



## South African *Helichrysum* species: A review of the traditional uses, biological activity and phytochemistry

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### ABSTRACT

**Aims of the study:** In South Africa, the genus *Helichrysum* is widely used in traditional medicine. The uses are well documented although renaming of species and the resulting confusing taxonomic nomenclature may cause uncertainty as to which specific species was referred to in some reports. The aim of this paper is to present a collated and coherent overview of the documented traditional uses of *Helichrysum* species and to update the botanical identity of previously studied species.

**Materials and methods:** Databases (Scifinder, ISI Web of Knowledge) and several books were used to collect information on South African *Helichrysum* species.

**Results:** The traditional uses, chemistry and biological activity of *Helichrysum* species have been summarized. It was attempted to give clarity as to exactly which species is referred to in the ethnobotanical literature.

**Conclusions:** Although a large number of ethnopharmacological uses have been documented and the chemistry of the genus has been studied extensively, only a few South African species have been investigated for their biological activity.

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## 1. Introduction

The genus *Helichrysum* Mill. derives its name from the Greek words *helios* (sun) and *chrysos* (gold) which is appropriate considering the attractive yellow flowers displayed by several species (Pooley, 2003). The genus belongs to the Asteraceae family, tribe Inuleae and subtribe Gnaphaliinae (Hilliard, 1983). This large genus consists of approximately 500–600 species and although *Helichrysum* species are also found in southern Europe, south-west Asia, southern India, Sri Lanka (previously Ceylon) and Australia, most species occur in Africa, including Madagascar (Hilliard, 1983). In South Africa (including Namibia), the ca. 244–250 species are widely distributed and the tremendous morphological diversity displayed by these species resulted in their subdivision into 30 morphological groups, using the shape and size of the flower heads as differentiating characteristics (Hilliard, 1983). The flower heads are either solitary or occur in compact or spreading inflorescences. The aerial parts are usually hairy or woolly and plants occur as herbs or shrublets that are sometimes dwarfed and cushion forming. They are often aromatic (Pooley, 1998, 2003; Van Wyk et al., 2000).

## 2. Traditional uses

Several *Helichrysums* are widely used in Southern African traditional medicine as summarised in Table 1. The first written record of the medicinal use of *Helichrysum* dates back to 1727 when Boerhaave noted that a *Helichrysum* species was used to treat nervousness and hysteria. The report of a *Helichrysum* species in the early literature could have been based on knowledge acquired from the local Khoi and San people, but is most probably due to the fact that European botanists used their knowledge of medicinal properties of European genera (Scott and Hewett, 2008).

### 2.1. Ambiguities in nomenclature

As is the case for all ethnobotanical data, the fact that plant names are changed (Germishuizen and Meyer, 2003) and frequently incorrectly cited (Arnold et al., 2002) is quite problematic. To complicate matters further, variation in spelling of names also occurs. Special care needs to be taken when consulting the original texts to unambiguously confirm that a plant selected for a particular study is in fact the same species cited by, for example, Watt and Breyer-Brandwijk (1962). In Table 1, current names are given and previously accepted names are shown in parenthesis. For the sake of clarity, the name as it appears in the reference is sometimes indicated in brackets after the reference.

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**Table 1**Traditional uses and biological activities reported for *Helichrysum* species

Species <sup>a</sup>	Plant part used	Dosage form	Traditional use	Classification of use <sup>b</sup>	Biological activity <sup>b</sup>	References
<i>Helichrysum acutatum</i> DC. <b>21<sup>c</sup></b>			Widely used as traditional medicine, sold commercially in large quantities	NS		Arnold et al. (2002), Cunningham (1988), Hutchings et al. (1996)
<i>Helichrysum adenocarpum</i> DC. <b>28</b>	Root	Decoction	Used to treat diarrhoea and vomiting in children.	GIT		Arnold et al. (2002), Jacot Guillarmod (1971), Neuwinger (1996), Phillips (1917), Pooley (2003), Walker (1996), Watt and Breyer-Brandwijk (1962)
<i>Helichrysum appendiculatum</i> (L.f.) Less. <b>24</b>	Leaf	Eaten raw	Chest problems or infection of the respiratory tract	Resp, Infec, Anth, W, P	B <sup>d</sup> , F <sup>d</sup>	Arnold et al. (2002), Githens (1949), Mathekgga (2001) <sup>e</sup> , Smith (1895), Smith (1966), Swanepoel (1997), Walker (1996), Watt and Breyer-Brandwijk (1962)
	Plant		Smallpox			
	Plant		Anthelmintic			
	Root		Coughs and colds and applied externally on wounds			
	Leaf	Wound dressing	Applied externally to wounds. Ground leaves are rubbed into areas which cramps or on wounds			
	Roots		Ground and burnt and smeared on body to relax body and to reduce swelling			
	Leaf		Used medicinally as tea			
<i>Helichrysum argyrophyllum</i> DC. <b>29</b>	Root	Infusion	Intestinal troubles Not grazed by stock, preventing soil erosion in overgrazed areas	GIT		Arnold et al. (2002), Batten and Bokelmann (1966), Smith (1966), Walker (1996), Watt and Breyer-Brandwijk (1962)
<i>Helichrysum argyrosphaerum</i> DC. <b>15</b>			Browsed by animals but poisonous if large quantities is ingested	Poi	B <sup>d</sup> , F <sup>d</sup>	Hutchings et al. (1996), Mathekgga (2001) <sup>e</sup> , Pooley (1998), Van Wyk et al. (2002)
<i>Helichrysum asperum</i> (Thunb.) Hilliard and Burt. (= <i>Helichrysum ericifolium</i> Less.) (Hilliard, 1983) <b>12<sup>f</sup></b>			The plants are casually browsed by sheep and said to be a cause of "Geilsiekte"	Poi		Smith (1966) ( <i>Helichrysum ericaefolium</i> DC.) <sup>g</sup>
<i>Helichrysum athrixifolium</i> (Kuntze) Moeser <b>9<sup>f</sup></b>	Leaf	Smoked	Chest complaints.	Resp		Arnold et al. (2002), Jacot Guillarmod (1971) ( <i>Helichrysum athrixifolium</i> O. Hoffm.) <sup>g</sup> , Phillips (1917) ( <i>Helichrysum athrixifolium</i> O. Hoffm.) <sup>g</sup> , Watt and Breyer-Brandwijk (1962) ( <i>Helichrysum athrixifolium</i> O. Hoffm.) <sup>g</sup>
<i>Helichrysum aureonitens</i> Sch. Bip. <b>8</b>	Leaves and stems	Burnt as incense	Used to invoke the goodwill of the ancestors and to induce trances	Psy, Psys, Infect, Insect	B <sup>d</sup> , F <sup>d</sup> , V	Afolayan and Meyer (1997) <sup>e</sup> , Cunningham (1988), Hutchings et al. (1996), Jacot Guillarmod (1971), Mathekgga (2001) <sup>e</sup> , Meyer and Afolayan (1995) <sup>e</sup> , Meyer et al. (1996) <sup>e</sup> , Meyer et al. (1997) <sup>e</sup> , Phillips (1917), Pooley (1998), Pooley (2003), Swanepoel (1997), Walker (1996), Watt and Breyer-Brandwijk (1962)
	Leaves and stems	Decoction Extracts	Commercially sold A remedy for inuresis in children Used topically for skin infections especially against <i>Herpes zoster</i> and infections associated with <i>Herpes simplex</i> Used to keep red mites away Used as tinder to start fire, used to make hats.			
<i>Helichrysum aureum</i> Houtt. Merr. var. <i>aureum/monocephalum</i> (= <i>Helichrysum fulgidum</i> (L.f.) Willd.) <b>30<sup>h</sup></b>		Decoction	Used for washing sore eyes	Eye		Arnold et al. (2002) ( <i>Helichrysum fulgidum</i> L.f.) Willd.) <sup>g</sup> , Batten and Bokelmann (1966) ( <i>Helichrysum fulgidum</i> Willd.) <sup>g</sup> , Jacot Guillarmod (1971) ( <i>Helichrysum fulgidum</i> (L.) Willd.) <sup>g</sup> , Phillips (1917) ( <i>Helichrysum fulgidum</i> Willd.) <sup>g</sup>

Table 1 (Continued)

