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File: ■ Ginkgo (*Ginkgo biloba*, Ginkgoaceae)
■ Adulteration
■ Quality

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RE: Study Finds over 90% of Ginkgo Products Adulterated or of Poor Quality

Booker A, Frommenwiler D, Reich E, Horsfield S, Heinrich M. Adulteration and poor quality of *Ginkgo biloba* supplements. *J Herb Med*. June 2016;6(2):79-87.

Globally, the market for ginkgo (*Ginkgo biloba*, Ginkgoaceae) leaf products is estimated to be over $850 million annually. A clinically proven, standardized ginkgo extract is expensive to produce, which has led to a situation where fraudulent suppliers have added pure flavonoids (e.g., rutin or quercetin) or flavonol-glycoside-rich extracts from less-expensive plant materials to ginkgo extracts in order to obtain materials that contain the required 24% of flavonol glycosides. The purpose of this study was to evaluate the authenticity of 35 commercial ginkgo products, using nuclear magnetic resonance (NMR) with subsequent statistical analysis by soft independent modeling of class analogy (SIMCA), and high-performance thin-layer chromatography (HPTLC).

Ginkgo products (n = 35) were purchased from health food stores, supermarkets, and pharmacies in Central London, United Kingdom, and from the internet. Product formulations included tablets (22), hard capsules (11), and caplets (2). A detailed description of all investigated products is provided in the supplementary data section of the article.

The reference standards used were as follows: quantified ginkgo leaf extract EGb 761® (Tebofortin® intense; Dr. Willmar Schwabe GmbH & Co. KG; Karlsruhe, Germany) and ginkgo extract tablets (LI 1370 extract; Lichtwer Pharma AG; Berlin, Germany) purchased from a pharmacy [Note: Lichtwer Pharma no longer exists, and the company that purchased most of the business is Klosterfrau Vertriebsgesellschaft mbH; Cologne, Germany. However, it is not known if they have the rights to this extract.]; ginkgo tablet (S1312) and ginkgo leaf (S1310) from the National Institute of Standards and Technology; ginkgo leaf samples (S11311, S15564) and powdered ginkgo leaf extracts (S10925 and S15571) from the American Herbal Pharmacopoeia; ginkgo chemical reference standard supplied by the European Pharmacopoeia for peak identification; and quercetin, chlorogenic acid, rutin, and ginkgo terpene lactones (mixture) from Sigma-Aldrich.

The NMR analyses showed that some samples had a similar chemical composition to the ginkgo reference extracts, while others were more similar to the rutin standard with only small concentrations of all other ginkgo constituents. One spectrum suggested that the product was composed primarily of a compound with structural similarity to 5-hydroxytryptophan (5-HTP). Some products had chemical compositions that were very different from those of the ginkgo reference standards. Only two of the 35 products had HPTLC fingerprints equivalent to EGb 761.

The claims on the product labels were evaluated in relation to the NMR and HPTLC findings. The label claims were categorized into seven categories, ranging from extracts standardized to 24% flavonol glycosides/6% terpene lactones, products listing a drug extract ratio of 50:1, all the way to products with no information; some products were listed in more than one category. All labels claimed the product contained ginkgo leaf or extract. The results of the label claims analyses were as follows:

- Category 1: Eighteen products claimed to contain standardized extract (24% flavonol glycosides and 6% terpene lactones). Fifteen of the 18 products had HPTLC fingerprints in compliance with the authentic ginkgo references, although the intensity of the quercetin band was much greater than those of the references. Three products had fingerprints that did not match authentic ginkgo extract at all.
- Category 2: Four products claimed to be standardized to 24% flavonol glycosides. The fingerprints of all four products complied with the acceptance criteria for identification.
- Category 3: Twenty-two product labels claimed to have a 50:1 drug extract ratio; of those, eight provided no further information, 12 claimed to be standardized, one declared 24% flavonol glycosides, and one claimed ginkgo leaf and extract. None of the 22 samples had fingerprint intensities equal to that of the reference standards, indicating they contained lower concentrations of ginkgo.
- Category 4: Two products claimed to contain ginkgo leaf and extract; however, both contained constituents not found in ginkgo.
- Category 5: Four product labels gave no specification about the extract, just the amount of extract in each dosage unit.
- Category 6: One product claimed to be enhanced with rutin; however, the fingerprint showed it was enhanced with quercetin, not rutin.
- Category 7: Two products claimed to contain only ginkgo leaf; however, the fingerprints were different from those of the leaf references.

In summary, 32/35 (91%) of the ginkgo products were adulterated or of poor quality. The results of this study suggest that the main ginkgo product quality problems are low concentrations of ginkgo constituents, addition of pure compounds (rutin) to increase flavonol-glycoside contents, and addition of other compounds, such as 5-HTP-type derivatives. Based on HPTLC fingerprints, only two products were equivalent to EGb 761, three products were of bad quality (contained no ginkgo at all or were not in compliance with labeling), and 30 products had a quality different from that described in the pharmacopeias (elevated levels of rutin and/or quercetin, or low levels of ginkgo constituents). The elevated levels of rutin and quercetin suggest adulteration, while low levels of ginkgo compounds may be due to adulteration or poor extraction methods. However, from a consumer safety and reliability perspective, only five products were not in compliance with their labeling. The authors point out that based on their data, price is

not always a reliable indicator of quality; while most of the cheap products were of poor quality, some of the expensive products also were of poor quality.

The authors state, "There seems little other recourse than to draw the conclusions that these companies are either being sold sub-standard material from third parties or are using poor quality and adulterated material intentionally in order to maximise profits. … Future investigations into the ratio of different flavonoids e.g. quercetin and kaempferol using NMR spectroscopy and HPTLC will provide further evidence as to the kind and degree of adulteration of gingko [*sic*] supplements and provide a measure of product quality that helps overcoming supplement adulteration."

—Heather S. Oliff, PhD

Editor's Note:
"The initial idea for this project was developed with researchers (Matt Barrett, Fay Finlay and Chris van Tulleken) for the BBC programme 'Trust Me I'm a Doctor' (BBC2) and many of the samples included were purchased with funds provided by the BBC. The initial results were broadcast on 15.07.2015. Anthony Booker's research position was funded through a charitable donation by Dr. Willmar Schwabe GmbH & Co. KG, Germany."