HANDBOOK

of

Biologically Active Phytochemicals and Their Activities

JAMES A. DUKE

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The Author

Born in Birmingham, Alabama in 1929, James A. "Jim" Duke is a Phi Beta Kappa Ph.D. (botany, 1961) graduate of the University of North Carolina. Following military service, Jim undertook postdoctoral activities at Washington University and Missouri Botanical Garden in St. Louis, Missouri. There he began studies of neotropical ethnobotany, his overriding interest to this day. From 1963 to 1965, Duke was ecologist at the USDA (Beltsville, Maryland), joining Battelle Columbus Laboratories (1965–1971) for ecological and ethnobotanical studies in Panama and Colombia. Rejoining USDA in 1971, Duke had assignments relating to crop diversification, medicinal plants, and energy plant studies in developing countries. He has studied and/or lectured widely, concentrating on tropical ecology, medical botany, and crop diversification. Currently, he is an Economic Botanist with the National Germplasm Resources Laboratory, Agricultural Research Service, USDA, Beltsville, Maryland, preparing an encyclopedia of economic plants. In developing these databases, he collaborated with the National Cancer Institute and the Food and Drug Administration, especially as they relate to Designer Foods. Duke's major goal lately is to reverse the disdain for alternative medicines in the U.S., where, as in the Third World, a larger and larger percentage of the people can no longer afford first-world pharmaceuticals.

Dr. Duke belongs to the American Botanical Council (Trustee), American Herb Association (Life), American Society of Pharmacognosy, Associates of the National Agricultural Library, Association for Tropical Biology (Life), Council of Agricultural Science and Technology (Cornerstone Life Member), Herb Research Foundation (Advisor), International Association of Plant Taxonomists (Life), International Society for Tropical Root Crops (Life), International Weed Science Society (Life), Organization for Tropical Studies (Life), Oriental Healing Arts Society (Honorary), Programa Interciencia de Recursos Biologicos (Advisory Council), Sigma Xi, Smithsonian Institution (Collaborator), Society for Conservation Biology (Life), Society for Economic Botany (Life), Southern Appalachian Botanical Club (Life), Tri-State Bluegrass Association (Life), and the Washington Academy of Sciences (Life).

In addition to popular and scientific articles, Duke has published: (1) *Handbook of Legumes of World Economic Importance*, Plenum Press, NY, 345 pp., 1981; (2) *Medicinal Plants of the Bible*, Trado-Medic Books, Buffalo, NY, 233 pp., 1981; (3) *Handbook of Medicinal Herbs*, CRC Press, Boca Raton, FL, 704 pp., 1985; (4) *Culinary Herbs: A Potpourri*, Trado-Medic Books, Buffalo, NY, 195 pp., 1985; (5) *Medicinal Plants of China* (with E. Ayensu), Reference Publications, Algonac, MI, 2 vols., 705 pp., 1985; (6) *Handbook of Proximate*

Analysis Tables of Higher Plants (with A. Atchley), CRC Press, Boca Raton, FL, 389 pp., 1986; (7) *Isthmian Ethnobotanical Dictionary*, 3rd ed., Scientific Publishers, Jodhpur, India, 205 pp., 1986; (8) *Handbook of Northeastern Indian Medicinal Plants*, Quarterman Press, Lincoln, MA, 212 pp., 1986; (9) *Living Liquers*, Quarterman Press, Lincoln, MA, 110 pp., 1987; (10) *Handbook of Agricultural Energy Potential for Developing Countries* (with A. Atchley, K. Ackerson, and P. Duke), CRC Press, Boca Raton, FL, 343 pp., 1989; (12) with Steven Foster, a Peterson *Field Guide to Medicinal Plants*, Houghton-Miflin, Boston, MA, 366 pp., 1990 (13) *Ginseng, a Concise Handbook*, Reference Publications, Algonac, MI, 273 pp., 1990, and (14) *Handbook of Edible Weeds*, CRC Press, Boca Raton, FL, 1990.

Introduction

Some jobs never come to an end. That's the way CRC's Harvey Kane and I feel about this one. But when I showed him how useful this compilation could be, used either as hard copy or database, he thought it was time CRC published the first installment, before it became too unwieldy. This compilation contains most, if not all of the generally recognized as safe (GRAS) herbs, and many medicinally important foods (GRAF or generally recognized as food). The compilation also contains and about 500 strictly medicinal plants (GRAP or generally recognized as poisonous or medicinal species) for which I found interesting data. All told, about 1,000 plants are covered in the *Handbook* or *Database of Phytochemical Constituents of GRAS Herbs and Other Economic Plants* and about 3,000 compounds are treated in the *Handbook* or *Database of Biologically Active Phytochemicals and Their Activities*. In collaboration with Drs. C. Rose Broome and James L. Reveal of the University of Maryland, I used their computer facility and a remote terminal at home to compile data on phytochemicals reported for various plants, concentrating on these GRAS and GRAF herbs. I termed these databases Father Nature's Farmacy, and under this copyrighted name, early entries were published in *HerbalGram*, the Education Publication of the American Botanical Council and the Herb Research Foundation.

