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BORON TRIFLURORIDE IN THE SYNTHESIS OF PLANT PHENOLICS: SYNTHESIS OF FLAVONES AND FLAVONOLS

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ABSTRACT

2,4-Dihydroxyphenyl styryl ketone and 2,3,4-trihydroxyphenyl styryl ketone, prepared by the boron trifluoride method, have been oxidized to 7-hydroxy-flavone and 7,8-dihydroxyflavone by means of selenium dioxide in acetic anhydride. 6-Hydroxy-5,7-dimethoxyflavone (*baicalein* dimethyl ether) and 5,6,7-trimethoxyflavone (*baicalein* trimethyl ether) have been prepared by the selenium dioxide oxidation of 2,5-dihydroxy-4,6-dimethoxyphenyl, and 2-hydroxy-4,5,6-trimethoxyphenyl styryl ketone respectively. Condensation of 2,5-dihydroxy-4,6-dimethoxyacetophenone and 2-hydroxy-4,5,6-trimethoxyacetophenone (prepared by the boron trifluoride method) with vanillin gave the corresponding styryl ketones which on oxidation with alkaline hydrogen peroxide gave the respective flavonols, 3,6,4'-trihydroxy-5,7,3'-trimethoxy-flavone and 3,4'-dihydroxy-5,6,7,3'-tetramethoxyflavone, which are of interest, because of their possible occurrence in nature. Demethylation with hydriodic acid gave *quercetagetin,* a naturally occurring flavonol. Partial demethylation of quercetagetin hexamethyl ether with hydrobromic acid gave *artemitin.* Demethylation of 3,4'-dihydroxy-5,6,7,3'-tetramethoxyflavone with aluminum chloride in ether gave the naturally occurring 3,5,4'-trihydroxy-6,7,3'-trimethoxyflavone.

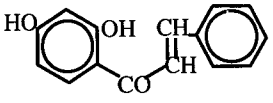
INTRODUCTION

A convenient method of preparation of phenyl styryl ketones, by condensation of phenols with cinnamic acid in presence of boron trifluoride, was described in an earlier paper (Mani, Herbert and Manise,1991).

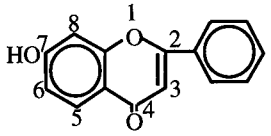
It is now our purpose to examine the conversion of the phenyl styryl ketones to flavones and flavonols.

Selenium Dioxide Oxidations: SYNTHESIS OF FLAVONES

The selenium dioxide oxidation method has been found suitable, in the present work, for the cyclization of phenyl styryl ketones, prepared by the condensation of di- and trihydroxy phenols with the boron fluoride complex of cinnamic acid. Thus, 2,4-dihydroxyphenyl styryl ketone (I) obtained from resorcinol, by reacting with boron fluoride-cinnamic acid complex, has been oxidized to 7-hydroxflavone (II) by means of selenium dioxide in acetic anhydride. Similarly 2,3,4-trihydroxyphenyl styryl ketone (III) could be readily oxidized to 7,8-dihydroxyflavone (IV).



I



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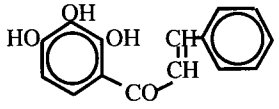

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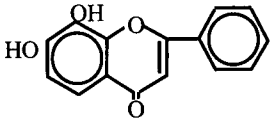
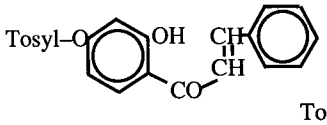
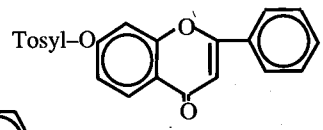


IV

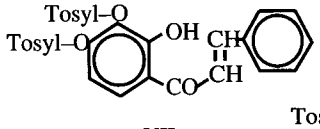
An alternative method which gave cleaner products was to prepare the mono- and ditosylates (V) and (VII), which could be cyclized readily to the 7-tosyloxy- and the 7,8-ditosyloxyflavones (VI) and (VIII) by means of selenium dioxide in n- amyl alcohol.



