QUERCETIN AND ITS GLUCOSIDES

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I N T R O D U C T I O N

Aside from their interest as yellow pigments and dyestuffs, and their widespread occurrence in plants, both as such and as glucosides, the flavones possess a new and peculiar interest due to their relationship to the anthocyanin pigments, and especially to the fact that the anthocyanins are believed to be derived from the flavones. This relationship is not quite generally admitted. The way in which the anthocyanins are derived from the flavones is, however, by no means clear, since a given anthocyanin may be either an isomer, a reduction product, or an oxidation product of the flavone from which it is derived. It would, at first thought, seem easy to decide this matter; but when we realize that the series of flavone pigments is almost duplicated by the series of anthocyanins we will understand that a given anthocyanin is actually an isomer of one flavone, an oxidation product of another, and a reduction product of a third yellow pigment. This parallelism of composition compiled with the fact that almost no investigations and very few observations have been made upon the yellow and red pigments of the same plant renders it impossible to determine, in our present state of knowledge, the exact relationship of any anthocyanin to the flavone from which it is derived.

The parallel series of flavones and anthocyanins follow:

FLAVONES	ANTHOCYANINS
Chrysine $C_{15}H_{10}O_4$	
Tecto Chrysine $C_{15}H_9O_4(CH_3)$	
Apegenin $C_{15}H_{10}O_5$	Pelargonidin $C_{15}H_{10}O_5$
Acacelene $C_{15}H_9O_5(CH_3)$	
Galangin $C_{15}H_{10}O_5$	
Methyl Ether $C_{15}H_9O_5(CH_3)$	
Luteolin $C_{15}H_{10}O_6$	Cyanid $C_{15}H_{10}O_6$
Methyl Ether $C_{15}H_9O_6(CH_3)$	Peonidin $C_{15}H_9O_6(CH_3)$
Lotoflavin $C_{15}H_{10}O_6$	
Feretin $C_{15}H_{10}O_6$	
Kaempherol $C_{15}H_{10}O_6$	
Kaempherid $C_{15}H_9O_6(CH_3)$	
Quercetin $C_{15}H_{10}O_7$	Delphinidin $C_{15}H_{10}O_7$
Rhamnetin $C_{15}H_9O_7(CH_3)$	Myrtillidin $C_{15}H_9O_7(CH_3)$
Isorhamnetin $C_{15}H_9O_7(CH_3)$	Ampelopsidin $C_{17}H_9O_7(CH_3)$
	Petunidin $C_{17}H_9O_7(CH_3)$
Rhamnazin $C_{15}H_8O_7(CH_3)_2$	Malverdin $C_{17}H_8O_7(CH_3)_2$
	Oenidin $C_{17}H_8O_7(CH_3)_2$
Morin $C_{15}H_{10}O_7$	
Myricetin $C_{15}H_{10}O_8$	

From the foregoing chart we see that pelargonidin may be an oxidation product of chrysin, an isomer of apegenin or galangin, or a reduction product of luteolin, lotoflavin , feretin or kaempherol. In the same way cyanidin may be considered as an oxidation product of apegenin, lotoflavin, feretin or kaempherol, or a reduction product of quercetin or morin; while peonin, the mono methyl ether of cyanidin may bear the same relationships to the mono methyl ethers of these yellow pigments, respectively. In the same way delphinidin and its methyl ethers may be produced in the plant by the oxidation of corresponding flavone pigments with six oxygen atoms, by isomerization of those with seven oxygen atoms or by reduction of those with eight oxygen atoms.

The fact that all of the anthocyanin pigments so far identified contain a hydroxyl group in the flavonol position might possibly eliminate from consideration, especially with reference to reduction, those flavones which are not flavonols. This would leave for consideration only galangin and its methyl ether, firetin, kaempherol and kaempherid, quercetin, rhamnetin, isorhamnetin, rhamnazin, morin and myricetin.

