THE NATURAL PLANT COLORING MATTERS.*

BY JOHN H. WURDACK.

Two decades ago our knowledge of the chemistry of chlorophyll and of the anthocyanins was virtually nil. Since that time the brilliant researches of Willstätter and his collaborators have opened up partially the structure of chlorophyll and have unveiled the constitution and characteristics of many of the red, violet and blue colors known collectively as anthocyanins. It is now possible to speak with a fair degree of intelligence about plant colors though numerous problems still await solution.

The number and variety of coloring matters in the plant world is large. Besides those that exist in the living plant there are also others which are formed only upon its death as the result of a natural or artificially induced fermentative action as illustrated in the preparation of litmus and indigo and in the coloration of cinchona bark when removed from the tree. Many have been from time immemorial, and still are, used as dyes, and some like alizarin and indigo are largely prepared synthetically from coal-tar constituents. Our discussion cannot deal with every known plant coloring but will confine itself to the following well-defined groups:

Chlorophylls, the practically universal green coloring of leaves, etc. They are insoluble in the cell sap and occur in the chloroplasts.

Carotinoids, which appear as yellow, orange or red pigments and include carotin, lycopin, xanthophylls, rhodoxanthin and fucoxanthin. They are insoluble in the cell sap and occur commonly either in a relatively pure form in the chromoplasts or associated with chlorophyll in the chloroplasts.

Anthoxanthins, including a number of yellow pigments sparingly soluble in water but soluble in acids or alkalies forming yellow to red solutions.

Anthocyanins, which are the red, violet or blue coloring matters of flowers, many fruits and some leaves. They are found in solution in the cell sap or, when the concentration is high, they may be seen as crystals or amorphous granules.

The anthoxanthins and the anthocyanins occur in the plant either in solution or separated out in crystalline or amorphous form, but chlorophyll and commonly the carotinoids are found in minute bodies known as chromatophores or plastids. Chromatophores occur in all plants except slime-moulds, bacteria and fungi; are not necessarily present in all cells and tissues, but are plentiful in those tissues concerned with specific physiological or ecological functions; and contain certain characteristic pigments or can form pigments under certain conditions. They are classified into the following groups:

Chloroplasts, of varying shape, and composed of the stroma (protoplasm) in which are imbedded the grana (green viscous drops or granules containing chiefly chlorophyll mixed with yellow pigments).

Chromoplasts, which are yellow, orange or red, the pigment occurring as amorphous globules or vesicles, or as crystals.

Leucoplasts, which are typically colorless but may change to chloroplasts or chromoplasts. Those which change transported soluble carbohydrate into starch grains in the storage cells are termed **amyloplasts.**

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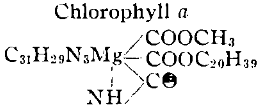
CHLOROPHYLL.

The chloroplasts of leaves are unequally distributed, more occurring on the upper surface, which is therefore deeper colored, than on the under side. The microscope shows them to be more plentiful in the palisade than in the spongy parenchyma cells; for instance, in the leaves of the castor oil plant, *Ricinus communis*, there are about 403,000 per square millimeter of surface in the palisade tissue and only 92,000 in the same area of spongy parenchyma. Chlorophyll constitutes their chief coloring matter but xanthophylls, carotin and sometimes other yellow pigments are also present. Chlorophyll does not develop in leaves grown in the dark as illustrated by the colorless sprouts of potatoes or onions stored in a dark cellar, and it gradually disappears from green parts denied light as in the blanching of celery when banked up with earth. It is soon destroyed by bright light, the plant remaining green only because of its continual renewal brought about by the agency of light in the active plant. In autumn, when the plant no longer produces chlorophyll, it disappears, being bleached to colorless products; and the yellow colors, which are less easily bleached by light, are seen because they are no longer masked by the chlorophyll.