I consulted five major sources when trying to determine if a plant is generally recognized as food.

1. Facciola, S., *Cornucopia: A Source Book of Edible Plants*, Kampong Publications, Vista, CA, 1990.
2. Hedrick, U. P., Ed., *Sturtevant's Edible Plants of the World*, Dover Publications Reprint (1972), New York, 1919.
3. Kunkel, G., *Plants for Human Consumption*, Koeltz Science Publishers, Koenigstein, Germany, 1984.
4. Tanaka, T., *Tanaka's Cyclopedia of Edible Plants of the World*, Keigaku Publishing Co., Tokyo, 1976.
5. Yanovsky, E., *Food Plants of the North American Indians*, USDA Misc. Publ. No. 237, U.S. Government Printing Office, Washington, DC, 1936.

Unfortunately, some plants like the opium poppy, *Papaver somniferum*, fall into all three categories of this newly recognized triad of acronyms, GRAF, GRAP, and GRAS. Poppy seeds are clearly GRAF (generally recognized as food), and are widely eaten in pastries, for example. From the GRAP (generally recognized as poisonous or medicinal) point of view, dried latex of the poppy (opium) and its derivative alkaloids, e.g., codeine and morphine, are poisonous

yet very important medicinally. I really think GRAM (generally recognized as medicinal) would have made a better acronym, but all medicines are poisonous; it's just a matter of dosage. Poppy seeds are (or at least once were) a GRAS (generally recognized as safe) spice or culinary additive to foods. The Herb Research Foundation (Rob McCaleb, President, Suite 200F, 1007 Pearl Street, Boulder, Colorado 80302) has a computerized list of GRAS herbs as things were interpreted in the 1980s. Recently, however, one cannot get a definitive opinion on whether an herb is GRAS or not. Such classification is always open to review, according to my interpretation of the latest FDA edicts. If you can get a copy of an intelligible GRAS list from the FDA, I'll gladly exchange a revised computerized Database of Biologically Active Phytochemicals for a copy. In spite of several letters, I have been unable to procure from FDA an FDA-revised GRAS list, so accurately classifying an herb as GRAS can be like trying to hit a moving target. And the latest list I have is from the Herb Research Foundation, not the FDA.

Apples are GRAF and apple extracts are GRAS, but the cyanide in the seeds is GRAP. A lot of people eat shoots of pokeweed (*Phytolacca americana*) in spring (even though poisonings sometimes ensue). Hence, parboiled pokeweed shoots are GRAF. Pokeweed antiviral proteins or mitogens are GRAP but have important medicinal potential. There are probably carcinogens, mutagens, and poisons, as well as anticarcinogens, antimutagens, and antidotes in all GRAF, GRAP, and GRAS species. Thus assigning the species treated herein, or plant parts thereof, to one or the other category could be more controversial than constructive or instructive. In these litigious times, the reader is reminded that every species treated herein contains poisonous compounds and that all the biologically active phytochemicals can be considered poisonous; again, it's a matter of dosage.

Early in the project, I systematically scanned some major references (AYL, BML, CCO, CRC, GEO, HHB, JAD, JEL, JFM, MPI, USA, WBB and WOI, see list of abbreviations below), not always citing these prime sources. Many of the essential oil data were gathered with all the books propped open and within reach, but the majority of essential oil data came from BML, GEO, and HHB, often uncited as they are in this volume. Maturing, I realized I frequently have to check back on some of my sources. As the database grew, I became more careful about sourcing my data, still keeping my citations as terse as possible.

In initiating the project, I entered any compound or element, whether accompanied by quantitative data or not. Finally I realized the futility of merely listing a universal element like *zinc*. Since all plants contain zinc, it is a useless listing, unless accompanied by quantitative data. Now as I write the introduction, 5 years after I started the unending compilation, I will no longer enter a ubiquitous element like zinc or a compound like sitosterol unless there is quantitative data to accompany it.

For quantitative data, I have resorted to the parts per million (ppm) unit as the default entry. Any time a number follows the name of a compound or

element, it is in ppm unless otherwise stated. Sometimes I use parts per billion (ppb), but that will be indicated.

