emulsifier, thus completely covering the three great food groups which supply the physical and mental requirements of man. No drugs which can be used for dyspeptic conditions in connection with Papoid are capable of inhibiting its digestive energy. On the contrary, many drugs, such as boracic acid, salicylic acid, common salt, lactic acid, etc., distinctly increase its solvent powers when administered with it.

The physiological action of Papoid is not alone confined to digestive action within the alimentary tract, but is equally energetic as a true proteolytic ferment in dissolving and digesting away all albuminous or fibrous substances, such as the false membrane of diphtheria and croup, sloughing tissue, muco-pus, ulcerations, blood coagula, coagula from abscesses, infiltrations, and, in fine, all superficial, sloughing or pus-containing lesions whatsoever.

Papoid is believed to be catalytic in its physiological action. It probably does not percolate, permeate or absorb itself into the stomach mass, but continuously renews its attack as the affected portions successively fall away. It should be stated, however, that few authorities believe that the attacking ferment, in some unknown way, takes part in the chemical reaction involved, though it is in the course of it always brought back to its orginal condition. In the case of Papoid it may be said that its rapid and energetic catalytic action in the solution of the ingesta renders it highly probable that it enters, at least, more deeply into the food substances or coagula than does any other ferment of either animal or vegetable origin.

Chittenden, Herschell, Finkler, Woodbury and others testify that Papoid in is physiological aspect has the power of digesting all forms of proteid substances, whether coagulated or uncoagulated, raw or cooked. It stands alone among the unorganized ferments in being capable of acting in all media without marked diminution of its proteolytic, amylolytic and emulsive activity. Papoid combines in itself the solvent properties of the saliva, the stomach fluids, and the pancreatic juice.

The solvent energy of Papoid is most pronounced in its action upon animal or vegetable albumen and casein, and upon raw blood fibrin. As an emulsifier its action is distinct and effective.

Below is given in condensed form the results obtained from the researches of Professor Chittenden and other authorities mentioned:

I. In digesting the casein of milk Papoid has a two-fold action. It first exercises a rennet-like action by precipitating the casein in light, feathery curds, thus presenting a much greater surface for proteolytic or peptic action, which persistently goes on until the precipitated casein is gradually converted into soluble peptone.

II. Papoid will coagulate egg albumen in all solutions, its power being increased in the presence of from two to four per cent. of sodium carbonate.

III. Papoid has an energetic action upon cooked beef and other forms of flesh, its solvent power being even more pronounced than in the case of coagulated albumen.

IV. Papoid will digest raw beef proteids as vigorously as in the case of cooked beef, causing a rapid disintegration and final passage into solution, or pultaceous mass.

V. Papoid will digest raw blood fibrin in three and one-half hours, the tests (by Chittenden) showing that raw fibrin is especially susceptible to the action of Papoid, both in a neutral and an acid solution. In the experiment above noted it is a remarkable fact that ninety per cent. of the fibrin was thoroughly dissolved. The pronounced action of Papoid on fibrin (raw blood fibrin being chemically near psuedomembranes) was a most happy augury of what it was destined to accomplish as an effective solvent of the false membranes present in diphtheria and membranous croup.

VI. " The action on boiled fibrin is not so rapid as on raw fibrin, but by continuing the digestion considerably longer, the boiled fibrin will finally pass into a state of almost complete solution. It is to be remembered that in the case of raw and cooked proteids, the time of digestion varies but little." (Chittenden.)

Were the proteolytic, milk-curdling and emulsive properties of Papoid the limit of its activities, it would fall short of a complete and comprehensive enzyme. Most happily this is not the case, or else its brilliant success would be somewhat abridged. Papoid on its physiological side has yet another activity, the amylolytic one, which is capable of acting on cooked starch and converting it into dextrine and maltose.

PAPOID AS A PHYSIOLOGICAL SOLVENT IN EXTERNAL LESIONS.

As in the case of its action on food substances, Papoid, when externally applied, accomplishes its physiological work by erosion, manifesting with marked vigor its solvent and detergent energy. Whenever applied to dead, diseased or sloughing tissue, pus cavities, indolent ulcers, blood coagula, running sores, and, in fact, all lesions where depraved and decomposed tissue is present, Papoid will readily digest away all dead, septic and extraneous matter. While it will dissolve and render soluble all morbid and pus formations, it is wholly inert in contact with normal tissue.