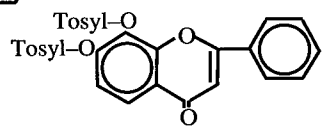
V



VI



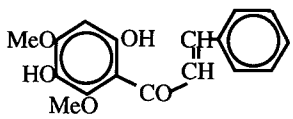
VII



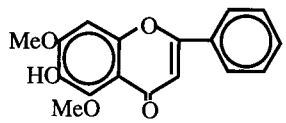
VIII

A 10% solution of potassium hydroxide in aqueous ethanol or acetone, at room temperature overnight, hydrolysed the tosyloxyflavones to the hydroxyflavones (II) and (IV).

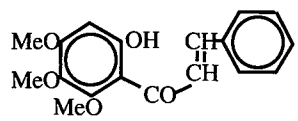
The selenium dioxide oxidation method has also been applied to the phenyl styryl ketones (IX) and (XI) prepared by the condensation of 2,6-dimethoxyhydroquinone and antiarol (3,4,5-trimethoxyphenol) with cinnamic acid in presence of boron fluoride (Mani, Herbert and Manise 1991).



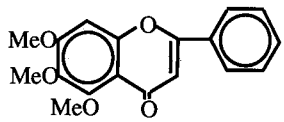
IX



X



XI

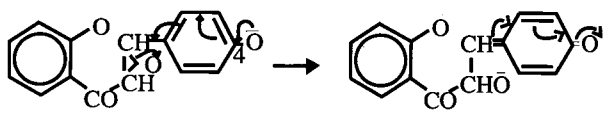


XII

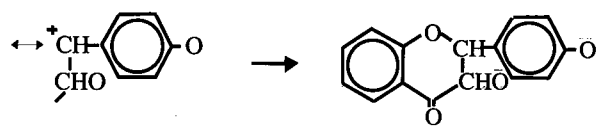
2,5-Dihydroxy-4,6-dimethoxyphenyl styryl ketone (IX) was oxidized in 60% yield to 5,7-dimethoxy-6-hydroxyflavone (baicalein 5,7-dimethyl ether; X) by means of selenium dioxide in acetic anhydride. Baicalein trimethyl ether (XII) was obtained in nearly 50% yield by the selenium dioxide oxidation of 2-hydroxy-4,5,6-trimethoxyphenyl styryl ketone (XI) in n–amyl alcohol.

Hydrogen Peroxide Oxidations: SYNTHESIS OF FLAVONOLS (3-HYDROXYFLAVONES)

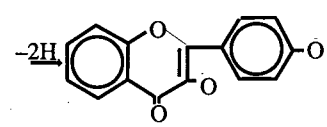
For the synthesis of flavonols, as distinct from flavones, a convenient procedure is the oxidation of 2-hydroxyphenyl styryl ketones with alkaline hydrogen peroxide. The presence of a 4-hydroxyl group in the styryl part of the ketone facilitates the formation of a flavonol according to the mechanisms:



XIII XIV



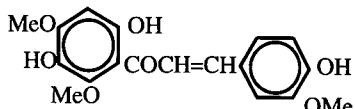
XV



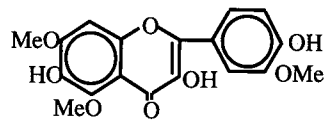
XVI

The conversion of the epoxide (XIII) to (XV), which finally undergoes dehydrogenation to the flavonol (XVI), is facilitated by the resonance of the phenolate ion and the opening of the epoxide ring.

2,5-Dihdroxy-4,6-dimethoxyacetophenone obtained by reaction of 2,6-dimethoxyhydroquinone with boron fluoride-acetic acid complex (Mani, Herbert and Manise 1991) was condensed with vanillin in presence of ethanolic potassium hydroxide to give 2,5-dihydroxy-4,6-dimethoxyphenyl-4-hydroxy-3-methoxystyryl ketone (XVII). Oxidation of (XVII) with alkaline hydrogen peroxide at 70-80° gave 3,6,4'-trihydroxy-5,7,3'-trimethoxyflavone (XVIII).

