FIELD REPORTS

Improving food security in famine-prone areas using invasive and underutilized prosopis trees

NICK M. PASIECZNIK, SIMON K. CHOGE, LIZ J. TRENCHARD and PHIL J.C. HARRIS

Climate change is already affecting food security across drylands in Africa and Asia. With challenges expected to increase in the future, peasant farmers, pastoralists, and policy-makers need as many options as possible available to them. This paper introduces the long golden fruit of the much-criticized prosopis tree. Wild prosopis beans are rich in protein, carbohydrates, and essential amino acids, and they were for centuries a staple food for indigenous peoples in the Americas. But in countries where they have been introduced they are not being eaten. The millions of tonnes produced each year are at best browsed by livestock, at worst left to rot. Advances in transforming prosopis into a valuable resource in famine-prone areas in the Greater Horn of Africa are presented, and governments, development organizations, and humanitarian agencies are invited to consider adopting this innovation.

Keywords: prosopis, underutilized crops, invasive species, tree legumes, food security, Horn of Africa

In traditional, cereal-producing farming systems in dry areas, crop failure and famine are expected to become more frequent. Availability of staple foods will decline and food prices are likely to rise, with far-reaching implications. Drought will become the norm rather than the exception and dependence on annual crops will become increasingly risky. When crops fail, people in drylands have historically turned to trees for food and fodder. Growing more tree crops is proposed as one of the best coping strategies for reliably and sustainably improving food security. Drought tolerant trees play an essential role in climate change adaptation in these areas though

Nick Pasiecznik (npasiecznik@wanadoo.fr) is an independent consultant with Agroforestry Enterprises, France, and has 25 years' experience with prosopis species and dryland development. Simon Choge (skchoge2002@yahoo.com) is a senior scientist at the Kenya Forestry Research Institute, Kenya, and Africa's leading specialist on prosopis management and utilization. Liz Trenchard (e.trenchard@coventry.ac.uk) is a research fellow at Centre for Agroecology and Food Security, Coventry University, UK. Phil Harris (p.harris@coventry.ac.uk) is Director of the Centre for Agroecology and Food Security at Coventry University and leader of many relevant global programmes.

doi: 10.3362/2046-1887.2012.017 ISSN: 2046-1879 (print) 2046-1887 (online)

planting them and getting them to survive in desert conditions is still challenging, so it is preferable to make the most of those trees that are already there.

Prosopis trees have huge potential to help feed millions of people

Prosopis is a group of trees that stands out as having huge potential to help feed millions of people, especially the species *Prosopis juliflora*. This is now one of the most numerous and widespread trees in dry areas of Africa and Asia. It is also one of the most underutilized. Prosopis trees produce masses of nutritious beans even in the driest years. Where they are native in North and South America, prosopis trees of various species have been, and still are, an important staple food for many indigenous peoples. But as a relatively recent arrival in Africa, Asia, and Oceania, people there have not yet learned of its valuable uses and some even think that the beans are poisonous.

The trees produce masses of nutritious beans even in the driest years

A similar situation occurred with the potato, which took almost a century to be adopted as a food plant in Europe after first being brought from South America. At first people ate the fruit and unripe tubers, becoming sick and believing it to be poisonous. Only much later did it became widespread as a food. Prosopis also has the potential to become a source of food for very many poor people in the dry areas of Africa and Asia. The sooner it does, the fewer poor people will go hungry.

Prosopis beans as a food

Prosopis beans are composed of hard seeds enclosed in a fibrous endocarp, surrounded by a sweet fleshy mesocarp, commonly 15 cm long, but up to 30 cm in some species. There is significant variation in nutritional values between species and even between trees of the same species. However, beans generally contain 10–20 per cent crude protein, 30–60 per cent carbohydrate including up to 40 per cent sugars in some varieties, acceptable amounts of minerals, and an acceptable amino acid profile (see Table 1). This makes the beans comparable or superior to most cereals, with no anti-nutritional factors detected (Pasiecznik et al., 2001; Felker et al., 2012).