As Papoid acts energetically in all media and is not inhibited by the presence of any antiseptic, it possesses advantages not enjoyed by any other ferment, and is able to successfully cope with external growths and to battle with the most distressing and discomforting malady that can affect mankind—dyspepsia.

As to the amount of physiological work which Papoid is capable of doing, we quote from Dr. George Herschell, physician to the Children's Hospital, London, and Dr. D. Finkler, professor of Physiology at the University of Bonn:

"Papoid, under proper conditions, will digest two thousand times its own weight of moistened fibrin when warm; and will soften muscular tissue in half an hour. Although so powerful, living membranes are not acted on—seventy-five grains were administered to dogs and rabbits without harmful results. Papoid will digest, or convert into true peptone, many more times its own weight of meat than pepsin or pancreatin are able to do. Papoid can be used where pepsin and pancreatin are powerless."

THE THERAPEUTIC ACTION OF PAPOID.

The therapeutic action of Papoid is almost in the direction of its application to the external surface of the body, where its curative properties are manifested in a most marked degree in all suppurating, or pus-discharging, hurts, wounds, degenerations, etc., which produce an obvious, degenerate change in cellular tissue.

The following typical pathogenic conditions involving external, structural lesions with suppuration, and also those relating to the solution of fibrinous membranes, are here subjoined in proof of the claim made for Papoid, powder or solution, as an active, energetic and efficient therapeutic agent, in all cases when dead, depraved or abnormal tissue is to be removed. The therapeutic action of Papoid in this direction is not theoretical, but has been reported by the most able men in nearly every state.

I. Large patches of fungus on the tonsils and pharynx and diphtheritic membrane were dissolved away, resulting in a rapid recovery. (Dr. Green, Cleveland, O.)

II. In the New York Foundling Asylum out of sixty-three cases of true diphtheria treated with Papoid, the parts being previously sprayed with peroxide of hydrogen, fifty recovered, and the fatal terminations were due to complications such as bronchs-pneumonia, active nephitis, etc., and not from the previous disease. (Dr. J. Lewis Smith, in a paper read before the New York Medical Association.)

III. Of twenty-six cases of true diphtheria treated in the Montreal Hospital, with a five per cent. Papoid solution every half-hour only one failed to recover. (Dr. George Ross, of the Montreal Chirurgical Society.)

IV. In the case of a child three years old, there was present an almost solid mass of diphtheria membrane. A mixture of Papoid glycerine and carbolic acid was used, and the recovery was prompt. (Dr. A. Dixon, Henderson, Ky.)

The above records testifying to the effective action of Papoid might be extended almost without limit, but space forbids. Papoid has been used with equally as good success in cases of membranous croup, catarrh of the bladder, cysts, abscesses, ischio rectal fistula, leg ulcers, indolent ulcers, gunpowder stains and tattoo marks, tape worm, eczema, psoriasis, boils, carbuncles, ear diseases, favus, herpes, acne, soboerhea, fissure of the tongue, and foreign bodies in the aesophagus.

The energetic and uninterrupted action of Papoid speedily reduces or converts the morbid processes, or structural lesions, to a soluble form in preparation for subsequent washings or irrigations by antiseptic dressings.

THE THERAPEUTIC ACTION OF JOHNSON'S DIGESTIVE TABLETS.

In no other field has more substantial advancement been made than in the treatment of disturbances of the normal functions of the alimentary tract. The etiological cause for these widespread derangements is the long-continued practice of taking into the stomach a greater amount of food substances than the digestive fluids can properly prepare for absorption, assimilation and elimination. Collectively, this abnormality of digestive functions, involving systemic decline, is called dyspepsia or indigestion.

The therapeutic action of Johnson's Digestive Tablets is similar to that of Papoid, the difference being wholly of one degree—the tablets containing other ingredients which greatly increase the therapeutic action. This therapeutic action of the tablets, as of Papoid, is simply the outcome of the physiological action, the latter necessarily preceding the former. If the therapeutic agent is indicated and its physiological action is adequately expended, relief or cure is the sequence.

The therapeutic action of a drug can be practically established in no other way than by its observed curative effect upon the specific diseased condition. Experience is the highest court to which we can take an appeal for confirmation of any theory. To this end the therapeutic action and clinical results of using our tablets were reported from able physicians in every part of the United States. These reports set forth in detail the clinical value of the tablets in the following pathogenic conditions:

I. In cases where there was a cessation in whole or part of digestive action (apepsia).

II. Where there was a deficiency in quality or quantity of the blood—a want of sufficient balance between the red and the white corpuscles (anernia).

