

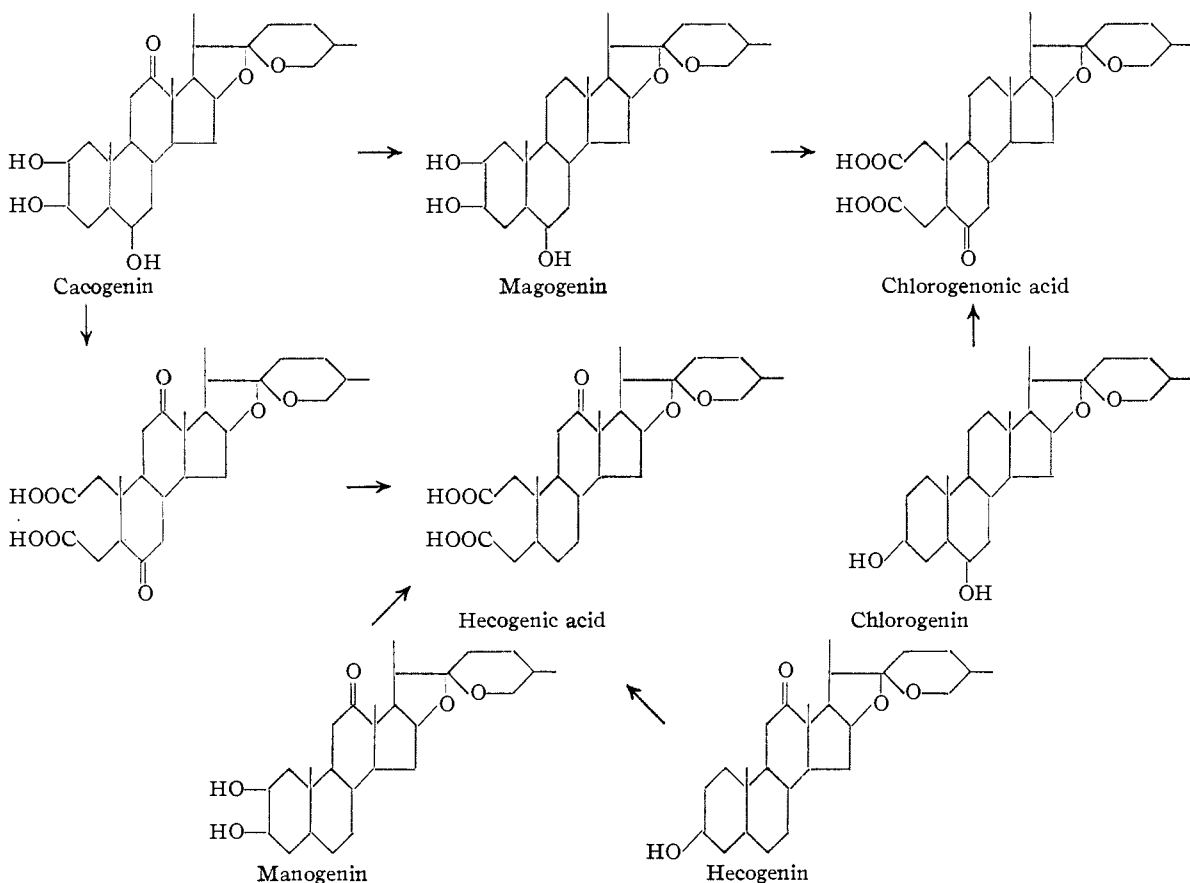
[CONTRIBUTION FROM THE LABORATORY OF BOTANICA-MEX., S. A.]

**Steroidal Sapogenins. No. 169. Magogenin and Cacogenin and their Biogenesis to Chlorogenin and Tigogenin**BY RUSSELL E. MARKER<sup>1</sup>

In a careful study of the steroidal sapogenins present in the plant species of *Yucca*, *Samuela*, *Agave* and *Dioscorea*,<sup>2</sup> we have previously demonstrated that as the plant approaches maturity the more complex steroidal sapogenins of the young plants are converted into those of simpler structure. Up to the present time the biogenesis of chlorogenin from the more complex sapogenins has not been shown. For this purpose a separate study of the steroidal sapogenins present in the young plants and mature plants of *Maguëy cacaya* has been made.

Kishner reduction of the ketone group of cacogenin to give magogenin, which does not contain a ketonic group. Oxidation of magogenin gave chlorogenonic acid which is identical with the acid obtained on the oxidation of chlorogenin. Oxidation of cacogenin followed by a mild Clemmensen reduction of the 6-keto group gave 12-keto-gitogenin acid, or hecogenic acid, which had previously been obtained on the oxidation of manogenin and hecogenin.<sup>3</sup>

The only sapogenins which could be isolated from the very young plants were cacogenin and



In the very young plants of *Maguëy cacaya* two new steroidal sapogenins were isolated and their structures determined. These sapogenins have been named magogenin and cacogenin. No other sapogenins could be isolated from the young plants.

