Uses of aloe in traditional and modern medicine

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Figure 1. Plantation of *Aloe vera* near Harlingen, Texas.

Amongst the numerous species of *Aloe* used in traditional medicine, *A. vera* stands on its own as the basis of an enormous global industry (Figures 1 & 2), with an estimated annual retail value exceeding 110 billion US dollars (International Aloe Science Council 2004). In South Africa, *A. ferox* has become an important commercial medicinal plant, not only for its traditional use as laxative bitters but more recently also as a source of raw material for health drinks and cosmetics formulations, which nowadays comprise the bulk of aloe-based consumer products. This broad review describes traditional and modern uses of aloe and highlights recent developments in the aloe industry from a scientific and commercial perspective.

Aloe has been the topic of many research projects in which basic information about its considerable morphological, chemical and genetic variation have been brought to light. These studies are ongoing and there is no doubt that important discoveries still await us. Likewise, studies on the medicinal properties of *Aloe* species are slowly uncovering a rational basis for the use of aloe products.

Interpretation of research results

Research results relating to the medicinal, pharmaceutical and cosmetic effects of aloe products and the interpretation of these results are complicated by two major considerations. Firstly, aloe formulations are usually a combination of two different products in variable ratios, namely the bitter laxative yellow juice, exuded from so-called aloin cells below the leaf rind and the non-bitter inner parenchyma gel (Figure 3). The former comprises chromone and anthraquinone glycosides, while the latter is a mixture of polysaccharides in combination with glycoproteins, enzymes and other minor constituents. It is therefore difficult to know which compound (or combination of compounds) in the mixture is responsible for the beneficial effects. Artificial chemical compounds with known or proven activity are often added to formulations, further complicating the observed benefits and the interpretation thereof. Secondly, sophisticated marketing techniques have played an important role in the popularity of aloe, so that the perceptions about aloe products are often unrealistic and not grounded in fact. As with many general tonics and other herbal health products, it is therefore difficult to distinguish between physical and psychological benefits (the latter of which are strongly influenced by the placebo effect and thus by clever marketing). Fortunately, the trend in marketing materials in recent years has moved towards being more honest and relying more on the long history of safe traditional use rather than on distorting or exaggerating modern scientific research results, as has happened so often in the past.

The scientific basis for the purgative action of aloe lump is well known – the non-active aloin (a so-called prodrug) is converted to the active aloe-emodin by bacteria in the colon. The efficacy of aloe bitters (aloe lump) in producing a laxative effect, traditionally considered to be beneficial as a "bowel-cleansing" or "blood-purifying" exercise, is very evident – there is no need for expensive clinical studies! All other biological activities are more complicated and are as yet not fully understood. There can be no doubt that aloe has important

medicinal, nutritional and cosmetic benefits but the process of generating convincing scientific facts is not easy. In pharmaceutical research, the "magic bullet approach" (i.e., the expectation that a single chemical compound is responsible for the observed biological activity) is unlikely to produce useful results; scientific progress is more likely to come from new, more holistic research methodologies that will allow for the evaluation of additive and possible synergistic effects.

Basic research

Basic scientific research on aloe is important because it improves our understanding of the complexities within the genus and provides new approaches to solving some long-standing mysteries (such as the relationships between the species and thus the inheritance of chemical and other traits that are of potential commercial value). Academic research on the genus *Aloe* and its relatives include the following:

Chemotaxonomic studies. These are aimed not only at describing the chemical complexity of aloes but also at finding additional taxonomic evidence to help understand relationships between species of *Aloe* and related genera. Examples include nectar sugars (Van Wyk *et al*. 1993), root aglycones (Van Wyk *et al*. 1995a) and especially leaf exudates and extracts (the topic of a Ph.D thesis by Alvaro Viljoen, which resulted in 16 scientific papers and the description of several new compounds). Examples of new chemotaxonomic insights include 10-hydroxyaloin and its derivatives in *Aloe* series *Asperifoliae* (Viljoen *et al*. 1996), the presence of flavonoids in grass aloes and a few other groups (Viljoen *et al*., 1998) and aloeresins E and F (two chromones) in the type section of *Aloe* (Viljoen & Van Wyk 1996). Geographical variation in the level of aloin was reported by Van Wyk *et al*. (1995b). A review of the chemistry of *Aloe* was published by Dagne *et al*. (2000).

Phylogenetic studies. These were initially based only on cladistic interpretations of morphological and chemical characters (e.g. Smith & Van Wyk 1998) but have expanded into modern molecular systematic studies using DNA sequencing data and genomic fingerprinting (e.g. Treutlein *et al*. 2003). Some profound new insights into the genetic complexities of *Aloe* and related genera have been published recently or are currently in press.