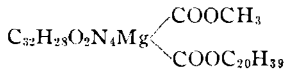
Leaves ordinarily contain 0.5% to 1% of their dry weight of chlorophyll except the conifers which contain less. In stinging nettle leaves Willstätter found 0.720, 0.580, 0.656, 0.675%; in grass, 0.671%; in horsechestnut leaves, 0.993-1.018%; etc.; but in pine needles only 0.254%. The usual method of extracting it from green tissues consists in first steeping the fresh material in hot water to destroy oxidizing enzymes and then extracting the coloring matter with warm alcohol. An improved method makes use of dried material, the extracting being performed in the cold by 90% alcohol or 80% aqueous acetone, ether or methyl alcohol also serving the purpose. Alcoholic extracts of leaves always contain, not only chlorophyll, but also carotin, xanthophylls, lecithin, wax, etc., which may be removed from the chlorophyll. Lengthy exposure of such solutions to light will cause the chlorophyll to disappear, the green solution becoming yellow from the presence of carotin and xanthophylls which do not bleach so readily. For details of extraction and purification see *Ann.*, 380, 177–211, 1911.

The natural chlorophyll of leaves is an amorphous mixture of two substances; namely, chlorophyll *a* ($C_{55}H_{72}O_5N_4Mg$) and chlorophyll *b* ($C_{55}H_{70}O_6N_4Mg$) to which the following provisional constitutions are assigned:

Chlorophyll *a*



Chlorophyll *b*



They are both methyl phytyl esters, the former containing also a lactam grouping. It may also be stated here that the crystals of "chlorophyll" sometimes obtained on moistening plant sections with alcohol and allowing this to evaporate slowly are not true plant chlorophyll which latter is non-crystalline, but are composed of a derivative of each of the above where the phytyl group has been replaced by the ethyl group through slow action of the ethyl alcohol in the presence of the enzyme chlorophyllase which ferment seems always to accompany chlorophyll in greater or less amount.

A close relationship exists between chlorophyll and hemoglobin, the red coloring matter of the blood. Both have a metallic element in the molecule. By oxidation of chlorophyll one of the products obtained is hematinic acid imide which has also been obtained from hemoglobin. By reduction one of the products is hemopyrrol which is also obtained by reduction of hematoporphyrin, a hemoglobin derivative.

The following table expressed in percentages based on dry material will give an idea of the relative amounts of the two natural chlorophyll components as well as of other pigments present in plants:

	Land plants.	Brown algae. (Fucus.)	Green algae. (Ulva.)
Chlorophyll *a*	0.62	0.16	0.093
Chlorophyll *b*	0.22	0.01	0.066
Carotin	0.055	0.0312	0.014
Xanthophyll	0.093	0.0305	0.036
Fucoxanthin	..	0.059	..

Concerning the physiological relationship of these pigments Willstätter has suggested that since chlorophyll *b* ($C_{55}H_{70}O_6N_4Mg$) contains more oxygen than chlorophyll *a* ($C_{55}H_{72}O_5N_4Mg$), the former compound is produced by the action of chlorophyll *a* upon carbon dioxide during assimilation, and that chlorophyll *b* is then reconverted into chlorophyll *a* with liberation of oxygen. On the other hand, the molecular formulas of carotin ($C_{40}H_{56}$) and xanthophyll ($C_{40}H_{56}O_2$) differ by only two atoms of oxygen, and the close association between the carotinoids and chlorophyll may be explained by assuming that the function of carotin is to reduce chlorophyll *b* to chlorophyll *a*, being itself oxidized to xanthophyll, and that the latter compound is reconverted by some enzyme into carotin with evolution of oxygen.

