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Monosaccharide analysis of succulent leaf tissue in *Aloe*

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ABSTRACT

Introduction: The succulent leaf mesophyll in *Aloe* species supports a burgeoning natural products industry, particularly in Africa. Comparative data necessary to prioritise species with economic potential have been lacking.
Objective: To survey leaf mesophyll monosaccharide composition in the genus *Aloe* using a predictive phylogenetic approach.
Methodology: Monosaccharide composition was assessed in 31 species, representing the morphological and taxonomic diversity of *Aloe sensu stricto*. Leaf mesophyll polysaccharides were partially hydrolysed in a trifluoroacetic acid (TFA)–SilA assay. Oximes and trimethylsilyl ether products were detected by GC–MS. Constituent monosaccharides accounting for the greatest variation among species were identified by principal component analysis. Two plant DNA barcoding regions were sequenced in 28 of the sampled species and the resulting maximum likelihood tree was used to evaluate phylogenetic signal in monosaccharide composition throughout the genus.
Results: Nineteen peaks (Rt = 16.76–23.67 min) were identified in the GC–MS spectra. All samples were dominated by one constituent; glucose was the major monosaccharide in 19 species, mannose in eight species, and xylose in one species (*Aloidendron pillansii*). Three monosaccharides therefore account for 90% of the variation in leaf mesophyll in *Aloe*. Species which do not share this typical monosaccharide profile appear to group outside the core *Aloe* clade in the phylogeny.
Conclusion: Preliminary findings suggest that leaf mesophyll monosaccharide composition is conservative in *Aloe*. Characterisation of within-species variation and quantitative differences between species will be necessary to authenticate leaf mesophyll products, whereas unusual monosaccharide profiles could be diagnostic in some species. The common glucose–mannose–xylose profile identified in commercially important species is shared by many other *Aloe* species.
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1. Introduction

The colourless spongy mesophyll or 'gel' from the leaves of *Aloe vera* L. (Xanthorrhoeaceae) is a natural product ingredient in cosmetics, topical preparations, foods and household commodities supporting a substantial global industry. The mesophyll comprises large, water-storing parenchyma cells and is one of a suite of adaptations which enable succulent plants to grow in seasonally dry environments (Ogburn and Edwards, 2010). All species of *Aloe* have succulent leaves, but there is considerable variation in the extent of the leaf mesophyll layer: the leaves are barely succulent in some species, whereas the leaf mesophyll is very well developed in others. The texture of the inner leaf mesophyll ranges from firm and dry, to mucilaginous and watery (Fig. 1). In addition to typical structural carbohydrates found in the cell walls, the cellular contents are rich in storage carbohydrates and free sugars (Ni et al., 2004). Polysaccharides in the leaf mesophyll of *Aloe. vera*, consisting primarily of glucomannans, have been associated with a range of clinical effects such as wound healing, anti-inflammatory and immunomodulatory activity and have been the subject of thorough reviews (Reynolds and Dweck, 1999; Ni and Tizard, 2004).

Prospects have been recognised for the leaf mesophyll of other species of *Aloe* to be used commercially like *Aloe. vera*, given there are over 500 species of *Aloe* are found throughout Africa, Madagascar and the Arabian Peninsula. *Aloe arborescens* Mill., a species native to southern Africa, supports a considerable industry in Japan (Newton and Chan, 1998). Localised industries based on the extraction of leaf mesophyll from one or two species have become established using *Aloe ferox* Mill. in South Africa, *A. macroclada* Baker in Madagascar, and several species in Kenya (Grace, 2011). Glucomannans, galactose and galacturonic acid polymers are the most commonly reported leaf mesophyll polysaccharides (Reynolds and Dweck, 1999) among