The numbers are strictly ballpark numbers, but are certainly better than no numbers at all. This is how I arrived at some of them. With many of the GRAS herbs, the active ingredients are in the essential oils which I have consistently abbreviated as EO (see the two-letter abbreviations for plant parts following these introductory comments). One source may tell you that, for example, the essential oil consists of 15 to 25% pinene. Until you know how much essential oil there is in the plant, that's almost useless information too. But once you learn from another source that the plant contains 1 to 2% EO on a fresh-weight basis, you then know that the plants contain 10,000 to 20,000 ppm EO. If 15% of that oil is pinene, the plant contains no less than 1,500 ppm pinene if it contains 10,000 ppm essential oil. If 25% of that oil is pinene, the plant could then possibly contain as much as 5,000 ppm pinene, if the plant contains the maximum or 20,000 ppm EO on a fresh-weight basis. Your data is further complicated by the classification as fresh-weight basis or as-purchased basis (APB). In another example, if your mint contained 90% water, as do many leaves on an as-purchased basis, you would multiply the high figure by ten to get the zero-moisture basis (ZMB), a theoretically possible maximum of 50,000 ppm pinene. That's why it is important to know the percentage of water.

Similarly, if one book said the plant contained 10% alkaloids, and another source said 5% of the alkaloids were berberine, I scored it as .05 x 100,000 ppm = 5,000 ppm berberine, rarely entering the ppm, since that is the default unit. With much of the USGS data, a plant's ash was estimated at 10% or 100,000 ppm, and if the ash was 1.3% aluminum, I multiplied the 100,000 by 0.013 to get 1,300 ppm aluminum. If one species in a genus had 10% ash or 1% essential oil, and I had data for another species in the genus, I often assumed that 10% ash or 1% essential oil, to estimate quantitative data. That's why the numbers in here are best considered a first approximation, gradually working closer to the truth, and better documented as I continue compiling.

Some sources, such as the USDA's *Agricultural Handbook No. 8* and its sequels, always present data on the fresh-weight or APB basis, rightly recognizing that as the most commonly edible form. Other sources consistently present their data on a zero-moisture basis (ZMB). Still other sources don't let you know. The okra entry (alphabetically our first entry) shows some of the liberties I have taken with USDA data. With okra, it is the fruit (FR) that we normally ingest, and that's the part to which the USDA data pertain. In *Agricultural Handbook No. 8-11*, the handbook for vegetables, okra is said to contain 89.58% water (89.58 g/100 g) which is equivalent to 895,800 ppm water. Like most fruits and vegetables, okra is approximately 90% (900,000 ppm) water. Unlike some fruits, such as apples, grapes, and plums, we rarely dry okra. But as energy becomes more and more expensive, solar-dried fruits and vegetables may become economically and energetically, if not culinarily, more attractive and competitive than canned, frozen, or processed fruits and vegetables. Fresh okra is also reported to contain 2 g protein per 100 g, which

is 2% or 20,000 ppm. If we somehow drove off all the water, the dried okra would then contain 20% or 200,000 ppm protein. For any plant material that contains 90% water, multiply a nutrient by 10 to calculate the nutrient content on a zero-moisture basis. If it's 95% moisture, multiply by 20; 90%, by 10; 80%, by 5; 75%, by 4; 66.7%, by 3; 50%, by 2, to get the ZMB equivalent. Where I have moisture percentages, I have already converted for you, such that you have the minimum value for fresh weight and the theoretical maximum value for dry weight. I have even incorporated the standard error for the USDA data. For magnesium, the USDA avergage of 57 mg per 100 g (570 ppm) may be high or low by 2.5 mg. That converts to 545 to 595 ppm for the fresh okra and 5,450 to 5,950 for the zero moisture okra, rounded up to 6,000. More extreme data from *The Wealth of India* (WOI) extend the lower end of the range down to 380 ppm fresh weight. Nutritionists may think me balmy to talk about dried okra. Remember that dried grapes and plums are promoted as being rich in iron, fiber, etc., when in fact, they are as soon termed poorer in water *as* richer in nutrients. Dry anything and it becomes increasingly richer in nutrient, poorer in water. WOI also gives data for okra seed. It contains 2,100 ppm calcium, but here no range is given. If new data become available, they will be added. But as of this printing, I have only the one bit of data.

The important biologically active compound gossypol, used as a male contraceptive in China, occurs in the seed of many Malvaceae, okra included. Note the gossypol entry. The 70 is ppm, the SD stands for seed, and JAF38:506 is the journal reference I used for recent new data, standing for *Journal of Agriculture and Food Chemistry*, Vol. 38, page 506. I assumed this data was on a dry-weight basis; hence, I did not convert to a zero-moisture basis. With seeds containing relatively little water, such conversions result in small incremental changes, not multiples such as we have with wet tissues like fruits and leaves. The journal abbreviations are explained below.

