Potential of Australian ***Acacias*** in combating hunger in semi-arid lands

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SUMMARY

People living in semi-arid regions of the developing, tropical world who are reliant on annual crops and / or pastures (for livestock) for food are particularly vulnerable to hunger and periodic famine.

A number of species of edible-seeded Australian acacias thrive under adverse conditions; conditions under which annual plants barely survive. These include ***A. colei***, ***A. coriacea*** sens. lat. (including ***A. sericophylla***), ***A. elachantha***, ***A. torulosa***, ***A. tumida*** and ***A. victoriae***. The seeds of these species are tasty, safe to consume as a moderate component of human diets and nutritious, being high in protein, carbohydrates and fats. In many regions, such as semi-arid tropical west Africa, the seeds ripen at a time of low labour demand when non-irrigated crops are not being cultivated. Being perennial and thus having an established root system, mature acacias can take advantage of rains that would be ineffective for annual crops (e.g. out of season or poorly distributed rains). Acacia seeds are easily harvested and processed into flour using simple, existing local technologies. The flour can be incorporated into local dishes and in 'non traditional' foods such as spaghetti, bread and biscuits. The seed also has great potential as feed for livestock. Being hard-coated, seeds can be stored for many years as a reserve for famine. Acacias can also supply various other products, especially fuelwood, and services such as improvement of soil fertility through fixation of atmospheric nitrogen.

This paper reviews current knowledge and trials and the use of edible acacias in Africa and India. Certain Australian species have a vast potential as new food crops, worthy of larger scale promotion, particularly in semi-arid regions of the world.

INTRODUCTION

The seeds of certain Australian acacias have formed a part of the traditional diets of Australian Aborigines in different parts of Australia. The most well-documented usage, which continues today, is from central and north-western Australia (e.g. O'Connell ***et al.*** 1983; Latz 1984; Cane 1987; Smith and Kalotas 1985; Goddard and Kalotas 1988; Devitt 1992), although ***Acacia*** seeds were consumed in other parts of Australia, e.g. Maslin ***et al.*** 1998. Many parts of the world that are subject to periodic or chronic famine, such as the Sahelian zone of Sub-Saharan Africa and dry regions of southern India, have climates similar to those of subtropical, arid and semiarid regions of Australia. Accordingly, certain ***Acacia*** species from Australia's hot, dry regions are considered to have potential to provide human food and a range of other products and services, such as fuelwood and charcoal, soil stabilisation, windbreaks, soil improvement and nitrogen fixation (Thomson 1992; Thomson ***et al.*** 1994, 1996).

In 1989, during a visit to west Africa sponsored by AusAID and the Australian Centre for International Agricultural Research (ACIAR), it was observed that species such as ***A. colei*** and ***A. tumida***[4], were producing very heavy seed crops less than two years after planting and might have potential as new human foods in the region (Thomson 1989). This potential has been explored actively over the past decade by the Society for International Ministries (SIM[5]) in the Maradi district of Niger Republic (Rinaudo 1999) and by Project Ecolake in Tamil Nadu, India (see two case studies in this paper). This development work has been backed by scientific research by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Forestry and Forest Products and its research partners, especially Obafemi Awolowo University in Nigeria, to confirm the safety of using Australian acacia seeds as human food in west Africa (Harwood ***et al***. 1999).

Staff of the Maradi Integrated Development Project (MIDP[6]) searched widely for suitable indigenous plants with food potential both before and during the acacia trials, resulting in a number of indigenous annuals and

[4] These species had been introduced by the Centre Technique Forestier Tropical (now CIRAD-Forêt) with the principal objective of identifying new animal fodders (e.g. Cossalter 1987)

[5] Recently renamed 'Serving in Mission.

[6] The Maradi Integrated development Project is managed by SIM.

fruiting trees being grown successfully, e.g. ***Ziziphus*** spp., ***Poupartia birrea***, ***Adansonia digitata***. In terms of growth rate, seed yield, nutritional value and capacity for long-term storage, however, none has yet been found to match the potential of edible Australian acacias. Most African acacias have toxic seeds and, in the few cases where they are used for human food, are subject to an elaborate detoxification process. An example is ***Faidherbia albida*** (syn. ***Acacia albida***), eaten in the Gokwe communal lands of Zimbabwe in times of food shortage (House and Harwood 1992). An exception is the non-toxic ***Acacia macrostachya*** which is eaten in Burkina Fasso. Although the species is also indigenous to the Maradi district there is no record of it being eaten there. Two-year-old trees of ***A. macrostachya*** reached barely one metre and failed to set seed, in contrast to ***A. colei*** which routinely reached 3-4 metres and yielded four to six kilograms of seed at the same trial site. The sharp, curved thorns of ***A. macrostachya*** also make harvesting difficult and disqualify it as a candidate for intercropping, though it may be suitable as a hedge that provides both protection and food. ***Boscia senegalensis***, which was also tested, produces a fruit that is also a traditional famine food in Niger. The seeds are highly toxic and must be soaked in changes of fresh water for several days. In rural districts water is often scarce, however, and inadequate soaking has resulted in deaths. Further, the seeds have a low germination rate (<5%) and growth rates are slow.

