Ginkgo biloba: Potential for Commercial Leaf Production in New Zealand©

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INTRODUCTION

Ginkgo (*Ginkgo biloba*) leaf extract is the largest selling herbal product with annual sales of about NZ$1 billion. In America approximately 11 million people take a ginkgo extract pill daily resulting in sales of US$138 million in 1998 in that country alone (Brevoort, 1998). Sold mainly as an aid to improving brain function, ginkgo is famous for its link with antiquity. As a species it has remained virtually unchanged for over 125 million years, while the family Ginkgoaceae has its origins in the Permian some 200 to 225 million years ago (Hori et al., 1997). Ginkgo has long been associated with Asia, where it is used as an ornamental plant, as a medicinal, and as a food. The wood is used for products where there is frequent wetting and drying, such as chopping boards, bowls and sake barrels as it does not crack, warp, or shrink rapidly (Hori and Hori, 1997). Ginkgo is believed to have religious significance and is frequently found around temples (Handa et al., 1997). The tree is tolerant of industrial pollution (Kim et al., 1997) and is often found thriving in densely populated industrial cities (Handa et al., 1997). Plantation production of ginkgo leaf for pharmaceutical use began initially in France and USA in the 1980s and then spread to China in the 1990s.

MEDICINAL USE

Clinical studies have confirmed the therapeutic value of ginkgo leaf extract for a wide variety of medical conditions. It's most well known use is to treat failing memory and senile dementia, specifically Alzheimer's disease (Murray, 1993; van Beek et al., 1998). It has also been recommended for many other medical conditions, including asthma, circulatory disorders, eye ailments, headaches, hemorrhoids, and impotency, and for its antioxidant and free radical scavenging abilities. Ginkgo extract has also been shown to influence chronic cerebral metabolic disturbances in elderly patients with Parkinson's disease (Funfgeld, 1997).

Although gingko nuts, which are eaten as a gourmet food, have been linked to food poisoning, especially in the young during periods of famine (Wada and Haga, 1997), there have been very few reported side effects from taking ginkgo leaf extract (Murray, 1993).

PLANT PROPAGATION

Ginkgo is commonly propagated from seed, while scion wood with desirable characteristics is often grafted onto rootstock. The large white seeds, which are encased in fruit resembling small yellow plums, are harvested in autumn. The fruit can be harvested directly from the tree or after the fruit has fallen to the ground. Seed collectors should wear rubber gloves to avoid skin sensitisation as a result of contact with the anacardic acid found in the fruit. Once the pulp has softened it can be easily removed. Lee (1987) recommended cleaning the seed with water immediately after harvest to remove the surrounding fruit and pulp. This can be done using wire screens or metal barrels, taking care to ensure the seed is not split or crushed. Water blasting is recommended so that the operator is not required to remain close to the acrid smell produced by the fruit pulp.

Anecdotal evidence suggests that warmth appears necessary for the development of the ginkgo seed embryo. For example, seed purchased in the Northern Hemisphere and cool stored in New Zealand for several months germinated very poorly, whereas seed subjected to a surface mail journey across the equator germinated well. This is supported by Leiss (1985) who found that seed after-ripened for 8 to 10 weeks at 18°C followed by stratification at 0°C until sown in May (November in New Zealand) produced good seed germination. Seed from the North Island (38° 30' S) of New Zealand and stored in a warm shed until sown in late winter has germinated well. However, similar treatments applied to seed collected in Nelson (41° 15' S) in the South Island gave poor germination. Seed collected in Christchurch (43° 30' S) failed to germinate although seed remained sound for up to 15 months after sowing. Geenty (1990) found that ginkgo seed collected from even further north in Hamilton (37° 47' S) in the North Island could be successfully sown immediately after harvesting when the seed is mature but not dry. This indicates that ginkgo seed embryos may carry out significant ripening on the tree provided temperatures are warm enough. Embryo maturation is usually complete 6 to 8 weeks after the fall of the seeds (van Beek et al., 1998). This is followed by a significant reduction in germination potential 8 to 10 months after seed harvest (Balz, 1991). Once sown, ginkgo seed needs to be protected from rodent predation. This can be successfully achieved by coating the seed with acrylic paint and thiram.

Once seedlings have been grown, asexual propagation is often used to ensure plants with desirable characteristics are produced. Ginkgo for parks and reserves will usually be propagated from scion wood from male trees to avoid problems associated with the smell of decaying fruit, while trees produced for commercial leaf production should use scion wood from trees high in bilobalide and gingolides. Grafting is recommended for ginkgo (Flemer III, 1986; Intven and Intven, 1989) as rooted cuttings are slow and ginkgo is difficult to bud (Flemer III, 1982; Flemer III, 1986). Care needs to exercised when selecting grafting and cutting wood as ginkgo is topophytic with the propagation wood maintaining the direction of growth it had while still attached to the parent plant (Del Tredica, 1991). One way to avoid this is to collect plant material from especially prepared stool beds. Ginkgo can also be propagated by tissue culture (Tulecke, 1997).