The structure and relationship of these two new steroidal sapogenins was proven by the Wolff-

magogenin, whereas, when the plant had reached its fruiting stage after many years of growth, these two sapogenins had disappeared entirely and had been converted into chlorogenin, manogenin, gitogenin and tigogenin. The biogenesis of the simpler sapogenins from the more complex ones substantiates our previously proposed scheme of the plant biogenesis of the steroidal sapogenins. The structural formulas above will show the pro-

(1) Present address: Hotel Geneve, Mexico City.

(2) Marker and Lopez, *THIS JOURNAL*, 69, 2380 (1947).(3) Marker and Lopez, *ibid.*, 69, 2397 (1947).

gressive biogenetic change in the *Maguey cacaya* from the more complex to the simpler steroidal sapogenins as the plant reaches maturity.

### Experimental Part

The plants used in this work were collected on the mountains near the peak of Mt. Orizaba in Vera Cruz, Mexico. They are known to the natives as *Maguey cacaya*. An examination of the sterols present was made in very young plants and also separately in plants which had reached maturity and were in the fruiting stage. For this work the entire plant was used. The fresh plant was shredded, dried and ground. In each case 10 kg. of the dried ground plant was extracted with alcohol, the extract concentrated to about 5 liters and refluxed with 1 liter of concentrated hydrochloric acid for three hours. It was extracted with a large volume of ether, washed well with sodium hydroxide solution and the solvent was removed.

**Cacogenin and Magogenin from Maguey Cacaya.**—The crude sterols which were isolated from the young plants were treated in alcohol with an excess of Girard reagent to separate into a ketonic and a non-ketonic fraction. The ketonic fraction was crystallized from ether to give a product which we have named cacogenin, m. p. 278°; yield 7.8 g.

*Anal.* Calcd. for  $C_{27}H_{42}O_6$ : C, 70.1; H, 9.1. Found: C, 69.8; H, 9.2.

Acetylation and crystallization from ether and from methanol gave the triacetate of cacogenin, m. p. 248°.

*Anal.* Calcd. for  $C_{33}H_{48}O_9$ : C, 67.2; H, 8.2. Found: C, 67.5; H, 8.4.

The non-ketonic steroidal fraction was boiled for thirty minutes with alcoholic potassium hydroxide, extracted with ether and washed well with water. Upon concentration to a small volume a product crystallized. This was recrystallized from ether, m. p. 284° (yield, 2.3 g.). We have named this product magogenin.

*Anal.* Calcd. for  $C_{27}H_{44}O_5$ : C, 72.3; H, 9.9. Found: C, 72.4; H, 9.7.

Acetylation and crystallization from methanol gave the triacetate of magogenin, m. p. 214°.

*Anal.* Calcd. for  $C_{33}H_{50}O_9$ : C, 69.0; H, 8.8. Found: C, 69.2; H, 9.0.

No other steroidal sapogenins could be isolated from the young plants.

**Sapogenins from Maguey Cacaya at Fruiting Time.**—The crude sapogenin mixture from the plant at the time of fruiting was treated in alcohol with Girard reagent to separate the ketonic fraction from the non-ketones. The ketonic fraction was crystallized from ether to give magogenin, m. p. and mixed m. p. 252°; yield 5.6 g.

*Anal.* Calcd. for  $C_{27}H_{42}O_5$ : C, 72.6; H, 9.5. Found: C, 72.6; H, 9.3.

Acetylation and crystallization from methanol gave magogenin diacetate, m. p. and mixed m. p. 242°.

*Anal.* Calcd. for  $C_{31}H_{46}O_7$ : C, 70.2; H, 8.7. Found: C, 70.5; H, 8.8.

The non-ketonic fraction of crude sterols was acetylated and crystallized from ether to give tigogenin diacetate, m. p. and mixed m. p. 242°; yield 4.3 g.

*Anal.* Calcd. for  $C_{31}H_{48}O_8$ : C, 72.1; H, 9.4. Found: C, 72.0; H, 9.7.

Hydrolysis and crystallization from ether gave tigogenin, m. p. and mixed m. p. 268°.

*Anal.* Calcd. for  $C_{27}H_{44}O_4$ : C, 75.0; H, 10.3. Found: C, 75.3; H, 10.0.

The mother liquors from the crystallization of the tigogenin diacetate were evaporated and the residue was crystallized from methanol to give tigogenin acetate, m. p. and mixed m. p. 203°; yield 2.8 g.

*Anal.* Calcd. for  $C_{29}H_{46}O_4$ : C, 75.9; H, 10.1. Found: C, 76.1; H, 10.3.