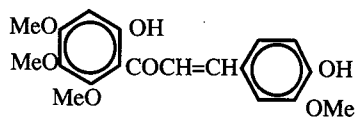


XVII

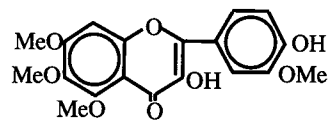


XVIII

Similarly, 2-hydroxy-4,5,6-trimethoxyacetophenone obtained by reaction of antiarol with boron fluoride-acetic acid complex (Mani, Herbert and Manise 1991) on condensation with vanillin gave 2-hydroxy-4,5,6-trimethoxyphenyl 4-hydroxy-3-methoxystyryl ketone (XIX) which on alkaline hydrogen peroxide oxidation gave 3,4'-dihydroxy-5,6,7,3'-tetramethoxyflavone (XX).



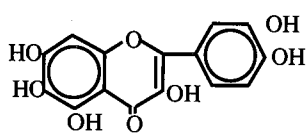
XIX



XX

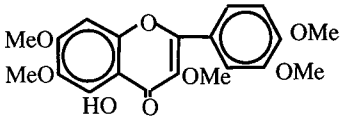
DEMETHYLATION STUDIES

Complete demethylation of either (XVIII) or (XX) with hydriodic acid gave 3,5,6,7,3',4'-hexahydroxyflavone (quercetagetin; XXI). Quercetagetin was isolated from the flowers of the African marigold, *Tagetes patula* by Latour and Magnier De Le Source (1977), and the structure assigned by Baker, Nodzu and Robinson (1929).

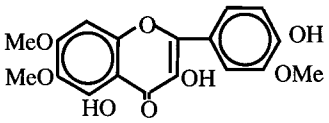


XXI

When the hexamethyl ether, obtained either from (XVIII) or (XX) by methylation with dimethyl sulfate and potassium carbonate in acetone, was treated with hydrobromic acid in acetic acid at room temperature, the 5-methoxy group was preferentially demethylated, and the product (XXII) was identical with natural artemitin (Baker, Nodzu and Robinson, 1929; Mazur and Meisels, 1955, 1956).



XXII

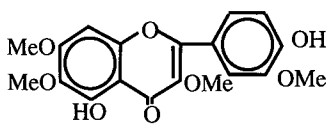


XXIII

Partial demethylation of (XX) with aluminum chloride in ether at 25° gave (XXIII). This was identical with the flavonol, isolated from *Chrysosplenium japonicum* by Nakaoki and Morita (1956), who had assigned it the structure, 3,5,4'-trihydroxy-6,7,3'-trimethoxyflavone.

This flavonol occurs as the 3- or 5-glucoside in *Chrysosplenium japonicum*, and was given the name 'chrysosplenetin' by Nakaoki and Morita (1956).

Later, the 3-methoxy derivative (XXIV), which also occurs as the glucoside in the *Chrysosplenium* plants, was isolated by Shimuzu and coworkers(1969), and was shown to have potent antiviral activity, especially against rhinovirus. A comparison of the activities of the compounds tested, indicated that 3-methoxyl and 5-hydroxyl groups in the flavone skeleton were both necessary for antiviral activity against rhinovirus (Tsuchiya, 1985). The name 'chrysosplenetin' in the literature (Shimuzu 1969, Tsuchiya 1985) refers to (XXIV) rather than (XXIII).



XXIV

A NOTE ON THE COLOR REACTIONS REPORTED IN THIS WORK (METHODS AND MATERIALS)

Throughout this investigation, two color reactions have been employed:

a. The ferric chloride coloration, showing the presence of phenolic hydroxyl groups. The color ranges from pale brown to green, depending on the number of hydroxyls in the molecule. A 5-hydroxyl group in the flavonoid compound, which is chelated to the carbonyl group, gives an intensification of color, usually green.

b. The magnesium-hydrochloric acid test.

A small amount of the compound dissolved in ethanol, is treated with a small piece of magnesium turning and a few drops of 5M HCl. A pink or orange color indicates the presence of a γ-pyrone ring, characteristic of flavonoids.