Wheldale and Bassett[1] here show that the red and magenta pigments of antirshinum majus are due to cyanidin while they have isolated apegenin from an ivory white variety of the same species. They consider this as evidence pointing toward the fact that cyanidin is formed in the plant by the oxidation of apegenin. On the other hand Coombes[2] holds that anthocyanins

1. Biochem. J., 7, p. 441; 8, 204
2. C. r., 158, p. 272

can be formed by the reduction of flavones. While Urllstaetter[3] and Everest[4] claim to have actually formed cyanidin by the reduction of quercetin.

It was thought that observing which of the flavones have been identified as occurring with the known anthocyanins in a large number of cases and noting the relationship which exists between these flavones and anthocyanins some idea might be obtained of the true relationship between flavones and anthocyanins. It was with this purpose in mind that this thesis was undertaken.

The work here presented consists of two parts:

I. A compilation of the instances in which quercetin and its glucosides, quercitrin, rutin, and isoquercitrin are reported.

II. A limited amount of experimental work upon the isolation of quercetin from onions.

3. Sitz Bei., Ak. Wisc., 1914, p. 769.

4. Proc. Roy. Soc., 90, p. 251.

The Occurrence of Quercetin and its Glucosides in Plants, as Reported in Chemical Literature.

The following list of the occurrence of quercetin and its glucosides in plants is compiled from Wehmer, Die Pflanzinstoffe. It probably contains by far the greater number of cases in which quercetin has been reported. In a number of cases it is very possible that the presence of quercetin has not been definitely established and that some other flavone, or flavones, has been reported as quercetin. However, the list should serve as a guide,not only to the distribution of quercetin and its glucosides in plants, but also as to the parts of the plants in which they occur.

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Q U E R C E T I N

Bulb - Allium cepa (onion)
Perkin & Hummel, Chem. News., 74, p.96 (1896)

Bark - Quercus tinctoria, with glucoside quercitrin
Chevreul, Journ. Chim. Med., 6, p. 58.
Brandt, - Arch. Pharm., 21, p. 25.
Prusser,- Jr. de Pharm., 1844, p. 191, 249.
Bolley ,- Ann. Chem., 37, p. 101; 62,p.136; 112,p.96.
Rigaud, -Ann. Chem., 90, p. 283.
Hlasewetz and Pfaundler,-Ann. Chem., 127,p.36.
Zwenger and Dronke, Ann. Chem., 123, p. 145.
Suppl. 1862. I, p. 257.
Rochledu,- S. Ber. Weiner Acad. Math.phys. 33,p.565,
55, p. 40.
Loewe,- Z.analyt. Chem., 14, p. 233; 21, p. 128.
Liebermann and Hamburger,- Ber., 12, 1178.
Liebermann,- Ber., 17, p. 1680.
Schunck,- Jr. Chem. Soc., 53,264; Chem News, 37,p.60.
Heizig,- Monatsh. f. Chem., 14, p. 53.
Wachs, - Dissert. Dorpat, 1893.
Soxhlet,- Chem. Ztg., 1890, p. 1345.

Leaves-
Rumex obtusifolius
Perkin,- J. Chem. Soc., 71, p. 1194.

Herb -
Polygonum persicaria
Horst,-Chem. Ztg., 25,1055.

Flowers
Delphinium Zoli.
Perkin and Pilgium,-Proc. Chem. Soc., 1897/98,p.55;
Jr. Chem. Soc., 73,p. 267.

Rhizome
Podophyllum peltatum
Dunstun and Henry., Jr. Chem. Soc., 73,p. 209; Proc.
Chem. Soc., 1897/98,p.42.

Flowers
Cherianthus Cheiri
Perkin and Hummel,-Chem. News, 74,p. 278; Jr. Chem.Soc.,
66, p. 1566.

Flowers
Crataegus Oxycantha
Perkin and Hummel,-Chem. News., 74,p.278.