CODES USED IN THE DATABASES

In the *Database of Phytochemical Constituents of GRAS Herbs and Other Economic Plants*, the species names are followed by an alphabetical listing of reported constituents. Where available, quantitative data follow the names of the elements or compounds. Such numbers are in ppm. Zero-moisture-basis (ZMB) values were calculated by multiplying high as-purchased-basis (APB) by 100, divided by 100 minus X, where X = fresh moisture percentage. Following the name of a compound, ND = not detected, and TR = trace.

Following the quantitative data, if any, are two-letter abbreviations, standing for plant parts:

AN = Anther
AR = Aril
AS = Ash
BD = Bud
EX = Exocarp
FL = Flower
FR = Fruit
GU = Gum
PO = Pollen or Spore
RE = Resin/Exudate/Sap
RH = Rhizome
RT = Root

BK = Bark
BR = Branches
BU = Bulb
CB = Cob
CP = Caryopsis
CX = Calyx
CY = Cotyledon
EC = Endocarp
EM = Embryo
EN = Endosperm
EO = Essential Oil
EP = Epidermis
HA = Hay
HU = Hull/Husk
IN = Inflorescence
JU = Juice
LF = Leaf
LX = Latex/Exudate
MC = Mesocarp
OL = Oil
PC = Pericarp
PE = Petiole
PI = Pith
PL = Plant
SH = Shoot
SI = Silk/Stigma/Style
SP = Sprout/Seedling
ST = Stem
TC = Tissue Culture
TE = Testa
TU = Tuber
TW = Twig
WD = Wood
WX = Wax

Then, there may be a three-letter abbreviation indicating a primary source, or an alphanumeric abbreviation indicating journal sources. I have indicated one volume with a year so readers can gauge how recent a reference is, but I may have cited many volumes of that journal over several years.

AAA = *Agents and Actions* (Vol. 31 = 1990)
AAS = *Acta Agriculturae Scandinavica*, Suppl.22:89–113, 1980.
ABC = *Agricultural Biological Chemistry* (Vol. 55 = 1991)
ABO = *Acta Botanica Sinica*
ABS = Abstract filed under the genus with Economic Botany Files at USDA. Often footnoted in the databases.
ACM = *Advance in Chinese Medicinal Materials Research.* Chang, H. M., Yeung, H. W., Tso, W. -W., and Koo, A., Eds., World Scientific Publishing Co., Philadelphia, 1985, 742 pp.
ALK = Alkaloid Books (2)

1. Willaman, J. J. and Li, H. L., Alkaloid-Bearing Plants and Their Contained Alkaloids, *J. Nat. Prod. (Lloydia)*, 33: Suppl. No. 3A; 286 pp.
2. Willaman, J. J. and Schubert, B.G., USDA Tech. Bull. 1234, Washington, DC, 1961, 287 pp.

APP = *Acta Physiol. Pharmacol. Bulg.* (Vol. 16 = 1990)
AVR = *Antiviral Research* (in many cases I consulted the abstract only) (Vol. 1 = 1981)
AYL = Leung, A. Y., *Encyclopedia of Common Natural Ingredients Used in Food, Drugs, and Cosmetics*, John Wiley & Sons, New York, 1980, 409 pp.
B&H = Bradbury, J. H., and Holloway, W. D., *Chemistry of Tropical Root Crops*, Australian Centre for International Research, Canaberra, 1988, 201 pp.
BML = Lawrence, B. M., Three annual compilations on essential oils

1. Lawrence, B. M., *Essential Oils 1976–1977*, Allured Publishing Corp., Wheaton, IL, 1978, 175 pp.
2. Lawrence, B. M., *Essential Oils 1978*, Allured Publishing Corp., Wheaton, IL, 1979, 192 pp.

3. Lawrence, B. M., *Essential Oils 1979–1980*, Allured Publishing Corp., Wheaton, IL, 1981, 292 pp.

BOB = *Betting on Boron*, Unpublished draft by J. A. Duke on file at USDA, draft and papers relating to boron percentages. Includes Internat. Z. Vit. Ern. Forschung 43:1973 (boron)

BP = *Biochemical Pharmacology* (Vol. 1 = 1958)

BPCC= *Biosynthetic Products for Cancer Chemotherapy* (Petit and associates)

1. Petit, G. R., *Biosynthetic Products for Cancer Chemotherapy*, Vol. 1, Plenum Press, New York, 1977, 215 pp.
2. Petit, G. R. and Cragg, G. M., Biosynthetic Products for Cancer Chemotherapy, Vol. 2, Plenum Press, New York, 1977, 150 pp.

CAL = Chen, H. C. and Lin, S. M., Determination of Mineral Elements in Certain Crude Drugs (Part 1), *Kaohsiung J. Med. Sci.*, 4:259-272, 1988.

CCG = Miller, D. F., *Composition of Cereal Grains and Forages*, Publ. 585, National Academy of Sciences–National Research Council, Washington, DC, 1958, 663 pp.