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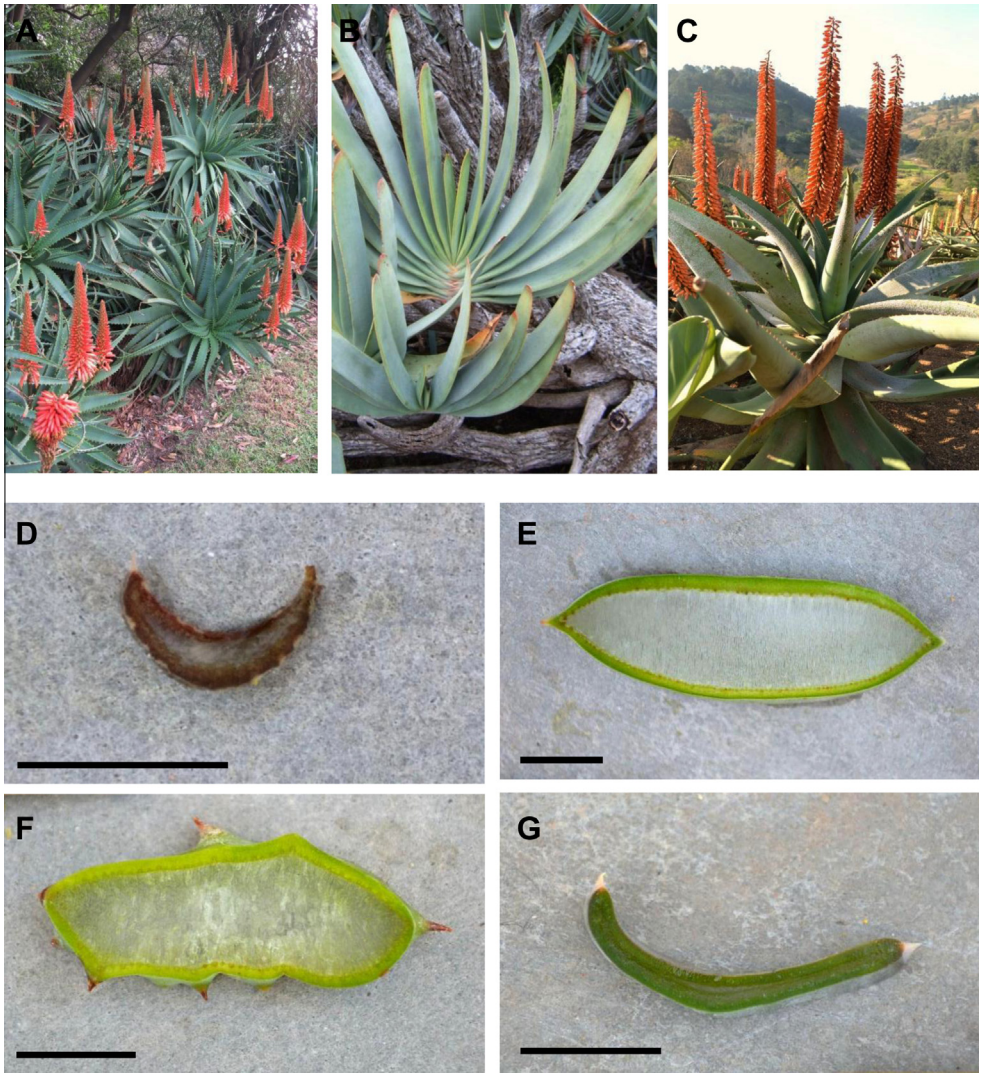

Fig. 1. Diversity in habit and leaf mesophyll in *Aloe*: A, *Aloe arborescens*, B, *Kumara disticha*, C, *Aloe ferox*; D–G, leaf sections of *Aloe alooides*, *Aloe ferox*, *Aloe excelsa* and *Aloidendron pillansii*. Scale bars = 1 cm.

the few species of *Aloe* studied to date (Table 1). The range of leaf mesophyll polysaccharides in *Aloe* spp. appears to be conservative (Grindlay and Reynolds, 1986), although their constituent monosaccharides have recently been suggested as a tool for authenticating *Aloe*-based natural products, given the observed differences between *A. ferox* and *A vera* (O'Brien et al., 2011). Structure–activity relationships suggest that monosaccharide composition and branching patterns play an important role in the bioactivity of plant polysaccharides (Paulsen and Barsett, 2005). Little is known, however, of the relationship between polysaccharide composition and therapeutic value of the leaf mesophyll in *Aloe*. Indeed, it is not yet clear whether polysaccharide composition in *Aloe* and related genera should be an important criterion for the selection of suitable taxa for new industries, as little is known of whether leaf mesophyll constituents differ between *Aloe* species, nor whether the market-dominant *A. vera* is superior to other species. Due to the lack of

Table 1
Types of monosaccharide components of polysaccharides reported from leaf tissues of *Aloe sensu lato*.

	Monosaccharide[1]							
Species	Arabinose	Fucose	Galactose	Glucose	Hexose	Mannose	Rhamnose	Xylose
Aloe arborescens	c	c	c	c		c, k	c	c
Aloe ferox	d, f	d	d, f	f		d	d	d, f
Aloe maculata (syn. *A. saponaria*)			a, l	a, l		a, l		
Aloe vaombe				i		i		
Aloe vanbalenii			a	a		a		
Aloe vera	j	e	b, j, e, l	b, j, e, m	m	b, f, e, m		j
Kumara disticha (syn. *Aloe plicatilis*)				h		h		

[1] Literature cited: a, Gowda (1980); b, Haq and Hannan (1981); c, Hikino et al. (1986); d, Mabusela et al. (1990); e, Ni et al. (2004); f, O'Brien et al. (2011); g, Olennikov et al. (2009); h, Paulsen et al. (1978); i, Radjabi et al. (1983); j, Segal et al. (1968); k, Yagi et al. (1977); l, Yagi et al. (1984); m, Yaron (1993).

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