Bark - Pirus Malus
Rochleder,- S.B. Wien. Acad., 53.p. 476; 55,p.20; 56,p. 140; Journ. prakt. Chem., 98,p. 205.

Leaves-
Prunus Cerasus
Rochleder,-S.-B.Wien Acad., 59;61,19; Ber., 3238.

Catechu
Acacia Catechu-
Loewe,-Z. Anal. Chem., 13, p. 113; 12,p. 127; Jr. Prakt. Chem., 105,75.
Etti,- Ber., 1881, p.2266; Monatsh.f. Chem., 2, 547; Ann. Chem, 186,p.327.

Leaves-
Haematoxylon campechianum
Perkin,- Proc. Chem. Soc., 16, p.45; Jr. Chem. Soc., 77, p. 426.

Seeds -
Trifolium repens.
Schulze and Boshard,- Zphynol. Chem., 9, p. 420.

Leaves-
Erythroxylon Coca
Eijkman,- Tijdschr. Pharm. 1887; Arm. Jard. Bot. Buitenzorg; 7, p. 225.
Hesse,- Journ. prakt. Chem., 174, p. 401.

Herb -
Ruta graveolen
Kuemmell,- Arch. Pharm., 31, p. 166.

Leaves-
Ailanthus glandulosa
Perkin and Wood,- Proc. Chem. Soc., 193,p.104.

Leaves-
Coraira myrtifolia
Perkin,-Proc. Chem. Soc., 16, p. 45; Jr. Chem. Soc., 77,424.

Heart wood-
Rhus cotinus
Bolley,-Schweiz Polytechn.Zts.,9,p.22;
Rochleder,-S.-B. Wien.Acad., 53,p.369.

Leaves - Rhus Melopuim
Perkin,-Proc. Chem. Soc., 16, p.45; Jr. Chem.Soc.,77,427.

Leaves -
Aesculus Hippocastanum.
Wachs,-Dissert. Dorpat., 1893.
Zwenger,-Ann. Chem., 90, p. 63.

Flowers -
Rochleder,- S.-B.Wien. Acad., 13, p. 169; 16,p.1;
33, p. 365; 40,p.37; 45,p.675; 48,p.236.

Seeds -
Stillesen; Chem. Ztg., 33, p. 497.

Fruit -
Rhamnus infectoria
Perkin, Geldard,-Jr. Chem. Soc., 67, p. 496;
Chem. News., 71, p. 240.
Lefort,-Jr. Pharm.,(4) 4, 420; C.r.,63, p. 840-1081;
67,p.343.
Perkin,Martin,-Jr. Chem. Soc., 71, p. 818; 73,p.272.

Fruit -
Rhamnus cathartica
Waljasko and Krasowski,-Jr. russ phys.-Chem. Ges., 40,
p. 1502; 40,p.1510.

Leaves -
Vitis vinifera
Neubauer,-Z. analyt. Chem., 12, p. 46; Landw. Versuchst.,
16, p. 427.

Fruit - "
Muntz and Laine,-Monit. scient., 20, p. 221.

Flowers -
Hibiscus Sabdariffa
Perkin, -Jr. Chem. Soc., 95,p. 1855; 75,p.825.

Flowers -
Gossypium herbaceum
Perkin,-Jr. Chem. Soc., 95,p. 2181.

Leaves -
Thea chinensis
Hlasiwetz and Malin,-S.-Ber.Wiener Acad., 55, p. 19.

Herb -
Viola tricolor
Maudelin,-Arch. Pharm., 220,p. 378; Dissert. Dorpat,
1881 Griffiths and Conrad,-Chem. News, 49, p.
146; 50, p. 102; Dismoulieres-Jr. Pharm. Chim.,
19,p. 121; Dragendorff,-S.-Ber. Naturf. Ges.
Dorpat, 5, p. 77

Fruits -
Hipphaë Rhamnoids
Bolley,-Dingl. Polyt. Journ., 162,p. 143.