The chief function of chlorophyll is its activity in photosynthesis. Plants containing chlorophyll make in the light a sugar which is commonly converted into starch, at least in part. The photosynthetic sugar made in green leaves is produced from water drawn from the soil and carbon dioxide derived chiefly from the atmosphere; oxygen is given off during the process. It is stated that one gram of sugar requires 750 cubic centimeters of carbon dioxide (ordinarily contained in about 2 cubic meters of air) and that this is the amount of carbon dioxide used (and oxygen given off) by a square meter of green leaf each hour on a bright summer day. It is this utilization of the carbon dioxide which is produced continually during combustion, decay and respiration throughout the earth, and the liberation of oxygen by the plant, that keeps the carbon dioxide content of the air uniformly low. The air we inhale outdoors contains about 0.04% of carbon dioxide; that which we exhale contains about 4% or 100 times as much; and, of course, the air has, during the respiration, been deprived of an equivalent amount of oxygen of which latter fresh air contains 20.6%. Fortunately for us, the carbon dioxide we exhale, and which is poisonous to us, is used by the plant for photosynthesis, while in the meantime the plant gives off oxygen necessary in our respiration. The respiration of a man is balanced by about 25 square meters of green leaf on an ordinary summer day; but, because the plant does not utilize carbon dioxide during the night, about 60 square meters are required for the 24 hours; and where the plant is active during the summer only, about 150 square meters are needed for the year. Were it not for plants the carbon dioxide content of the air, vast though the volume of the atmosphere, would ultimately in the course of the centuries become too high and the oxygen content simultaneously too low for animal life.

A study of the mechanism of photosynthesis involves the action of sunlight which is the source of the energy required. Visible light coming to us from the sun is composed of the well-defined colors violet, indigo, blue, green, yellow, orange, red and their intermediate shadings, although certain comparatively negligible portions are missing because of absorption by the gaseous solar envelope and the earth's atmosphere. When the sunlight strikes a body it may be partly or almost entirely transmitted, reflected or absorbed, being almost entirely transmitted by colorless, transparent bodies, almost entirely reflected by white opaque bodies, and almost entirely absorbed by black opaque objects. In the case of colored transparent bodies the light that passes through is the unabsorbed portion; with colored opaque objects the color reflected (which we designate as the color of the object) is the color or blend of colors which has not been absorbed.

On passing sunlight through a solution of chlorophyll in a spectroscope it is found that most of the red and nearly all of the blue, indigo and violet have been absorbed, thus indicating these to be the light constituents useful in photosynthesis which fact may be confirmed by growing plants in red, blue or violet light when starch will be formed, whereas in yellow, orange or green light no starch is produced. The blend of green and less pronounced yellow which constitutes the color of vegetation is simply that portion of the sunlight which has not been absorbed because useless in photosynthesis; the orange and unabsorbed blue, being complementary, have formed white light as have also a little of the red and green-blue. If, instead of red and blue, the red and green had been the useful colors, vegetation would appear blue; if green and blue were the useful kinds, plants would be red.

In the case of seaweeds growing at different depths, the rays of light which are most effective in photosynthesis are invariably those which are complementary to the coloration of the respective plants, the reason being that it is, of course, precisely these complementary rays that are absorbed by the pigments concerned. Passage of light through the water robs it of some of its vibrations so that even at comparatively slight depths below the surface of the ocean green and blue-green light predominate; under such circumstances the pigments are undoubtedly adapted to this altered light as in the beautiful rose-red "sea mosses." It has been found that prolonged exposure of certain species of *Oscillatoria* to colored lights causes a change in color, the alteration always being a closer approximation to the tint which is complementary to that of the light employed. In red light, for instance, the plants assume a green, in green light a red, and in blue light a brownish yellow hue.

The chemistry involved in photosynthesis is still the subject of fragmentary and conflicting hypotheses. Even the question of what sugar is first produced is still unsettled. Sucrose and its hydrolytic products, dextrose and levulose, are the sugars commonly found in the sugar-producing leaves such as those of *Saccharum officinarum;* for starch-producing plants the assumption is that dextrose is the primary product, it being formed according to the generalized equation: $6H_2O + 6CO_2 = C_6H_{12}O_6 + 6O_2$.

