

Phytochemistry of *Nectandra umbrosa* Berries, Cloudforest Food of the Resplendent Quetzal

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The Family Lauraceae was part of African Gondwanaland flora and many genera migrated to South America via Antarctica and midocean bridges by Paleocene time. There they spread over most of the continent. When the north and south American tectonic plates joined in late Neogene, volcanic mountain building created island chains which later formed the meso-American landbridge. Pliocene elevation created new habitats for speciation. While some genera died out in increasingly xerophytic Africa, starting with the freezing of Antarctica about 20 million years ago and the formation of the Benguela current, others, like *Beilschmiedea* (Gay) Kostern., *Octotea* Standl., and *Nectandra* (H.B.K.) Mez., which also reached south and meso-America, are still surviving today in Africa in a number of species. The genus *Persea*, however, died out in Africa, except for *Persea indica* (L.) K. Spreng., surviving in the fog shrouded mountains of the Canary Islands, which with Madagascar constitutes Africa's plant refugia. In meso-America, the genus *Nectandra* proliferated into new species and the berries of some of them constitute a valuable food supply for the quetzal.

This Resplendent Quetzal *Pharomachrus mocinno* (Trogonidae) lives in the montane rainforests of meso-America. Because of its splendid plumage, it has been chosen as the national bird of Guatemala. It also has given its name to currency and its feathers adorned the headdresses of Mayan caciques. Since its habitat is constantly threatened by encroaching agriculture, the quetzal has already become rare in many of its former habitats and is also threatened by poaching.

The quetzal is a specialized frugivore, eating occasionally insects, lizards, snails and frogs, especially at nesting time. Their favorite fruits however are berries of relatives of the avocado family. Their differing maturing times in the cloudforest determine the migratory movements of the quetzals to differing elevation levels in the forests. With a gape width of 21 mm (as we measured on quetzal skins at the Museo Nacional, San Jose, Costa Rica) the quetzal swallows the small berry (aquacatillo) whole, which he catches while flying through the lower canopy of the tree, and then regurgitates the seed within 100 meters from the tree. Wheelright (1983) observed that parent quetzals take far less time intervals to deliver fruits to the young brood than insects or lizards, reflecting the ease of procuring fruits, as opposed to capturing animal prey. Since the young are fed exclusively berries in the first 2 weeks after hatching, these berries must be of high nutritional value. Usually only the total percentage of water, sugar, nitrogen, crude fats and carbohydrates are reported by ornithologists.

We had the opportunity to observe the quetzal for three consecutive summers at a

Monte Verde, Costa Rica cloudforest and became interested in the chemical composition of the berries of *Nectandra umbrosa*, a widely eaten lauraceous fruit in June and July in the rainforest of Monte Verde, Costa Rica. We investigated the individual chemical components of minerals, lipids, essential oils,



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and bioflavonoids, all for the first time in this species. We would like to add that alkaloids

and other pharmaceutically valuable components have been reported on in other species of this genus (Castro 1993).

EXPERIMENTAL Collection

Berries collected from an isolated woodlot in Monte Verde, Costa Rica were immersed in chloroform at room temperature for five minutes. This procedure was repeated twice. The decanted chloroform portions were united and by evaporation brought to a syrupy consistency containing the hydrocarbons (raw wax).

For essential oil analysis, 50 berries were immersed in 95% sugar cane alcohol for transport. Later, water was added to bring the mixture to 500 ml for hydrodistillation.

For mineral analysis, ten berries were immersed in 70% alcohol and equally as many berries were macerated in 70% EtOH for phenolic investigation. Also, IOg of soil from a soil strata 10 cm under the leaf litter were collected from four sides of the feeding tree.

Analysis

For hydrocarbon analysis the procedure of Guelz *et al.* (1987) was followed, and for essential oil gaschromatographic separation that of Scora and Scora (1998).

For mineral analysis, the material was treated as follows: (1) the material was dried at 65 C until it reached a constant weight. Then it was ground to pass a screen with 0.1 micrometer openings, (2) of the sample, 0.1 g was digested with a mixture of 1 ml of concentrated HNO₃ and 1 ml of HClO₄ at 70 C overnight, (3) the digest was diluted to 10 ml and the solution filtered through #1 filter paper, (4) elemental content of the solution was determined using atomic absorption spectroscopy (Perkin Elmer model 5000 Atomic Absorption Spectrophotometer), (5) the concentration in the solution was expressed as microgram/kg dry weight of the material.