Rinds -
Olea glaudulifera
Dymock, Warden and Hooper,-Pharmacographic indica, II, p.379.

Herb -
Lippia dulcis
Podwissotzki,- Pharm. z.f. Ruszl., 1882, p.902; Maisch, 1885.

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Osyris compressa
Perkin,- Jr. Chem. Soc., 97, p. 1776; Proc. Chem. Soc., 17, p. 87.

Leaves -
Prunus serotina
Power and Moore,- Jr. Chem. Soc., 97, p. 1099.

Leaves -
Eugenia Chequeu
Czapek,- Biochemic, II.p.518.

Fruits -
Cornus mas
Czapek, - Biochemic II, p. 517.

Entire Plant -
Pedum palustre
Rochleder, - S.- Ber. Wien. Acad., 53, p. 369.

Leaves -
Arctostaphylos Uva Ursi
Perkin,-Proc. Chem. Soc., 16, p. 45; Jr. Chem. Soc. 77, p. 424.

Herb -
Callima vulgaris
Perkin and Newbury,- Proc. Chem. Soc., 15, p. 179.

Flowers-
Thespesia Lampas
Perkin,- Nr. 2653, p. 821.

Flowers-
Trifolium incarnatum
Rogerson, - Jr. Chem. Soc., 97, p. 1004.

Q U E R C I T R I N

Leaves -
Salix fragilis
Johansen,__ Nr.,p. 352.

Rinds -
Juglan suleata
Smith, __Amer. Jr. Phar., 51, p. 118

Rinds -
Carya porúna
Smith,- Amer. Jr. Pharm., 51, p. 118.

Rinds -
Quercus tinctorio
Cheureul,__Journ. Chim. Med., 6, p. 158.
Brandt,__Arib. Pharm., 21, p. 25.
Preisser, __Jr. de Pharm., 1844,p.191 and 249.
Bolley,__ Ann. Chem., 37, p. 101; 62,p. 136;112,p.96.
Rigand,__Am. Chem., 90,p.283.
Hlosiwetz and Pfoundler,__Ann. Chem., 127, p. 362.
Zwenger and Dronke,__Ann. Chem., 123, p. 145;
Suppl., 1, p. 257.
Roehleder,__S. Ber. Wiener Acad.Math.- phys. Cl.,
" 33, p. 565; 55,p.40
Löwe,__Z. analyt. Chem., 14, p. 233; 21, p. 128.
Liebermann and Hamburger,- Ber. Chem. Ges., 12, p.1178.
Liebermann,ibid.,- 17, p. 1680.
Schimck,-Journ. Chem. Soc., 53, p. 264; Chem. Soc.,
53,p. 264; Chem. News, 57, p. 60.
Herzig,- Monatsh.f.Chem., 14, p. 53.
Wachs,-
Dissert. Dorpat, 1893.
Rupe,- Naturliche Farlstoffe Bramschweig,1900,p.32.

_____ -
Humnlus Lupulus
Wagner,- Jahresber.f. Chem., 1859,p.585.

Leaves -
Adonis verualis
Podwyssotzky,- nach Drogendorff,
Heilpflanzen 229 cit.

Flowering Buds
Capparis spinosa
Hlasiwetz,- Ann. Chem., 96,p.123;
Herzig,-Monatsh.f.Chem., 6, p. 863;
Foerster,- Ber.Chem.Ges., 15, p. 214

Wachs,-Dissert. Dorpat,1893;
Schunck,-Journ. Chem. Soc., 67, p. 30.

Flowers -
Crataegus Oxyacantha
Perkin and Hummel,-Chem. News, 74,p.278

Flowers -
Crataegus momgyna
Wittstein,-Wittst. Vierteljahrschr. prakt.Pharm., 8,p.33; 2,p.402.

Petals -
Rosa centifolia
Du Menil,-Arch. Pharm., 15, p. 352.
Senier,-Pharm. Jr. Trans.,(3) 7,p.650.
Enz,-Vierteljahrschr. pr.Pharm., 16,p.53.

