

Supercharged safflower

Nutritionally healthy, safflowerseed oil is gathering interest from the food, biofuel and oleochemical industries, due to its high level of oleic acids and ability to grow in most regions of the world.

Charlotte Niemiec writes

As a crop that shows some potential as a biofuel feedstock, safflower remains a surprisingly neglected crop in comparison to the oil giants of palm, soyabean and rapeseed. World production is around 600,000 tonnes/year, with the majority grown in India (41%, on around 300,000ha).

Safflower oil contains many health properties, but it does not nearly approach the popularity of sunflower oil, to which it is nutritionally similar. The safflower plant grows up to 150cm tall with globular flower heads that have yellow, orange or red flowers. It resembles a thistle and each branch has one to five flower

heads containing 15 to 20 seeds/head. It is an ancient crop, with evidence of its use dating back to the 12th century – dyes made from safflower were identified in the tomb of Tutankhamen. Its colourings have been used for making red and yellow dyes, which were known as carthamine in the 19th century. According to safflowerseedoil.org, the plant has enjoyed a rich history in both the east and the west and could be described as “one item that bridges the commercialisation of agriculture

from ancient times to modern day.”

Safflower seeds produce both monounsaturated oil and polyunsaturated oil, the former commonly used as a cooking oil and the latter as a cold oil, for example, mixed into salad dressings. Both contain Vitamin E, Vitamin K and omega-3 fatty acids.

Recently, agricultural biotechnology company Arcadia Bioscience Inc launched its Sonova Ultra GLA safflower oil. The oil has 55% gamma linoleic acid (GLA) at twice the concentration produced in any other oilseed, the company says. To put that into perspective, evening primrose oil contains approximately 10% GLA and borage oil contains around 20%. GLA is an omega-6 fatty acid that is claimed to provide dietary support in weight management and, in combination with the omega-6 fatty acids EPA and DHA, can support heart and eye health and reduce inflammation, asthma, diabetic neuropathy and rheumatoid arthritis.

Aside from its edible oil uses, safflower seeds, which are rich in methionine, are useful as an ingredient in formulated poultry feed.

India the key producer

Regardless of its relatively small world production, safflower is grown in around 60 countries, including India – which produces almost half the world total – followed by the USA, where California state leads.

According to a January 2011 *Business Line* article, while India is ranked number one in safflower production, it has some of the poorest productivity levels, with low yields of an average 630kg/ha compared to the global average of 893kg/ha. Other producing countries include the USA (17%), Argentina (13%) and Kazakhstan (12%). China leads in productivity, reaching an average yield of 2,519kg/ha, followed by the USA at 1,639kg/ha, Argentina, 897kg/ha and Kazakhstan, 750kg/ha.

The article further notes that safflower occupies seventh place in the area dedicated to oilseeds in India, and 99% of it is grown in the southern plateau region (see *Table 1*, pg 30). The states of Maharashtra and Karnataka contribute 55% and 31%, respectively, but Gujarat has the highest productivity (1,000kg/ha), followed by Karnataka (795kg/ha), Maharashtra (565kg/ha) and Andhra Pradesh (462kg/ha).

Headed for the highway

In 2010, the US Army turned its attention towards safflower in Utah, where it grew wild on 20 acres of government land, according to a *Salt Lake Tribune* article. Noting the potential, officials decided to cultivate the land and harvest the crop, capable of producing 50 gallons/acre of biofuel. While 20 acres was initially selected to trial the scheme, the crop is expected to be planted on the entire 200 acre property.

Utah State University (USU) – a key player in the scheme – is pursuing a “FreeWays to Fuel” programme that aims to plant oilseed crops such

RESEMBLING SUNFLOWERSEED AND OIL, SAFFLOWER IS BEING EYED AS A WINTER ROTATION CROP FOR BIOFUEL.
(PHOTO: ANDREY SHUPILO/DREAMSTIME.COM)

as safflower, canola and flaxseed along the often unused roadsides in the USA. USU researchers suggested that the nation could produce around one billion gallons/year of biodiesel by harvesting along highways.

Safflower has also been selected as an ideal winter crop for Texas. One study, conducted at the Department of Agriculture and Applied Economics, Texas Tech University, Texas, USA, concluded that winter safflower would be a profitable feedstock for biodiesel production in that state. The study noted: "With a positive net economic value (NEV) of 99,886 BTU/gallon and net energy ratio (NER) of significantly greater than one, the safflower-derived biodiesel system yields more useful energy out than is required during production, processing and transport."

On-location biofuel in Afghanistan?

Interest in safflower has been growing throughout the world. In a June 2010 paper titled "*Producing and using biodiesel in Afghanistan*", authors Wayne Arden and John Fox suggest the US military grows the crop in Afghanistan and builds biodiesel refineries to produce biofuel for use in their vehicles.

Arden and Fox explain that, as importing fuel into the country is an expensive business, producing biodiesel 'on location' would make solid financial sense, provide the country with an additional crop and source of income, and perhaps even lessen its production and trade of opium.

This out-of-the-box thinking demonstrates the versatility of safflower, which is "best suited as Afghanistan's first biodiesel crop. It is native to the

region and, although not a major crop, safflower is already cultivated in Afghanistan. Safflower has a long tap root and is highly drought-resistant. If more safflower is planted than is needed to supply the first biodiesel plant, the oil could be sold to consumers – safflower oil is one of the healthiest vegetable oils for human consumption (Afghanistan currently imports most of its vegetable oil). Safflower oil's cold weather properties approach those of petroleum diesel. For subsequent biodiesel plants, crops such as camelina and pennycress should be considered; these crops are not, however, currently grown in Afghanistan."

Cost savings to the US military were estimated at US\$3.7bn in the first year and US\$3.8bn in subsequent years, with the cost of an estimated US\$90M to build the plant itself.