Although many indigenous species were tested in Tamil Nadu, India, their performance in terms of survival, growth rates and yield were poor compared to some Australian acacias grown under rainfed conditions on highly degraded land. Several Australian acacias showed promise for afforestation under these conditions, producing high yields of fuel wood and fruit. Seed pods of the indigenous ***Acacia leucophloea*** and ***A. nilotica*** are used for animal feed on some areas but proved less drought-resistant than ***A. colei***. Neither species is used for human food. Likewise, ***Prosopis cineraria*** is used for animal food and possibly human consumption in times of severe drought, but it did not perform as well as the hardiest Australian acacias. ***Prosopis juliflora*** occurs throughout India and is used for fuelwood and animal feed but is not accepted as human food.

The uses and characteristics of 44 ***Acacia*** species with potential for human food and originating from Australia's tropical and sub-tropical dry-zones have been documented (Thomson 1992). The species with the most promise for human food include ***A. colei***, ***A. coriacea sens. lat.*** (including ***A. sericophylla***), ***A. elachantha***, ***A. torulosa***, ***A. tumida*** and ***A. victoriae***.

Advantages of these species include:

1. Perennial habit

Some species, but probably not ***A. colei*** (see Harwood 1994) have potential to exploit soil water below the crop root zone and to produce seed in years when rainfall is distributed erratically and / or when untimely (for annual crops) and when annual crops fail due to moisture stress. Nevertheless, the heaviest seed crops in species such as ***A. colei*** follow good rainfall (totalling in excess of 300-400 mm), especially when distributed between the time of flower initiation and early to mid fruit set.

2. Adaptability to infertile and otherwise non-arable sites

Many of the promising acacias with human food potential, including ***A. colei***, ***A. elachantha***, ***A. sericophylla***, ***A. torulosa*** and ***A. tumida***, are very well adapted to infertile sands which are not well-suited to agricultural crops. In northern Nigeria (north-west of Kano), ***A. colei*** was grown successfully in areas with loose, infertile sand which had become unsuitable for local crops. The same species grows well in claypans with additional run-off water in Niger. ***Acacia ampliceps*** thrives in highly alkaline soils (pH >10) and is moderately salt-tolerant, while ***A. thomsonii*** is well adapted to rocky soils with a lateritic hardpan close to the surface (Thomson ***et al.*** 1994). Adaptation to non-arable sites is an especially significant attribute considering the widespread and ongoing land degradation and increasing use of marginal land for farming in tropical regions. Also, poor farmers usually cannot afford to set aside potential cropland for tree planting.

3. Nutritious, safe seeds that can be incorporated into a wide range of dishes

The ***Acacia*** species dealt with in this paper include those long consumed by Australian Aborigines (see earlier references). In recent years there has been a considerable research effort into the safety and nutritional aspects of Australian acacia seeds, notably ***A. colei*** as the main species being consumed in Africa. The conclusions from these investigations are that ***A. colei*** flour will be useful both as a famine food and as a supplement to regular human diets, if incorporated at not more than 25 percent of the total diet by weight (Harwood ***et al***. 1999 and references cited therein). This is based on chemical tests, animal feeding trial results, a human volunteer trial and insights from Australian Aboriginal diets.

Acacia colei, and to a lesser extent ***A. tumida***, are the only species to have been tested extensively for anti-nutritional effects and toxicity. These species were chosen because, at the time, both were performing well in trials in Niger and showed promise as food crops. Both CSIRO and MIDP needed to be sure of their safety for human consumption before promoting them. The results from ***A. colei*** cannot be extrapolated to other species, hence each must be tested independently, but the expense and time are fully justified. Although there is some assurance in knowing of species that were eaten by Australian Aborigines, testing for the many unknowns involved is still justified. If a species must be cooked to destroy anti-nutritional properties then consumers must be warned not to eat green seed. During a famine some people may have no option but to eat a diet of only acacia. ***Acacia colei*** has been shown to be safe at concentrations up to 25%, but the effect of eating higher concentrations over a long period is unknown. Project Ecolake has been incorporating seed of ***A. colei*** (and its flour) into recipes for more than 10 years. Seed of ***A. tumida***, ***A. torulosa*** and ***A. ampliceps*** has also been used occasionally, with no ill effects. Project Ecolake has repeatedly tried, unsuccessfully, to interest the Indian Government in an official study of the potential and safety of Australian acacias, hence their potential has not been promoted there. Given the fact that, in many poor regions of the world the only option during drought is to eat bran, grass, tree leaves etc., there seems to be an urgent need to investigate further the safety of promising species.

