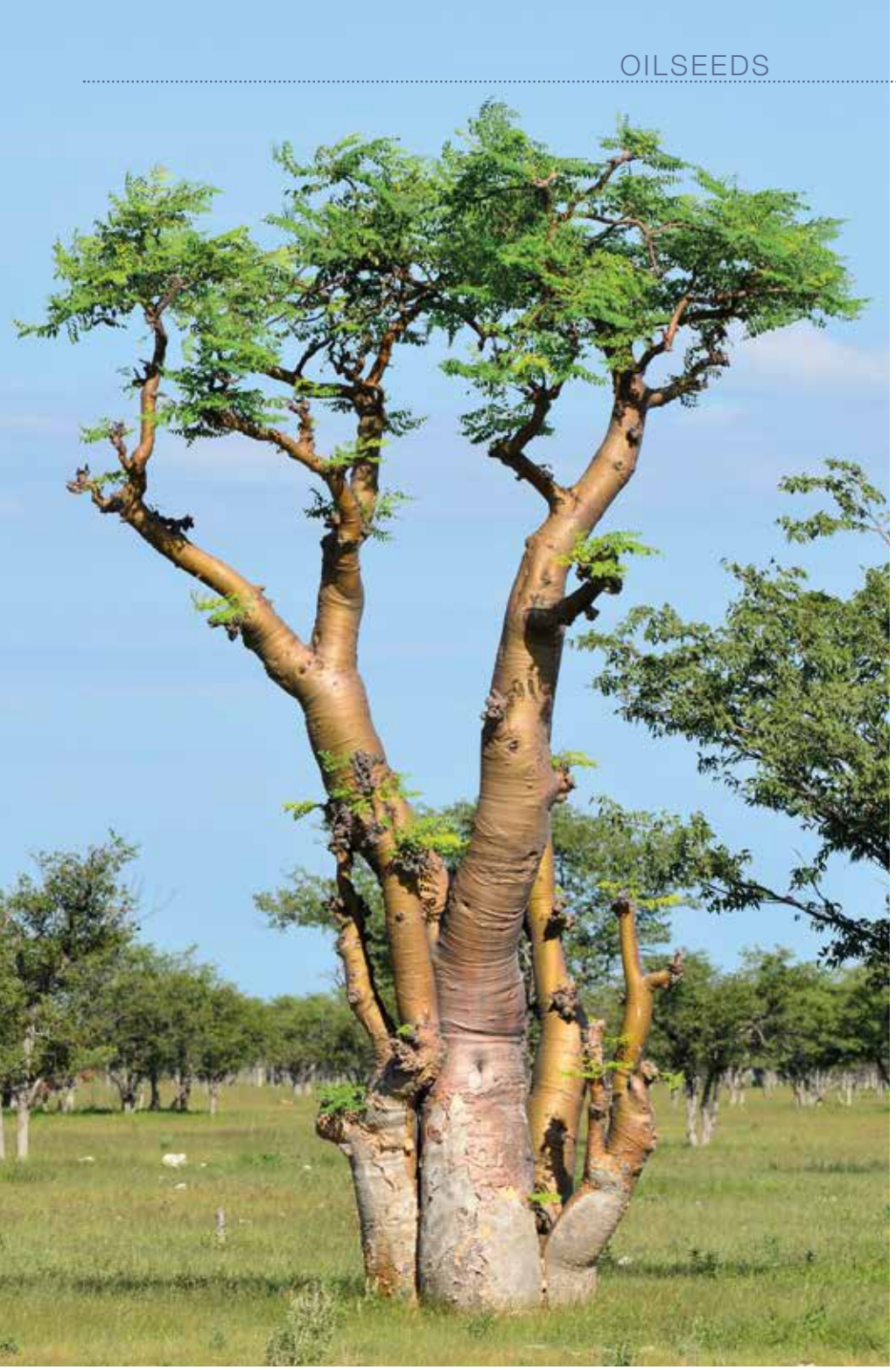

The tree of life

Not only can its leaves and fruit help us overcome world hunger, the tropical moringa tree has something to offer for everyone. Ile Kauppila explores the many uses of the moringa, from cosmetics to biofuels

Imagine, if you will, a plant whose seeds provide a high yield of oil for potential biodiesel use. Not only that, but the same oil also possesses several properties that make it promising for cosmetics and pharmaceutical applications. Imagine if practically all parts of the plant can be used as well, for purposes such as water purification, medicine and pesticide production. And that the plant is edible as well, and, in fact, so nutritious that it could eradicate malnutrition in hunger-stricken countries. And that it is highly resistant to drought, is easily cultivated through several different methods and is practically immune to any diseases in its growing range.