Carbohydrate formation in the leaf occurs very rapidly in sunlight, less rapidly in diffused daylight, and is non-existent in darkness. The average production is conventionally stated to be 1 gram of dextrose per square meter of green leaf per hour in the summer. In the process carbon dioxide contained in the air finds entry through the stomata of the leaves and moves along the air passages, whence it passes in solution into the cells and the chloroplasts, the necessary water being supplied by the ducts which have brought it up from the roots. In some manner still awaiting definite knowledge the chlorophyll of the chloroplasts, energized by the absorbed light vibrations, reacts with the carbon dioxide and water, forming a sugar. More of the sugar is produced in the palisade cells near the upper surface of the leaf where most of the chlorophyll is located; a lesser amount is formed in the spongy parenchyma cells lying between the palisade cells and the epidermis of the under surface of the leaf. In accordance with the well-known law in vegetable physiology that a metabolic process can be carried on continuously only so long as the products are promptly removed, it is readily seen that in order that the production of the sugar may go on continuously its removal is necessary either by transportation to other tissues or by conversion into the insoluble starch or glucosides, otherwise the process slows down by closure of the stomata to retard the ingress of carbon dioxide. In some leaves the facilities for removal are very good, special collecting cells being present beneath the palisade cells into each of which a number of the palisade cells may empty their product; from the collecting cells the sugar solution passes through one or more spongy parenchyma cells or directly through the endodermis of the wood bundle into the veins, thence into the midrib and through the petiole into the twig, branch and stem, continuing its progress until it arrives in the plant part where it is to be used or stored as sugar or starch, the amyloplasts accomplishing its conversion into starch, as in the tuber of the potato, or the seeds of plants, etc.

We have just mentioned that in some plants the facilities for rapid transportation are excellent and the sugar is conducted away about as fast as it is formed, in which case we are not apt to find starch in the leaf. In others, part of the sugar is converted temporarily in the leaf into starch, thus removing it from solution and leaving the way open for the continuance of sugar production. This conversion into starch is especially apt to occur on very bright days when sugar is formed so rapidly that only part of it can be translocated to other plant parts during the day. However, during the night, when carbohydrate production has stopped because of absence of light, a diastatic enzyme converts the insoluble, untransportable starch into the soluble and therefore transportable sugar, this occurring first in the most highly specialized photosynthetic cells (palisade cells) and progressively in the others, the sugar solution being then slowly transported away to leave the field clear for operation the next day.

In some plants the sugar which cannot be transported away during the day is converted into glucosides thus lowering the sugar concentration. Some of these glucosides, like salicin, are acted upon by an enzyme during the night and split into the sugar, which is then transported away, and some other substance (saligenin in the case of salicin) which can recombine with sugar the next day. They also act as reserve food material by furnishing their sugar content for new plant growth in spring.

Photosynthesis in green leaves in summer is on an average about twelve times as active as respiration. It must be remembered that plants respire in their normal metabolism as do animals (although it is not active breathing), taking in oxygen and giving off carbon dioxide, day and night, and it is only during the day (in light) that carbon dioxide is used in photosynthesis, the latter process overshadowing by far the respiratory activity. At night any carbon dioxide given off in respiration passes out through the stomata; during the day any carbon dioxide given off is absorbed and a constant additional supply (in air) comes in through the stomata, while simultaneously a part of the oxygen given off by the chloroplasts as a by-product of photosynthesis is absorbed by the protoplasm of the same cells for their respiration, the excess passing out through the stomata. Since the activity of photosynthesis declines with decrease of light intensity it is evident that in the early morning near sunrise, in the evening after sunset, and on gloomy days, there is a state of balance where photosynthesis is not twelve times as active, but instead is just about equally as active as respiration, and the carbon dioxide of respiration is all that is required for the carbohydrate production possible in such poor light, the oxygen given off in photosynthesis thus being sufficient for respiration—a case of reciprocity. Such a state of balance accounts for the fact that sweat plants, partridge berries, etc., may be kept for a long time under closed globes in the moderate dark of a room.