Species <sup>a</sup>	Plant part used	Dosage form	Traditional use	Classification of use <sup>b</sup>	Biological activity <sup>b</sup>	References
<i>Helichrysum bellum</i> Hilliard <b>28</b>					B <sup>d</sup> , F <sup>d</sup>	Mathekga (2001) <sup>e</sup>
<i>Helichrysum caespitium</i> (DC.) Harv <b>12<sup>f</sup></b>	Plant	Crushed and burnt and smoke inhaled	Used to treat head and chest colds (headaches)	Resp, Infect, GIT, Vi, W	B <sup>d</sup> , F <sup>d</sup> , I, My	Arnold et al. (2002), Dekker et al. (1983) <sup>e</sup> , Gelfand et al. (1985) ( <i>Helichrysum caespitium</i> Sond.) <sup>g</sup> , Hutchings and Van Staden (1994), Jacot Guillarmod (1971) ( <i>Helichrysum caespitium</i> Sond.) <sup>g</sup> , Mathekga et al. (2000) <sup>e</sup> , Mathekga (2001) <sup>e</sup> , Meyer et al. (2002) <sup>e</sup> , Neuwinger (1996), Phillips (1917) ( <i>Helichrysum caespitium</i> Sond.) <sup>g</sup> , Pooley (1998), Pooley (2003), Swanepoel (1997) <sup>e</sup> , Watt and Breyer-Brandwijk (1962)
	Plant	Decoction	Drunk by the Kwena and the Kgatla to treat gonorrhoea			
	Root	Decoction	Nausea			
	Roots		Virility			
	Plant	Ointment	Ointment is applied to the roof of the mouth for a depressed fontanelle Used as dressing for open wounds during circumcision rites			
<i>Helichrysum callicomum</i> Harv <b>2</b>		Enema	Protective charm. Mixed with <i>Aster bakerianus</i> ( <i>hispidis</i> ) and <i>Helichrysum</i> <del>used as fuel</del> in winter Used as an ingredient in an enema for colic	M, GIT	B <sup>d</sup> , F <sup>d</sup>	Arnold et al. (2002), Jacot Guillarmod (1971), Mathekga and Meyer (1998) <sup>e</sup> , Mathekga (2001) <sup>e</sup> , Phillips (1917), Pooley (2003), Watt and Breyer-Brandwijk (1962)
<i>Helichrysum calocephalum</i> Klatt <b>23</b>						Arnold et al. (2002) refers to others using <i>Helichrysum calocephalum</i> Schltr, which is classified as <i>Helichrysum ecklonis</i> Sond (Germishuizen and Meyer, 2003)
<i>Helichrysum calophalum</i> Klatt <b>23</b>	Root		Used for hyperfunction of the lower gastro-intestinal tract	GIT		Swanepoel (1997), information obtained from TRAMED database. It is not clear to these authors whether this use pertains to <i>Helichrysum calocephalum</i> Klatt or <i>Helichrysum ecklonis</i> Sond
<i>Helichrysum candolleianum</i> Buek <b>15</b>					B <sup>d</sup> , F <sup>d</sup>	Mathekga (2001) <sup>e</sup>
<i>Helichrysum chionosphaerum</i> DC. <b>25</b>					B <sup>d</sup> , F <sup>d</sup>	Mathekga (2001) <sup>e</sup>
<i>Helichrysum cephaloideum</i> DC. (= <i>Helichrysum adscendens</i> Less. var. <i>cephaloideum</i> Moes.) <b>24</b>			Irritant poisoning in sheep demonstrated. Known to be poisonous to sheep (symptoms similar to that of poisoning caused by <i>Geigeria</i> )	Poi		Van Wyk et al. (2002), Watt and Breyer-Brandwijk (1962)
<i>Helichrysum cochleariforme</i> DC. (= <i>Helichrysum imbricatum</i> Less.) <b>15</b>		Tea, infusion	Demulcent in coughs and other pulmonary affections. In the Western Cape area the plant is used to treat whooping cough, other coughs, bronchial catarrh and bronchitis	Resp		Arnold et al. (2002), Neuwinger (1996), Smith (1966), Swanepoel (1997), Watt and Breyer-Brandwijk (1962)
	Whole plant	Decoction	Drunk for infections of the respiratory tract			
<i>Helichrysum cooperi</i> Harv. <b>30</b>	Leaf	Ointment, applied after bathing	Used as love charm. The ointment is applied after bathing and as a result the desired lady finds the man irresistible	M, Fum, Snakebite		Arnold et al. (2002), Hutchings et al. (1996), Pooley (1998), Pooley (2003), Walker (1996), Watt and Breyer-Brandwijk (1962)
	Leaves		Used to make Zulu headdress distinctive to married women Used as a fumigant and as part of a traditional remedy for snakebite.			

<i>Helichrysum crispum</i> (L.) D. Don. <b>17</b>			Used medicinally as a calming tea Coughs, bronchitis, urinary tract infections and tuberculosis.	Resp, Renal	B	Arnold et al. (2002) (with reference to Smith, 1966), Kling as quoted by Salie et al., 1996 <sup>e</sup> , Roberts (1990) ( <i>Helichrysum crispum</i> ) <sup>g</sup> These authors are not certain whether Kling is referring to <i>Helichrysum crispum</i> (L.) D. Don. or <i>Helichrysum crispum</i> Less.
<i>Helichrysum cymosum</i> (L.) D. Don. <b>8</b>	Leaf Root Leaf Leaf	Decoction/tea Extract Boiled, and vapours from boiling leaves inhaled	Used to invoke the goodwill of the ancestors and to induce trances Used to treat colds and coughs Used as emetic and purgative Filtrate drunk to treat colds and fever Vapour bath used to treat headaches	M, Psy, Resp, GIT, P	B <sup>d</sup> , F <sup>d</sup> , PI	Arnold et al. (2002), Bhat and Jacobs (1995), Kokwaro as quoted by Neuwinger (1996), Neuwinger (1996), Pooley (2003), Van Vuuren et al. (2006) <sup>e</sup> , Van Wyk et al. (2000)
<i>Helichrysum dasymallum</i> Hilliard (= <i>Helichrysum lanatum</i> Harv.) <b>21</b>			Used as medicinal tea. Woolly coat used for tinder boxes	NS		Arnold et al. (2002), Lucas and Pike (1971), Smith (1966)
<i>Helichrysum decorum</i> DC. <b>30</b>	Plant	Burned and smoked inhaled	Used to induce trances	Psy	B <sup>d</sup> , F <sup>d</sup>	Arnold et al. (2002), Hutchings et al. (1996), Mathekga (2001) <sup>e</sup> , Neuwinger (1996)
<i>Helichrysum dregeanum</i> Sond. and Harv. <b>9</b>	Leaf	Smoked Infusion	Used to treat head colds Used to treat hiccups Browsed by stock	Resp, GIT		Arnold et al. (2002), Hutchings and Van Staden (1994), Jacot Guillarmod (1971), Neuwinger (1996), Phillips (1917), Smith (1966), Watt and Breyer-Brandwijk (1962)
<i>Helichrysum ecklonis</i> Sond (= <i>Helichrysum calocephalum</i> Schltr.) <b>28</b>			Used by the Xhosas to ward of evil magic spells, which follow on seeing <i>iChanti</i> , the water snake Used to treat diarrhoea in children.	M, GIT		Batten and Bokelmann (1966), Jacot Guillarmod (1971), Phillips (1917), Pooley (2003), Watt and Breyer-Brandwijk (1962)
<i>Helichrysum epapposum</i> Bolus <b>3</b>	Leaves and stems Leaves and stems	Burned as incense	Used to invoke the goodwill of the ancestors Commercially sold	M		Arnold et al. (2002), Cunningham (1988), Hutchings et al. (1996)
<i>Helichrysum excisum</i> (Thunb.) Less. <b>12</b>					B <sup>d</sup> , I	Lourens et al. (2004) <sup>e</sup>
<i>Helichrysum felinum</i> Less. <b>17</b>					B <sup>d</sup> , I	Lourens et al. (2004) <sup>e</sup>
<i>Helichrysum flanaganii</i> Bolus <b>13</b>	Leaves	Burned	Incense	M		Walker (1996)
<i>Helichrysum foetidum</i> (L.) Moench <b>30<sup>f</sup></b>	Plant Leaf Leaf Leaf Root Leaf Plant	Extract is drunk/smoke inhaled Extract Wound dressing Preparation Extract	Used to induce trances Used to treat flu (influenza) Used to treat circumcision and infected wounds (festering sores) Applied to treat <i>Herpes</i> Eye problems, used to bath eyes Used in making headdress distinctive of married women Aromatic and astringent (used to draw out infection). Used to treat menstrual pain	Psy, Infect, Resp, W, Eye, P	B	Arnold et al. (2002), Batten and Bokelmann (1966) ( <i>Helichrysum foetidum</i> Cass.) <sup>g</sup> , Gerstner (1938) ( <i>Helichrysum foetidum</i> Cass.) <sup>g</sup> , Hulme (1954), Hutchings et al. (1996), Kokwaro quoted by Neuwinger (1996), Neuwinger (1996) Roberts (1990), Rwangabo, quoted by Neuwinger (1996), Steenkamp et al. (2004) <sup>e</sup> , Swanepoel (1997), Van Wyk and Gericke (2000), Watt and Breyer-Brandwijk (1962) ( <i>Helichrysum foetidum</i> Cass.) <sup>g</sup>
<i>Helichrysum glomeratum</i> Klatt <b>6</b>					B, F <sup>d</sup>	Mathekga and Meyer (1998) <sup>e</sup> , Mathekga (2001) <sup>e</sup>
<i>Helichrysum griseum</i> Sond (= <i>Helichrysum agrostophilum</i> Klatt) <b>23<sup>h</sup></b>			Preventative charm against illness. Burnt as fuel in winter	M		Arnold et al. (2002), Phillips (1917)
<i>Helichrysum gymnocomum</i> DC. <b>4</b>	Stems and leaves	Burned as incense Ointment	Used to invoke the goodwill of the ancestors Mixed with fat, only the wives of chiefs were previously allowed to use it Used to fumigate sick rooms Commercially sold	Skin, M, Fum	B <sup>d</sup> , F <sup>d</sup>	Cunningham (1988), Drewes and Van Vuuren (2008) <sup>e</sup> , Hutchings et al. (1996), Phillips (1917)
<i>Helichrysum herbaceum</i> (Andrews) Sweet <b>29</b>	Stems and leaves Stems and leaves	Burned as incense	Used to invoke the goodwill of the ancestors Commercially sold	M	B <sup>d</sup> , F <sup>d</sup>	Arnold et al. (2002), Cunningham (1988), Hutchings et al. (1996), Mathekga (2001) <sup>e</sup> , Neuwinger (1996), Pooley (1998), Pooley (2003)

