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Exploitation of *Agave americana* L plant for food security in Swaziland

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ABSTRACT

Swaziland is not self sufficient in food production, and this predisposes the country to food insecurity. There is need to exploit plant resources for food security attainment. *Agave americana* L (AA) is one naturalised plant growing in abundance in Swaziland. This plant has multiple uses and has great potential of employment creation, provision of food security and sustainable development. The areas requiring immediate attention for the success of the AA programme include the following: producing AA plants using local farmers by exploiting improved agronomic methods, incubating, up-scaling and commercialisation of fructan and inulin production, developing locally adaptable methods for AA fibre extraction by women's groups, developing AA fibre based nonwoven materials for composites and geo-textile manufacture, pulp use as animal feed and textile waste utilisation for paper making. This paper will review the potential of research and applied programmes aimed at evaluating AA industrialization in order to attain food security. The study was carried out through literature review and informal interviews of key stakeholders.

Keywords: *Agave americana* (AA); Food security; Textile technology; Sustainable development; Climate change; Employment creation

INTRODUCTION

Swaziland is located in the Southern African Development Community (SADC) region with a population of 1, 126 million people (Thompson, 2009). The economy of the country is agri-based with an emerging strong emphasis on the development of small and medium enterprises (SMEs) in different sectors. Between 62% and 84 % of SMEs in Lesotho, South Africa, Swaziland and Zimbabwe are owned by women (Sharif, 2000). About 69 % of the Swazi population live below the poverty datum line. A significant sector of the population relies on the sale of handicrafts made from locally available raw materials that are of timber and non-timber origin. Swaziland is located in south eastern Africa and covers an area of about 17, 364 km^2, lies between latitudes 25° 43′ and 27° 19′ S longitudes 30° 47′ and 32° 08′ E. Swaziland is a landlocked country: surrounded on the north, west and south by South Africa; and on the east by Mozambique (Thompson, 2009). The country is divided into four agro-ecological zones namely Highveld, Middleveld, Lowveld and Lubombo, plateau See Fig. I. Swaziland is considered a developing country, but not one of the least developed countries, although grappling with poverty problems (Zwane and Masarirambi, 2009) and the scourge of HIV and AIDS. Agriculture plays an important socio-economic role in Swaziland by contributing about 11% to GDP (Thompson, 2009) and providing employment to the population (Manyatsi, 2005).

METHODOLOGY

This study was a qualitative study. Information pertaining to this study was gathered through review of existing literature. Mini surveys were carried out throughout the various agro-ecological zones of Swaziland were information was gathered from key informants of various stakeholders of the potential AA industry. Discussions and participatory appraisals were carried out with key informants in the industry.

FINDINGS

Our findings revealed that there is great potential and potential multiple uses of the AA plant not only at