4. Seeds with good harvest characteristics

The seeds of most acacia species can be quickly and efficiently harvested at full maturity without the need for any specialised equipment, e.g. when a crop is heavy one person can harvest 3-5 kg of clean seed of ***A. colei*** or ***A. tumida*** per hour. Small seed-bearing branches can be cut and beaten on sheets, or bushes can be beaten or shaken directly onto large sheets. In Niger, farmers prefer the curly-podded form of ***A. colei*** (var. ***ileocarpa***) because less seed is lost through shattering prior to harvest. In Australia the curved-podded form is preferred by seed collectors because the seed is more easily and completely dislodged from the pod during beating. In Niger, all phases of ***Acacia*** seed preparation (harvesting, threshing, cleaning, milling or cooking) can be undertaken without need for new or specialised skills or equipment.

5. Long-term storage of seed

Acacia seeds that have matured fully on the bush and have been properly dried have a hard seed coat. Such seed can be stored in closed containers without deterioration for many years (e.g. 5-10 years) in dry conditions at ambient temperatures. There is less risk of seed spoilage from moulds if the aril is removed prior to storage. The aril attracts weevils, the waste products of which encourage moulds and hence seed spoilage. The arils are easily removed by placing the seeds in water and rubbing them between the hands. Most arils are poured out with the water, and those remaining may be separated by winnowing after drying the seeds.

6. Seeds produced in large quantity from an early age

Under field conditions on sites near Maradi, yields of up to 6 kg per tree (***A. colei*** and ***A. elachantha***) have been realised (SIM Niger 1996). More commonly, average yields of 1.8 kg per tree have been measured on trees 2-5 years old planted in rows 8 metres apart (25 metres between rows), receiving 300–400 mm of rain, regular cultivation and annual pruning. Rainfall level, plant spacing, level of weed and crop competition and the practice of pruning have a strong influence on crop yields.

7. Ability to provide other products and services

Acacias can also make a valuable contribution to local wood supplies, especially in areas where there is severe pressure on native vegetation for wood products. A number of acacias highlighted in this article (***A. colei***, ***A. tumida***, ***A. elachantha***) produce large quantities of biomass in the early years of growth, thus providing firewood and light construction timber and ultimately making significant contributions to rural incomes. In Niger, an erect form of ***A. torulosa*** with very straight branches, known as ‘dogon torulosa’ (tall ***torulosa***), has become very popular for local building purposes. By harvesting planted acacias, some harvesting pressure can be taken off native vegetation. Millet crops in Niger are often buffeted by damaging winds of up to 70 km / hr. To counter this, Acacias planted in rows can form effective windbreaks. Dried foliage of ***A. colei*** can be used as low-grade animal fodder, and other species such as ***A. ampliceps*** and ***A. victoriae*** are good browse species. Tannins, gums and compounds with medicinal properties are all untapped resources in a number of these species.

8. Ability to fix nitrogen and improve organic matter content of soils

In developing countries, few poor farmers can afford costly inputs such as artificial fertilisers. Cultivated soils in hotter climates generally have low organic matter content. These problems may be addressed at least partially by acacias which, given the correct strain of rhizobium bacteria, can fix atmospheric nitrogen and, through leaf fall and root / nodule breakdown, raise soil nitrogen and carbon levels.

9. Reduced risk of famine

Acacias are unlikely to be susceptible to many of the common crop pests and diseases. Indeed, trees planted in Niger have been little affected by insects, including attacks from termites and locusts. They are unrelated to common grain and root crops grown in Africa and fruit at times different from those crops.

10. Foliage of most Australian *Acacia* species is not attractive to livestock

Tree planting in many developing countries has been rendered impossible or very expensive because of destruction of young plants by wandering stock. In Niger, plants of ***Acacia colei***, ***A. torulosa***, ***A. elachantha*** and ***A. coriacea*** have survived without protection from livestock, even where there is little fodder available.

Disadvantages

1. Short life span

Most of the promising species being used, such as ***A. colei***, ***A. elachantha*** and ***A. tumida,*** are relatively short-lived, with lifespans of only three to ten years. Dieback and death are hastened by moisture stress, associated with close spacing and intense inter-plant competition and / or drought. Life span may be increased, however, by pollarding the main branches (while retaining some live branches) at the end of fruiting and onset of the dry season. Sandplain forms of ***A. tumida*** may be coppiced successfully and rejuvenated, and ***A. ampliceps*** may live for 20 years or more in better-watered sites. ***Acacia ampliceps*** also regenerates by means of root suckers. ***A. coriacea sens. lat***. is generally long-lived, the gnarled sandplain forms (described as ***A. sericophylla***) living for many decades and having the potential to supply food over a similar time-frame.