The beans are comparable or superior to most cereals, with no anti-nutritional factors detected

In countries such as Argentina, Chile, Peru, Mexico, and the USA where prosopis is native, the beans were an important staple food in times past, (D'Antoni and Solbrig, 1977; Felger, 1977; Beresford-Jones et al., 2009). Although they go by many names, they are commonly known as 'mesquite' in North America and 'algarrobo' in much of South America. They were traditionally ground into flour using stone mills, and mixed with maize or other flours to make bread, cakes, or a rich gruel. Alternatively, they were boiled into a molasses-like syrup for sweet drinks, and home-made products are still sold in local markets (Felker, 2005; Felker et al., 2012). Prosopis gum is similar to gum Arabic and can be used in cooking; the honey is of excellent

Table 1. Nutritional content of whole Prosopis juliflora bean flour from Kenya, compared with unfortified white bread wheat flour from South Africa

Nutritional content	*Prosopis flour*	*Wheat flour*
Dry matter (%)	93.5	86.0
Energy (kJ/100 g)	1,530	1,473
Proximate composition (g/100 g)		
Protein	16.2	10.4
Carbohydrate	69.2	71.7
Total sugars	13.0	1.5
Fat	2.1	0.9
Ash	6.0	0.5
Minerals (mg/100 g)		
Phosphorus	218	45
Sodium	20	6
Amino acids (g/100 g)		
Alanine	0.47	0.36
Arginine	0.76	0.49
Aspartic acid	1.99	0.42
Cystine	0.07	0.28
Glutamic acid	1.43	3.60
Glycine	0.41	0.41
Histidine	0.32	0.31
Isoleucine	0.34	0.42
Leucine	0.82	0.75
Lysine	0.47	0.22
Methionine	0.08	0.15
Phenylalanine	0.38	0.54
Proline	1.22	1.37
Serine	0.62	0.58
Threonine	0.42	0.34
Tryptophan	0.00	0.12
Tyrosine	0.18	0.27
Valine	0.54	0.46

Source: data for prosopis beans adapted from Choge et al. (2007) and Pasiecznik et al. (2007); data for wheat flour from Danster et al. (2008)

Beans are ground to flour and mixed with other flours to make bread or cakes

quality and all parts of the tree have traditional medicinal uses (Pasiecznik et al., 2001).

International trade in the flour is increasing, owing in part to research on the nutritional content and processing methods over the last four decades (e.g. Becker and Grosjean, 1980; Meyer et al., 1986; Del Valle et al., 1989; Bravo et al., 1998; Felker et al., 2003). 'Mesquite flour' is promoted as a gluten-free high-fibre supplement, with a subtle sweet, smoky and spicy flavour including hints of cacao, coconut, clove, burnt almond, and hazelnut (Felker et al., 2012). Several companies market it as a certified organic product and offer recipes for its use (e.g. www.casadefruta.com/mesquite.php). A

Ripe prosopis beans ready for picking, also showing foliage and dead thorny branches
Photo: Simon Choge

Beans are also boiled to a syrup for sweet drinks and the honey is of excellent quality

company in Brazil has also pioneered industrial-scale processing for producing livestock rations with community initiatives for equitable benefit-sharing.

A valuable resource or an invasive weed?

Prosopis was planted for fuelwood and was very successful, too successful perhaps

The various species and varieties of prosopis can be tall, thornless trees, growing in open stands with lush undergrowth, or shrubby and thorny trees growing in dense, sometimes impenetrable thickets. They were introduced to Africa, Asia, and Oceania over the last 200 years by the British, French, and Portuguese to provide firewood and fodder, and were chosen because they were seen to be fast growing and very drought resistant. But the wide distribution of prosopis seen today in tropical Africa has resulted largely from the introduction of a particularly thorny form of one species, *Prosopis juliflora*, planted in the 1980s and 1990s as a response to the 'fuelwood crisis'. It was very successful, too successful perhaps, and with little knowledge of its use, it began to spread and became an invasive weed in many countries. Roaming animals eat the fallen fruit and spread the seeds. Left unmanaged, the trees invade farms and pasture lands, lake and river sides, protected areas, and nature reserves. As it can crowd out native species, ecologists have called for its eradication. Pastoralists

It spread to become an invasive weed covering 10 million hectares across Africa

also dislike the tree as it can make paths and watersides impassable and reduce the growth of understorey grasses. Prosopis beans are a valuable fodder, but like most other feeds, they should be used as part of a balanced diet and not as the sole source of dietary intake. If whole beans are eaten in excess, as in the dry season when little other fodder is available, animals can become ill and may even die.