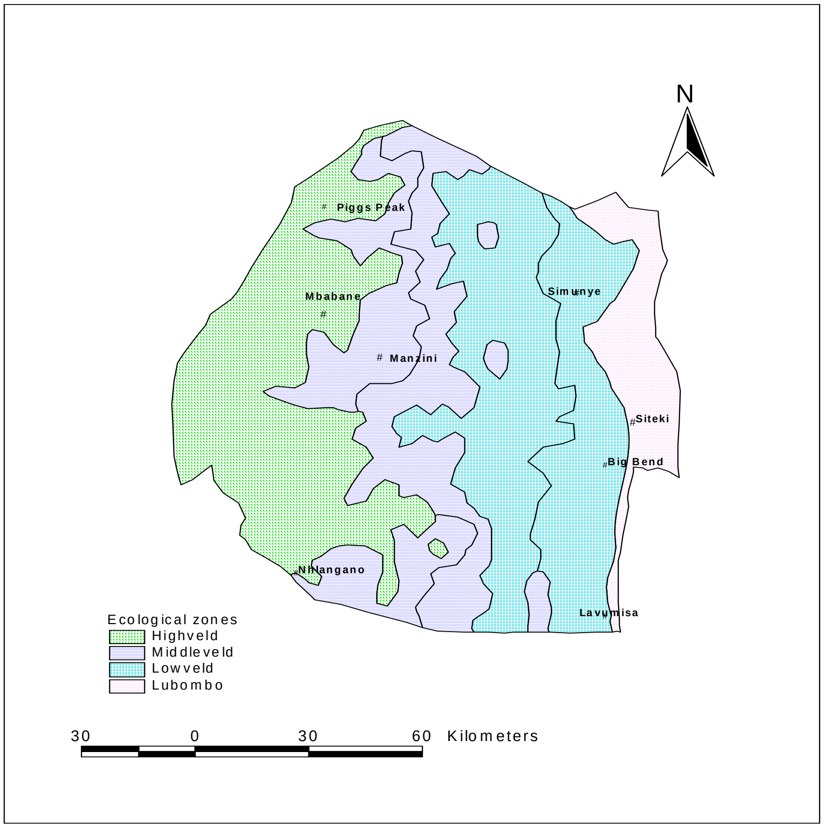

Fig. 1. Ecological zones of Swaziland

household level but up to industial scale. The various uses and products obtainable from the

AA plant in order to attain food security in Swaziland are disscused in appropriate sections that follow.

Food Security: Food security refers to the availability of food and an individual's access to it. A household is considered food secure when its occupants do not live in hunger or fear of starvation. Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (Anonymous, 2009).

About seventy percent of Swazi people live in rural areas ravaged by drought and the resulting food crisis that constantly threatens hundreds of thousands with hunger (Anonymous, 2008). The World Food Programme (WFP) has been providing support to vulnerable, food-insecure people in Swaziland since year 2002 to help alleviate the impact of drought and poverty (Anonymous, 2009). Global warming affecting climate change is threatening an already precarious situation in as far as food security is concerned in the country. According to Thompson (2009), the Ministry of Commerce, Industry and Trade has developed a strategic plan for small enterprise development and employment creation in order to alleviate among other situations food insecurity. In 2007, a group of women were taken for a training course on *Agave americana* petroleum jelly production as part of an initiative to improve lives of rural people. Products made and sold by rural women receive preference from buyers because shoppers sympathize with local producers whom they perceive as struggling, marginalized, and deserving special attention (Toler *et al*., 2009).

Botany: The genus Agave is comprised of about 140 species which occur and are cultivated in semi-arid and arid regions of the world. Important fibre plants in this genus include *Agave tequilana* (AT), *Agave* *sisalana* (AS) and *Agave americana* (AA). The most common exploitation of AT is in the production of tequila, an alcoholic beverage produced by fermentation of sap from the pinas of the plant. The AS has been utilized over centuries for the production of fibre and subsequent products like rope, cordage and bags. On the other hand, AA has been used in many ways including a source of fibre and has potentially many more ways in which it can be utilized as described in this review.

Agave americana (AA*)* is one of the plants that are available in abundance in Swaziland especially in the Lowveld and Middleveld and has naturalised in most countries of Southern Africa. This plant is a monocotyledon that belongs to the Agavaceae family. It is a native of Mexico and other parts of tropical America. The plant was taken from its native land to Africa, Europe and the far East by the Portuguese and the Spaniards, where the plant quickly naturalized (Lewin and Pearce, 1985). Common names include century plant, maguey, or American aloe. It is characterized by fleshy, rigid and hard-surfaced leaves growing directly out from the central stock to form a dense rosette. The leaves of the various species range in length from 1 to 2 m, and in most species, the edges of the leaves contain sharp spines or thorns. According to Anonymous (2008), the name "century plant" refers to the long time the plant takes to flower; although the number of years before flowering occurs, depends on the vigor of an individual plant, the richness of the soil, and the climate. The plant flowers from 4 to 20 years from planting and when the flowering is completed, the older plant dies and a new one grows in its place. Popular cultivars are 'Marginata' with yellow margins on the leaves, 'Mediopicta' with a broad yellow band down the center of each leaf, and 'Striata' with strips.

Horticultural Requirements: The century plant can be propagated by use of seeds or offsets. This plant requires well-drained soils with a pH range of 6 to 7.5. The plant grows best when exposed to full sun but can adapt to some shade. Natural rainfall can be a source of water in summer and in winter it can be supplemented with irrigation. It requires minimal maintenance since removal of lower leaves can be dangerous and removal of the entire plant after blooming can be difficult due to the large size of plant (Moore, 2006). Information about growing and utilization of AA has attracted considerable interests from local academics, farmers, researchers, industrial participants, potential investors and other stake holders. There is need to form a committee for AA industry establishment in Swaziland involving local authorities, governmental departments, research and development (R & D) organizations, industrial partners and other interested stakeholders.