Table 1 (Continued)

Species <sup>a</sup>	Plant part used	Dosage form	Traditional use	Classification of use <sup>b</sup>	Biological activity <sup>b</sup>	References
<i>Helichrysum hypoleucum</i> Harv <b>16</b>					B <sup>d</sup> , F <sup>d</sup>	Mathekga and Meyer (1998) <sup>e</sup> , Mathekga (2001) <sup>e</sup>
<i>Helichrysum indicum</i> (L.) Grierson (= <i>Helichrysum expansum</i> (Thunb.) Less.) <b>15</b>	Plant	Burned and crushed	Mixed with <i>Conyza pinnata</i> . Crushed and burnt to drive sickness from a room	M		Arnold et al. (2002), Jacot Guillarmod (1971)
<i>Helichrysum kraussii</i> Sch. Bip <b>8</b>	Leaf	Decoction	Use to wash keloid scars	Skin, M, Resp, Infect	B <sup>d</sup> , F <sup>d</sup>	Arnold et al. (2002), Arnold and Gulumian as quoted by Neuwinger (1996), Bremner and Meyer (2000) <sup>e</sup> , Mathekga (2001) <sup>e</sup> , Gelfand et al. (1985), Mabogo (1990), Neuwinger (1996), Swanepoel (1997), Walker (1996), Watt and Breyer-Brandwijk (1962)
	Root and leaves	Infusion	Used to drive bad spirits away, used to wash body			
	Dried flower and seed	Smoked in a pipe	The Karanga smoke this as a remedy for coughs and pulmonary tuberculosis			
	Plant	Burnt, salt is added to ash and ingested by mouth	Cough			
	Root	Mixed with salt and other ingredients	Venereal disease			
<i>Helichrysum lepidissimum</i> S. Moore <b>19</b>	Root	Powder or ointment	Applied to child's side with small amount given orally			
			Used as a body perfume	Skin		Dlamini (1981), Watt and Breyer-Brandwijk (1962)
<i>Helichrysum litorale</i> Bolus (= <i>Leontonyx angustifolius</i> DC. = <i>Leontonyx spathulatus</i> Less.) <b>14</b>	Plant		Dried and pounded or mixed with lard or fat, was used for applying to ulcers. In the Western Cape province an ointment for boils, carbuncles and abscesses is made from this plant, <i>Cyanella lutea</i> and "tiendaegeneesbossie"	W, Skin		Smith (1966), Swanepoel (1997), Watt and Breyer-Brandwijk (1962)
<i>Helichrysum longifolium</i> DC. <b>24</b>	Leaf		Used by the Pondos to treat circumcision wounds. The leaves are heated over very hot ash before being used as a bandage for the treatment of wounds after circumcision	W	B <sup>d</sup> , F <sup>d</sup>	Dilika et al. (1997) <sup>e</sup> , Mathekga (2001) <sup>e</sup>
<i>Helichrysum lucilioides</i> Less. <b>12</b>			Excellent stock feed			Smith (1966)
<i>Helichrysum melanacme</i> DC. <b>8</b>			Used as bedding. Used medicinally as tea. Used for cough, fever, headache, colds and chest pain	Resp, P	B <sup>d</sup> , F <sup>d</sup> , My, V	Arnold et al. (2002), Lall and Meyer (1999) <sup>e</sup> , Lall et al. (2006) <sup>e</sup> , Mathekga (2001) <sup>e</sup> , Smith (1966)
<i>Helichrysum miconiifolium</i> DC. <b>23</b>	Leaf	Tea	Used medicinally as tea The Xhosa grind and boil the leaves and use it as a wash for pain after circumcision	P, Anthel	B <sup>d</sup> , F <sup>d</sup>	Smith (1966) ( <i>Helichrysum miconiaefolium</i> DC.) <sup>g</sup> , Arnold et al. (2002), Mathekga (2001) <sup>e</sup> , Swanepoel (1997)
	Root		The powdered root is used for intestinal parasites and for ticks on poultry			
<i>Helichrysum montanum</i> DC. <b>22</b>					B, F <sup>d</sup>	Mathekga (2001) <sup>e</sup>
<i>Helichrysum monticola</i> Hilliard <b>28</b>					B, F <sup>d</sup>	Mathekga (2001) <sup>e</sup>
<i>Helichrysum mundtii</i> Harv. <b>23</b>	Plant	Decoction	Chest complaints	Resp		Arnold et al. (2002), Jacot Guillarmod (1971), Pooley (1998), Pooley (2003), Phillips (1917) ( <i>Helichrysum mundtii</i> , Harv.) <sup>g</sup> , Watt and Breyer-Brandwijk (1962)
<i>Helichrysum natalitium</i> DC. <b>3</b>	Leaves and stems	Burnt as incense	Used to invoke the goodwill of the ancestors	M		Arnold et al. (2002), Cunningham (1988), Hutchings et al. (1996), Pooley (2003)
	Leaves and stems		Commercially sold			