A popular belief is to the effect that it is unsafe to have plants in the bedroom at night. Thousands of people camp in the woods during the summer and although surrounded at night by respiring vegetation above, below and on all sides, they experience no ill effects due to carbon dioxide poisoning. A square meter of leaf releases in respiration only about the $^1/_{300}$th part of the carbon dioxide exhaled in the same time by a person and although buds and roots respire more freely, a whole windowful of plants gives off during the night only a very small fractional part of the amount produced by one person.

THE CAROTINOIDS.

The carotinoids, as has been previously mentioned, are yellow, orange or red pigments which are insoluble in the cell sap and appear in the chloroplasts with chlorophyll or in the chromoplasts. They are quite universally distributed, being found not only in the plant world but, by derivation, also in the animal kingdom. Usually several carotinoids may be found together in the same plant, as, for instance, both carotin and xanthophyll are present in the green algae, in celandine poppy (*Chelidonium majus*), the daffodil (*Narcissus pseudo-narcissus*), common dandelion (*Taraxacum officinale*), and numerous other flowers; lycopin, carotin and xanthophyll are present in the flesh of the watermelon.

Carotin, $C_{40}H_{56}$, is a colored hydrocarbon found widely distributed, occurring not only associated with chlorophyll in the chloroplasts, but also in amorphous or crystalline forms in various parts of many plants. Chiefly to it is due the color of yellow and orange pollen and of various seeds, and it constitutes partly or entirely the yellow or orange color of many fruits and of most yellow to orange-red flowers such as the poet's narcissus (*Narcissus poeticus* L.), cowslip (*Primula officinalis*), asphodel (*Asphodelus cerasifer*), tulip tree blossom (*Liriodendron tulipifera*), and many others. In the buttercup it occurs dissolved in the cells in an oil instead of being present in plastids and in the carrot root, from which it was first isolated, it is present as innumerable small crystals. It is the principal pigment in diatoms and in *B. egregrium* and *Spaerotilus roseus*.

Lycopin is a red isomer of carotin and constitutes the characteristic red pigment of tomatoes (which also contain a little carotin), red peppers, the pulp of watermelons (which also contain carotin and xanthophyll) and a number of tropical fruits. An interesting observation is the fact that above 30° C. green tomato fruits do not form lycopin but only carotin (possibly xanthophylls also), producing a yellow fruit, but the induced yellow fruits form lycopin if the temperature is reduced to the usual ripening temperature (20–25° C.).

Xanthophylls, $C_{40}H_{56}O_2$, are apparently a group of isomorphous or isomeric (?), still very imperfectly differentiated coloring matters not so reddish as carotin. They occur in many flowers usually associated with more or less carotin and have been found in the wallflower (*Cheiranthus cheira*), sunflower (*Helianthus annuus*), orange hawkweed (*Hieraceum aurantiacum*), nasturtium (*Tropaeolum majus*), common garden tulip (*Tulipa Gesneriana*), coltsfoot (*Tussilago Farfara*), mullein (*Verbascum* species), pansy (*Viola tricolor*), marigold (*Calendula officinalis* and *C. arvensis*), and others. They are a common associate of chlorophyll and it seems that probably not more than four are present in the chloroplasts of green leaves. They are closely related to carotin and the assumption is that in the plant there is an interchangeability with the latter as has already been mentioned under chlorophyll; in fact, in the laboratory xanthophyll has been converted into carotin by the action of zinc dust and water. In green leaves the presence of carotin and xanthophylls is masked by the preponderance of chlorophyll, although in some leaves they are sufficiently pronounced to give the leaves a yellowish cast. Chlorophyll is bleached more readily in light than are the yellow pigments, and in autumn when the plant ceases to produce chlorophyll this latter soon disappears and the yellow of the carotin, xanthophylls and possibly other yellow pigments, which has been hidden till then, persists, thus being one of the factors in the beauty of autumn leaves.

Rhodoxanthin is a red isomer of the xanthophylls occurring in the Russian pond weed, *Potamogeton natans;* in the arillus of the seed of the yew, *Taxus baccata;* and constituting the winter red color of the arbor vitae, *Thuja orientalis*.