2. Competition with agricultural crops

A. colei and ***A. tumida*** have shallow, wide-spreading root systems that compete heavily with nearby crops. Farmers who have planted their fields to millet for generations will not readily adopt tree crops that depress yields of traditional crops without seeing clear benefits. Research is required to select acacias that are more compatible for interplanting with agricultural crops. Preliminary results from Niger indicate that species with deeper root systems and which cast less shade, such as ***A. coriacea*** and ***A. torulosa***, show promise in such systems. In the meantime, planting competitive species should be concentrated on marginal and non-arable lands and around villages.

3. Propagation difficulties where water is limited

Australian acacias are generally easy to propagate from seed in nurseries. However, water is typically in scarce supply in areas where the plants are raised in Africa, and water tables are often deep (e.g. 30-100 metres in Niger), making nursery operations difficult. While direct sowing has been successful in wetter areas of Senegal and in northern Nigeria, it has not worked in zones with extended dry seasons and large numbers of free-range livestock. Even though trials at Maradi have failed to establish acacias by direct seeding, the technique should not be discounted without further trial in other areas where acacias might be grown. This is because the process of raising plants in a nursery and transplanting them to the field can be a stumbling block to poor farmers who already have heavy demands on their time.

4. Potential weediness

Caution must be exercised when introducing acacias into a new area as they are a pioneer species and have the potential to spread rapidly. For example, Australian species such as ***A. cyclops*** and ***A. saligna*** have become environmental weeds in the Republic of South Africa (Roux and Middlemiss 1963). The likelihood of a species becoming a weed in a new environment is highly dependent on factors such as climate, pressure from livestock and the availability and demand for firewood. Thus, in Ethiopia, we have observed that ***A. saligna*** is a widely used species for agroforestry and revegetation but is not considered a weed. During 20 years of careful observation around Maradi in Niger, Australian acacias have shown no tendency to become weedy.

CASE STUDIES

In researching this paper, various scientists, institutes and projects were contacted in countries in tropical, dry zones where Australian acacias were known to have been trialled successfully and adopted, at least to some extent for firewood, reforestation and land restoration purposes. The objective of these communications was to identify any countries and regions where these species were additionally being adopted as human food sources. Countries contacted included Cape Verde Islands, Burkina Faso, Cameroon, Ethiopia, India, Kenya, Mali, Nigeria, Niger, Senegal, Sudan, Tanzania and Zimbabwe. The only two examples where acacias were being adopted to any extent for human food were those already known prior to the survey, viz. SIM in the Maradi district of Niger and by Project Ecolake in Tamil Nadu, India. World Vision Australia is seeking ways of testing the concept of edible acacia seeds in receptive African countries. The International Centre for Research in Agroforestry (ICRAF) and national research partners are actively exploring the potential of ***Acacia colei*** as a short duration improved fallow[7] in the Sahel (Amadou Niang[8], personal communication).

1. Maradi district, Niger Republic

Niger Republic is a landlocked nation in west Africa which has a mainly dry climate with considerable temperature ranges. Some 200-600 mm of rain falls during three to four months of the year (June-September). There is a (relatively) cool season, when temperatures drop considerably, particularly at night (November to February) followed by a hot season, when average daily maximum temperatures exceed 40° C in the shade (Renaudeau 1978). At Maradi, the seasonal rainfall and temperature profiles are similar to those at Halls Creek, in the far north of Western Australia.

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[7] Improved fallow is used as an improvement in shifting cultivation by shortening the fallow period and increasing biomass and nutrient accumulation. Improved fallow also restores land that is not cropped for a few months to three years in the same way, and it smothers weeds. Species that grow quickly and fix nitrogen are used in the technique. See http://www.icraf.cgiar.org.

[8] ICRAF, Mali

Initial interest in acacias in Niger came out of a realisation that famine could occur in any year as long as farmers relied on annual crops in the uncertain climate. In one season in 1988, farmers had to replant their millet (***Pennisetum glaucum***) crops 5-8 times due to drought, windstorms and / or pests. Average yields of millet are low (approximately 300 kg / ha), even in good years. Few of the options remaining to perplexed farmers (including exodus, sale of assets, and hunger) are acceptable.