METHODS AND MATERIALS

2-Hydroxy-4-tosyloxyphenyl styryl ketone (V)

2,4-Dihydroxyphenyl styryl ketone (I) obtained from resorcinol and cinnamic acid in presence of boron trifluoride (1.2 g), was dissolved in Na_2C0_3 solution (2 g in 150 ml) and *p*-toluenesulfonyl chloride (1 g, 1 mol) added. The mixture was stirred mechanically for 3 1/2 hours at room temperature keeping it alkaline throughout the reaction. A yellowish mass separated. The reaction mixture was then acidified, filtered and the residue washed with water. The product crystallized from dilute ethanol in yellow needles (1.5 g), m.p. 125°. It gave a pale brown coloration with ethanolic ferric chloride. (Found, C, 67.2; H, 4.5; S, 8.0. $C_{22}H_{18}0_5S$ requires: C, 67.0; H, 4.5; S, 8.1%).

7-Tosyloxyflavone (VI)

2-Hydroxy-4-tosyloxyphenyl styryl ketone (V) (1 g), $Se0_2$ (1 g) dry n-amyl alcohol (200 ml) were refluxed in an oil bath at 150° for 12 hours and filtered hot from selenium. The amyl alcohol was removed by steam distillation; and the residue after steam distillation was ether extracted, and the ether extract washed with cold 1% Na_2C0_3 solution, then with water, dried and distilled. The product, obtained after removal of ether, crystallized from dilute ethanol in pale yellow needles (0.8 g), m.p. 159°. It gave a pink color with magnesium-HCl, but not coloration with ethanolic ferric chloride. (Found: C, 67.1; H, 4.1;
S, 7.9. $C_{22}H_{16}0_5S$ requires: C, 67.3; H, 4.0; S, 8.2%).

7-Hydroxyflavone (II)

Method a. 7-Tosyloxyflavone (VI; 0.5 g) was mixed with KOH in aqueous acetone (5% solution) and kept at room temperature overnight. The acetone was distilled off, and the residue dissolved in water and acidified. The pale brown product which was obtained, crystallized from dilute ethanol in yellow needles (0.2 g), m.p. 240° (lit. m.p. 240°)(Allan and Robinson, 1924; Robinson and Venkataraman, 1924). It gave a brown coloration with ethanolic ferric chloride and a pink color with Mg-HCl. (Found: C, 75.2; H, 4.0 $C_{15}H_{10}0_3$ requires: C, 75.6; H, 4.2%).

Method b. 2,4-Dihydroxyphenyl styryl ketone (I, 0.5 g) was dissolved in acetic anhydride (10 ml) and selenium dioxide (0.5 g) was added. The mixture was refluxed for four hours at 150° in an oil bath. The color of the solution changed to pale yellow and black selenium deposited. At the end of the reaction, the selenium was filtered off, and the filtrate poured into water when a brown solid separated, which was filtered and hydrolysed by boiling with 5% ethanolic KOH (50 ml) for three hours. The alcohol was distilled off, and the residue dissolved in water and acidified. The brownish product which was obtained, crystallized from dilute ethanol in yellow needles (0.3 g), m.p. 239-240° and was identical with the product obtained in method a.

2-Hydroxy-3,4-ditosyloxyphenyl styryl ketone (VII)

2,3,4-Trihydroxyphenyl styryl ketone (III), obtained from pyrogallol and cinnamic acid in presence of boron fluoride (1g), was dissolved in chloroform (6 ml) and treated with *p*-toluenesul-

fonyl chloride (2.8 g, 3 mol). Pyridine was added dropwise to the reaction mixture and after two hours, 25 ml ethanol was added. The yellow solid, which was obtained, (2 g) was filtered, triturated with 5% $NaHCO_3$ solution and crystallized from ethanol, yellow plates, m.p. 175°. It gave a light brown coloration with ethanolic ferric chloride. (Found: C, 61.5; H, 44; S, 11.8. $C_{29}H_{24}0_8S_2$ requires: C, 61.7; H, 4.3; S, 11.3%).