<i>Helichrysum nudifolium</i> (L.) Less. var. <i>nudifolium</i> = <i>H. coriaceum</i> Harv. <sup>f</sup> =also <i>Helichrysum gerberifolium</i> A. Rich. =also <i>Helichrysum leiopodium</i> DC. =also <i>Helichrysum nudifolium</i> var. <i>quinquenerve</i> =also <i>Helichrysum nudifolium</i> var. <i>leiopodium</i> ) <b>23</b>	Leaf	Burnt as incense	To invoke the goodwill of the ancestors	M, Resp, W,	B <sup>d</sup> , F <sup>d</sup> , I	Arnold et al. (2002), Gerstner (1938) ( <i>Helichrysum undifolium</i> , also <i>Helichrysum leiopodium</i> DC.) <sup>g</sup> , Githens (1949) ( <i>Helichrysum nudifolium</i> , also <i>Helichrysum leiopodium</i> ) <sup>g</sup> , Glover et al. quoted by Neuwinger (1996), Hulme (1954), Hutchings et al. (1996), Hutchings and Johnson (1986), Hutchings and Van Staden (1994), Jacot Guillarmod (1971) ( <i>Helichrysum nudifolium</i> var. <i>leiopodium</i> ) <sup>g</sup> , Jäger et al. (1996) <sup>e</sup> , Mabogo (1990), Phillips (1917) ( <i>Helichrysum leiopodium</i> DC.) <sup>g</sup> , Rood (1994), Smith (1895) ( <i>Helichrysum nudiflorum</i> ) <sup>g</sup> , Smith (1966) ( <i>Helichrysum coriaceum</i> Sond. and <i>Helichrysum nudifolium</i> var. <i>quinquenerve</i> ) <sup>g</sup> , Swanepoel (1997) <sup>e</sup> ( <i>Helichrysum gerberifolium</i> ) <sup>g</sup> , Van Wyk et al. (2000), Neuwinger (1996) (also <i>Helichrysum gerberifolium</i> Sch. Bip) <sup>g</sup> , Watt and Breyer-Brandwijk (1962) ( <i>Helichrysum gerberaeifolium</i> Sch. Bip. Ex A.Rich) <sup>g</sup>
		Infusion	Colds (Zulu and Khoi—administration route not indicated)	Infect, P, Skin, GIT		
	Leaf	Eaten raw	Used to treat colds by the Xhosa			
	Plant	Infusion	Regarded as demulcent, used to treat catarrh, phthisis and other pulmonary affections			
	Leaf/plant		Respiratory infections			
	Root		Coughs and colds			
	Leaf	Wound dressing	Wounds			
	Root/Leaf		Applied to sores on the genitalia by the Xhosa			
	Plant/leaf	Smoke inhaled	Headache			
	Leaf	Infusion	Rectal prolapse			
		Powder mixed with butter and eaten	Protection of children from illness			
	Root	Decoction	Chest problems, used as emetic by the Zulu			
	Leaf	Decoction	To encourage weaning in babies			
	Leaf	Infusion	Diseases in goats			
Plant	Infusion on hot stones	Used as steam bath to treat fever and nightmares				
Plant	Poultice	Swellings				
	Decoction	Colic in children (administered as enema)				
		Rubbed into scarifications over bruises.				
		Used as tea				
Root	Decoction	Internal sores (intestinal ulceration)				
<i>Helichrysum nudifolium</i> var. <i>oxyphyllum</i> (= <i>Helichrysum oxyphyllum</i> DC. =also <i>Helichrysum undatum</i> Less.) <b>23</b>			Protective charm against thunder	M	Arnold et al. (2002), Gertsner (1938), Hutchings et al. (1996)	
<i>Helichrysum nudifolium</i> var. <i>pilosellum</i> (= <i>Helichrysum latifolium</i> (Thunb.) Less. = <i>Helichrysum pilosellum</i> (L.f.) Less.) <b>23</b>			Used for “doctoring” people who wish some deed concealed and who are afraid of being found out	M, GIT	B, F <sup>d</sup>	Arnold et al. (2002) ( <i>H. pilosellum</i> ) <sup>g</sup> , Hulme (1954) ( <i>Helichrysum latifolium</i> ) <sup>g</sup> , Hutchings et al. (1996) ( <i>Helichrysum pilosellum</i> (L.f.) Less.) <sup>g</sup> , Jacot Guillarmod (1971) ( <i>Helichrysum latifolium</i> (Thunb.) Less.) <sup>g</sup> , Mathekgga and Meyer (1998) <sup>e</sup> , Mathekgga (2001) <sup>e</sup> , Neuwinger (1996) ( <i>Helichrysum pilosellum</i> (L.f.) Less.) <sup>g</sup> , Phillips (1917) ( <i>Helichrysum latifolium</i> Less.) <sup>g</sup> , Phillips (1917) ( <i>Helichrysum latifolium</i> Less.) <sup>g</sup> , Pooley (2003) ( <i>Helichrysum pilosellum</i> ) <sup>g</sup> , Swanepoel (1997), Walker (1996) ( <i>Helichrysum pilosellum</i> (L.f.) Less.) <sup>g</sup> , Watt and Breyer-Brandwijk (1962) ( <i>Helichrysum latifolium</i> Less.) <sup>g</sup>
<i>Helichrysum nudifolium</i> var. <i>pilosellum</i> (= <i>Helichrysum pilosellum</i> (L.f.) Less. = <i>Helichrysum pedunculare</i> (L.) DC. var. <i>pilosellum</i> ) <b>23</b> <sup>h</sup>	Leaf	Infusion	Ingredient in colic remedy			Arnold et al. (2002), the sources below are indicated in Arnold et al., under <i>Helichrysum pedunculare</i> DC.: Batten and Bokelmann (1966) ( <i>isicwe, isiGutsi</i> ) <sup>j</sup> , Githens (1949) ( <i>Helichrysum pedunculare</i> ) <sup>g</sup> , Smith (1895) ( <i>isi-Cwe</i> ) <sup>j</sup> , Smith (1966)
	Roots	Ground and burnt	Stomach ache in children Ground and burnt near cattle suffering from black leg			
			As an antiseptic and to induce fast healing: used after circumcision to prevent inflammation externally Also externally applied to wounds and used for infections of the respiratory tract As an antiseptic Stomach ailments	W, Resp, GIT		

Table 1 (Continued)

Species <sup>a</sup>	Plant part used	Dosage form	Traditional use	Classification of use <sup>b</sup>	Biological activity <sup>b</sup>	References
<i>Helichrysum odoratissimum</i> (L.) Sweet <b>4</b>	Leaf/ground plants	Used as wound dressing/leaf pulp	Wounds and burns	W, Fum, Psy, Psyc, M, Resp, Eye, GIT, P	B <sup>d</sup> , F <sup>d</sup> , My	Adjanohoun quoted by Neuwinger (1996), Arnold et al. (2002), Baerts and Lehmann quoted by Neuwinger (1996), Cunningham (1988), Dlamini (1981), Hutchings and Johnson (1986), Hutchings et al. (1996), Hutchings and Van Staden (1994), Jacot Guillarmod (1971), Kokwaro quoted by Neuwinger (1996), Lall and Meyer (1999) <sup>e</sup> , Lourens et al. (2004) <sup>e</sup> , Mathekga and Meyer (1998) <sup>e</sup> , Mathekga (2001) <sup>e</sup> , Neuwinger (1996), Pooley (1998), Pooley (2003), Rwangabo quoted by Neuwinger (1996), Smith (1966), Swanepoel (1997), Van Puyvelde et al., 1989, Van Wyk et al. (2000), Van Wyk and Gericke (2000), Watt and Breyer-Brandwijk (1962)
	Plant	Ointment	The Southern Sotho use this plant to fumigate huts It is mixed with fat to form pleasantly smelling ointment, formerly only used by wives of chiefs			
	Leaf	Ash is rubbed into scarifications Burnt as incense	Insanity, possession Used to invoke the goodwill of the ancestors, protective charm			
		Tea	Aids sleep, relieves muscle tension and cramps			
	Plant, leaf, stems	Smoke inhaled	Used as a sedative and to treat insomnia and as protective cleanser.			
	Root		Colds, coughs			
	Leafy twigs	Ash is eaten	Coughs			
	Leaf and twigs	Extract or sap used as eye drop	Conjunctivitis			
		Decoction	Abdominal pain			
	Aerial parts	Extract	Used to treat dehydration			
	Leaf	Sap	Heartburn, flatulence			
	Root	Extract	Purgative (extract is drunk)			
	Leaf	Ash is eaten	Vomiting			
		Tea	Colic and stitch			
	Leaf	Decoction	Febrile convulsions (part of preparation)			
	Leaf	Smoke inhaled	Headache			
	Leaf	Infusion	Fever (also used as wash)			
	Leaf and twigs	Decoction	Used to treat female sterility, menstrual pain and eczema in Rwanda			
	Leafy twigs	Decoction	Tonic for pregnant women			
Leaf	Decoction	Galactagoque Used a bedding material since it is an effective insect repellent. Sold commercially. The Xhosa also use the plant for spiritual purposes, as a fumigant when a baby is born				
<i>Helichrysum oreophilum</i> Klatt <b>21</b>					B, F <sup>d</sup>	Mathekga and Meyer (1998) <sup>e</sup> , Mathekga (2001) <sup>e</sup>
<i>Helichrysum pallidum</i> DC. (= <i>Helichrysum agrostophilum</i> Klatt (in part) = <i>Helichrysum undatum</i> (Thunb.) Less. var. <i>agrostophilum</i> (Klatt) Moeser = <i>Helichrysum undatum</i> var. <i>pallidum</i> <b>23</b> <sup>h</sup> )	Roots	Bathing in decoction	Preventative charm for illness Burnt as fuel in winter The act of forgetting, The bath is suppose to make a person invisible/or forgotten by his enemies, witchcraft	M		Arnold et al. (2002), Jacot Guillarmod (1971) ( <i>Helichrysum undatum</i> var. <i>agrostophilum</i> ) <sup>g</sup> , Phillips (1917) ( <i>Helichrysum undatum</i> Less., var. <i>pallidum</i> and <i>Helichrysum agrostophilum</i> Klatt) <sup>g</sup>
<i>Helichrysum panduratum</i> O. Hoffm. <b>18</b>	Leaf	Decoction	Febrile convulsions in children (part of a preparation)	P, Infect	A, I	Adjanohoun quoted by Neuwinger (1996), Haerdi quoted by Neuwinger (1996), Neuwinger (1996), Neuwinger (1996), Pooley (1998), Swanepoel (1997) <sup>e</sup>
	Plant	Sap	Used to treat malaria in children Used to make herbal tea			
<i>Helichrysum pandurifolium</i> Schrank. (= <i>Helichrysum auriculatum</i> Less.) <b>18</b>		Infusion, demulcent	Respiratory conditions Backpain, heart trouble, kidney disease, kidney stones Historically been used as a tea	Resp, P, Ca, Renal		Arnold et al. (2002), Roberts (1990) ( <i>Helichrysum auriculatum</i> Less.) <sup>g</sup> , Rood (1994), Smith (1966) ( <i>Helichrysum auriculatum</i> Less.) <sup>g</sup> , Swanepoel (1997), Watt and Breyer-Brandwijk (1962) ( <i>Helichrysum auriculatum</i> Less.) <sup>g</sup>