CCO = (Chemical Constituents of Oriental Plants) Three books edited by H. Hsu, Oriental Healing Arts Institutes.

1. Hsu, H. Y., Chen, Y. P., and Hong, M., *The Chemical Constituents of Oriental Herbs*, Vol. 1, Oriental Healing Arts Institute, Los Angeles, 1982, 1546 pp.
2. Hsu, H. Y., Chen. Y. P., and Hong, M., *The Chemical Constituents of Oriental Herbs*, Vol. 2, Oriental Healing Arts Institute, Long Beach, CA, 1985, 829 pp.
3. Hsu, H. Y., Chen, Y. P., Shen, S. J., Hsu, C. S., Chen C. C., and Chang, H. C., *Oriental Materia Medica: A Concise Guide*, Oriental Healing Arts Institute, Long Beach, CA, 1986, 932 pp.

CJB = *Canadian Journal of Botany* (Vol. 69 = 1991)

CJT = *Chin. J. Tuber. Respir. Dis.*

CLE = *Cancer Letters* (Vol. 56 = 1991)

CMR = Chemical Marketing Reporter; a weekly tabloid

CPA = *Can. Pharm. Assoc. Medication.* 1988

CPB = *Chemical and Pharmaceutical Bulletin* (Vol. 1 = 1953)

CR = *Cancer Research* (Vol. 1 = 1941)

CRC = CRC Press Inc., Boca Raton, FL (2 books)

1. Duke, J. A., *Handbook of Medicinal Herbs*, CRC Press, Boca Raton, FL, 1985, 667 pp.
2. Duke, J. A. and Atchley, A. A., *Handbook of Proximate Analysis Tables of Higher Plants*, CRC Press, Boca Raton, FL, 1986, 389 pp.

DAA = Duke, J. A. and Ayensu, E. E., *Medicinal Plants of China*, 2 vols., Reference Publications, Algonac, MI, 1985, 705 pp.

DAS = Davies, S. and Stewart, A., *Nutritional Medicine*, Avon Books, New York, 1990, 509 pp.

DMD = *Drug Metabolism and Disposition* (Vol. 1 = 1973)

EB = *Economic Botany* (Vol. 45 = 1991)

EEB = *Envir. Exp. Bot.* (Vol. 31 = 1991)
EFN = *Ecology of Food and Nutrition* (Vol. 26 = 1991)
EJP = *European Journal of Pharmacology*
EMM = *Environ. Mol. Mutagen.* (Vol. 18 = 1991)
EMP = *Economic & Medicinal Plant Research*
FFJ = *Flavour & Fragrance Journal* (Vol. 6 = 1991)
FNF = Father Nature's Farmacy: The aggregate of all these three-letter citations. Early entries did not include citation for each element.
FUR = Furr, A. K., MacDaniels, L. H., St. John, L. E., Jr., Gutenmann, W. H., Pakkala, I. S., and Lisk, D. J., Elemental Composition of Tree Nuts, *Bull. Environ. Contam. Toxicol.*, 21:392, 1979.
FT = *Fitoterapia* (Since there is no volume number, I cite a little differently, e.g., FT5:1990 with no page.
GBM = Graedon, J. and Graeden, T., *Graedon's Best Medicine: From Herbal Remedies to High-Tech Rx Breakthroughs*, Bantam Books, New York, 1991, 444 pp.
GEO = Guenther, E., *The Essential Oils*, 6 volumes, D. van Nostrand, New York, 1948–1952.
HAM = *Hamdard Medicus*. A quarterly *Journal of Science and Medicine*.
HEG = *Hegnauer's Chemotaxonomie der Pflanzen*, 8 vols., Volume 8 (Band 8), Birkhauser Verlag, Berlin, 1989, 718 pp.
HG = *HerbalGram* (followed by number without space, e.g., HG17 = *HerbalGram* No. 17, c/o American Botanical Council, P. O. Box 20160, Austin, TX 79720. (No. 19/19 = Fall 1988/Winter 1989)
HH = *Herbal Healthline*, (newsletter compiled by Michael Weiner) P. O. Box 2056, San Rafael, CA 94912 (Vol. 2 = 1991)
HHB = List, P. H. and Horhammer, L., *Hager's Handbuch der Pharmazeutischen Praxis*, Vols. 2–6, Springer-Verlag, Berlin, 1969–1979.
HSC = *HortScience* (Vol. 27 = 1992)
HUL = Hulme, A. C., Ed., *The Biochemistry of Fruits and Their Products*, 2 vols., Academic Press, New York, 1970.
IB = *Indian Biology* (Vol. 23 = 1991)
ID = *Indian Drugs* (Vol. 25 = 1988)
IJE = *Indian Journal of Experimental Biology* (Vol. 29 = 1991)
IJI = *International Journal of Immunopharmacology* (Vol. 10 = 1988)
IJO = *International Journal of Oriental Medicine* (formerly OHAI, Oriental Healing Arts Institute) (Vol. 15 = 1990)
IJP = *Indian Journal of Pharmaceutical Sciences* (Vol. 52 = 1990)
JAD = Duke, J. A. Writeups or information summaries on approximately 2,000 economic plants, USDA, ARS, Beltsville, MD 20705.
JAF = *J. Agri. Food Chemistry* (Vol. 40 = 1992)
JCE = *Journal of Chemical Ecology*
JE = *Journal of Ethnopharmacology* (Vol 29 = 1990)
JEL = Laferriere, J. E., 1988, Nutricomp Program, Nutricomp Database;