For phenolic analysis, a 1 ml aliquot of the macerated material was mixed with 1 ml of dimethylsulfoxide and centrifuged. The supernatant was filtered through a 0.45 micron syringe filter. Fifty microliters were injected onto a Licrosorb CIS reverse phase analytical column (25 x 0.4 cm, ODS 3,5 micron particle size) and UV diode-array detector. Parameters for gradient elution were as follows: 2 min. at 80% 0.01 M phosphoric acid and 20% methanol followed by linear gradient of 100% MEOH over 55 min. at 1 ml/min. flowrate. Two hundred eighty-five (285) nm monitoring wave-length was chosen for retention times and spectral characteristics of eluted compounds.

RESULTS & DISCUSSION

Hydrocarbons are important to plants because they regulate their water household, preventing evaporation of water and barring entry of bacteria and other pathogens into the tissues.

The berries saturated hydrocarbons or paraffins ranged from C14 to C36. The uneven carbon components were larger than the even, and even numbered ones with C31 and C29 were dominant. The olefms or unsaturated hydrocarbons are almost always much smaller than the saturated ones, except C24 or tetracosane, which surpassed its paraffin homologue in a small quantity. How the quetzal is able to digest the relatively large amount of wax in relation to the relatively small amount of mesocarp flesh is remarkable.

The composition of the essential oils consisted of more than 50 individual components with methoxsalen, indene, cadinol, germacrene B and spathulenol the five largest components, accounting for over 54% of the total oil as determined by capillary gas chromatography.

The mineral content of the mesocarp falls within the range of *Persea americana* (avocado) fruit. While zinc content was abnormally low in the soil under the tree, it was high in the fruit. Cadmium, not detected in the soil, was also very high in the fruit. Usually there is a correlation between tree soil and tree fruit, which held not true for both of the above elements. Perhaps aerial volcanic pollution from previous years of Arenal may have been the cause.

The phenolic profile was a relative simple one. Of a total of 11 components, the first four were phenyl propanoids and the remaining ones flavones (except for peak 9, which was probably psoralene).

Peak 1 with 21.7% was a ferulic derivative, peak 2 with 10.3% a sinapic derivative, followed by another sinapic derivative of 14.3%. Peak 4 was again a ferulic derivative with 20.9% followed by four flavone peaks with 1.6, 4.5, 4.3, and 2.0% respectively. Then came sporaleone with 13.4% followed by two further flavone peaks of 1.0 and 1.2%.

Since the young of the quetzal already eat *Nectandra* berries early after hatching, and get an increased diet including lizards, frogs, and insects (presumably for more protein) only before fledging, the berries must be of high nutritive value. With 4% sugar, about 20% fat, 8% of carbohydrates, 60% water (Snow 1981), and an abundance of minerals, these wild lauraceous berries constitute a very valuable food source.

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Bibliography

Castro O.C. 1993. Chemical and biological extractives of Lauraceae species in Costa Rican tropical forests. Chapter 3 In: Recent Advances in Phyto Chemistry. 27: 65-87, Plenum Press, New York and London.

Cloud J. 1987. Cloud forests, quetzals, and coffee. Animal Kingdom, Jan. - Dec. 1990-1991.

Guelz P.O., R.W. Scora, E. Mueller and F.J. Manner. 1987. Epicuticular waxes in *Citrus halimii* Stone. J. Agr. Food Chem. 35: 716-720.

Lawton R. and V. Dryer. 1980. The Vegetation of Monte Verde Cloud Forest Reserve. Brenesia 8: 101-116.

Santana E.G. and E.G. Milligan. 1984. Behavior of Toucanets Bell-birds and Quetzals

feeding on lauraceous fruits. *Biotropa* 16(2): 152-154.

Scora R.W. and P.E. Scora. 1998. Leaf oils of two new Avocado varieties endemic to Costa Rica. *J. Essent. Oil Res.* 10: 705-707.

Schieber E. and G.A. Zentmeyer. 1978. The Quetzal and the Persea. *Calif. Avoc. Soc. Yearbook* 34-39.

Skutch A.F. 1994. Life history of the Quetzal. *The Condor* 46: 213-235.

Snow S.W. 1966. A possible selective factor in the evaluation of fruiting seasons in tropical forests. *Oikos* 15: 274-281.