Hydrolysis and crystallization from ether gave tigogenin, m. p. and mixed m. p. 206°.

*Anal.* Calcd. for  $C_{27}H_{44}O_3$ : C, 77.8; H, 10.7. Found: C, 77.8; H, 11.0.

The mother liquors from the crystallization of tigogenin acetate were hydrolyzed with alcoholic potassium hydroxide and the product was crystallized from ether to give chlorogenin, m. p. and mixed m. p. 278°; yield, 5.8 g.

*Anal.* Calcd. for  $C_{27}H_{44}O_4$ : C, 75.0; H, 10.3. Found: C, 75.2; H, 10.4.

Acetylation and crystallization from dilute methanol gave chlorogenin diacetate, m. p. and mixed m. p. 152°.

*Anal.* Calcd. for  $C_{31}H_{48}O_6$ : C, 72.1; H, 9.4. Found: C, 72.0; H, 9.7.

No other sapogenins could be isolated from the mature plants.

**Magogenin from Cacogenin.**—To a solution of 5 g. of sodium in 100 cc. of absolute ethyl alcohol was added 1 g. of cacogenin and 10 cc. of 85% hydrazine hydrate. The product was heated in a bomb tube at 200° for twelve hours. After cooling, it was poured into water and the precipitate was extracted with ether. The ethereal solution was washed with water and dilute hydrochloric acid. Upon concentrating and cooling the product crystallized. It was recrystallized from ether, m. p. and mixed m. p. with magogenin, 284°.

*Anal.* Calcd. for  $C_{27}H_{44}O_5$ : C, 72.3; H, 9.9. Found: C, 72.3; H, 10.2.

Acetylation and crystallization from methanol gave the triacetate of magogenin, m. p. and mixed m. p. 214°.

*Anal.* Calcd. for  $C_{33}H_{50}O_9$ : C, 69.0; H, 8.8. Found: C, 69.1; H, 8.8.

**Chlorogenic Acid from Magogenin.**—To a solution of 0.5 g. of magogenin in 50 cc. of acetic acid was added a solution of 1 g. of chromic anhydride in 10 cc. of 80% acetic acid. After standing for thirty minutes at room temperature water was added and the product was extracted with ether. The ethereal solution was washed well with water and finally with potassium hydroxide solution. The alkaline solution was acidified and extracted with ether. The solvent was removed and the residue was crystallized from aqueous acetic acid to give chlorogenic acid, m. p. and mixed m. p. 234°; yield 150 mg.

*Anal.* Calcd. for  $C_{27}H_{40}O_7$ : C, 68.0; H, 8.5. Found: C, 68.2; H, 8.4.

**Hecogenin Acid from Cacogenin.**—To a solution of 3 g. of cacogenin in 200 cc. of acetic acid was added a solution of 3 g. of chromic anhydride in 30 cc. of 90% acetic acid. The mixture was kept at room temperature for thirty minutes. Water was added and the product was extracted with ether and washed well with water. It was then extracted with potassium hydroxide solution and the alkaline layer was acidified and extracted with ether. The solvent was removed and the residue was dissolved in 300 cc. of ethanol to which was added 20 g. of 20-mesh zinc. The mixture was heated under reflux on a steam-bath and 5-cc. portions of concentrated hydrochloric acid were added every thirty minutes for eight hours. The reaction mixture was poured into water and extracted with ether. The solvent was removed and the product was hydrolyzed by refluxing for thirty minutes with alcoholic potassium hydroxide. The solution was acidified and extracted with ether. Upon concentrating and cooling it crystallized. It was recrystallized from ether, m. p. and mixed m. p. with hecogenin acid prepared by the oxidation of hecogenin or magogenin, 268° dec.

*Anal.* Calcd. for  $C_{27}H_{40}O_7$ : C, 68.0; H, 8.5. Found: C, 68.3; H, 8.7.

### Summary

Cacogenin and magogenin, two new steroidal sapogenins, have been isolated from the young

plants of *Maguey cacaya* and their structures determined. Old plants gave manogenin, gito-