<i>Helichrysum patulum</i> (L.). Don. (= <i>Helichrysum crispum</i> Less.) <b>18</b>			Heart trouble, backache, kidney disease, also 'heart weakness' (also heart treatment in animals). Stress and fatigue Hyperpiesia, (hyperpepsia is probably a spelling error in Neuwinger), coronary thrombosis, bladder conditions/infections Asthma, Influenza Gynaecological disorders Used as bedding	P, Ca, Renal, Resp		Neuwinger (1996) ( <i>Helichrysum crispum</i> Less.) <sup>g</sup> , Roberts (1990) ( <i>Helichrysum crispum</i> ) <sup>g</sup> , Scott et al. (2004), Smith (1966) ( <i>Helichrysum crispum</i> Less.) <sup>g</sup> , Watt and Breyer-Brandwijk (1962) ( <i>Helichrysum crispum</i> Less.) <sup>g</sup>
<i>Helichrysum pedunculatum</i> Hilliard and Burttt (= <i>Helichrysum pedunculare</i> DC.) <b>23</b>	Leaf and root		As an antiseptic and to induce fast healing: used after circumcision to prevent inflammation externally	W, Resp, Infect, GIT	B	Arnold et al. (2002), Batten and Bokelmann (1966) ( <i>Helichrysum pedunculare</i> DC. <sup>g</sup> , isiCwe <sup>i</sup> , isiGqutsi <sup>i</sup> , Xhosa), Bhat and Jacobs (1995) ( <i>Helichrysum pedunculatum</i> Hilliard and Burttt <sup>g</sup> , isiCwe <sup>i</sup> , siGqutsi <sup>i</sup> , Xhosa), Dilika et al. (1997) <sup>e</sup> , Gerstner (1938) ( <i>Helichrysum pedunculare</i> DC. <sup>g</sup> , isiCwe <sup>i</sup> , Zulu), Githens (1949) ( <i>Helichrysum pedunculare</i> <sup>g</sup> , isicwe <sup>i</sup> , Zulu), Hutchings et al. (1996) ( <i>Helichrysum pedunculatum</i> Hilliard et Burttt <sup>g</sup> , Meyer and Dilika (1996) <sup>e</sup> , Rood (1994) ( <i>Helichrysum pedunculatum</i> <sup>g</sup> , ery'kue <sup>i</sup> , Fingo), Smith (1895) ( <i>Helichrysum pedunculare</i> DC. <sup>g</sup> , isiCwe <sup>e</sup> ), Smith (1966) ( <i>Helichrysum pedunculare</i> DC.) <sup>g</sup> , Neuwinger (1996) ( <i>Helichrysum pedunculatum</i> Hilliard and Burttt <sup>g</sup> , Swanepoel (1997), Watt and Breyer-Brandwijk (1962) ( <i>Helichrysum pedunculare</i> DC.) <sup>g</sup>
<i>Helichrysum petiolare</i> Hilliard and Burttt <b>18</b>	Leaf	Tea	Coughs, colds, catarrh, headache, fever, menstrual disorders, urinary tract infections Antiseptic wound dressing Tea taken for heart conditions, stress, hypertension, anxiety and over-excitement Used as bedding		B <sup>d</sup>	Arnold et al. (2002), Lourens et al. (2004) <sup>e</sup> , Kirstenbosch Botanical Garden, Neuwinger (1996), Roberts (1990) ( <i>Helichrysum petiolatum</i> ) <sup>g</sup> , Scott et al. (2004), Smith (1966) ( <i>Helichrysum petiolatum</i> DC.) <sup>g</sup> , Van Wyk et al. (2000)
<i>Helichrysum platypterum</i> DC. <b>20</b>	Root	Decoction	Renew virility in men	Vi		Arnold et al. (2002), Jacot Guillarmod (1971), Phillips (1917), Watt and Breyer-Brandwijk (1962), Jakupovic et al., 1987
<i>Helichrysum psilolepis</i> Harv. <b>22</b>	Root	Decoction	Dysmenorrhoea Used to weave hats	P	B <sup>d</sup> , F <sup>d</sup>	Arnold et al. (2002), Jacot Guillarmod (1971), Mathekgga (2001) <sup>e</sup> , Phillips (1917), Neuwinger (1996), Watt and Breyer-Brandwijk (1962)
<i>Helichrysum rotundatum</i> (= <i>H. coriaceum</i> (DC.) Harv.) <sup>f</sup> <i>Helichrysum rugulosum</i> Less. <b>9</b>			Used as tea	NS		Smith (1966) ( <i>Helichrysum coriaceum</i> Sond.) <sup>g</sup>
<i>Helichrysum setosum</i> Harv. <b>30</b>	Leaf	Decoction	Protective charm (with <i>Helichrysum callicomum</i> and <i>Aster bakerianus</i> Colic (an ingredient) Used to fumigate huts when children are ill (cold) Love potion Epilepsy Fumigate rooms	M, GIT, Fum	B <sup>d</sup> , F <sup>d</sup>	Arnold et al. (2002), Dlamini (1981), Jacot Guillarmod (1971), Mathekgga and Meyer (1998) <sup>e</sup> , Mathekgga (2001) <sup>e</sup> , Phillips (1917), Pooley (1998), Pooley (2003), Watt and Breyer-Brandwijk (1962) Chabra quoted by Neuwinger (1996), Jacot Guillarmod (1971), Lucas and Pike (1971), Neuwinger (1996), Phillips (1917), Watt and Breyer-Brandwijk (1962)
	Root	Powdered and rubbed into the wound	Snakebite, roots are also mixed with the flesh of the snake and put in the patient's porridge	M, Epilepsy, Fum, Snakebite		



Table 1 (Continued)

Species <sup>a</sup>	Plant part used	Dosage form	Traditional use	Classification of use <sup>b</sup>	Biological activity <sup>b</sup>	References
<i>Helichrysum simillimum</i> DC. <b>8</b>					B <sup>d</sup> , F <sup>d</sup>	Mathekga (2001) <sup>e</sup>
<i>Helichrysum splendidum</i> (Thunb.) Less. <b>22</b>	Roots		Used to treat rheumatism Fuel plant in the mountains	P, Skin		Arnold et al. (2002), Dlamini (1981), Jacot Guillarmod (1971), Pooley (2003), Swanepoel (1997)
	Leaf		The leaves are boiled and the steam inhaled to induce sweating It is used together with <i>Senecio</i> species to treat pimples			
<i>Helichrysum subglomeratum</i> Less. <b>6</b>	Aerial parts	Smoke inhaled	Headaches	P	I	Jäger et al. (1996) <sup>e</sup>
<i>Helichrysum sutherlandii</i> Harv. <b>17</b>	Plant	Burnt, powdered plant material	Powder applied to cuts in the skin of a sick person	M	B <sup>d</sup> , F <sup>d</sup>	Arnold et al. (2002), Jacot Guillarmod (1971), Mathekga (2001) <sup>e</sup> , Phillips (1917), Pooley (1998), Pooley (2003), Watt and Breyer-Brandwijk (1962)
<i>Helichrysum tenax</i> M.D. Hend var. <i>tenax</i> (= <i>Helichrysum fulgidum</i> (L.f) Willd. <b>30</b> <sup>h</sup> )		Decoction	Used for washing sore eyes	Eye	B <sup>d</sup> , F <sup>d</sup>	Arnold et al. (2002) ( <i>Helichrysum fulgidum</i> (L.f) Willd.) <sup>g</sup> , Batten and Bokelmann (1966) ( <i>Helichrysum fulgidum</i> Willd.) <sup>g</sup> , Drewes et al. (2006) <sup>e</sup> , Jacot Guillarmod (1971) ( <i>Helichrysum fulgidum</i> (L.) Willd.) <sup>g</sup> , Phillips (1917) ( <i>Helichrysum fulgidum</i> Willd.) <sup>g</sup>
<i>Helichrysum tomentosulum</i> (Klatt) Merxm <b>1</b>	Twigs	Extract	Used as a perfume (subsp.) <i>aromaticum</i> Twigs are pounded in water and used as mouth wash for tooth ache	P, Renal		Neuwinger (1996), Van Wyk and Gericke (2000), Von Koenen (2001)
	Plant	Smoke inhaled	The entire plant is placed on red hot coals and smoke inhaled for body pain. The same treatment is used by pregnant women suffering from antepartum haemorrhage			
	Root	Decoction	Bladder problems (dribbling) Used as thatching.			
<i>Helichrysum trilineatum</i> DC. <b>22</b>					B <sup>d</sup> , F <sup>d</sup>	Bremner and Meyer (1998) <sup>e</sup> , Mathekga (2001) <sup>e</sup>
<i>Helichrysum umbraculigerum</i> Less. <b>5</b>			Heavily grazed		B <sup>d</sup> , F <sup>d</sup>	Mathekga (2001) <sup>e</sup> , Pooley (1998)
<i>Helichrysum uninervium</i> Burt Davy <b>12</b>			The Swazi use the plant as a purgative or an emetic. They add one teaspoon of the plant to soft porridge which is then eaten by the patient	GIT		Swanepoel (1997)