Edible Uses: Edible parts are the leaves, stem, sap (called *aguamiel*—honey water) and the seeds(Davidson, 1999). The heart of the plant is very rich in saccharine matter and can be eaten when baked. It is sweet and nutritious, but rather fibrous. Seeds are ground into flour and used as a thickener in soups or used with cereal flours when making bread. The flower stalk is roasted or used like asparagus. Sap from the cut flowering stems is used as syrup (Gentry, 1982). Comparatively little knowledge is available on the agronomy of the AA plant particularly the influence of environmental factors on fructan, inulin and fibre production and subsequent properties of produced fibres.

Pharmaceutical and Medicinal Uses: The pina of the *AA* contains up to 25% of inulin per weight basis (NUTRA, 2005). The leaf base contains up to 16% of fructans. Pina and leaf base can be used for the commercial production of fructans and long-chain inulin , which can be used as vaccine adjuvant in the pharmaceutical industry (Brown, 2009).

Inulin is a valuable component used widely in the food industry as an additive, sugar substitute and prebiotic agent (Roberfroid *et al*., 1998, Boguslavsky *et al*., 2007, Brown, 2009). Inulin is a generic term for a polydisperse chain of fructose units having degrees of polymerisation (DP) varying from 2-60, normally with an average of about 12 fructose units. Fructans are oligo- or polysaccharides which comprise at least two adjacent fructose monomers. They have value in the health and food arenas, and occur in nature in a polydisperse form. They can be hydrolysed and used for diabetic patients because fructose does not require insulin for metabolism (Pamploma-Roger, 2004) The DP has a bearing on the functional behaviour of the fructans and determines their end use. Molecules with a DP of 2-7 are known as oligofructose, while the larger molecules are known as inulin (Boguslavsky *et al*., 2007). Inulin from the Agave plant has been reported to be more soluble in cold water when compared to inulin extracted from chickory thereby giving it a wider application in the food industry. Inulin from Agave is relatively cheaper than inulin from chickory. Potential export of inulin may be targeted for American, European, Japanese and other markets. Long chain or ‘gamma’ inulin has been successfully tested as vaccine adjuvant (Perovsky, 2005; Cooper, 1995) due to the ability to stimulate the alternative compliment pathway, and has been used in the preparation of 'microspheres' for the slow release of drugs (Poulain *et al*., 2003; Wu and Lee, 2000).

Fructans function as prebiotics due to the inability of the human gut to digest them. They are available in the colon for a relatively longer time, where health benefits arise due to the stimulation of bacteria, such as bifidobacteria, with subsequent production of short chain fatty acids which enhance gastrointestinal functions (Manning and Gibson, 2004; Roberfroid *et al*., 1998;) and thus prevent predisposition to colon cancer. Fructans have also been shown to modulate endocrine and immune functions (Silva *et al*., 2004), which are important in alleviating symptoms of HIV and AIDS, promote absorption of calcium and magnesium, reduce cholesterol and stimulate vitamin synthesis (Roberfroid, 2005). Fructans are used to control viscosity and moisture in the food industry (Silva, 1996); in that role, they substitute fat and are used as low calorie sweeteners (Lopez-Molina *et al*., 2005).

Antimicrobial applications of *Agave americana*:The use of different parts of *Agave americana* L, as a medicament, dates back to time immemorial. In modern times, the plant has been popularized by its use in the production of tequila as opposed to its medicinal properties. However, the emergence of new diseases such as HIV and AIDS and the associated opportunistic infections has rekindled interest in identifying new antimicrobial compounds from this plant. The plant has been shown to have both antibacterial and antifungal properties (Khare, 2007).

Two different derivatives of triacontanol, isolated from the leaves, have been shown to have antibacterial activity against *Staphylococcus* spp, *Pseudomonas aeruginosa* and *Escherichia coli* (Khare 2007). Using the technique of serial dilution in a freezing solid environment, the leaf extract of *A. americana* has been shown to have an activity estimated at 5mg/ml, which is comparable to the antibiotic streptomycin and the antifungal agent griseofulvin (Boukef, 1991).