Based on the few reports available, prosopis trees now cover at least 10 million hectares across Africa. There are an estimated 1.2 million hectares of *Prosopis juliflora* in Kenya alone, a million hectares in Ethiopia, at least half a million in Sudan, and large but unsurveyed areas in every other country from Senegal to Somalia. In southern Africa, other species of prosopis are more common and there are more than 2 million hectares in South Africa and known invasions in all neighbouring countries. There are few reported estimates from elsewhere, but *Prosopis juliflora* is considered to be the most common and widespread tree in dryland India and it is very common in parts of Pakistan, Sri Lanka, Iran, and the Arabian Peninsula. Prosopis species have also been introduced and become the most common trees in parts of other countries including Haiti, Brazil, and Australia.

Although the beans are in abundance, people largely ignore them

However, indigenous knowledge on the use of the beans has yet to follow prosopis trees across the Atlantic, and although the beans are in abundance, people largely ignore them. The trees are declared a noxious weed in several countries, with some governments advocating their total eradication, rather than making efforts to benefit from this free food. People can be nourished and collect fuelwood, timber, and other resources in huge quantities for home use or sale, all of which can help reduce poverty and food insecurity with very little investment.

‘Control by utilization’ in Kenya

Beginning in the 1990s, there were widespread calls to eradicate prosopis, especially in the Greater Horn of Africa. In 2004, a man brought a sick goat into a Nairobi courthouse, suing the Kenyan government for introducing prosopis and ruining his community’s livelihood. This attracted international attention, and experts proposed ‘control by utilization’ as the way forward. Others disagreed and worked on biological control options. In the following years, a few training and demonstration courses were run on a limited budget and a small pilot project began to show people the benefits of prosopis as a resource, for food, fodder, charcoal, and timber (Choge et al., 2006, 2007; Pasiecznik et al., 2006, 2007).

Food security has increased in famine-prone areas of Kenya by using prosopis, not yet directly as a food, but by providing income to buy food. In prosopis-invaded regions in Kenya, families can collect

25–35 sacks of prosopis beans (about 1 tonne) per week in season, with a market value of US$35–55. Businesses also became interested: one company in Kenya began buying beans to mill into flour as a livestock feed ingredient. In 2007, 21 tonnes were collected, which earned communities more than $1,000 (Choge et al., 2012), although problems in agreeing a price and issues of storage and transport caused the initial purchaser to cease buying after the first year. However, community groups in two districts began collecting beans again in 2011, with a total of 11 tonnes of beans made into mixed livestock feeds and feed blocks for sale in local markets (Choge et al., 2012). In addition, each tonne of beans that is processed destroys at least 2 million seeds that would be potential weeds.

In 2007 the Kenyan government lifted the blanket ban on making and selling charcoal from prosopis wood and the impacts have been extraordinary. Government records reveal that communities are now earning more than $10,000 per month from charcoal sales in Garissa County, more than $20,000 a month in Tana River County, and more than $60,000 per month in Baringo County, where the bulk of the early training took place (Choge et al., 2012). Managing prosopis stands for production also means clearing and pruning trees, and this promotes the growth of understorey fodder grasses and discourages future prosopis regeneration.

When the ban on making charcoal from prosopis wood was lifted, the impacts were extraordinary

The trade in other tree products, such as honey, exudate gum, poles, and sawn timber is more difficult to quantify as official figures are not available and only estimates are possible. The Dadaab refugee camp in north-eastern Kenya, for example, provides a huge market for prosopis poles from Garissa County for the construction of huts and 'manyattas'. The trade is considered to be worth some $6,000 per month and is expected to rise as the size of the camp expands (Choge et al., 2012). The Government of Kenya is also considering the use of prosopis biomass to produce green electricity and the carbon credit earnings associated with the process. Several companies have shown interest and feasibility studies are being concluded with encouraging interim results.

The idea of control by utilization was also adopted in Ethiopia (Sertse and Pasiecznik, 2005) where FARM Africa worked with pastoral communities in Afar to promote the use and sale of prosopis beans and charcoal (Dubale, 2008). Recent reports indicate that several communities have adopted these practices and are continuing to benefit, and that the Government of Djibouti is also beginning to collect and mill prosopis beans. All this has been done in less than 10 years and with relatively little funding. But these real success stories are only just starting to overcome the weight of negative public and government opinion, by yielding measurable impacts. However, in Sudan it remains a declared noxious weed requiring eradication, and

Real success stories are just starting to overcome the weight of negative public opinion

millions of tonnes of food, fodder, and fuelwood remain unexploited across the region, including Somalia, northern Kenya, and other areas stricken by drought, famine, and under-investment.