<sup>a</sup> Where the species name has been changed, the previously accepted name is given in brackets. The following species are no longer classified as *Helichrysum*: *Helichrysum capillaceum* (Thunb.) Less. (Phillips, 1917; Jacot Guillarmod, 1971; Watt and Breyer-Brandwijk, 1962) accepted name now *Troglophyton capillaceum* subsp. *capillaceum* (Thunb.) Hilliard and B.L. Burt (Gibbs Russell et al., 1987); *Helichrysum orbiculare* (Thunb.) Druce (Smith, 1966) accepted name now *Plecostachys serpyllifolia* (P.J. Bergius) Hilliard and B.L. Burt (Gibbs Russell et al., 1987); *Helichrysum sesamoides* Willd. (Smith, 1966) accepted name now *Edmondia sesamoides* (L.) Hilliard (Gibbs Russell et al., 1987); *Helichrysum vestitum* (L.) Willd. (Smith, 1966) accepted name now *Syncarpha vestita* (L.) B. Nord. (Gibbs Russell et al., 1987); *Helichrysum hochstetteri* (A. Rich) Hook. F. (Githens, 1949) and *Helichrysum stenopterum* DC. (Dlamini, 1981) accepted name now *Achyrocline stenoptera* (DC.) Hilliard (Gibbs Russell et al., 1987).

<sup>b</sup> Abbreviations used: A = analgesic activity determined; Anth = anthelmintic; B = antibacterial activity determined; Ca = cardiac conditions; Eye = used in eye conditions; F = antifungal activity determined; Fum = used as fumigant, often plants are burnt in room of a sick person; GIT = gastrointestinal conditions, which include mainly colic, nausea and vomiting, diarrhoea and stomach pain; I = anti-inflammatory activity determined; Infect = conditions associated with infections, such as gonorrhoea and smallpox; Inflam = conditions associated with inflammation such as swelling, menstrual pain; Insect = plants are used to deter insects such as red mites; M = used in a magical sense, to invoke the goodwill of the ancestors and as charms (protective, love); My = antimycobacterial activity determined; NS = not specified; P = conditions associated with pain, inflammation and fever, which include headache, convulsions and dysmenorrhoea; Pl = antiparasitodal (antimalarial) activity determined; Psy = psychotropic use—plants that are used to induce trances; Psc = psychological conditions such as inuresis in children and insomnia; Poi = possible poison, mainly when stock ingest excessive amounts; Renal = conditions associated with kidney and bladder problems; Resp = respiratory conditions, which include colds, coughs, flu, tuberculosis; Skin = used for skin conditions such as keloid scars, abscesses, as ointments; W = used to dress wounds; V = antiviral activity determined; Vi = used for virility in men.

<sup>c</sup> The number refers to the morphological group according to Hilliard (1983).

<sup>d</sup> Antimicrobial activity of 1 mg/ml or less observed for one or more micro-organisms.

<sup>e</sup> Reference associated with biological activity.

<sup>f</sup> In some cases the author name, as indicated in the source, is not present in either Hilliard (1983) or Germishuizen and Meyer (2003). The current author is then chosen.

<sup>g</sup> In cases where the name in the source and the current name differ, the name used in the source is indicated in brackets for clarification.

<sup>h</sup> In cases where the old name is used to describe two different species in the current system, the uses are indicated under both the current names.

<sup>i</sup> Vernacular name.

In some cases, one species name was changed to another, for example *Helichrysum adscendens* Less. var. *cephaloideum* Moeser. in Watt and Breyer-Brandwijk (1962) is now known as *Helichrysum cephaloideum* DC. In other instances, a *Helichrysum* species now belongs to a different genus for example, *Helichrysum capillaceum* (Thunb.) Less. (Watt and Breyer-Brandwijk, 1962) is now classified as *Troglophyton capillaceum* subsp. *capillaceum* (Hilliard, 1983).

Sometimes the same species name with only a different author name refers to a different species, for example *Helichrysum calocephalum* Schltr, which is now classified as *Helichrysum ecklonis* and not *Helichrysum calocephalum* Klatt (Gibbs Russell et al., 1987; Germishuizen and Meyer, 2003). Batten and Bokelmann (1966), Jacot Guillarmod (1971), Phillips (1917) and Watt and Breyer-Brandwijk (1962) all used *Helichrysum calocephalum* Schltr., which is now recognised as *Helichrysum ecklonis*, but in Arnold et al. (2002) there is no reference to *Helichrysum ecklonis* yet the above-mentioned sources are used as references under *Helichrysum calocephalum* Klatt.

The specific *Helichrysum* species referred to when *Helichrysum crispum* is used in ethnobotanical literature is also ambiguous. Germishuizen and Meyer (2003) stated that *Helichrysum crispum* of authors other than (L.) D. Don. is *Helichrysum patulum* (L.) D. Don. and not *Helichrysum crispum* (L.) D. Don. In Watt and Breyer-Brandwijk (1962) and Smith (1966), the name appears as *Helichrysum crispum* Less. therefore indicating *Helichrysum patulum*, although Arnold et al. (2002) cited the name *Helichrysum crispum* (L.) D. Don. (with reference to Smith, 1966) as well as *Helichrysum patulum* with reference to Watt and Breyer-Brandwijk (1962). Roberts (1990) used *Helichrysum crispum* without an author name, causing uncertainty as to which particular species is referred to; the cited medicinal uses are however similar to those indicated by Watt and Breyer-Brandwijk (1962) for *Helichrysum crispum* Less. Salie and co-workers (1996) determined that *Helichrysum crispum* (L.) D. Don. had weak (10 mg/ml) antimicrobial activity against *Pseudomonas aeruginosa*. Both Salie et al. (1996) and Swanepoel (1997) use the name *Helichrysum crispum* (L.) D. Don., but when indicating its traditional uses refer to Watt and Breyer-Brandwijk (1962). Scott et al. (2004) showed that *Helichrysum patulum* had antimicrobial activity against *Staphylococcus aureus* in the disc diffusion assay that was comparable to that of the ciprofloxacin control, while the traditional uses indicated correspond very well to those reported in Watt and Breyer-Brandwijk (1962) for *Helichrysum crispum* Less. Both species occur in the same region making exclusion of one species on the basis of distribution impossible.

*Helichrysum pedunculare* DC. is another name with an unfortunate and confusing history. In this case, it seems that *Helichrysum pedunculare* DC. in ethnobotanical literature could refer to either *Helichrysum pedunculatum* Hilliard and Burt or *Helichrysum nudifolium* var. *pilosellum* (previously known as *Helichrysum pedunculare* (L.) DC. var. *pilosellum*) (Hilliard, 1983; Arnold et al., 2002; Germishuizen and Meyer, 2003). The vernacular name and uses indicated by for example Watt and Breyer-Brandwijk (1962) for *Helichrysum pedunculare* DC. and Bhat and Jacobs (1995) for *Helichrysum pedunculatum* Hilliard and Burt. is similar. According to Hilliard (1983), *Helichrysum pedunculare* (L.) DC. is also a synonym for *Helichrysum odoratissimum* (L.) Sweet.

In some instances it is impossible to decide to which species an author refers, for example *Helichrysum agrostophilum* Klatt (Watt and Breyer-Brandwijk, 1962) that was in part changed to *Helichrysum pallidum* DC. and in part to *Helichrysum griseum* Sond (Germishuizen and Meyer, 2003).

## 2.2. Administration routes

Plant parts used include the leaves, stems, flowers, roots and sometimes the whole plant. The plant remedies are administered in different ways, including the preparation of teas, inhalation of smoke and vapours and placement of leaves in the form of a poultice on wounds to prevent infection (Table 1). Several of these species are known by the same vernacular names, for example *Helichrysum cymosum*, *Helichrysum nudifolium*, *Helichrysum odoratissimum* and *Helichrysum petiolare* are all known as *imphepho* which indicates that they can be used interchangeably, as Van Wyk et al. (2000), noted that “use often depends on local availability rather than preference for a particular species”.