Fucoxanthin, $C_{40}H_{54}O_6$, is an algae carotinoid furnishing the olive-brown tint in fresh brown seaweeds which also contain carotin and xanthophyll.

In addition to the above-mentioned occurrences carotinoids have been found in the blue-green algae, in rusts, and in some mushrooms. Although occurring in the orange, none has been found in the lemon. They occur in seeds yielding yellow oils on expression such as flax, mustard, sesame and cotton seeds which last contains a mixture of carotin and xanthophyll. Of course, the expressed oils are tinctured by the same pigments. Cereal grains also contain them and the coloring of yellow Indian corn, *Zea Mays*, is almost entirely xanthophyll with a little carotin; wheat also contains both carotin and xanthophyll.

It may not be amiss here to mention some carotinoid occurrences in animals. The carotinoids are, of course, derived from the plant food. Carotinoid pigmentation of animal tissues or fluids is not, however, universal even among animals whose diet is normally rich in these pigments. The carotinoids of adipose tissue, internal organs, nerve cells, and skin of mammals are those which characterize the blood serum (plasma), only those animals whose blood serum (plasma) is normally pigmented with carotinoids depositing the pigments in their body tissues and organs.

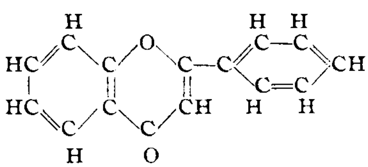
No or almost no carotinoid is present in the serum of swine, sheep, goats, dogs, cats, guinea pigs and rats, nor is any to be found in new-born animals. Cattle and horse serums contain carotin primarily; human serum is colored by carotin or xanthophyll or both; fowl serum contains xanthophyll chiefly. As a consequence we find the corpus luteum, the butter-fat and the adipose tissue of cattle to be colored by carotin, and the egg yolks and adipose tissue of fowl to be colored by xanthophyll with practically none of the other coloring present in either case, and it is possible by proper choice of carotin-rich or xanthophyll-rich rations, respectively, to intensify the colorations. A plentiful diet of carrots, oranges or eggs may tint the skin especially of children and the frequent yellow color of non-jaundiced, dieting diabetics is no doubt due to their plentiful vegetable diet. Young or moulting canary birds are fed with a mixture of red pepper (containing lycopin), egg yolk (containing xanthophyll) and bread to tint their feathers deep yellow or reddish.

Carotinoids are undoubtedly the cause of the yellow to red color of the feathers of certain birds, the yellow color of fishes, the yellow pigment of the skin, adipose tissue and retina of frogs, toads and salamanders; they are present in the larvae and pupae of butterflies, in bugs, beetles, locusts, crustaceae, echinoderms, marine and fresh water worms, and in sponges.

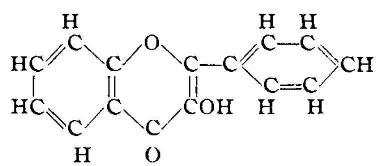
THE ANTHOXANTHINS.

The term anthoxanthin is a group name for a number of yellow-colored flavone (or flavonol) and xanthone derivatives which occur sometimes uncombined but usually in combination with dextrose or rhamnose or both as glucosides and frequently are associated with tannins. They are found in the vegetative organs and flowers of many plants and constitute the yellow coloring of many woods, roots, barks, buds and berries. They are mostly yellow crystalline solids, slightly soluble in water, readily soluble in acids and alkalies, forming yellow to red solutions. Some of the flavones are almost colorless in neutral or acid solutions, but

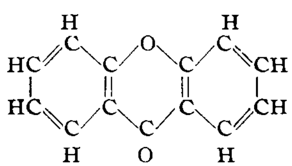
Flavone



Flavonol



Xanthone



intensely yellow in alkaline solutions. Chemically the flavones are closely related to the anthocyanins and in the plant the red anthocyanins of spring leaves change to the colorless or yellow flavones of the summer period hidden by chlorophyll and in autumn are reconverted to the red anthocyanins of red autumn foliage.