7,8-Ditosyloxyflavone (VIII)

The chalkone-ditosylate (VII, 0.5 g), selenium dioxide (0.5 g), n-amyl alcohol (50 ml) were refluxed in an oil bath at 145-150° for 10 hours. Black selenium separated at about 100°. The selenium was filtered off hot and the filtrate steam distilled to remove amyl alcohol, when an oil was obtained, which solidified. It crystallized from ethanol in needles (0.3 g), m.p.203°. It gave a pink color with magnesium and HCl and no coloration with ethanolic ferric chloride. (Found: C, 61.6; H, 3.7; S, 10.9. $C_{29}H_{22}0_8S_2$ requires C, 61.8; H, 4.1; S, 11.4%).

7,8-Dihydroxyflavone (IV)

Method a. 2,3,4-Trihydroxyphenyl styryl ketone (III, 0.5 g), obtained from pyrogallol and cinnamic acid in presence of boron trifluoride, was dissolved in acetic anhydride (10 ml) and selenium dioxide (0.5 g) added. The mixture was refluxed for five hours at 150-160° in an oil bath. The reaction mixture was then filtered to remove selenium and the filtrate poured in water when a dark brown sticky mass was obtained, which was boiled for one hour with 5% ethanolic KOH (50 ml). The alcohol was distilled off and the residue dissolved in water and acidified. The brownish product was crystallized from dilute methanol. Needles (0.25 g), m.p. 245°. (Found: C, 70.5; H, 4.0. $C_{15}H_{10}0_4$ requires: C, 70.9; H, 3.9%). It gave a greenish violet color with ethanolic ferric chloride and an orange color with magnesium and HC1 (lit. m.p. 246°)(Venkataraman 1929; Baker 1939).

Method b. 7,9-Ditosyloxyflavone (VIII 0.1 g) was dissolved in ethanol (10 ml) and treated with 20% ethanolic KOH solution (15 ml) and the mixture left overnight at room temperature. The alcohol was distilled off in vacuum and the residue diluted with water and acidified. The pale brown product which was obtained, crystallized from dilute methanol in needles (0.05 g), m.p. 246°, and was identical with the product obtained in method a.

5,7-Dimethoxy-6-hydroxyflavone (X)

2,5-Dihydroxy-4,6-dimethoxyphenyl styryl ketone (IX), obtained from 2,6-dimethoxyhydroquinone and cinnamic acid (0.5 g) in presence of boron trifluoride (Mani, Herbert and Manise 1991), was dissolved in acetic anhydride (10 ml) and selenium dioxide (0.5 g) added. The mixture was boiled for six hours under reflux at 150-160° in an oil bath. The solution became pale yellow and black selenium deposited. This was filtered off at the end of the reaction and filtrate poured into water, when a brown precipitate was obtained, which was filtered off and boiled with 5% ethanolic KOH (50 ml). The alcohol was distilled off and the residue dissolved in water and acidified. The brown substance, which was obtained, crystallized from dilute ethanol in yellow needles (0.3 g), m.p. 210° (lit. m.p. 212-213°)(Sastri and Seshadri 1946; Krishnamurti and Seshadri 1954). (Found: C, 68.2; H, 4.5. C17H1405 requires: C, 68.5; H, 4,7%). It gave a brownish color with ethanolic ferric chloride and a reddish orange color with magnesium and HCl.

The acetate, prepared by boiling the flavone with acetic anyhydride and a few drops of pyridine, crystallized from methanol in needles, m.p. 220° (lit. m.p. 218-219°)(Sastri and Seshadri 1946; Krishnamurti and Seshadri 1954). (Found: C, 66.9; H, 4.2. $C_{19}H_{16}0_6$ requires: C, 67.1; H, 4.7%).

5,6,7-Trimethoxyflavone (XII; baicalein trimethyl ether)-

2-Hydroxy-4,5,6-trimethoxyphenylstyryl ketone (XI) obtained from antiarol and cinnamic acid in presence of boron trifluoride (Mani, Herbert and Manise 1991)(0.2 g), $Se0_2$ (0.2 g), dry n–amyl alcohol (40 ml) were refluxed in an oil bath at 150° for 12 hours and filtered hot from selenium, which deposited as a black powder. The amyl alcohol was removed by steam distillation and the residue after steam distillation was ether extracted, and the ether extract washed with cold 1% Na_2C0_3 solution, then with water, dried and distilled. The product, which was obtained after removal of the ether, crystallized from dilute methanol in colorless needles (0.09 g), m.p. 166° (lit. m.p. 165-166°(Sastri and Seshadri 1946). (Found: C, 68.8; H, 4.8. $C_{18}H_{16}0_5$ requires: C, 69.2; H, 5.1%). It did not give a coloration with ethanolic ferric chloride.