Surely such a miracle plant sounds too good to be true? Yet it actually exists and has already been used for all the above purposes and more. The plant is *Moringa oleifera*, known also by a a variety of nicknames, including moringa, the drumstick tree, the ben oil tree, the wonder tree, and the tree of life.

Some of these names are less than humble, but moringa deserves them. Native to the southern foothills of the Himalayas in northwest India, moringa is today cultivated all over the tropical and subtropical areas of the world. India remains the largest moringa producer with a total annual production of 1.1-1.3M tonnes of moringa seedpods in 2011 from a planted area of 38,200ha. However, moringa is also grown in several areas elsewhere in Asia, including the Philippines and Indonesia, along with Africa and the Caribbean. Test plantings in Hawaii were performed in 2010.

Moringa is grown primarily for food. Its leaves, fruit, seedpods, seeds, flowers and oil can all be eaten, with the leaves being the most commonly consumed part of the plant. Moringa is highly nutritious. It contains vitamins A, B, C and K, is high in protein and also contains minerals, fibre and other essential nutrients.

In addition to its high nutritional value, moringa is not particularly picky about where it grows. Within the tropical/subtropical zone, moringa can grow in elevations ranging from sea level to 2km. It tolerates a wide range of soil conditions and thrives in both arid and humid areas. According to Alberto Leone *et al* in their 2015 study '*Cultivation, Genetics, Ethnopharmacology, Phytochemisty and Pharmacology of Moringa oleifera leaves*', moringa is also an exceptionally fast-growing tree, capable of reaching a height of 3m in just three months and its average full height of 12m in just a few years.

All of these facts have translated to moringa's use in alleviating malnutrition, particularly among infants and nursing mothers. Its leaves' high protein, mineral, beta-carotene and antioxidant compounds provide nutrition often lacking in underdeveloped or developing countries, according to Leone, and the easy cultivation of the plant means that it can provide a reliable source of food around the year.

The moringa oil

While the leaves, fruit and seedpods provide a valuable source of food, moringa still has more to offer. Its seeds can be eaten like peas or nuts, but they also provide a potentially lucrative financial opportunity.

The seeds have a relatively high oil content, ranging from 28% to 44%. According to a 2008 study *'Moringa oleifera oil: A possible source of biodiesel'* by Rashid *et al*, the oil is high in oleic acid with a concentration of more than 70% (*see Table 1, page 27*). Moringa oil, also called ben oil, has a high behenic acid content, which makes it resistant to oxidative degradation. In other words, it is slow to go rancid.

Yields of the oil vary greatly due to moringa's tolerance of wildly different environments. On the low end of the scale, in dry conditions, the tree produces approximately 3.03 tonnes/ha of seeds, while in irrigated or naturally humid areas the yield doubles to 6.6 tonnes/ha. A 2011 study by

MORINGA LEAVES, SEEDS AND PODS ARE HIGLY NUTRITIOUS AND USED FOR A WIDE RANGE OF APPLICATIONS

Ted Radovich found that moringa can produce an oil yield of 250l/ha, assuming a relatively low oil content of 20% in the seeds.

Moringa oil has been known and used for centuries. Ancient Indians used it in Ayurvedic medicine and it continues to be used as a base for perfumes. More recent studies have discovered that the leftovers of the crushed seeds can be utilised to replace expensive and potentially dangerous chemicals in water purification. Another application where moringa oil is used is in the enflaurage process through which fragrances and essential oils are extracted from plant materials.

The oil can be eaten as well, and it has been compared to olive oil in taste and cooking characteristics. Radovich says small family farms could sell it to high-end venues as a local alternative to olive oil, thus increasing rural incomes.

For beauty…

A more international and lucrative revenue stream for moringa oil can be found in cosmetics. Moringa has a long history in beauty applications, Leone notes. Ancient Egyptians realised its cosmetic properties and rubbed it on their skin to revitalise it and protect themselves from the sun.