Collaborative efforts between CSIRO's Australian Tree Seed Centre (ATSC), the local community, the Nigerian Government and SIM has resulted in an understanding of the potential and limitations of a number of Australian edible-seeded Acacias. Of the species tested so far, ***A. colei*** and ***A. elachantha*** excel in terms of ease of propagation, growth rate, survival and seed production. These species have shown the most potential for development as a new food crop, with good agronomic, harvesting and food characteristics. ***Acacia torulosa***, a species which had grown well in windbreaks at the ICRISAT Sahelian Centre in Niger, was trialled much later and is also showing promise.

Acacia colei was planted quite widely in southern Niger during the late 1980s, as a fast-growing small tree for windbreaks and firewood production, and its potential to produce seed had already been established. Trials were commenced in 1992 to determine whether there were other species, also suited to local conditions, that might be superior to ***A. colei***. Results from these trials formed the basis of widespread promotion of ***A. colei*** around Maradi. Selection of ***Acacia*** species and provenances to suit local agro-climatic conditions can mean the difference between success and failure. For example, ***A. colei*** thrives on the slightly acidic sandy soils of Maradi district. While ***A. ampliceps*** and ***A. victoriae*** survived in this district, they did not perform well. In the alkaline, potash-rich soils of the Lake Chad region of eastern Niger, however, ***A. colei*** was a total failure but ***A. ampliceps*** and ***A. victoriae*** proved well-adapted and grew quickly (SIM Niger, 1999). There are marked differences in performance between provenances of the same species. This highlights the need to test a wide range of species and provenances.

One component of SIM's Maradi Integrated Development Project (MIDP) 'Food for Work' program during the famine of 1994 required farmers to raise and plant acacia trees on their own land. Through this and subsequent programs, well over 100,000 acacia trees were planted. In addition, workshops on how to cook acacia seed were conducted in key villages to introduce people to the new food and preparation methods.

A milestone was passed when a three-week human volunteer trial was conducted in 1995 (Adewusi ***et al***. submitted). As it was a completely new food, the community held doubts about acacia's safety and authorities could not give endorsement without scientific testing. The trial received official approval and almost unanimous backing from Government agencies (health, agriculture, forestry, State Government) and traditional leaders. People fed on diets incorporating 25% flour from seed of ***Acacia colei*** put on more weight than those on traditional 'control' diets and experienced no ill effects, and the results were welcomed by the local population.

Today, people in more than 55 villages harvest and eat acacia seed (Tiedjani Abas, Institut National de Recherches Agronomiques du Niger [INRAN], Niger Republic , personal communication 2001). Members of one village have an open day each year at harvest time when all residents are free to collect seed. In this village acacia seed is not regarded as a famine food, but rather a much sought-after, regular part of their diet. Children have become particularly adept at harvesting the seed and rapidly preparing a tasty snack (seed is ground, roasted and salted). Because of the widespread 'food for work' plantations, many farmers have a daily reminder of the potential of these trees. In 1998, despite good rains, both millet in control plots and millet grown between rows of ***A. elachantha*** barely produced any grain. This was the result of a late start to the rains and insect attacks. The acacias were not affected by this and produced good quantities of wood and edible seed. Noticing that goats ate the fallen seed of acacias, some farmers have begun collecting seed and feeding it as a supplement to their goats during the 8-month dry season when fodder is scarce and of poor quality. Farmers have even begun purchasing acacia seeds as a food supplement for goats.

Another significant turning point occurred in 1998 when the Australian Government sponsored a cultural exchange visit. Rosie Nangala and Kay Napaljarri, two Aboriginal women from Central Australia, travelled to Niger to share their knowledge on various acacia species and how to prepare them for eating. Rosie and Kay's visit and shared experiences demonstrated that acacia seeds were an important traditional food item in Australia.

Poor farmers are particularly interested in growing acacias as a multi-product cash crop. However, it may be difficult to create a market for acacia seed until it is more widely used, and this is likely to occur only gradually. Acacia seed has not yet entered the formal market place on a regular basis but there are increasing instances of farmers buying seed from each other for human and animal consumption. On occasion, women have sold popular deep-fried bean cakes made with 15-25% acacia flour. Two charismatic farmers (Barro Mahaman and Dan Mani Idi) have become unofficial champions of acacias through their sheer inventiveness and enthusiasm. Both men made up new acacia recipes and consumed acacia foods regularly, introducing them to their neighbours in the process. Two popular, readily sold products are a coffee substitute (not containing caffeine) and 'Bitamin' (a mixture of acacia, corn, bean and peanut flour for malnourished children). Such developments may be the essential first steps towards more widespread acceptance of acacia seeds as human foods.