Australia leading safflower research

A group of researchers and scientists at Australia's Commonwealth Scientific & Industrial Research Organisation (CSIRO), the country's national science agency, are working towards the commercialisation of industrial chemicals derived from safflower.

The researchers are attempting to 'supercharge' safflower to produce increased amounts of fatty acids. Deputy chief of CSIRO Plant Industry, Dr Allen Green, spoke to Glen Paul about the possibilities and why the team chose safflower as its platform.

"It was a consultation with the growers themselves. The Grains Research & Development Corporation (GRDC) surveyed and worked out

what would be best as an additional crop for farmers in Australia, and safflower works very well in the northern parts ... Also, because it has a very small production for food, we think we'll be able to segregate it quite easily for the food and industrial types in production and handling."

He explained that the team were using CSIRO's gene silencing technology (RNAi technology) to switch off the conversion of a desirable fatty acid, oleic acid, which is very valuable for industrial products, and switch off its conversion to the polyunsaturates, which are good for food, but not good for industrial products.

Dr Green explained that safflower could have a significant impact on lessening our dependence on fossil fuel petrochemicals as a biomaterial. Using safflower has the additional advantage of producing greater energy than that put into producing the crop.

Green notes that "we will need to grow and produce more product per unit area of all our crops in the future, as demand for food and industrial products goes up, so the challenge is to get more productive and get more value out of our cropping systems."

Oleic acid is an important oleochemical platform that can be used in a range of industrial applications, such as high-stability lubricants, dielectric fluids (electrical insulators) in power transformers, and as raw materials for bio-based polymers (plastics).

"It's interesting that the high oleic oil that we produce could be suitable for food, but in our food oils we need to have a balance of fatty acids for nutrition, so high oleic oils have been developed overseas but they've generally been up to 80%, so ▶

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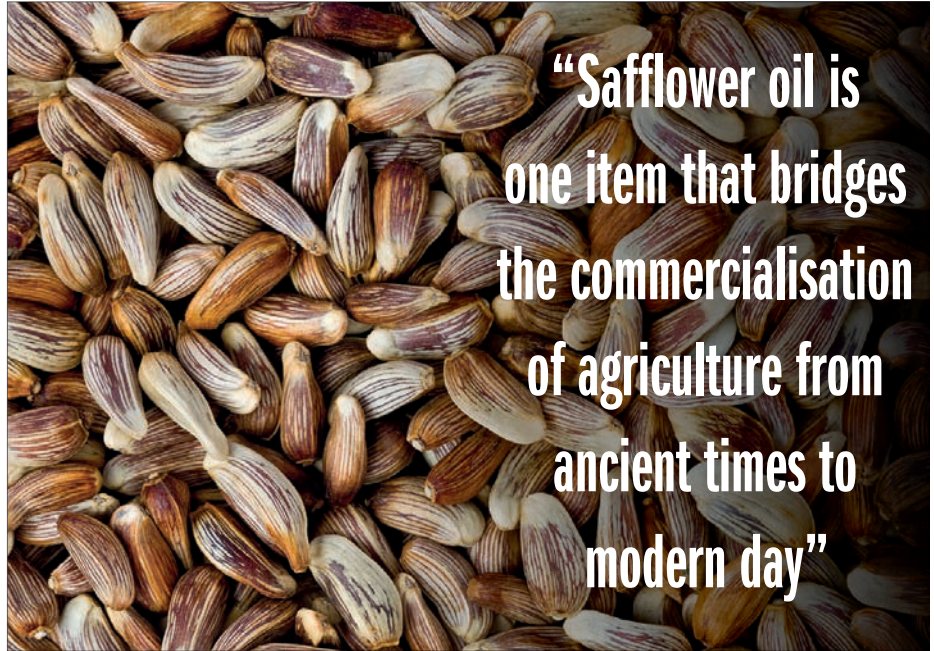
▶ that you still get the nutritional fatty acids in those oils. It's completely different for industrial uses – you want as high a purity as possible, so really to push this up to 93%, potentially to 95% of one particular compound is a very big advantage for industrial use. We wouldn't think that that oil would be used in food production, although it would be perfectly safe for human consumption."

He added: "It's still a number of years before we get this to market. Obviously, we've made this breakthrough and we now have to develop varieties and commercialise those, so it's probably five or six years down the track before farmers can get involved. But we're interested in this particular product because we thought it had potential for about 100,000ha of additional production for Australian farmers, so it's a sizeable new crop benefit, and that's why the GRDC was interested as well. And they see that, in the long-term, these industrial products will also have premium prices, compared to traditional crops, so there's an opportunity for added value for the growers."

In January this year, the Office of the Gene Technology Regulator (OGTR) approved the team's application to establish field plots of experimental safflower lines. If the outcomes are positive, the group would work toward making commercial varieties available by 2018. "It'll be a GM crop, even though it doesn't have any new transgenes, it has only its own DNA replaced."

Finally, Green notes, the GRDC is looking into safflower improvement in anticipation that the crop will be bigger in the future.

Charlotte Niemiec is OFF's assistant editor



"Safflower oil is one item that bridges the commercialisation of agriculture from ancient times to modern day"

PHOTO: RAPTORCAPTOR/FOTOLIA.COM

OIL PRODUCED FROM SAFFLOWERSEEDS IS FLAVOURLESS AND COLOURLESS AND NUTRITIONALLY SIMILAR TO SUNFLOWER OIL

Year	Total oilseeds* Area	Total oilseeds* Production	Safflower % total Area	Safflower % total Production
1990-93	25.1	19.1	2.7	1.5
1995-98	26.2	22.8	2.6	1.4

Source: Kalpana Sastry et al, 2001 * 3-year average

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