Agave crude leaf extracts have also been shown to have molluscicidal and insecticidal properties. The leaves contain angiotensin converting enzymes that are a potent medicine to treat hypertension. In addition, the leaves also contain several sapogenins; e.g. hecogenin, which can be used in the manufacture of semisynthetic corticosteroids. Tigogenin, a constituent of *A. americana* leaf extract, is a base material for the production of other steroids (Boukef, 1991).

In plant protection studies, crude leaf extracts of *A. americana* have been shown to have antisporulant activity against *Sclerospora graminicola* (Deepak *et al*., 2007). Guleria and Kumar (2009) reported that methanolic extracts of *A. americana* had very strong antifungal activity against *Alternaria brassicae*, the causal agent of *Alternaria* blight of Indian mustard *Brassica juncea* (L.). Central to the antimicrobial activities of *A. americana* leaf extract is the presence of a diverse variety of compounds known as saponins (Guleria and Kumar, 2006). Saponins have hemolytic, expectorative, anti-inflammatory and immune-stimulating activity. Beyond that, saponins demonstrate antimicrobial properties particularly against fungi and additionally against bacteria and protozoa.

The antifungal activity of steroidal saponins, particularly against agricultural pathogens, has been known for a long time (Wolters, 1965; Wolters, 1966; Imai, 1967; Dimoglo *et al*., 1985), while other reported activities for this class of compounds include antitumor, hypoglycemic, immunoregulatory, and cardiovascular disease prevention and treatment (Sparg *et al*., 2004).

Ornamental Uses: Century plants can be used as an accent or as a specimen plant. They are often used for fencing in some African homesteads including Swaziland and Zimbabwe. A dense hedge of these spiny succulents is impermeable to farm and domestic animals and tress-passing people. As an ornamental, the century plant usually is grown in rock gardens, in cactus and succulent gardens, in borders, or as a specimen in Swaziland and other African countries. It tends to dominate the landscape wherever it is grown. Century plant is also grown in containers where it stays much smaller than in outdoors (Mahmood, 2007) making it an ornamental plant of potential in urban areas, where space can be limited particularly in city apartment balconies. As an ornamental, *Agave americana* is planted in private and public gardens and on roadsides. It is used as a hedge plant and planted along contours for erosion control and for reclamation of denuded and overgrazed land.

Other Uses: The plant can be used for fibre extraction, making petroleum jelly, insecticides, needles, paper, pins, soap, for soil reclamation and for thatching. The root and leaves are the best sources of the saponins that are used for making soap. A very strong fibre obtained from the leaves is used for making rope and coarse fabrics.. The leaf flesh is used for making facial jelly. Paper can also be made from the leaves. The thorns on the leaves are used as pins and needles. The dried flowering stems are used as a waterproof thatch and as a razor strop. The plants are used in land-reclamation schemes in arid areas of the world (Long, 2009).

Fibres, composites and geotextiles; *Agave americana* fibres run along the length of the plant leaves and are part of the vascular system. These fibres can be extracted from leaves using several methods as described by Zwane and Cloud (2002). Fibre extraction can be achieved through mechanical and chemical processing. Mechanical means are usually done by rural folks, where manual decorticators using rudimentary tools like cans or lids of aluminium containers are used. Alternatively, manual decortification can be done efficiently through the use of a machine decorticator modified to have a rotor, which prevents the blockage of machine by the pulp or fibre waste (Boguslavsky *et al*., 2007). Mechanical extraction methods are not efficient in the removal of cementing compounds between fibres, mostly waxes, hemicellulose, lignin and hydrocarbons, but they do work in rural areas.

Chemical fibre extraction involves the use of acids, alkali and enzymes (Zwane and Cloud, 2002). The use of acids in fibre extraction hydrolyses lignin and hemicellulose into shorter chain pentose molecules for cellulosic fibres. Acid treatment results in the formation of reactive groups and causes fibres to fibrillate, revealing a higher degree of crystallinity of fibrils (Zwane, 1997). Alkali use in fibre extraction dissolves the lignocellulosic material between fibres and lead to increased surface area, degree of polymerisation, separate structural linkages between lignin and cellulose , and lower the breaking strength (Zwane and Cloud, 2002). Enzymatic processing degrades the lignocellulosic complex in fibres and increases the volume of extracted fibres. Furthermore, enzymes increase fibre swelling, lower the degree of polymerisation and make fibres more pliable and softer (Zwane, 1997; Dutta *et al*,, 2000). A group of enzymes that include cellulose, pectinase and hemicellulase have been used to control hydrolysis of the constituents in jute and made the fibres soft, more pliable and spinnable than untreated fibres (Dutta *et al*., 2000).