The short lifespan of ***Acacia colei*** (5-10 years) has been seen as a major obstacle to its use, particularly by the Nigerien Forestry Department. However, ***A. colei*** should be considered as a short-lived perennial crop, like pigeon pea, rather than as a long-lived tree. ***Acacia colei*** need be planted only once in about every 5-7 years, whereas millet may have to be replanted up to seven times in one year if conditions are unfavourable. A number of management strategies can be implemented to reduce the negative impact of a short lifespan or even slightly lengthen the lifespan. By minimising stress through planting at recommended distances, regular weeding, pruning and digging micro-catchments, ***A. colei*** will live longer. A few replacement trees could be planted annually, ensuring stable seed production each year. Also, short-lived, early-producing species such as ***A. colei*** could be grown along with longer-lived species such as ***A.coriacea*** and ***A. torulosa***, which take longer to bear seed.

Another blockage in the minds of some Nigeriens was the fact that acacia seeds are not incorporated in 'mainstream' food items in Australia. While this is true, acacia seeds are being used increasingly by the rapidly expanding 'bush tucker' industry, especially as flavouring agents and in gourmet products. They may become increasingly popular, as shown by Coles Supermarkets' 'Taste of Australia' campaign, which is promoting native products, including foods incorporating acacia seed flour.

In traditional societies there is considerable social pressure working against anyone who dares to be different. In the Maradi district, nomadic Fulani cattle herders look down on any type of farming and actually despise anyone who would cultivate trees for a living, as their traditional, sedentary enemies do. For Hausa people, whose identity as farmers is often linked to their ability to grow millet, it is ludicrous to think of spoiling good farmland by planting trees on it. For both groups, there is a need for good understanding of the advantages of growing acacias in order to be motivated and committed to plant them. In fact, hunger–the great leveller–has made deep inroads into such attitudes and traditional thinking and modes of behaviour are changing by necessity. As an example, in some areas greater attention is now being paid to the protection of coppice and management of indigenous trees on farmlands.

2. Tamil Nadu, India

During the 1980s, Project Ecolake[9] introduced several Australian ***Acacia*** species for the purpose of rain-fed afforestation. In 1990, project staff learnt of their potential food value from the ATSC. This was an unexpected but most welcome development. It offered some hope of addressing concerns about food security by using wastelands for social forestry, with the expectation of producing additional protein-rich food in regions traditionally experiencing scarcity. In the case of ***Acacia colei***, annual yields of seed have been estimated roughly as up to 1000 kg per hectare from age 3-4 up to about age 8-9, but appropriately-designed trials are needed to verify such estimates.

A wide range of dishes were prepared using seeds or flour of selected Australian acacias. The main species used have been ***Acacia colei***, along with ***A. tumida, A. ampliceps*** and ***A. torulosa***. This research established the palatability of dishes made from acacia seeds and seed flour, including a number of Indian and Western preparations, most commonly biscuits and cakes. The percentage of ***A. colei*** content in the flour generally ranged from 50% to (exceptionally) 100%. In ***ad hoc*** taste trials most people were well satisfied with the taste. However, when the seed coat was not removed from the flour, the resultant dark colour often caused some people to hesitate in eating dishes that have a lighter colour when prepared with traditional ingredients. Removing the seed coat by sieving, either before or after grinding into flour, took care of this problem. Some people experience a slightly itchy tang that persisted for some time after eating some dishes. This is presumably caused by tannin in the acacia seeds and may be relative to the proportion of flour used, removal of seed coats, and the method of preparation.

Project Ecolake has sought to spread awareness of this new food source by making presentations to many visiting groups including about 25 Indian Forest Service officers each year from different parts of the country. Items made from acacia seeds and flour have always been appreciated by the groups. The Project has endeavoured to interest the Government of India (Ministry of State for Wasteland Development) in the development of Australian acacias as human food, through having an official assessment of their potential. Discussions have taken place with experts including scientists of the Tamil Nadu Agricultural University. While there is consensus in favour of the use of acacias as a food source, the Project felt that it would not be appropriate to encourage wider consumption until there had been an official Indian Government clearance in the matter of food safety. Accordingly, in December 2000 samples of ***Acacia colei*** seed, flour and two batches of biscuits made using the flour in different proportions were sent to the Central Food Technological Research Institute, Mysore, for analysis. Their evaluation was as follows:

Test parameters	*A.colei* seeds	*A.colei* seed flour	*A.colei* biscuits
Protein (estimated as N ´ 6.25, % w/w)	25.40	22.10	13.40
Carbohydrates (estimated by difference, % w/w)	47.03	46.06	46.14
Extracted fat (% w/w)	15.80	13.80	30.53
Energy kJ per 100 g (derived)	1808	1661	2185
Crude fibre (% w/w)	6.70	10.90	2.33
Moisture (% w/w)	2.35	4.42	5.70
Total ash (% w/w)	2.72	2.72	1.90
Acid insoluble ash (% w/w)	0.01	NIL	0.12

After about a decade of exploring the use of ***Acacia*** seeds and seed flour in a wide range of both savoury and sweet dishes, Project Ecolake staff are convinced of the potential of Australian acacia seeds as a food source. Species such as ***A. colei*** could make significant contributions towards meeting food shortfalls in drought-prone areas of the tropics.