Petals -
Rosa Gallica
Rorhleder;__Repert.Pharm. 16.p. 1736.

Leaves -
Erythroxylon Coca
Ejikman,-Nederl.Tyoschr.Pharm.,1887.

Herb -
Ruta graveolens
Nischo,-Pharmac. Post., 29,p.333.
Schmidt,-Apoth.-Ztg., 16,p.357.

Leaves -
Pleurostylia Wightii
Greshoff,-Ber. Pharm. Ges.,9,p.214.

Leaves -
Aesculus Hippocastauum
Rochleder,-S.-Ber. Wiener Acad. Math.-phys.Cl.,33, p.365.
Wachs,-Dissert.Dorpat.1893.
Zwenger,-Ann.Chem.,90,p.63.

Flowers -
Rochleder,-S.-Ber.Wiener Acad. Math,-Phys.,1852. Dez; 1853,Jan.13,p.169; 16,p.1; 33,p.365.

Buds -
Same as under leaves.

Seeds -
Roehleder,- 1858.
Wachs,-Dissert.Dorpat,1893.

Rinds -

Ceanothus americanus
Buehuer,-Heilpflouzen 414

Leaves-

Vitis vinifera
Neubauer,-z. analyt.Chem., 12,p.46; Landw.Versuchst., 16,p.427.

Leaves-

Thea chinensis
Hlosiwetz and Malin,-S.-Ber. Wiener Acad., 55, p.19.
Namminga,-Mededel & Lands Ploutent.,46.

———

Prangos pabulorio
van Rijin,-Glykoside,1900,p.333.

Leaves-

Fraxinus excelsior
Gintl and Remitzer,-Monatsh.f.Chem., 3,p.745.
Gintl,-S.-Ber.Wien.Acad.Math.naturw.,57,p.709; 59,p.51

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I S O Q U E R C I T R I N

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Herb -

Ruta groveolens
After Wiseho,-Pharmac.Post.,29,p.333.
Schmidt,-Apoth.-Ztg.16,p.357.

Flowers

Gossypium herbaceum
Perkin,-p.Chem.Soc.,95,p.2181

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R U T I N - REFERENCES

Herb -

Fagopyrum tataricum
Schunck,-Chem.News,57,p.60
Chem. Gaz.,1859,p.303.

Flowering Buds

Capparis spinosa
Rochleder and Hlasiwetz,-Am. Chem., 82,p.197.
Jr. prakt. Chem.,56,p.96.
S.-Ber.Wiener Acad.Math.-phys.1852,Jan.
Zwenger and Dronke,-Am. Chem., 123,p.145.
Hlasiwetz,-Ann. Chem.,96,p.123.
Schmidt,-Arch.Pharm., 246,p.214.
Schunck,-Journ. Chem. Soc., 67, p. 30.
Schmidt,-Arch. Pharm., 242,p.210
Brauns,-ibid., 242,p.556 and 547.

Sedum purpurascens
Mylins,-Arch.Pharm.,201,p.97.
Oben and Wagner,-D.Med. Ztg., 1885, p.99

Flowering Buds

Sophora japonica
Schmidt,-Arch.Pharm., 242,p.210.
Brauns,-ibid.,242,p.547.
Waljaschko,-ibid., 242,p.225.
Schunck,-Journ.Chem. Soc., 67,p.30

Herb -

Ruta gaveolens
Weiss,-Pharm. Centralbl.Nr.,57,p.903.
Hlasiwetz,-Ann.Chem. 96,p.121.
Bornträger,-Ann. Chem., 53,p.385.
Schmidt,-Arch.Pharm., 242,p.210.
Waliaschko,-Arch.Pharm.,242,p.225.
Schunck,-Journ.Chem.Soc., 67,p.30.