reviewed in *J. Ethnobiology* 9(1):27–29; see journal for ordering information.

JEO = *Journal of Essential Oil Research*

JETB= *Journal of Economic and Taxonomic Botany*

JFM = 1. Morton, J. F., *Major Medicinal Plants*, C.C. Thomas, Springfield, IL, 1977, 431 pp.
2. Morton, J. F., *Atlas of Medicinal Plants of Middle America. Bahamas to Yucatan*, C.C. Thomas, Springfield, IL, 1981, 1420 pp.

JFS = *Journal of Food Science* (Vol. 26 = 1961)

JLS = *Journal of the Linnaean Society*

JMC = *Journal Medicinal Chemistry*

JNP = *J. Nat. Prod.* (Vol. 53 = 1990) (formerly *Lloydia*)

JPN = *Journal of Plant Nutrition* (Vol. 14 = 1991)

JPP = *Journal of Pharmacy and Pharmacology* (Vol. 41 = 1990)

JPS = *Journal of Pharmaceutical Sciences* (Vol. 50 = 1961)

JRM = *Journal of Reproductive Medicine* (Vol. 26 = 1981)

JSF = *J. Sci. Food Agric.*

JSG = Glasby, J. H., *Dictionary of Plants Containing Secondary Metabolites*, Taylor & Francis, New York, 1991, 488 pp.

KAD = Felter, H. W. and Lloyd, J. U., *King's American Dispensatory*, 18th ed., 3rd revision, reprinted 1983, Eclectic Medical Publications, Portland, OR, 1898, 2 vols.

LEL = Lewis, W. H. and Elvin-Lewis, M. P. F., *Medical Botany*, John Wiley & Sons, New York, 1977, 515 pp.

LL = *Let's Live*

LWT = *Lebensmittel Wissenschaft & Technologie* (Vol. 24 = 1991)

MPI = *Medicinal Plants of India* (2 volumes so far)

1. ICMR, (Indian Council of Medical Research), *Medicinal Plants of India*, Vol. 1, Satyavati, G. V., Raina, M. K., and Sharma, M., Eds., ICMR, New Delhi, 1976, 48 pp.
2. ICMR, (Indian Council of Medical Research), *Medicinal Plants of India*, Vol. 2, Satyavati, G. V., Gupta, A. K., and Tandon, S. N., Eds., ICMR, New Delhi, 1987, 600 pp.

MUO (MOB) = *Material und Organismen* (Vol. 24 = 1989)

M7 = *Merck* 7th edition, 1960. See below.

M10 = *Merck* 10th edition, 1983. See below.

M11 = *The Merck Index. An Encyclopedia of Chemicals, Drugs, and Biologicals*, 11th ed., Merck & Co., Inc., Rahway, NJ, 1989.

MAR (M28) = Martindale's 28th. *Martindale, The Extra Pharmacopoeia.* See below for publisher information.

M29 = Martindale's 29th. Reynolds, J. E. F., Ed., *Martindale, The Extra Pharmacopoeia*, 29th ed., The Pharmaceutical Press, London, 1989, 1896 pp.

NAH = *Nutrition Action Healthletter* (Vol. 18 = 1991)

NAP = NAPRALERT Database (National Product Alert). With permission

of Norman Farnsworth, College of Pharmacy, University of Illinois at Chicago, P. O. Box 6998, Chicago, IL 60680.

NUT = Duke, J. A., *Handbook of Nuts,* CRC Press, Boca Raton, FL, 1989, 343 pp.

NYT = *The New York Times,* followed by month, date, year

OMM = Oriental Materia Medica. Hsu, H. Y., Chen, Y. P., Shen, S. J., Hsu, C. S., Chen C. C. , and Chang, H. C., *Oriental Materia Medica: A Concise Guide,* Oriental Healting Arts Institute, Long Beach, CA, 1986, 932 pp.