Snow S.W. 1971. Evolutionary aspects of fruit eating by birds. *Oikos* 113: 194-202.

Snow, S.W. 1981. Tropical frugivorous birds and their food plants: A world survey. *Biotropa* 13(t): 1-14.

Wheelright N.T. 1982. Fruits and the ecology of Resplendent Quetzals. *The Auk* 100: 286-301.

Wheelright N.T., W.A. Haber, K.G. Murray and C. Guindon. 1984. Tropical fruit-eating birds and their food plants. A survey of a Costa Rican lower Montane forest. *Biotropa* 16:173-192

Table 1. Average mineral content of Nectandra umbrosa berry pericarp and of tree soil.

Average of 5 samples in microgram per gram dry weight.

| | <u>Pericarp</u> | <u>Tree Soil</u> | | <u>Pericarp</u> | <u>Tree Soil</u> |
|----|-----------------|------------------|----|-----------------|------------------|
| CA | 1446.0 | 29780.0 | CR | 5.546 | 39.16 |
| MG | 1704.0 | 14940.0 | BE | 0.01172 | 2.882 |
| NA | 100.9 | 10072.0 | TL | 0.000015 | 0.0 |
| K | 9540.0 | 0.000327 | GA | 40.78 | 1058.8 |
| P | 2088.0 | 907.0 | AU | 0.00005 | 0.0 |
| SI | 105.14 | 177600.0 | U | 8.42 | 0.0 |
| B | 20.68 | 6.562 | SC | 0.1687 | 11.866 |
| BA | 11.12 | 275.2 | UG | 0.0 | 0.000061 |
| SR | 17.08 | 422.8 | SE | 0.0 | 0.000018 |
| LI | 0.3910608 | 3.6000004 | GE | 29.800002 | 0.0 |
| TI | 8.346 | 3960.0 | SN | 0.000009 | 0.0 |
| AL | 172.4 | 76400.0 | AS | 0.0638016 | 0.0 |
| FE | 313.8 | 57280.0 | SB | 5.556 | 41.16 |
| MN | 12.58 | 1580.0 | BI | 0.000015 | 0.0 |
| CU | 28.14 | 31.4 | TE | 0.0 | 0.000004 |
| ZN | 139.0 | 31.4 | W | 0.000014 | 0.0 |
| CD | 0.5094 | 0.0 | Y | 0.0959158 | 15.1 |
| AG | 0.0 | 0.0 | LA | 4.006 | 27.52 |
| V | 0.6140016 | 0.000006 | ZR | 0.000002 | 0.000017 |
| LA | 4.006 | 27.52 | TH | 7.1680042 | 0.0 |

Table 2. Hydrocarbon percent of *Nectandra umbrosa* exocarp.

| Carbon Number | | Alkanes Paraffins | Alkenes Olefins |
|-----------------------------|-------------------|--------------------------|------------------------|
| 14 | tetra decane | trace | |
| 15 | penta decane | 0.01 | trace |
| 16 | hexa decane | 0.01 | trace |
| 17 | hepta decane | 0.02 | trace |
| 18 | octo decane | 0.05 | trace |
| 19 | nona decane | 0.04 | 0.03 |
| 20 | cosane | 0.05 | 0.02 |
| 21 | hen cosane | 0.58 | 0.06 |
| 22 | do cosane | 1.27 | 0.40 |
| 23 | tri cosane | 2.91 | 0.05 |
| 24 | tetra cosane | 2.41 | 2.66 |
| 25 | penta cosane | 8.93 | 0.03 |
| 26 | hexa cosane | 0.37 | 3.38 |
| 27 | hepta cosane | 11.60 | 0.07 |
| 28 | octo cosane | 3.81 | 0.06 |
| 29 | nona cosane | 21.38 | 0.09 |
| 30 | tria contane | 3.15 | 0.06 |
| 31 | hentria contane | 19.97 | 0.05 |
| 32 | dotria contane | 1.63 | trace |
| 33 | tritria contane | 1.22 | trace |
| 34 | tetratria contane | 0.44 | 0.06 |
| 35 | pentatria contane | 0.38 | - |
| 36 | hexatria contane | 0.19 | - |
| 37 | heptatria contane | trace | - |
| total | | 80.42 | 7.02 |
| Solvents and Lost on column | | 12.5 | |
| Total | | 100.00% | |