[9] Location: Sri Aurobindo Ashram, Pondicherry, Tamil Nadu.

POTENTIAL OF AUSTRALIAN *ACACIAS*

A number of factors give edible-seeded acacias the potential to become a significant food crop. Enough is known about them to warrant introduction, testing and promotion in new areas. In Africa, 56% of the population depends upon agriculture (FAO 2000). For most, food security is tied to a small selection of mostly annual crops. In Africa, five cereals (maize, sorghum, wheat, millet, rice) account for 94% of all cereal production and two root crops (cassava and yams) account for 80% of root crop production (FAO 1999). Commonly, these crops are growing under unfavourable agro-climatic conditions. In these environments such high dependency on a limited number of crop species is risky and increases the possibility of periodic famine.

Those areas in Africa that are climatically suitable for growing ***Acacia colei*** are shown in Figure 1[10]. According to this modeling, parts of 26 African countries are suitable for growing ***A. colei***, which is just one of 44 tropical and subtropical Australian ***Acacia*** species with food potential. In 14 of these countries, over 35% of the population are undernourished, in another seven countries, between 20 and 34% are undernourished and in three others, 5-19% are undernourished (World Food Program, 2001).

Changing world conditions, in particular the effects of climate change (CGIAR 2001; Nash 2000.) and the HIV/AIDS pandemic, will have a great influence on peoples' ability to meet food needs using conventional crops and farming methods. While not immune to the vagaries of the weather, acacias, being perennial and for some species having a deeper root system, are better suited to grow and produce seed consistently despite excessive rain, drought or erratic rainfall.

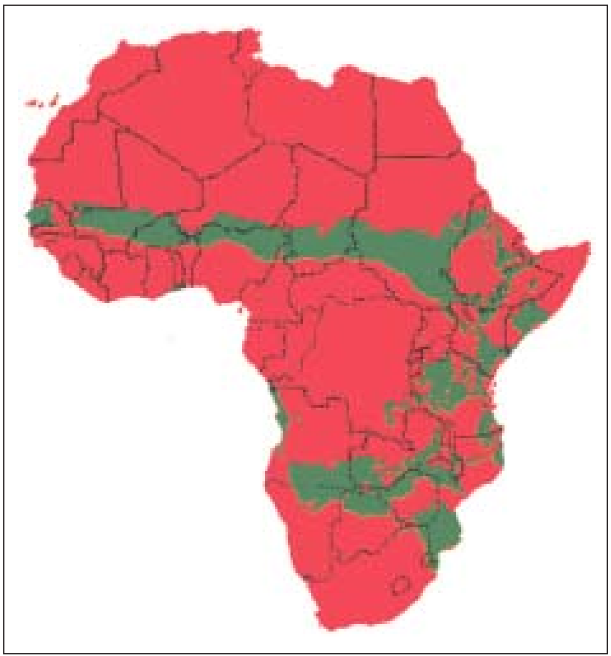

Figure 1

[10] Prepared by Trevor Booth, CSIRO.

The green revolution that dramatically increased grain crop yields in the tropics and subtropics bypassed Africa (Vietmeyer 1996). If there is to be a 'green revolution' for the arid and semiarid subtropics, it will have to be through plants that thrive under such conditions, yield well and require minimal inputs. Millions of third-world farmers have no access to the usual green revolution inputs. Increasingly they are farming on exhausted, marginal lands under adverse climatic conditions that are unsuitable for conventional crops. For them, a biological revolution is needed, in which plants are selected and bred to suit the prevailing environmental conditions, rather than a green revolution to suit the plants, in which the crop environment is modified (through irrigation, fertilisers and pesticides). Nevertheless, if acacias do yield large amounts of seed, and this is withdrawn from the farming areas where they are grown, without replacement of nutrients (P, K, Ca etc.), yields will not be sustainable in the longer-term in the infertile, sandy soils of the Sahel.