PAACR= *Proceedings of the American Association for Cancer Research*

PAM = Pizzorno, J. E. and Murray, M. T., *A Textbook of Natural Medicine,* John Bastyr College Publications, Seattle, WA, 1985, (looseleaf)

PAN = *El Pan de America* (E. Estrella, 1990)

PAS = Stitt, P. A., *Why George Should Eat Broccoli,* Dougherty Co., Milwaukee, WI, 1990, 399 pp.

PC = *Phytochemistry* (Vol. 29 = 1990)

PDR = *Physicians' Desk Reference* (Vol. 45 = 1991)

PED = Pedersen, M., *Nutritional Herbology.* Pederson Publishing, Bountiful, UT, 1987, 377 pp. (some quantitative data, e.g., selenium, seems inaccurate)

PEP = Ur-Rahman, A., Said, H. M., and Ahmad, V. U., *Pakistan Encyclopaedia Planta Medica,* Vol. 1, Hamdard Foundation Press, Karachi, Pakistan, 1986, 373 pp.

PM = *Planta Medica* (Vol. 56 = 1990)

PMP = *Plantes Medicinales et Phytotherapie*

PMPP= *Physiological and Molecular Plant Pathology* (Vol. 37 = 1990) (abstracts only)

PR = *Phytotherapy Research* (Vol. 4 = 1990)

PS = *Plant Science (Ireland)* (Vol. 75 = 1991)

PTD = Potential Toxic Dose (after Wm. Barnhil, 1991, *AARP Bulletin* 32{11}:3)

QJC = recently became *Int. J. Crude Drug Res.* (Vol. 4 = 1990)

RAA = Rizk, A. F. M. and Al-Nowaihi, A. S., *The Phytochemistry of the Horticultural Plants of Qatar,* Scientific and Applied Research Centre, University of Qatar, Alden Press Ltd, Oxford, 1989, 285 pp.

RDA = Recommended Dietary Allowances, Rev. 1989. NAS. Lowest (usually for infants) to highest (often for lactating females) from National Research Council RDA 10th ed., 1989

RIZ = Rizk, A. F. M., *The Phytochemistry of the Flora of Qatar,* Scientific and Applied Research Centre, University of Qatar, Kingprint, Richmond, UK, 1986, 582 pp.

RR = *Rastitel'nye Resursy* (abstract only) (Vol. 5 = 1969)

SHA = *Scientia Horticulturae (Amsterdam)* (Vol. 47 = 1991)

SMO = Suziki, A., Morimoto, I., and Okitzu, T., *Elution of Metals from Crude Drugs,* Shoykugaku Zasshi 36(3):190–195, 1982.

SN = *Science News*

STE = *Stermitz Codex Vegetabilis* (ca. 1957). No date, no pagination.

TET = *Tetrahedron* (Vol. 47 = 1991)

TL = *Tetrahedron Letters* (Vol. 32 = 1991)

TOT = Duke, J. A., *Touting Tocopherol* (unpublished draft of miscellaneous tocopherol data, on file at USDA)

UNE = UNESCO, *Medicinal Plants of the Arid Zones*, Chopra, I. C., Abrol, B. K., and Hands, K. L., Eds., (botany); Paris, R. and Dillemann, G., Eds., (pharmacology), UNESCO, Paris, 1960, 96 pp.

USA(USD) = USDA *Agricultural Handbook No. 8* and sequels; strictly nutritional data (always with fresh and converted dry weights)

1. Watt, B. K. and Merrill, A. L., *Composition of Foods, Agricultural Handbook No. 8*, USDA, Washington, DC, revised 1963, 190 pp
2. Marsh, A. C., Moss, M. K., and Murphy, E. W., *Composition of Foods: Spices and Herbs, Agricultural Handbook No. 8-2*, Consumer and Food Economics Institute, 1977, looseleaf
3. Haytowitz, D. B. and Matthews, R. H., *Composition of Foods: Vegetables and Vegetable Products, Agricultural Handbook No. 8-11*, Nutrition Monitoring Division, 1984, looseleaf
4. Haytowitz, D. B. and Matthews, R. H., *Composition of Foods: Legumes and Legume Products, Agricultural Handbook No. 8-16*, Nutrition Monitoring Division, 1986, looseleaf
5. Gebhardt, S. E., Cutrufelli, R., and Matthews, R. H., *Composition of Foods: Fruits and Fruit Juices, Agricultural Handbook No. 8-9*, Consumer Nutrition Center, 1982, looseleaf.

USG = USGS. Two U. S. Geological Survey papers by H. T. Shacklette and associates giving the mineral composition of soils and associated wild and cultivated plants.

1. Boergen, J. G. and Shacklette, H. T., U. S. Geological Survey Open File Report 80-84.
2. Conner, J. J., Shacklette, H. T., et al., U. S. Geological Survey Professional Paper 574-F, 1975, 168 pp.

V&D = Vlietinck, A. J. and Dommisse, R. A., Eds., *Advances in Medicinal Plant Research*, Wissenschaftliche Verlagsgesellscharft, mbH Stuttgart, 1985.