genin, chlorogenin and tigogenin. TEXCOCO, MEXICO

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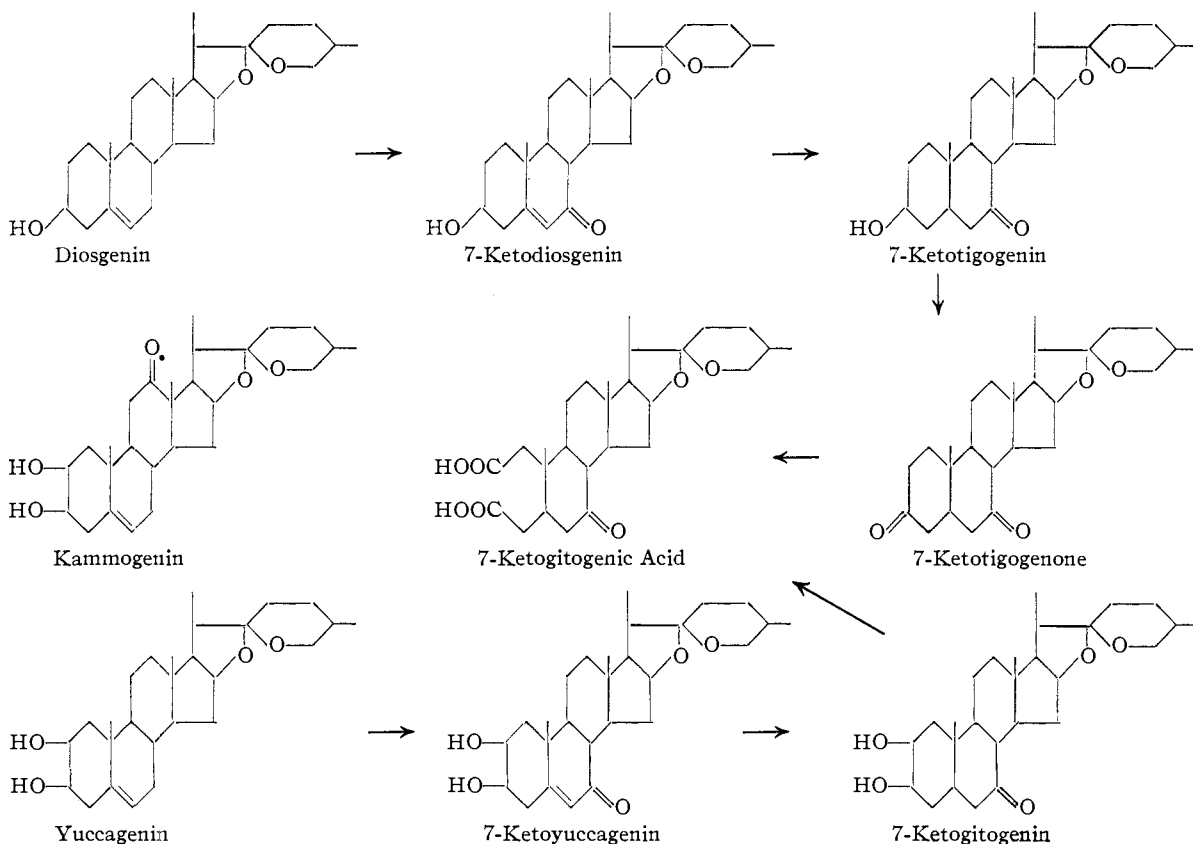
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## Steroidal Sapogenins. No. 170. The Position of the Double Bond in Yuccagenin and Kammogenin

BY RUSSELL E. MARKER<sup>1</sup> AND JOSEFINA LOPEZ

Reduction of the ketone group of kammogenin gives yuccagenin,<sup>2</sup> both of which compounds have been isolated as naturally occurring steroidal sapogenins. The position of the double bond in these compounds is shown by the reactions

prepared from diosgenin. As the oxidation produces a ketone group adjacent to the double bond the only position that this can have is identical with that in diosgenin or the 5,6-position in the molecule.



Oxidation of diosgenin acetate gave 7-ketodiosgenin acetate<sup>3</sup> which upon reduction with palladium catalyst gave 7-ketotigogenin. Mild oxidation of the latter gave 7-ketotigogenone, which upon further oxidation gave 7-ketogitogenic acid.

Likewise, oxidation of yuccagenin diacetate gave 7-ketoyuccagenin diacetate, which upon reduction and hydrolysis gave 7-ketogitogenic acid. Oxidation of the 7-ketogitogenic acid which was identical with the product

The ketonic steroidal sapogenins, manogenin, hecogenin, kammogenin, etc., contain the ketone group in the same position in the molecule.<sup>2</sup> Oxidation of hecogenin gave hecogenone which is not identical with 7-ketotigogenone, nor with 6-ketotigogenone (chlorogenone). This furnishes direct proof that the ketonic group in these sapogenins is not in the 6 or 7 positions in the molecule. As a further proof, oxidation of manogenin or hecogenin gives hecogenic acid with cleavage at the 2,3-position. This acid is not identical with either 6-ketogitogenic acid (chlorogenonic acid) or with 7-ketogitogenic acid.

(1) Present address: Hotel Geneve, Mexico City.

(2) Marker and Lopez, *THIS JOURNAL*, **69**, 2375 (1947).

(3) Marker and Turner, *ibid.*, **63**, 767 (1941).