## 2.3. Traditional uses of South African *Helichrysum* species

The traditional uses of *Helichrysum* in South Africa are summarised in Table 1. There are several recurring South African traditional uses for plants from this genus. Smoke is often inhaled to induce trances or to invoke the goodwill of the ancestors. They are often used to treat respiratory conditions and leaves are often applied as wound dressings. They are used in the treatment of gastro-intestinal disorders such as abdominal pain and colic and also eye conditions. They also seem to have an effect on the relief of pain and inflammation as they are used to treat menstrual pain, rheumatism and headaches. The plants are used to fumigate huts and also used as bedding to repel insects.

## 2.4. Correlation between medicinal uses and morphological groups

Plants from almost all morphological groups are used medicinally and the broad spectrum of uses are not restricted to a specific morphological group. In some cases there does seem to be a relationship between the morphological group (according to Hilliard, 1983) or adjacent morphological classes and the traditional uses of these plants. *Helichrysum epapposum* (group 3), *Helichrysum natalitium* (group 3), *Helichrysum gymnocomum* (group 4) and *Helichrysum odoratissimum* (group 4) all share the Zulu/Xhosa name *imphepho* and all are burnt as incense to invoke the goodwill of the ancestors. However, this particular use applies to many species such as, *Helichrysum cymosum* (group 8), *Helichrysum petiolare* (group 18), *Helichrysum dregeanum* (30) and in some sources *Helichrysum nudifolium* (23) share the same vernacular name and use. *Helichrysum cymosum* (group 8), *Helichrysum kraussii* (group 8), *Helichrysum melanacme* (group 8), *Helichrysum athrixiifolium* (group 9) and *Helichrysum dregeanum* (group 9) are all used to treat respiratory complaints such as coughs and colds. The administration route of these remedies do however vary; for *Helichrysum athrixiifolium* the leaf is smoked, for *Helichrysum kraussii* the dried flowers and seeds are smoked in a pipe, for *Helichrysum cymosum* a decoction of leaves is drunk, for *Helichrysum dregeanum* the leaf is smoked and the administration route is not indicated in the source for *Helichrysum melanacme*.

South African species are not often used to treat heart and kidney ailments. Both *Helichrysum pandurifolium* and *Helichrysum patulum* belongs to group 18, and are indicated in the treatment of kidney disease and heart disorders. Both are also used to treat backpain and respiratory conditions by the same administration route. Plants from groups 23 and 24 are often used to treat wounds. The leaves of *Helichrysum miconiifolium* (group 23), *Helichrysum nudifolium* (group 23), *Helichrysum pedunculatum* (group 23), *Helichrysum appendiculatum* (group 24) and *Helichrysum longifolium* (group 24) are all used as wound dressings. However, *Helichrysum foetidum* (group 30) is mentioned as a replacement for *Helichrysum pedun-*

*culatum* in the treatment of circumcision wounds (Gerstner, 1938). The species constituting group 23 are also used for respiratory conditions including, *Helichrysum mundtii*, *Helichrysum nudifolium* and *Helichrysum pedunculatum*. Root decoctions of both *Helichrysum adenocarpum* and *Helichrysum ecklonis* belonging to group 28 are used to treat diarrhoea in children, while a root infusion from *Helichrysum argyrophyllum* (group 29) is used to treat intestinal troubles. It is interesting to note that the only two species indicated for the treatment of snakebite both belong to group 30, namely *Helichrysum cooperi* and *Helichrysum setosum*.

### 3. Phytochemistry

The chemistry of this genus is complex with a wide variety of chemical classes occurring as is evident from the three major publications by Bohlmann and Jakupovic (Bohlmann and Zdero, 1980a; Jakupovic et al., 1986; Jakupovic et al., 1989) in which a total of 63 South African *Helichrysum* species were investigated chemically. The classes of compounds isolated from the South African *Helichrysum* species are summarised in Table 2 and Fig. 1. Acylphloroglucinols (**1–3**) are common, often with prenyl or geranyl side chains. The replacement of the cinnamic moiety by other acyl CoA derivatives in the biosynthesis of the main constituents seem to be characteristic (Jakupovic et al., 1989). The presence of humulone derivatives, such as helihumulone (**4**) is also widespread (Jakupovic et al., 1989).

Flavonoids (**5–11**) derived from phloroglucinol are very common and often have unsubstituted B rings (Bohlmann and Abraham, 1979a,d; Jakupovic et al., 1986) which is a characteristic feature of plants from the Inuleae tribe (Harborne, 1977). The presence of 6- and 8-hydroxyflavonols and their methyl ethers (**7**) are also frequent as in other members of the tribe (Harborne, 1977). A wide variety of chalcones (**8–10**) are also found, including dihydrochalcones (**11**), pyranochalcones (**10**) and those substituted with prenyl (**9**) or geranyl groups. As in other Inuleae species, these chalcones are often accompanied by their structurally and biogenetically related flavanones (Harborne, 1977) as can be seen for *Helichrysum acutatum* (**5** and **8**) (Bohlmann and Abraham, 1979c), *Helichrysum cymosum* (Jakupovic et al., 1989) and *Helichrysum oreophilum* (Jakupovic et al., 1986).

The presence of  $\alpha$ -pyrones (**12**) is rather common (they occur in plants from morphologic groups 1, 2, 4, 12, 15, 18, 19 and 24) and they are often isolated from the roots of these plants (Hänsel et al., 1980; Jakupovic et al., 1986, 1989). Different types of diterpenes occur; these include the kaurenoic acid type (**15**, Jakupovic et al., 1989) as well as those derived from helifulvanic acid (**13**, Bohlmann et al., 1980b). Sesquiterpenes representing a variety of skeletal types occur, as is characteristic for the rest of the family (Hegnauer, 1977). Some skeletal types, such as the humulenes, are widely distributed across the genus, whereas others such as the guaianolides (**16**) are restricted to a few species (morphological groups 10 and 22). *Helichrysum* species are known for their aromaticity and a variety of monoterpenes are reported in the essential oils of some species (Lourens et al., 2004; Frum and Viljoen, 2006; Van Vuuren et al., 2006; Asekun et al., 2007). Squalene is the most common triterpene found and is often in high concentration.

Another unusual type of compound that occurs is thiophene derivatives (**17**, **18**) which have been isolated from the roots of species such as *Helichrysum acutatum* and *Helichrysum tenuifolium*. These thiophenes are the result of addition reactions of a common chloro-acetylene precursor with H<sub>2</sub>S (Bohlmann and Abraham, 1979b,c). Simple polyacetylenes (**20**) are widespread. Acetylenes with pyran (**19**) and furan moieties, some with epoxy and/or chlorine substitution, occur in these plants and is characteristic of the

Gnaphaliineae (Harborne, 1977).

As for the traditional uses, one particular class of compound is not restricted to a particular morphologic group. However, there are some compounds that occur mainly in a specific morphological class. For example, phloroglucinols (excluding those belonging to the flavonoid class) feature as major compounds in morphological classes 2, 3, 4, 12, 14, 15, 20, 24 and 28. Flavonoids are present in almost all of the morphological groups, but a large number are found in plants from groups 8, 9 and 27. Diterpenes were isolated in large quantities from species in groups 23, 25 and 30 (all 10 plants investigated in this group had this type of compound as the major chemical species). *Helichrysum umbraculigerum* from group 5 seems to be the only species investigated that contains compounds of the cannabigerol type (**21**) as the major constituent and *Helichrysum dasyanthum* (group 10) and *Helichrysum splendidum* (group 22) contain mainly sesquiterpenes of the guaianolide type (which is absent in the other species). Plants from groups 6, 18 and 19 are also rich in sesquiterpenes (Table 2).

Although there seem to be similarities in the chemistry of the European and South African species, the Australian species are chemically different from their South African counterparts (Jakupovic et al., 1989, 1989a).

### 4. Biological activity

#### 4.1. Anti-infective activity

Considering the traditional uses of this genus (specifically the treatment of wounds and respiratory tract infections and the application as a fumigant for example), there seems to be a strong indication that these plants and their compounds should exhibit antimicrobial activity. Several studies on the antimicrobial activity of *Helichrysum* species was done by the group of Meyer from the University of Pretoria, South Africa. Extracts of several species (Table 1) were submitted to antibacterial testing using a group of randomly selected bacteria which normally included the Gram-positive bacteria: *Bacillus cereus*, *Bacillus pumilis*, *Bacillus subtilis*, *Micrococcus kristinae*, *Staphylococcus aureus* and the Gram-negatives: *Enterobacter cloacae*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Serratia marcescens*. Acetone extracts were mostly tested, but in a few cases methanol, water and dichloromethane extracts were used. Assays involving agar dilution and direct autobiography were employed (Meyer and Afolayan, 1995; Meyer and Dilika, 1996; Afolayan and Meyer, 1997; Dilika et al., 1997; Mathekgga and Meyer, 1998; Bremner and Meyer, 2000; Mathekgga et al., 2000; Mathekgga, 2001). Antifungal activity was also determined for fungi such as *Aspergillus flavus*, *Aspergillus niger*, *Cladosporium cladosporioides*, *Cladosporium cucumerinum*, *Cladosporium sphaerospermum* and *Phytophthora capsici* (Mathekgga, 2001).