VET = Tyler, V. E., *The Honest Herbal*, George F. Stickley Co., Philadelphia, 1982, 263 pp.

W&W = Wagner, H. and Wolff, P., Eds., *New Natural Products and Plant Drugs with Pharmacological, Biological or Therapeutic Activity*, Springer-Verlag, New York, 1977.

WBB = Watt, J. M. and Breyer-Brandwijk, M. G., *The Medicinal and Poisonous Plants of Southern and Eastern Africa*, 2nd ed., E. & S. Livingstone, Ltd., Edinburgh, 1962, 1457 pp.

WIC = Wichtl, M., *Teedrogen. Ein Handbuck fur Apotheker und Arzte*, Wissenschaftliche Verlagsgesellscharft, mbH Stuttgart, 1984, 393 pp.

WOI = *The Wealth of India*, Council of Scientific and Industrial Research, New Delhi, 1948–1976, 11 vols.
YAK = *Yakugaku Zasshi* (Vol. 111 = 1991)
25th = 25th Dispensatory. Osol, A., Farrar, G. E., Jr., et al., *The Dispensatory of the United States of America*, 25th ed., J. B. Lippincott, Philadelphia, 1955, 2139 pp.

The *Database of Biologically Active Phytochemicals and Their Activities* is an alphabetical listing of biologically active phytochemicals. After each phytochemical is an alphabetical listing of the reported activities. Where available, effective or inhibitory concentrations or doses are reported as well. In more recent entries, each biological activity entry will be followed by a reference similar to those used in the *Database of Phytochemical Constituents of GRAS Herbs and Other Economic Plants*. The following abbreviations are unique to the *Database of Biologically Active Phytochemicals and Their Activities:*

ED50 = effective dose at which 50% of subjects are "cured", "effected", "affected" or "altered"
IC = inhibitory concentration

Some activity abbreviations occur in admixtures like ASTH-genic or DME-inhibitor:

ACE-Inhibitor = angiotensin converting enzyme inhibitor
DME = drug metabolizing enzyme
MAO = monamine oxidase

LD50 abbreviations follow the National Institute of Occupational Safety and Health (NIOSH) and the 1977 CRC *Phytotoxin Tables*, published in the CRC *Critical Reviews in Toxicology:*

LD50 = lethal dose at which 50% of experimental population is killed
LDlo = lowest reported lethal dose

Unfortunately, MLD has been used by different sources differently, *Merck* uses minimum lethal dose, some other sources use mean lethal dose, and some don't define it. LD50 data are reserved for the end position at the end of the recitation for each phytochemical. The LD50 is almost always given im mg/kg. The LD50 is often followed by a pair of three-letter abbreviations in lower case letters indicating the mode of administration (e.g., orl for oral and mus for mouse).

cat = cat
chd = child
ckn = chicken
dog = dog
frg = frog
gpg = guinea pig

unk = unknown
gvg = gavage
hmn = human
iar = intraarterial
ihl = inhalation
inf = infusion
ims = intramuscular
ipr = intraper.
inv = intravenous
mky = monkey
mus = mouse
orl = oral
par = parenteral
pgn = pigeon
rat = rat
rbt = rabbit
scu = subcutaneous
sup = suppository
uns = unspecified
wmn = woman

Where available, these three-letter abbreviations are strung out in pairs, without periods, e.g., orl rbt stands for orally in rabbits. Where human dosages are available, I use hmn, man, or wmn followed by a slash (/). Temporal abbreviations used include hr(s), day, wk(s), mo(s), and yr(s). In many cases, the doses are based on salts or halides of the natural compound rather than the straight compound. For these and other reasons, as well as numerous caveats, the reader must always consult the original sources. Dosages vary greatly, from edition to edition, of various sources. For example, one consulting early NIOSH editions will find an oral rat LD50 of 192 mg/kg body weight for caffeine. The most recent edition of the *Merck Index*, cited herein as M11, gives a higher LD50 for caffeine.

WARNING: This compendium of biologically active elements and compounds is a growing and tentative list of reputed biological activities which I have seen reported in the last decade. This is an unannotated compilation, *not* a prescription. The fact that an isolated element or compound has a given activity does not necessarily imply that a plant species containing that element or compound has the same activity. Most of the studies have been on animals or microorganisms *in vivo* or *in vitro*.

Readers are advised that animal studies cannot be reliably extrapolated to other animals or humans. Many of these compounds and the plants containing them may be poisonous. In many cases, lethal doses (LD50 or LDlo) available to me have also been recorded (the information taken primarily from the *Handbook of Medicinal Herbs*, available from CRC Press).

Occasionally ADIs, acceptable daily intakes, from *Martindale's Extra*