Practical action: four steps to turn prosopis beans into a valuable source of food

1. Collect ripe fruit when golden-yellow, either from the tree or recently fallen, leaving old or discoloured fruit. Fill used cereal sacks with 20–25 kg beans. Use strong clothing, machetes, and leather gloves when collecting in thorny thickets.
2. Dry freshly collected beans in the sun on roofs or concrete floors. Store in sacks or in piles protected from animals. Use a covered shed for longer-term storage. Beans can be kept for more than a year before milling, though fumigation against seed-eating beetles may be required.
3. Mill using the grain mills found in villages for preparing maize or other cereals, or pestles and mortars. Beans must be completely dry or the sugary pulp will gum up the mill, which will then need cleaning. Convincing a mill owner to use the mill for prosopis may not be straightforward, especially in areas where they think the beans are poisonous.
4. Mix up to 20 per cent prosopis flour with wheat or maize (or any other) flour for human food (e.g. chapattis, tortillas, bread, biscuits, cakes or pancakes) and up to 50 per cent in livestock rations. The flour can also be mixed with water to make a refreshing drink. Traditional foods also include syrups and coffee substitutes.

Constraints and conclusions

Lack of awareness and the need to link with other initiatives are repeatedly highlighted as key issues in dissemination of new uses for prosopis. Introducing new sources of food in rural communities does take time, especially when they start with a negative opinion of the plant and the food it produces. Nonetheless, a number of agricultural extension services and development organizations have success stories to share on the development of other underutilized crops and promoting further exchange would be useful. As well as informing farmers and small-scale processors, it is also essential to raise awareness among national and international policy-makers. From the successes in Kenya that are now beginning to spread, it appears that the potential can become a reality by adapting and incorporating relevant aspects into current and future initiatives across a broad range of activities. Prosopis trees are very widely distributed

Prosopis beans from field to food. Top left: typical form of young prosopis trees and shrubs, here invading native acacia stands (Djibouti); top right: women carrying one day's collection of beans to a central storage point for sale (Djibouti); bottom left: beans laid out for sun-drying, and removal of diseased and damaged pods (Kenya); bottom right: beans being milled in a small cereal mill, and flour being made into feed blocks for livestock (Kenya)
Photos: Simon Choge and Nick Pasiecznik

in arid and semi-arid lands; they fruit even in drought years and the beans are nutritious and can be processed with simple equipment. Development of prosopis should be of interest to government departments responsible for health, nutrition, food security, forestry, rural development, and the environment; research and development organizations; and humanitarian agencies working in the many famine-prone areas where prosopis grows in abundance.

References

Becker, B. and Grosjean, O.-K.K. (1980) 'A compositional study of two varieties of mesquite (*Prosopis glandulosa, P. velutina*)', *Journal of Agriculture and Food Chemistry* 28: 22–25 <http://dx.doi.org/10.1021/jf60227a024>.

Beresford-Jones, D.G., Arce, S., Oliver, T., Whaley, Q. and Chepstow-Lusty, A. (2009) 'The role of *Prosopis* in ecological and landscape change in the Samaca basin, lower Ica Valley, south coast Peru from the Earlier Horizon to the Late Intermediate period', *Latin American Antiquity* 20: 303–32 <www.jstor.org/stable/40650197>

Bravo, L., Grados, N. and Saura-Calixto, F. (1998) 'Characterization of syrups and dietary fiber obtained from mesquite pods (*Prosopis pallida* L.)', *Journal of Agriculture and Food Chemistry* 46: 1727–33 <http://dx.doi.org/10.1021/jf970867p>.

Choge, S.K., Harvey, M., Chesang, S. and Pasiecznik, N.M. (2006) *Cooking with* Prosopis *Flour: Recipes Tried and Tested in Baringo District, Kenya*, KEFRI, Nairobi, and HDRA, Coventry.

Choge, S.K., Pasiecznik, N.M., Harvey, M., Wright, J., Awan, S.Z. and Harris, P.J.C. (2007) '*Prosopis* pods as human food, with special reference to Kenya', *Water SA* 33: 419–24 <www.ajol.info/index.php/wsa/article/viewFile/49162/35505>.