Fibres of AA can be used in the production of composites and geotextiles. Fibers of AA can be used as a substitute of imported kenaf fibers (Boguslavsky *et al*., 2007) and plastics for composites and geotextiles manufacture. The AA fibres like kenaf fibres are natural fibres which are preferred these days because they are environmentally friendly in that they are biodegradable (Zwane and Masarirambi, 2009). Considerable amount of work has been done on composites and geotextiles (Geotextile-Wikipedia, 2010**;** Boguslavsky *et al*., 2007; Zwane and Masarirambi, 2009). Composites have local potential in the manufacture of protective clothing considering the fact that the country's economy is agri-based. Geotextiles and related products have many applications and currently support many civil engineering applications on roads, rail roads, airfields embarkments, retaining structures, canals, reservoirs, dams, bank protection, coastal engineering and construction site silt fences (Geotextile-Wikipedia, 2010). The aforementioned civil engineering applications are of importance to Swaziland while some are of importance to neighboring countries which enjoy coastal lines. Support structures are of paramount importance when natural disasters like earthquakes are put into consideration like the recent earthquake to hit Port au Prince, Haiti in the Western hemisphere and Fukushima, Daichi, Japan, in the Eastern hemisphere.

The Recent Role of AA Plant in Swaziland: It is amazing that a common plant can create employment and bring wealth to the Swazi nation. Some of the plant's products produced in Swaziland have transformed the rural economy and provided jobs for many women in poor regions. The incomes obtained after selling products made from *Agave* ensure food security at household level. Currently, the country has people with small business in AA fibre extraction, AA petroleum jelly making and nurseries that sell the plant to potential growers.

Evaluation of AA as a source of fiber was launched recently in Tunisia, where fibers are extracted traditionally and used for making twines and ropes (Msahli *et al*., 2005). In Swaziland the extraction process is done manually by old women and children in the rural areas. The fibers are then dried in the sun and twisted to produce cord. The fibers can be dyed with different colours. Fibers are sold locally in the Manzini market. The fiber is also used for making a variety of items including mats, rope, brooms, cord, bags, clothing, footwear, and other household goods, that have a reliable market in Manzini, Mbabane and tourist attraction outlets. After selling, the people get money to buy some of their household needs.

AA Petroleum Jelly; Women who went abroad for a training course for AA petroleum jelly production taught other women in their areas and this has had a positive impact on development of the country as a whole. They formed organizations like *Emandla Esivivane*, a women organization in Pigg's Peak, Swaziland that makes AA petroleum jelly. The skill of making the petroleum jelly has been shared with other women's group in the country like the one in Mbabane East (Zwane *et al*., 2010). The groups sell their products to the public and supply some to retail shops in the country. The profit they get after selling jelly products is shared among members. Some of the women prefer to operate as cooperatives and they enjoy profits as a group. The incomes they obtain in form of profit contribute to food security at household level.

CONCLUSIONS AND RECOMMENDATIONS:

The AA or century plant has proved to be a plant of life to a majority of women in Swaziland for now, especially in the rural areas. There is a need for construction and up-scaling of AA industry around the country to create more job opportunities. Currently, the AA business is done on a small scale basis by women in the rural areas and there is a need for establishment of a bigger industry for its processing. This will result in massive job creation and income generation. New and appropriate methods of fiber extraction should be developed or adapted to speed up the processes and to ensure the production of high quality fiber. Presently, workers are manually extracting fiber from leaves which is a long and tedious process. As for now workers are using naturally growing AA plants that are not properly managed. Large scale cultivation of the plant using good farming practices will result in the production of high quality plants suited for the production of various products described previously.

Urgent work needs to be undertaken on fiber extraction methods, fiber yield determination, fiber testing, production of Agave fiber based non-woven fabrics, composites and geotextiles of importance to Swaziland, preparation, extraction and analysis of fructan and inulin for both local use and export. Alternatively, adoption of work done in South Africa and Lesotho can be of much needed help (Boguslavsky *et al*., 2007) for the Swaziland situation.

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