FUTURE RESEARCH NEEDS

Individuals working alone will always be confronted by the questions: 'Where in the world are these seeds eaten?' and 'Who else is promoting this new food?' Without wider support, many who see the potential of acacias for human food in their region will not receive the backing or approval they need to start experimenting. In an article in ***Unasylva***, Harwood ***et al.*** (1999) called on national agricultural research agencies, Non-Government Organisations (NGOs) involved in rural development, the Food and Agriculture Organisation of the United Nations (FAO), the Future Harvest Centres, and bilateral and multilateral donor agencies to seriously examine the potential of acacias. Until now there appears to have been little response despite the positive results of research. CGIAR chairman, Ian Johnson has stated that 'a warmer world will surely impact yields of staple crops, increase the incidence of pest attacks, and exacerbate drought, all with profound effects on the well-being of small farmers in developing countries (CGIAR 2001).' Further research and development of acacias for human food is an obvious field for support from the CGIAR (especially ICRAF) and/or ACIAR given the interest in these species in the developing tropical world and likely mutual benefits from such work.

Areas for research include:

- for each new provenance to be introduced, to determine optimal management practices, including planting methods, spacing, planting system (orchard, intercropping, improved fallow, etc), cultivation and pruning regime etc.

- a cost-benefit analysis for acacias compared to alternative systems. The investment of funds and labour and the output in terms of seed yield, firewood, organic matter for mulch, fodder, soil stabilisation, increase in soil fertility and environmental protection over a number of seasons must be measured. In India, lentils are an important source of protein for a large part of the population, yet they are often too expensive for poorer people to purchase regularly, consequently there is widespread protein malnutrition. Project Ecolake staff have estimated that substituting ***A. colei*** for lentils provides comparable nutritional intake for about one third of the cost.
- selection and breeding of acacias for consistent high yield and for specific agro-climatic situations.

CONCLUSIONS

We now have a decade of experience with the research and development of selected Australian acacias for human food in tropical dry zones. This work has been undertaken mainly in Australia, Nigeria, Niger and India by CSIRO Forestry and Forest Products, Obafemi Awolowo University, Tamil Nadu Agricultural University and the NGOs, SIM and Project Ecolake. This work has built on a foundation of Australian Aboriginal traditional knowledge and use of acacia seeds as food. The main conclusions to date are:

1. Certain *Acacia* species, such as *A. colei* and *A. tumida*, have a demonstrated potential to provide human food in tropical dry zones.

They can make important contributions to human food production in regions with erratic rainfall and infertile soils, where cultivation of traditional agricultural crop species is risky or impossible. Appropriately managed, widely spaced plantings (e.g. 100-150 plants per hectare) can be expected to yield around 200-300 kg per hectare for 3 or 4 harvests over a period of 7-10 years in drier climates and >500 kg per hectare in wetter climates.

The seeds have been shown to be nutritious and amenable to incorporation in a diverse range of food products, including over 20 local dishes in Niger and both savoury and sweet local dishes in India, as well as pasta, bread, biscuits and coffee substitutes. Animal and human feeding trials in west Africa have shown that seed of ***Acacia colei*** can be incorporated safely into millet and / or sorghum-based diets at rates of up to 25% by modifying traditional recipes (Harwood ***et al***. 1999). The taste of acacia food products has been found acceptable to people living in regions prone to famine and malnutrition, including west Africa and India. In fact, the seeds are tasty and are accepted as a regular food in Niger, not just as a famine food.

2. Planting Australian *Acacias* in tropical, dry zones of developing countries will provide several products and services, food being an important one of these.

Because of the difficulties and expense of establishing perennial plants in such environments growers will be seeking to optimise their returns from such activities. Other products include fuelwood and charcoal from prunings and final harvest and improvement of soil fertility / organic matter from nitrogen fixation. Judiciously spaced windbreaks of appropriate acacias could enhance food security by reducing wind speeds and by yielding edible seeds. The objective should be not to replace traditional crops with acacias but to complement them and provide a back-up food for when they fail.

3. Broad-scale adoption of *Acacia* seeds as human food has yet to occur.

CSIRO and its NGO partners have adopted a conservative approach to promotion of these species. Firstly, it had to be established that the seeds of the species with potential for human food were going to be safe at reasonably high levels of intake. This work has now been undertaken in Niger, west Africa, while official acceptance has yet to be obtained in India. Secondly, it was felt that a gradual, progressive process of adoption and transfer of information from areas such as Maradi, as opposed to broad-scale promotion, was more likely to lead to a sustainable adoption of acacia seeds for human food. This would reduce the associated hazards and risks of large-scale promotion from an inadequate research and development base.

Based on a decade of overall positive experience in Maradi and Tamil Nadu it would now seem that the time is right to promote more widely these species in famine-prone parts of dry, tropical Africa and elsewhere. Such work should be based on a thorough examination of the factors that have either promoted or hindered the planting and uptake and adoption of acacias to produce human food in the Maradi district. It is recommended that ICRAF conduct such a study in co-operation with the relevant national authorities and SIM.

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