Choge, S., Clement, N., Gitonga, M. and Okuye, J. (2012) *Status Report on Commercialization of* Prosopis *Tree Resources in Kenya*, Technical report for the KEFRI/KFS Technical Forest Management and Research Liaison Committee, KEFRI, Nairobi.

Danster, N., Wolmarans, P., Buitendag, C.S. and de Jager, A. (2008) *Energy and Nutrient Composition of South African Wheat, Wheat Flour and Bread*, Technical Report to the Winter Cereal Trust of South Africa, Medical Research Council, Cape Town.

D'Antoni, H.L. and Solbrig, O.T. (1977) 'Algarrobos in South American cultures past and present', in B. Simpson (ed.), *Mesquite, its Biology in Two Desert Scrub Ecosystems*, pp. 189–99, Dowden, Hutchinson & Ross, Stroudsburg, PA.

Del Valle, F.R., Marco, E., Becker, R. and Saunders, R.M. (1989) 'Development of products containing mesquite (*Prosopis* spp.) pod flour and their nutritional and organoleptic evaluation', *Journal of Food Processing and Preservation* 13: 447–56 <http://dx.doi.org/10.1111/j.1745-4549.1989.tb00118.x>.

Dubale, A. (2008) *Invasive Plants and Food Security: The Case of* Prosopis juliflora *in the Afar Region of Ethiopia*, FARM Africa and IUCN, Addis Ababa, Ethiopia.

Felger, R.S. (1977) 'Mesquite in Indian cultures of southwestern North America', in B. Simpson (ed.), *Mesquite, its Biology in Two Desert Scrub Ecosystems*, pp. 150–76, Dowden, Hutchinson & Ross, Stroudsburg, PA.

Felker, P. (2005) 'Mesquite flour: New life for an ancient staple', *Gastronomica* 5: 85–9 <www.jstor.org/stable/10.1525/gfc.2005.5.2.85>.

Felker, P., Grados, N., Cruz, G. and Prokopiuk, D. (2003) 'Economic assessment of production of flour from *Prosopis alba* and *P. pallida* pods for human food applications', *Journal of Arid Environments* 53: 517–23 <http://dx.doi.org/10.1006/jare.2002.1064>.

Felker, P., Takeoka, G. and Dao, L. (2012) 'Pod mesocarp flour of North and South American species of leguminous tree prosopis (mesquite): Composition and food applications', *Food Reviews International* 29 (1): 49–66 <http://dx.doi.org/10.1080/87559129.2012.692139>.

Meyer, D., Becker, R., Gumbmann, M.R., Vohra, R., Neukom, H. and Saunders, R.M. (1986) 'Processing, composition, nutritional evaluation, and utilization of mesquite (*Prosopis* spp.) pods as a raw material for the food industry', *Journal of Agriculture and Food Chemistry* 34: 914–19 <http://dx.doi.org/10.1021/jf00071a037>.

Pasiecznik, N.M., Felker, P., Harris, P.J.C., Harsh, L.N., Cruz, G., Tewari, J.C., Cadoret, K. and Maldonado, L.J. (2001) *The* Prosopis juliflora - Prosopis pallida *Complex: A Monograph*, HDRA, Coventry <www.gardenorganic.org.uk/pdfs/international_programme/ProsopisMonographComplete.pdf>

Pasiecznik, N.M., Choge, S.K., Muthike, G.M., Chesang, S., Fehr, C., Bakewell-Stone, P., Wright, J. and Harris, P.J.C. (2006) *Putting Knowledge on* Prosopis *Into Use in Kenya: Pioneering Advances in 2006*, HDRA, Coventry.

Pasiecznik, N.M., Choge, S.K., Rosenfeld, A.B. and Harris, P.J.C. (2007) 'Underutilised crops for famine and poverty alleviation: A case study on the potential of the multipurpose Prosopis tree', in J. Smartt and N. Haq (eds), *5th International Symposium on New Crops and Uses: Their Role in a Rapidly Changing World*, pp. 326–46, University of Southampton, UK.

Sertse, D.M. and Pasiecznik, N.M. (2005) *Controlling the Spread of* Prosopis *in Ethiopia by its Utilisation*, policy brief, HDRA, Coventry.