Because of their use as dyes the plants containing anthoxanthins have for many years been the subject of investigation and the molecular structure of many of the constituent coloring matters has been determined. The mother substances of which they are derivatives have the foregoing formulas.

Among the derivatives of flavone and flavonol are:

Chrysin (a dihydroxy-flavone), found in the leaf buds of several varieties of poplar, such as *Populus nigra, P. pyramidalis, P. deltoides.*

Apigenin (a trihydroxy-flavone), found as the glucoside **apiin** in parsley leaves, stems and seeds.

Acacetin (apigenin monomethyl ether), from the leaves of *Robinia Pseudo-Acacia,* our common locust tree.

Lotoflavin (probably a tetrahydroxy-flavone), found as the glucoside **lotusin** in *Lotus arabicus.*

Luteolin (a tetrahydroxy-flavone), from *Reseda Luteola* (weld, the oldest European dyestuff known; used by the Gauls, etc., in Caesar's time) and *Genista tinctoria* (dyer's broom).

Galangin (a dihydroxy-flavonol), from galanga root.

Fisetin (a trihydroxy-flavonol), found free and as a glucosidal tannin compound in the wood of *Cotinus Coggygria* (young fustic).

Kaempferol (another isomeric trihydroxy-flavonol), in *Delphinium consolida, Rhamnus cathartica* berries, etc., and as the gluco-dirhamnoside **robinin** in the flowers of *Robinia Pseudo-Acacia* and of the white azalea.

Quercetin (a tetrahydroxy-flavonol), occurring either uncombined or as the rhamnoside **quercitrin** in onion skins, tea leaves, horse-chestnut blossoms, apple tree bark, red, crimson and white clover flowers, heather, common fuchsia blossoms, yellow wall flowers, quercitron bark, and many others.

Violaquercitrin, from *Viola Rafinesquii;* **Osyritin,** from *Colpoon compressum;* **Myrticolorin,** from *Eucalyptus macrorhyncha;* and **Rutin,** from *Ruta graveolens, Capparis spinosa,* and *Fagopyrum esculentum,* are one and the same compound being a quercetin gluco-rhamnoside.

Rhamnetin (quercetin monomethyl ether), occurs as the dirhamno-galactoside **xanthorhamnin** in the dried berries of *Rhamnus cathartica, R. tinctoria,* etc.

Isorhamnetin (an isomer of rhamnetin), from *Delphinium Zalil,* the common garden wall flower and red clover flowers.

Rhamnazin (quercetin dimethyl ether), from the berries of *Rhamnus infectoria.*

Morin (an isomer of quercetin), from the wood of *Morus tinctoria* (old fustic), where it is accompanied by another coloring matter (**maclurin**).

Myricetin (a pentahydroxy-flavonol), occurs free and as the rhamnoside **myricitrin;** it is found in the bark of *Myrica nagi* and in *Myrica Gale,* and in the leaves of *Cotinus Coggygria, Rhus Coriaria, Rhus Metopium, Haematoxylon campechianum,* and in *Pistacia Lentiscus* and *Coriaria myrtifolia.*

The yellow colors derived from xanthone include:

Gentisin, from the root of *Gentiana lutea.*

Datiscetin occurring as the rhamnoside **datiscin** in *Datisca cannabina.*

(*To be continued.*)

NATIONAL DRUG STOCKHOLDERS DENIED STORE SALE INJUNCTION.

The petition of Ralph B. Wattley, former President of the National Drug Stores Corporation, and other stockholders for an injunction restraining the company from selling its retail store at Broadway and 42nd St., New York City, to Louis K. Liggett Co., has been denied by Justice Wagner in the Supreme Court of New York City. Justice Wagner held that the sale of a store was not sale of assets within the Delaware construction of the charter but was a sale of the ordinary course of business as authorized by the certificate of incorporation.