Flowers

Viola tricolor
Schmidt,-Arch.Pharm.,246,p.214.
Wunderlich,-ibid.,246,p.224.

Leaves

Globularia alypum and G. vulgaris
Wunderlich,-Arch.Pharm., 246,p.256.

Osyris compressa
Perkin,-Jr. Chem. Soc., 97,p.1776;
Proc. Chem. Soc., 17,p.87.

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EXPERIMENTAL

Extraction-

The dried outer scales of yellow onions(Allium cepa) were placed in a large jar and covered with ether. The stopper of the container was sealed with wax to prevent evaporation, and the extraction was allowed to proceed for about two weeks. The ether washed out dust and soil particles. It extracted a considerable quantity of fatty and waxy material and some yellow pigment. A portion of this extract, from which the ether was evaporated was partitioned between amye alcohol and water. The pigment went quantitatively into the amyl alcohol layer, indicating the absence of glucosides.

A second ether extract was made in the same way. This like the first, consisted principally of fatty and waxy material with some yellow, non glucosidal, pigment.

For convenience in handling and extracting, the scales, which had already been treated twice with ether, were packed into a large cylindrical percolator. They were now covered with 95 per cent alcohol and allowed to stand about two weeks. The alcohol was then drawn off and evaporated to a small volume. A large quantity of yellow, non glucosidal pigment, quercetin, separated out, contaminated with much smaller quantities of fat, waxes and other impurities than had been the ether extracts. A second extraction with 95 per cent alcohol was made in the same way, with similar results.

Alcohol of 50 per cent strength was next used for extracting, followed by an extraction with 50 per cent methyl alcohol. When these extracts were partitioned between amyl

alcohol and water, as before a considerable quantity of the pigment remained in the aqueous layer indicating the presence of glucosidal yellow pigments. The methyl alcohol extract was lost during the process of purification.

The last extraction was made with acetone. The scales still retained a slight yellow color.

Purification -

The solid residues obtained from the ether and alcoholic extracts were washed with distilled water until the washings shaken up with amyl alcohol no longer showed the presence of a glucoside, all the color going into the amyl alcohol.

Each residue, separately, was now dissolved in alcohol under a reflux condenser, and filtered while warm into 1000cc of ether. Separation into an aqueous layer and an ether alcohol layer took place and another 1000cc of ether was added. The ether alcohol layer was now washed with distilled water until the washings were colorless. The washings were saved and evaporated to dryness.

The ether alcohol solution was next washed with 10 per cent potassium hydroxide solution. All of the color went into the alkaline solution and the pigment was precipitated out by the addition of dilute hydrochloric acid. This was fairly pure quercetin and would serve for the formation of derivatives. The quercetin was identified by the formation of acetyl and benzoyl derivaties.

The quercetin was further purified by crystallization as follows: It was dissolved in alcohol by the aid of heat and filtered. Water was then added until a precipitate began to form; then alcohol was added in just sufficient quantity to dissolve the precipitate, when it was allowed to stand to crystallize. Fine yellow crystals were obtained in this way.

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B I B L I O G R A P H Y

Bolley, P. A. 1841.

Ueber dan golben Farbstoffe der Quercitronrinde.
Ann., 37, p. 101.

An account of the extration purification and properties.

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Rig aud, L. 1854.

Ueber das Quercitrins.
Ann., 90, p., 283

A brief history of quercitrin giving properties and results of elementary analysis.

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Hlasiwetz, H. 1855.

Ueber Quercitrin und Rutinsaeure.
Ann., 96, p. 123.

An analysis of quercitrin from Capparis Spinosa, also of "Rutinsaeure".

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Bolley, P. 1861.

Farbsloff des Sanddorns
Jahresber ueber Forts.Chem.,(1861) p.708.

Quercetin identified in the pigment of Hippophae rhamnoides.

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Hlasiwetz and Pfaundler 1864.

Quercitrin
Jahresber ueber Forts. Chem.,(1864)p. 564.