A 2014 study by Atif Ali *et al* on moringa's effect on human skin confirmed that the Egyptians were on to something. Using an active cream containing 3% of concentrated moringa leaf extract, the study discovered that the plant's active ingredients were beneficial for skin health.

"The results achieved in this investigation suggest that topical formulation of moringa extract is capable revitalising the skin and reducing signs of skin aging," Ali says.

Moringa oil is catching on elsewhere in the beauty and cosmetics industry as well. Debra Jaliman, an assistant professor of dermatology at the Icahn School of Medicine at Mount Sinai in New York, and Jeanette Graf, assistant clinical professor of dermatology at the Mount Sinai Medical Center, told *Stylecaster* in an interview that one of moringa oil's greatest strengths in cosmetics was its antioxidant content.

"Moringa oil is packed with vitamins. It stacks up against other popular oils since it has many therapeutic properties. It's a good exfoliant as well as an emollient," Jaliman says. She recommends using moringa oil particularly for those with acneic skin, as although oils generally do not go together well with an already greasy skin, moringa's antiseptic properties mean it can hydrate skin without clogging pores.

Susie Wang, a cosmetic chemist and founder of the 100% Pure line of skincare and cosmetics products, says moringa oil benefits from being combined with vitamin E, which makes it more potent and stable in skincare applications.

"With serum and cream formulas, there's usually heating involved, which alters the nutritional phytochemicals found in moringa oil. Because of the sensitivity of moringa, it's best if the oil is not heat processed," Wang advises.

In addition to skincare, moringa oil could be used in haircare. Both Jaliman and Graf say the oil is a good hydrator for hair and it is used in all kinds of conditioners, including sprays, leave-in treatments and masks to help boost hair health.

"The oleic acid in moringa oil can help strengthen the hair and retain moisture," says Jaliman. "Its antibacterial properties can help keep dandruff and/or dry scalp away as well."

…and biodiesel

Moringa oil has also been widely researched as a potential biodiesel feedstock and several studies show that it may hold great potential for the biofuels industry. Rashid notes that moringa oil has an acid value of 2.9, which necessitates acid pre-treatment before transesterification. Moringa's oleic acid content at 70% is higher than other common vegetable oils used in biodiesel production, including rapeseed (61.6%), palm (39%), sunflower (24.9%) and soya (23.4%).

"Also significant is the disproportionately high content (7.1%) of behenic acid in moringa oil compared to other more conventional oilseed crops," says Rashid. The behenic acid is what makes moringa oil resistant to oxidation, which in theory indicates that moringa biodiesel would have a longer shelf life than other comparable biodiesels. However, Rashid notes that the oxidative stability of moringa biodiesel is significantly reduced from the pure oil.

"Possible explanations are that the antioxidants naturally present in moringa oil are either deactivated through the transesterification process and/or removed by the subsequent purification or separation procedures," Rashid says.

The biodiesel has still met all necessary standards in Rashid's tests. Drumstick Biodiesel, a Rwandan biofuel venture, notes that moringa oil's oxidative stability gives it an edge over conventional vegetable oils as resistance to rancidity translates into longer possible storage times.

Both Drumstick Biodiesel and Rashid also mention moringa oil's high cetane rating. "Cetane rating is a universal measure of the quality of a fuel leading to improved fuel efficiency, reduction of harmful emissions and less wear and tear on both car starters and batteries," says Drumstick. Methyl esters prepared from moringa oil have one of the highest cetane numbers (67.07) ever recorded in biodiesel fuels.

Moringa biodiesel could also have a price advantage over conventional feedstocks. As the moringa tree is easy and cheap to cultivate on land that is too arid for farming food products, requires few nutrients from the ground and is low maintenance, the production costs of moringa oil are lower than, for example, rapeseed's or soya's.

Social benefits

The miracle tree's ability to thrive in low-moisture environments means, in addition to cheaper biodiesel, that it has two significant social and environmental advantages over conventional oilseeds. First, moringa is already being planted in areas suffering from malnutrition to offer a cheap and reliable food source. As the most popular food items from moringa are the leaves, fruits and seedpods, farmers could sell the seeds either directly to local processors or retailers, who then sell the seeds to foreign companies.