III. When the stomach was lacking in normal tone and vigor (atonic dyspepsia).

IV. When there appeared a disproportion between the secretion of hydrochloric acid and pepsin.

V. When there was a diminished condition of the stomach tubes of absorption (atrophy).

VI. When a deficiency of hydrochloric acid existed in the gastric juice.

VII. When acute gastritis followed a period of over-feeding and the free use of intoxicants (achlorlydria).

VIII. When there existed catarrhal deposits in the stomach, obstructing the end tube by tenaceous mucous, through which absorption is effected.

IX. When hypor-acidity prevailed by reason of the presence of an over-supply of hydrochloric acid and the generation of an unusual amount of lactic, butyric and acetic acids.

X. Where decomposition and fermentation of the ingesta generated a great quantity of gases.

XI. Where there was nausea and vomiting.

XII. Where either constipation or diarrhea prevailed, due to intemperance or eating and drinking.

XIII. When there was present intestinal worms.

It is not the claim that all of the one thousand cases were cured. Indeed. it would be a miracle of miracles were such the case: But out of one thousand and ninety-one cases, the total failures numbered but one hundred and fifty-two. The remainder were fully restored to health or satisfactory progress was made.

In the failures it more than probable that a large majority were failures because the instructions of the physician were not strictly obeyed, or there was a lack of observance of all those dietetic aids which are so indispensable in dyspeptic state, a want of self-cheer and confident hope, and lastly a failure to continue the use of the tablets a sufficiently long time.

In conclusion. we express the firm and confident belief that the therapeutic properties of Johnson's Digestive Tablets far surpass those of any other known farment. The reasons for such belief are as follows:

I. Because Johnson's Digestive Tablets readily digest all kinds of food stuffs, proteids, carbohydrates or fats.

II. Because they exert a positive solvent action upon the entire ingesta.

III. Because of their solvent activity in any media, acid, alkaline or neutral.

IV Because of their persistent action in widely varying degrees of temperature.

V. Because, while they attack food substances with great vigor, normal tissue remains entirely unaffected.

VI. Because they are in chemical harmony with almost all drugs known to medical science, many of which are increased in their activity, and, finally,

VII. Because of their absolute purity, strength, reliability and certainty of physiological and therapeutic action.

HOW TO USE PAPOID.

Papoid is a creamy white, impalpable, floury, almost tasteless powder, and is soluble in glycerine, moderately soluble in water, more so in acidulated water, insoluble in alcohol. Its digestive action is not destroyed by combination with corrosive sublimate, salol or boric acid, or the ordinary articles of food, such as sodium chloride, acids or alkalies. As its digestive activity is most pronounced in alkaline solutions, it is usually combined with sodium bicarbonate. Owing to the convenience of the tablet form, Papoid has been used very largely by physicians in this manner, each tablet containing one grain of Papoid with three grains of bicarbonate of sodium, and flavored with peppermint. These are known under the name of Johnson's Digestive Tablets.

An aqueous solution of Papoid soon spoils, but a glycerine solution will not readily ferment. A glycerine solution is particularly employed for dissolving false membrane in the throat and diphtheria and in cleansing of foul wounds in surgical practice. Any of the usual chemical antiseptic agents may be prescribed with Papoid. Where it is desired to increase its activity, the addition of five grains of sodium bicarbonate to each 100 minims of the solution is a decided advantage. It acts at any temperature, but when possible, as in surgical cases and certain forms of skin disease, it is advised that the part to which it is applied should be kept warm with hot cloths or some other means, as a moderately elevated temperature favors its action.

The dose of Papoid, ordinarily, is one or two grains, but five grains or more may be used, the only objection being that of useless expense and waste. Where very prompt effects are desired, even larger doses of the remedy may be administered.

In addition to the powdered Papoid, the following tablets are supplied: Papoid pellets—each pellet containing one grain Papoid. Papoid and boracic acid tablets—each tablet containing Papoid, gr. i., boracic acid, grs. iijs.

Johnson's Digestive Tablets contain one grain of Papoid, three grains of sodium bicarbonate, peppermint and sugar of milk sufficient to form a five-grain tablet.

PAPOID AND PREPARATIONS.

Exact Size,

Physicians' Size; contains One Hundred and Fifty Tablets.

Price Reduced to Two Dollars and Twenty Cents per Ounce to Physicians.

Exact Size.

Pellets of Pure Papoid, 1 grain each.