Results of analysis of quercetin and quercitrin, also compounds with sodium and zinc.

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Rochleder, J. 1867.

Quercetin und Quercitrin
Jahresber. ueber Forts.Chem.(1867) p.731.

Analysis of pigments from horse chestnut, also from bark of the apple tree.

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Giuth, W. 1868.

Eschen-blaetter.
Johresber.ueber Forts.Chem.,(1868),p.800.

Quercetin obtained from the lead acetate precipitate of the aqueous extract of Fraxinus excelsior L. No Quercitrin obtained.

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Wagner, Rud. 1873.

Uber das Vorkommen des quercitrins im Sumach

Chemisches Central-Blatt., 44, p. 586.

An account of the yellow pigments obtained from various species of Sumach, which seemed identical with Quercetrin.

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Löwe, Jul. 1873.

Uber das Vorkommen des Quercetins und Quercitrins im Catechu und Sumach.

Chemisches Central-Blatt.,44,p.536.

Outline of method of isolation of querectin.

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Liebermann, C. and Hamburger, S. 1879.

Ueber die Formel des quercitrins und des Quercetins.

Berichte Der Deutschen Chemischen Gesellschaft., 12.1,p.1178.

Results of formulas obtained by various observers, for Quercetin and Quercitrin with their compounds.

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Liebermann, C. and Hoermann,O. 1879.

Ueber die Farbstoffe und den Glycosidzucker der Gelbeeren

Ann., 198.p. 299.

A chemical study of the glucoside, as to isolation, properties, analysis and structure of rhamnetin.

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Foerster,P. 1882

Zur Identitatsfrage der Farbstoffe der chinesesehin Gelbbeeren, der Kapern und der Raute mit dem quercitrin und quercetin.

Berliner Chemische Berichte,15.p.214.

A brief method of extraction and crystallization of quercetin and quercitrin from Sophora japonica.

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Herzig,J. 1885

Studien uber Quercetin und seine Derivate.(II Abhandlung.)

Monatschefte für Chemie,6,p.863.

An account of the identification of Quercetin and its derivatives.

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Herzig,J. 1888

Studien uber Quercetin und seine Derivate (III Abhandlung)

Monatschefte für Chemie,9,p.537

An analysis of the Molecular size-of Quercetin

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Herzig,J. 1894.

Studien uber Quercetin und seine Derivate.(X Abhandlung)

Monatschefte für Chemie, 15,p.683.

Discussion of some quercetin derivatives,fisetin,rhamnetin,etc.

Results of investigation of reaction of quercetin and fisetin with Sulphuric, hydrochloric, hydrochromic and hydriodic acids.

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Perkin,A.G. and Hummel,J.J. 1896.

Occurrence of Quercetin in Outer Skins of Bulb of the Onion (Allium cepa.)

Journal Chemical Society,69,p.1295.

A brief history of early uses of onion skins and method of extraction of the colouring matter.

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Perkin,A.G. 1897.

The yellow Colouring Principles of Various Tannin Matters.

Journal Chemical Society,71,p.1131.

A discussion of the uses in the tanning industry, and method of extraction for investigation.

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Dunstan,N.R. and Henry,T.A. 1898.

Constituents of Indian and American Podophyllum. (P. emodi. and P. peltatum.)

Chem. Soc. Jr., Tr., 73,p. 219.

Method and results obtained from analysis of Indian and American Podophyllum.

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Perkin,A.G. 1900.

Yellow Colouring Principles in Various Tannin Matters.

Journal Chemical Society,77,p.424.

Isolation and formation of compound of Quercetin..from Arctostaphylos uva ursi(Bearberry.)

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Perkin,A.G. and Phipps.S. 1901.

Notes on some Natural Colouring Matters.

Journal Chemical Society,85,p.56.

An account of the yellow colouring matter obtained from the flowers of Prunus spinosa, and some compounds formed therefrom.

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Instr in Pharm.