This additional income has not been lost to the countries cultivating moringa. Nigeria's *The Sun* newspaper reported in October 2016 that moringa had opened a window for farmer's to boost their earnings by selling the seeds to American, Chinese and European buyers. According to the newspaper, in the city of Lagos, a bag of moringa seeds can fetch a price between 150,000 naira (US$416) and 170,000 naira (US$470) depending on weight, and in the state of Kano, Chinese buyers were paying farmers in advance far ahead of harvest periods. In northwestern Zamfara state, a moringa seed trader could earn 6M naira (US$16,581) annually, with moringa seeds fetching prices of 1,800-2,000 naira (US$5-5.5)/kg.

Ojiefoh Enahoro Martins, deputy managing director of Lagos-headquartered international seed company Peniel Gerar International, calls moringa "one of the world's most useful plants".

"Moringa seeds have both international and local market values," Martins says. "Since the introduction of moringa, the price has seen a 50% increase annually because of new research and development. Between 2015 and 2016, the price jumped from 50 naira (US$0.13)/kg – which is 500,000 naira (US$1,386)/tonne – to 200 naira (US$0.55)/kg, which is 2M naira (US$5,547)/tonne. Our company has sold tonnes worth millions."

Moringa's other advantage concerns the food vs. fuel debate when it is used as a biodiesel feedstock. The tree is positioned somewhat outside the food-fuel controversy as it produces both food and fuel. In fact, the tree was for the longest time considered a source of food instead of an oil plant, says K. Shane Tyson, a strategic planning, biodiesel technology evaluation and market development consultant at Rocky Mountain Biofuel Consulting. "Everybody in India knows moringa as the drumstick tree. They don't see it as an oilseed crop," he told *Biodiesel Magazine* in 2008.

Drumstick Biodiesel agrees, saying that moringa has no direct competition with food crops due it being an edible source of fuel. Furthermore, it does not compete directly with existing farmland, as moringa can be grown on land not suitable for traditional farming. Even if actual potential farmland were used, moringa would still cater to food production, possibly more than to oilseed production due to the larger number of edible parts in the plant.

TABLE 1: FATTY ACID COMPOSITION OF MORINGA OIL

Type of fatty acid	Percentage (%)
Palmitic acid (C16:0)	5.5
Stearic acid (18:0)	5.7
Oleic acid (C18:1)	73.2
Linoleic acid (C18:2)	1.0
Arachidic acid (C20:0)	3.9
Behenic acid (C22:0)	6.8
Eicosenoic acid (C20:1)	2.6

SOURCE: TRAKARNPRUK, CHUAYPLOD, 2012

More to come

Providing food, oil and being an extremely easily cultivated plant is still not enough for moringa. It seems new applications and benefits are constantly being discovered every time a researcher decides to take a look at the plant.

To mention just a few, moringa seed cake works as a coagulant in water treatment with the same efficiency as conventional aluminium sulphate, its leaf extracts show biopesticide activity and experimental evidence suggests its antioxidant properties could possibly protect cells and organisms from cancer and other degenerative diseases.

With all the value-adding properties and benefits of moringa, the question becomes why the plant is not more widely used if it provides everything from food and fuel to medicine and cosmetics. There are of course limits to moringa cultivation. Drumstick lists cold weather, the need to extract and store the oil rapidly to maintain quality and fluctuating biofuel prices as the main challenges for a more widespread introduction of moringa.

Another factor is that moringa's value for purposes other than food is a relatively new discovery. However, research is advancing rapidly and new propagation techniques have begun to be developed.

For example, the Indian Biodiesel Business Academy of the Advanced Biofuel Center (ABC) announced in January 2016 that it had developed a microcutting mass propagation method for moringa through the use of its MOMax3 seed product line and tested and proven best cultivation practices.

"The ABC's goal is to triple moringa yields within 10 years and increase the oil content to 48%. In combination with other crops, the target oil yield is 1,500 gallons/ha," the research centre says.

While moringa has not yet reached its full potential, work has begun to make the plant the best it can be. As if addressing malnutrition, providing a multipurpose oil and possibly improving our chances of battling cancer weren't enough. Truly, moringa has earned the moniker of the wonder tree. ●

Ile Kauppila is the assistant editor at Oils & Fats International