Light shade until mid summer will produce taller seedlings than those germinated and grown under full light. However, a lengthy period of hardening off is necessary to avoid damage from autumn frosts. The green stem below the terminal bud in a 1-year-old seedling is susceptible to frost damage, but a firm brown stem will

normally be unharmed. Rabbits, which seem to enjoy ginkgo leaves and buds, can also be a problem.

Undercut and wrenched bare-rooted seedlings can be transplanted with few problems provided the roots are not allowed to dry out during transportation.

LEAF PRODUCTION

Ginkgo trees have been cultivated for nuts in China for at least the last 2000 years (Shan-An, 1997). However, it was not until the 1980s that the pharmaceutical industry's developing demand for leaf extract lead to ginkgo plantations specifically for leaf harvest. These were established firstly in France then the United States, and China followed in 1990 (Shan-An et al., 1997). Approximately 3000 tonne of dried leaf is harvested from these plantations in China annually, and a further 4000 tonne is harvested from other sources (Shan-An et al., 1997). Tree density for leaf production varies from 20,000 to 150,000 trees per hectare (He et al., 1999). Leaves from plantation-grown ginkgo are machine harvested, with the first harvest in the second year after planting 2-year old seedlings.

In response to the high demand for leaf material, a pilot commercial orchard of 1000 trees was established in 1998 in the Hawkes Bay, New Zealand, by the Disability Training Services (DTS). The aim was to produce ginkgo leaves for the Chinese market in a joint venture established with Pizhou City, China. Leaves from the first harvest have been analysed in China with results as reported by the Chinese exceeding international quality standards. It is now intended to expand the programme with further plantings in August 2001. Initially dried leaf will be exported, with extraction being carried out in China. If the programme continues to be successful it will be extended into other locations throughout New Zealand. It is expected that the DTS will coordinate a joint marketing approach with other New Zealand growers to bulk up the supply. The Chinese joint venture partners are keen to secure product from New Zealand because of its high quality and the ability to supply out of season to the Northern Hemisphere crop. Other New Zealand companies are also investigating the commercial development of this crop.

CHEMICAL CONSTITUENTS

Leaves are collected, and dried in low temperature drying kilns, before being cleaned, baled, and shipped to extraction plants. The dried leaves are milled then extracted using an acetone-water mixture under vacuum (Tyler, 1993). The organic solvent is removed and the extract processed to remove inactive and undesirable substances with the active ingredients concentrated by more than 20 processing steps (Juretzek, 1997; van Beek et al., 1998). After processing the concentrate contains 24% flavonoids. Chemists have now identified over 40 flavonoids, many of them unique to ginkgo (Yoshitama, 1997). The most common are called kaempferol and quercetin. Ginkgo leaf extract also contains lactonic terpenes, including ginkgolide A, B, and C and bilobalide. Manufactured leaf extract is characterised by 22% to 27% flavon glycosides and 5% to 7% terpene lactones of which 2.8% to 3.4% are the ginkgolides A, B and C and 2.6% to 3.2% bilobalide. There is a requirement for the extract to contain less than 5 ppm ginkgolic acid (Blumenthal et al., 1998).

A Crop & Food Research programme has sampled trees in the Waikato, Bay of Plenty, Canterbury and Otago to compare active ingredient concentrations in the leaves of New Zealand-grown ginkgo. These unpublished studies have found

concentrations of bilobalide ranging from 79 to 4213 mg g^{-1} dry weight of leaves. Ginkgolide A ranged from 0-1386 mg g^{-1}, while ginkgolide B ranged from 0-718 mg g^{-1}. These results show that New Zealand-grown ginkgo has active ingredient concentrations similar to or greater than overseas figures.

POTENTIAL FOR NEW ZEALAND

Gingko leaf production has been recognised as a potential new industry for New Zealand. There is little doubt that gingkos grow well in this country, with large healthy trees found in many city gardens. Gingko for leaf production is grown in high density hedges which are harvested by row straddle harvesters. Plantations have been established from seedlings and kept vigorous by cutting to ground level every 6 or 7 years. The New Zealand information shows that significant variation exists between plants in their concentrations of bioactives and consequently there is the possibility of growing trees of higher quality than the mixed seedling populations of overseas plantations. It is not known whether a price premium would be paid for higher quality leaf. New Zealand already has a nursery industry that could easily be geared up to supply suitable trees if the extra expense of grafting was warranted along with a number of trees already identified as having high concentrations of active ingredients. This along with the development of a greater understanding of the agronomic requirements of plantation-grown gingko for leaf harvest and coordinated marketing of the dried leaf or leaf extract, could help establish a successful new industry in this country.

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