Ethnobotanical studies. These contribute to a better understanding of the traditional uses of numerous *Aloe* species in various parts of Africa. Reviews of ethnobotanical uses were published by Grace *et al*. (2008, 2009) and Chen *et al*. (2012) and include the following: Purgative (laxative) medicine in humans and cattle; relief of arthritis, sinusitis and conjunctivitis, as well as opthalmia and eye ailments; treatment of wounds, sores, burns, venereal ulcers, herpes and shingles (also sores and injuries in livestock); stem and leaf decoctions taken as emetics or gargled for a sore throat; leaf or root infusions taken for hypertension and stress, infertility in women and impotence in men; the treatment of redwater and various other ailments in cattle and sheep; addition to drinking water of livestock (including poultry) to improve general health and reduce parasite loads; blood purification to treat acne and various cosmetic uses (e.g. washing of hair). Recent ethnobotanical studies have resulted in new contributions to the literature. An example is the use of *A. microstigma* in the Agter-Hantam region as an energy booster and stomach cleanser and to treat back pain, to dress wounds and to treat lice in chickens (De Beer & Van Wyk 2011). It is noteworthy that *Aloe ferox* is one of the few plants depicted in San rock paintings. A painting showing humans interacting

Figure 2. Large-scale production of *Aloe vera* gel. a, bulk aloe gel for export; b, refrigerated bulk trailer for transporting fresh gel to the factory; c, mechanical filleting of aloe leaves; d, bottling of the gel as a health drink.

Figure 3. Section through a leaf of *Aloe ferox*, showing the bitter yellow exudate (oozing from so-called aloin cells just below the green part of the leaf) and the non-bitter, colourless inner leaf parenchyma gel.

with *A. ferox* and *A. broomii* plants was published in the classical book on *Aloe* by Reynolds (1950) and served as the inspiration for the logo of the Indigenous Plant Use Forum. The forum organizes annual conferences on all aspects of ethnobotany and commercial plant use and gives an award for the most innovative product based on an indigenous plant. The rock painting of *A. ferox* was also the inspiration for the IPUF best product award – a framed slab of sandstone painted in the traditional way with ochre (but using egg white as a binder instead of the traditional eland blood). In 2005, the award went to Joyce Musy of Veld's Nature Primale (Paris, France) for her innovative use of *A. ferox* gel in sophisticated cosmetic products (Figure 4).

Pharmaceutical studies. These investigations explore the possible modes of action of aloe for treating numerous ailments and try to provide a scientific rationale for various modern uses. Examples include the testing of skin care products and tonic drinks, the treatment of chronic leg ulcers, the improvement of some cases of eczema, the relief of acute sunburn and various cosmetic applications such as cleansers, moisturisers, shampoos, suntan lotions and sunburn screens (*A. vera* reviewed by Reynolds & Dweck 1999 and Reynolds 2004; *A. ferox* by Chen *et al*. 2012). Aloesin (a common chromone derivative in many aloes) shows promise as a pigmentation-altering agent for cosmetic or therapeutic applications (e.g. skin hyperpigmentation, the overproduction of epidermal melanin). A potentially important new application is the use of aloe gel as an intestinal permeation-enhancing agent for poorly permeable drugs. *Aloe vera* has been the subject of numerous studies (see Reynolds 2004) but *A. ferox* has now also become the focus of several research projects. Chen *et al*. (2012) summarized the main results of recent studies on the skin and wound-healing properties of *A. ferox* products as well as laxative, anti-oxidant, anti-inflammatory, antimicrobial, anti-cancer, antimalarial and anthelmintic activities.

The use of the non-bitter gel of *A. ferox* as a food supplement is a modern development (Van Wyk 2011a, 2011b): there is no documentation of any traditional use as food except for the production of jam (preserve) by Cape farmers. The health benefits of beverages and fortified food products containing the leaf parenchyma of *A. ferox* have been described but much more research is needed to adequately explain the value of aloe health drinks as a "functional food". One of the mechanisms of action is the so-called *amarum* effect (bitter tonic effect), where the bitter taste in the mouth stimulates (via the *nervus vagus*) an increase in the secretion of gastric juices, resulting in improved digestion. Surprisingly, it has also been found that bitter substances may reduce stress through their beneficial effects on heart function (the lowering of the rate and intensity of heartbeats). There is evidence to suggest that aloe gel has the same or similar healing effects on the mucous membranes of the digestive tract that it has on external wounds, which would explain anecdotal evidence for the relief of the symptoms of peptic ulcers and associated ailments.