2,5-Dihydroxy-4,6-dimethoxyphenyl 4-hydroxy-3-methoxy-styryl ketone (XVII)

2,5-Dihydroxy-4,6-dimethoxyacetophenone (Mani, Herbert and Manise 1991) (2 g) was dissolved in ethanol (30 ml) and mixed with vanillin (4 g). Potassium hydroxide (4 g as 50% solution) was then added and the orange solution refluxed on the steam-bath for 15 minutes. The flask was then corked tightly while still hot, and left to stand overnight at room temperature. After 24 hours the reaction mixture was diluted with water and cooled. The solution, on acidification, gave a reddish oil. After leaving in the refrigerator overnight the supernatant layer was decanted and the orange red sticky mass which remained was crystallized from dilute ethanol. Orange yellow needles, m.p. 175°. Yield after two crystallizations 1.5 g. (Found: C, 62.5; H, 5.1. $C_{18}H_{18}0_7$ requires: C, 62.4; H, 5.2%). The substance gave a reddish brown coloration with ethanolic ferric chloride and a reddish solution with concentrated H_2S0_4.

3,6,4'-Trihydroxy-5,7,3'-trimethoxyflavone (XVIII)

2,5-Dihydroxy-4,6-dimethoxyphenyl-4-hydroxy-3-methoxy-sty ryl ketone (XVII), 1 g) was dissolved in 20% NaOH (20 ml). Water (50 ml) was added and the solution cooled to 0°. Hydrogen peroxide (50%; 2.5 ml) previously cooled to 0° was added dropwise and the deep red solution was then left to stand at room temperature for 16 hours when the color of the solution changed to pale orange. The reaction mixture was heated at 70-80° on a water-bath for three hours when the solution turned yellow. The reaction mixture was cooled and acidified, and the yellow precipitate which was obtained, was filtered and crystallized from ethanol. Yellow needles (0.5 g), m.p. 265°. (Found: C, 60.2; H, 4.2. $C_{18}H_{16}0_8$ require: C, 60.0; H, 4.5%). The substance gave a greenish brown coloration with ethanolic ferric chloride and a pink color with magnesium and HCl.

2-Hydroxy-4,5,6-trimethoxy phenyl-4-hydroxy-3-methoxy-styryl ketone (XIX)

2-Hydroxy-4,5,6-trimethoxyacetophenone (Mani, Herbert and Manise 1991)(2.5 g) was dissolved in ethanol (30 ml, 95%) and mixed with vanillin (5.2 g). Potassium hydroxide (2.5 g as 50% solution) was added and the deep orange solution refluxed on a steam-bath for 15 minutes. The solution was corked tightly and left overnight at room temperature. It was then diluted with water, cooled and acidified, when a reddish oil separated. The latter solidified, on leaving in the refrigerator overnight. The supernatant layer was decanted and the sticky mass was crystallized from ethanol. Bright yellow prismatic needles (1.9 g), m.p. 150°. (Found: C, 63.6; H, 5.6. $C_{19}H_{20}0_7$ requires: C, 63.3; H, 5.5%). The substance gave a brown ferric color and a red solution with conc H_2S0_4.

3,4'-Dihydroxy-5,6,7,3'-tetramethoxyflavone (XX)

2-Hydroxy-4,5,6-trimethoxy phenyl-4-hydroxy-3-methoxy-styryl ketone (XIX), 1 g) was dissolved in 20% NaOH (20 ml). Water (50 ml) was added and the solution cooled to 0° and treated with a cooled solution of hydrogen peroxide (50%; 2.5 ml). The reddish solution was left to stand overnight at room temperature, and then heated on a water-bath at 70-80° for two hours when the solution turned yellow. The cooled reaction mixture was acidified and the yellow precipitate, which was obtained, was crystallized from ethanol. Pale yellow needles (0.5 g), m.p. 235°. (Found: C, 69.5; H, 4.8. $C_{19}H_{18}0_8$ requires: C, 69.9; H, 4.9%). The substance gave a pink color with magnesium and HCl and a green color with ethanolic ferric chloride.