Recent developments in the *Aloe ferox* industry

Aloe is listed by the Council of Europe as a natural source of *food flavouring*. This category indicates that aloes can be added to foodstuff in the traditionally accepted manner, although there is insufficient information available for an adequate assessment of potential toxicity. An important breakthrough for the South African aloe industry is the fact that the American Food and Drug Administration (Food and Drug Administration, 2002) has permitted the use of *A. ferox* as a direct food additive for human consumption as a natural flavouring substance. Other notable developments in the South African aloe industry include:

Figure 4. Dr Carl Albrecht (first chairman of the Indigenous Plant Use Forum) hands over the 2005 "IPUF Best Product Award" to Joyce Musy of Veld's Nature Primale (Paris, France) for her innovative use of *Aloe ferox* gel in cosmetic products.

Figure 5. Members of the Aloe Council of South Africa, photographed below a giant statue of *Aloe ferox* at Albertinia.

The founding, in 2006, of the Aloe Council of South Africa (Pty) Ltd. This is a section 21 (non-profit) company devoted to the development of the aloe industry in South Africa (Figure 5). Apart for uniting the industry and promoting communication between the main role players, the council has also succeeded in developing a *National Standard for Aloe raw materials*, which was published by Standards South Africa (formerly known as the South African Bureau of Standards) in 2007 (Standards South Africa 2007). This was the first National Standard for a herbal product in South Africa, aimed at ensuring that raw materials comply with minimum quality standards. The quality control methods used in the National Standard were partly based on an M.Sc. study, the main findings of which are summarized in O'Brien *et al*. (2011). The raw materials described in the National

Standard fall into three main categories: Type 1 – latex (e.g. bitter sap, lump, bitter leaf powder, lump powder, aloe granulated), Type 2 – fillet (fillet, gel and gel powder) and Type 3 – whole leaf (whole leaf sap, whole leaf powder, pectin jelly, low bitter leaf powder, and various others). The traditional method of tapping the aloe plants to produce the latex (aloe lump) is still widely used by rural entrepreneurs (Figure 6) but a number of new, factory-based methods have been developed to improve the quality and uniformity of the products. Examples include the patented methods to extract jelly from the leaf parenchyma (Botha 1994) and to convert aloeresin A to aloesin (Steenkamp *et al*. 2008).

The establishment of plantations of *A. ferox*. This innovation not only produces high quality raw materials at a much lower cost, but contributes towards conservation and sustainability in the industry. The listing of aloe under CITES unfortunately has a negative effect on marketing perceptions and on exports, so that cultivation seems unavoidable as a long term strategy to ensure growth in exports and to reduce the natural variability of the raw materials. This despite the fact that wild-harvesting is sustainable (Newton & Vaughan 1996), with little or no damage to what is undoubtedly an abundant natural resource. Examples of *A. ferox* plantations include 6 ha planted by Dr Tewis Muller on the farm Vinklaagte near Albertinia in 1976 – the first commercial plantation and a pioneering effort which has proven that the concept is financially viable (Figure 7) – and the more recent 19 ha on the farm Tierfontein near Albertinia, planted in February 2008.

Conclusions

The traditional uses of aloe are relatively well documented and the dried latex continues to be valuable as a commercial laxative medicine (and also as a food flavourant and source of aloesin). The use of the leaf parenchyma gel in wound healing has ancient origins but the production of cosmetics and health drinks is a new development that has become by far the most lucrative part of the aloe industry. The wound-healing properties of the gel are well documented but deserve further scientific study to determine the mechanisms of action. In addition to the obvious protective and moisturizing effects, research should focus on the reduction of inflammation and the increase of epithelial migration and collagen maturation. Likewise, the health benefits of ingesting the gel as a tonic drink deserves further study. It is possible that there are subtle synergistic effects amongst the various gel components, in addition to the stimulation of digestion (and possible reduction in stress) through the *amarum* effect, as well as internal healing activity associated with direct contact between the gel and mucus membranes of the digestive system. There is considerable interest in the aloe industry as a source of income. Important elements that may contribute to long term success include focused scientific research, official support, innovative new product development and imaginative marketing. The *Aloe vera* industry is a good example of the tremendous success that can be achieved by hard work and a market-driven approach.

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Figure 6. The traditional method of harvesting the sap of *Aloe ferox* leaves. The yellow exudate drips into a hollow in the ground lined with a plastic sheet. Note that the thorns along the leaf edges prevent the stack from collapsing.

Figure 7. The first commercial plantation of *Aloe ferox*, established in 1976 by Dr Tewis Muller on the farm Vinklaagte near Albertinia.

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