3,5,6,7,3',4'-Hexahydroxyflavone (XXI), quercetagetin

(A) 3,6,4'-Trihydroxy-5,7,3'-trimethoxyflavone (XVIII), 0.3 g) was refluxed with hydriodic acid (*d* 1.7, 15 ml) for three hours. The red mixture was cooled and poured into saturated sodium bisulfite solution. The yellow solid, which separated, was collected and after three crystallizations from dilute methanol was obtained as yellow needles (0.1 g), melting with decomposition at 318° (lit m.p. 316°)(Baker, Nodzu and Robinson 1929). (Found in a sample dried at 150°/0.003 mm over P_20_5 for three hours: C, 56.2; H, 3.5. $C_{15}H_{10}0_8$ requires: C, 56.6; H, 3.2%). The substance gave a green coloration with ethanolic ferric chloride.
(B) 3,4'-Dihydroxy-5,6,7,3'-tetramethoxyflavone (XX), 0.3 g) was refluxed with hydriodic acid (*d* 1.7, 15 ml) for three hours and the mixture after cooling was poured into saturated sodium bisulfite solution. The reddish brown precipitate was filtered and washed with cold water. After three crystallizations from methanol the substance was obtained as yellow needles (0.15 g) darkening at 318-320° and was identical with the product obtained in (A). (Found in a sample dried at 150°/0.003 mm over P_20_5 for three hours: C, 56.1; H, 3.7. $C_{15}H_{10}0_8$ requires: C, 56.6; H, 3.2%). The substance gave a green coloration with ethanolic ferric chloride.

3,5,6,7,3',4'-Hexamethoxyflavone (quercetagetin hexamethyl ether)

0.1g of (XXI) was refluxed with dimethyl sulphate (0.2 ml) and potassium carbonate (2g) in anhydrous acetone (25 ml) for 12 hours. After distilling off the acetone, the residue was treated with water. An almost colorless product separated, which crystallized from ethanol in needles, m.p. 142° (lit. m.p. of quercetagetin hexamethyl ether 141-142°)(Row and Seshadri 1946).

5-Hydroxy-3,3',4',6,7-pentamethoxyflavone (artemitin) (XXII)

A solution of quercetagetin hexamethyl ether (0.1g) in hot glacial acetic acid (2 ml) was treated with 50% hydrogen bromide in acetic acid (5 ml). The reaction mixture was kept overnight (18 hours). It was then diluted with water (20 ml) and extracted with ether. The ether extract, on washing the dilute NaOH (5% solution) and evaporation, gave a residue which crystallized from ethanol in pale yellow needles, m.p. 161-162° (Lit. m.p. 163-64°)(Baker, Nodzu and Robinson 1929; Mazur and Meisels 1955, 1956; Cekan and Herout, 1955, 1956; Tummann and Isaac, 1955, 1957). (Found: C, 61.6; H, 4.8. $C_{20}H_{20}0_8$ requires: C, 61.9; H, 5.2%). It gave a green coloration with ethanolic ferric chloride.

3,5,4'-Trihydroxy-6,7,3'-trimethoxyflavone

3,4'-Dihydroxy-5,6,7,3'-tetramethoxyflavone (XX, 0.2 g) in diethyl ether (80 ml) was treated with anhydrous aluminium chloride (4 g) and the mixture mechanically shaken for 24 hours at room temperature (25°). The ether was distilled off and the aluminum chloride complex was decomposed by treating with dil. HCl (2M) and subsequent warming for half an hour. The substance was filtered, washed with water and dried. It crystallized from ethanol as yellow needles, m.p. 174° (Lit. m.p. 171-2°)(Nakaoki and Morita 1956). (Found: C, 60.3; H, 4.9. $C_{18}H_{16}0_8$ requires: C, 60.0; H, 4.5%). It gave a green ferric chloride coloration.

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