Reports on antimicrobial activities from other laboratories include the relatively weak antimicrobial activity (Gibbons, 2004) documented for extracts of *Helichrysum foetidum* (MIC's of more than 4 mg/ml against all selected bacteria in the 96-well plate assay, Steenkamp et al. (2004) and *Helichrysum crispum* (L.) D. Don. where MIC's of 10 mg/ml were reported against *Pseudomonas aeruginosa* and *Candida albicans* (Salie et al., 1996). Activities ranging from 0.078 to 0.3 mg/ml against Gram-positive bacteria, Gram-negative bacteria and yeasts were also reported for a *Helichrysum cymosum* extract (Van Vuuren et al., 2006). Acetone and methanol extracts of *Helichrysum odoratissimum* (incorrectly identified as *Helichrysum dasyanthum* in Lourens et al., 2004), *Helichrysum excisum*, *Helichrysum felinum* and *Helichrysum petiolare* displayed activity against *Staphylococcus aureus* and *Bacillus cereus*. The species with the best

**Table 2**  
Classes of compounds isolated from South African *Helichrysum* species

Species	Morphologic group	Flavonoid derivatives <sup>a,b</sup>						Phloroglucinols <sup>b</sup>	Pyrones <sup>b</sup>	Diterpenes <sup>b</sup>	Terpenes <sup>b</sup>	Other <sup>b</sup>	Reference
		A	B	C	D	E	F						
<i>Helichrysum acutatum</i> DC. <sup>c</sup> Roots and aerial parts	21	X	X						X	X	X	Bohlmann and Abraham (1979c)	
<i>Helichrysum adenocarpum</i> DC. <sup>c</sup> Roots and aerial parts	28										X	Bohlmann et al. (1980a)	
<i>Helichrysum albirosulatum</i> Killick Roots and aerial parts	6								X	X		Bohlmann et al. (1980a), Bohlmann et al. (1978a)	
<i>Helichrysum allioides</i> Less. Roots	23										X	Bohlmann and Zdero (1973)	
<i>Helichrysum anomalum</i> Less. Aerial parts	9						X			X		Jakupovic et al. (1989)	
<i>Helichrysum appendiculatum</i> (L.f.) <sup>c</sup> Less. Aerial parts	24									X		Bohlmann et al. (1980a)	
<i>Helichrysum argentissimum</i> J.M. Wood. Roots	28								X	X	X	Bohlmann et al. (1980a)	
<i>Helichrysum argyrolepis</i> MacOwan Aerial parts	29		X	X								Bohlmann et al. (1984)	
<i>Helichrysum argyrophyllum</i> DC. <sup>c</sup> Aerial parts and roots	29				X				X	X	XX	Jakupovic et al. (1989), Bohlmann and Zdero (1973)	
<i>Helichrysum asperum</i> (Thunb.) Hilliard et Burtt. var. <i>albidulum</i> (DC.) Hilliard Aerial parts	12							XXXX				Jakupovic et al. (1989)	
<i>Helichrysum athrixifolium</i> (Kuntze) <sup>c</sup> Moeser Aerial parts and roots	9	X	X									Bohlmann and Ates (1984)	
<i>Helichrysum aureonitens</i> Sch. Bip. <sup>c</sup> Roots and aerial parts	8				X					XX	X	Bohlmann and Ziesche (1979), Afolayan and Meyer (1997), Meyer et al. (1997)	
<i>Helichrysum aureum</i> (Houtt.) Merr. <sup>c</sup> Aerial parts and roots	30								XX	X		Jakupovic et al. (1989)	
<i>Helichrysum aureum</i> (Houtt.) Merr. var. <i>monocephalum</i> (DC.) Hilliard Aerial parts and roots	30								XX	X		Bohlmann et al. (1978a)	
<i>Helichrysum auriceps</i> Hilliard Roots	24						X	X			X	Bohlmann and Zdero (1980)	
<i>Helichrysum bellum</i> Hilliard Aerial parts and roots	28						X		X	X	X	Bohlmann and Zdero (1979a)	
<i>Helichrysum caespitium</i> DC. Harv. <sup>c</sup> Whole plant Aerial parts	12						X					Dekker et al. (1983), Mathekga et al. (2000)	

Table 2 (Continued)

Species	Morphologic group	Flavonoid derivatives <sup>a,b</sup>						Phloroglucinols <sup>b</sup>	Pyrones <sup>b</sup>	Diterpenes <sup>b</sup>	Terpenes <sup>b</sup>	Other <sup>b</sup>	Reference
		A	B	C	D	E	F						
<i>Helichrysum callicomum</i> Harv. <sup>c</sup> Aerial parts and roots	2	X						XX	X	X	XX	X	Bohlmann and Abraham (1979a) ( <i>Helichrysum callicomum</i> <sup>d</sup> ) Bohlmann et al. (1984)
<i>Helichrysum candolleianum</i> H. Buek Aerial parts	15							X		X			Jakupovic et al. (1989)
<i>Helichrysum cephaloideum</i> DC. Roots and aerial parts	24				X			XXX	XX		X		Hänsel et al. (1980), Bohlmann and Zdero (1980), Jakupovic et al. (1986)
<i>Helichrysum cerastioides</i> DC. Aerial parts	15							X	X			X	Bohlmann et al. (1984), Jakupovic et al. (1989) ( <i>Helichrysum cerastioides</i> DC. ssp. <i>aurosicum</i> Merxm. et A. Schreiber <sup>d</sup> )
<i>Helichrysum chionosphaerum</i> DC. Aerial parts and roots	25				X					XXX	XX	X	Bohlmann et al. (1980b), Jakupovic et al. (1989)
<i>Helichrysum chrysargyrum</i> Moeser Aerial parts and roots	22				X			XX			X		Bohlmann et al. (1979a)
<i>Helichrysum confertum</i> N.E.Br Roots	17								XX				Bohlmann et al. (1978a)
<i>Helichrysum cooperi</i> Harv. <sup>c</sup> Roots and aerial parts	30					X			X				Bohlmann et al. (1978a)
<i>Helichrysum cooperi</i> ps. aff. <i>Helichrysum cooperi</i> Harv.	?		X										Wright (1976)
<i>Helichrysum cymosum</i> (L.) D. Don. <sup>c</sup> Aerial parts	8	XX	X	X	X							X	Jakupovic et al. (1989)
<i>Helichrysum cymosum</i> (L.) Don. ssp. <sup>c</sup> <i>calvum</i> Roots and aerial parts	8		XX	X							X		Bohlmann et al. (1979b)
<i>Helichrysum cymosum</i> (L.) D. Don. <sup>c</sup> ssp. <i>cymosum</i>	8				X								Van Vuuren et al. (2006)
<i>Helichrysum dasyanthum</i> (Willd.) Sweet Aerial parts	10				X				X		XX	X	Jakupovic et al. (1989)
<i>Helichrysum dasymallum</i> Hilliard (= <i>Helichrysum lanatum</i> Harv.) Roots	21											X	Bohlmann and Zdero (1973) ( <i>Helichrysum lanatum</i> DC. <sup>d</sup> )
<i>Helichrysum decorum</i> DC. <sup>c</sup> Aerial parts	30		X										Bohlmann et al. (1980a)
<i>Helichrysum drakensbergense</i> Killick Roots and aerial parts	19								X	X	XX	X	Bohlmann and Suwita (1979)
<i>Helichrysum dregeanum</i> Sond. and Harv. <sup>c</sup> Aerial parts	9		X		X			X			X		Jakupovic et al. (1989)
<i>Helichrysum felinum</i> Less. Aerial parts	17		X		X			X					Jakupovic et al. (1989)

<i>Helichrysum flanaganii</i> Bolus <sup>c</sup> Aerial parts and roots	13					X															Bohlmann et al. (1980a)						
<i>Helichrysum foetidum</i> (L.) Moench. <sup>c</sup> Roots	30																				X	Bohlmann and Zdero (1973)					
<i>Helichrysum fulvum</i> N. E. Br. Aerial parts and roots	30																				XX	X	Bohlmann et al. (1979c)				
<i>Helichrysum glaciale</i> Hilliard Aerial parts	27	X																					Bohlmann et al. (1980a)				
<i>Helichrysum glomeratum</i> Klatt Aerial parts	6		X																		X	XX	Bohlmann and Suwita (1979)				
<i>Helichrysum grandiflorum</i> (L.) D. Don. Roots	17																						X	Bohlmann and Zdero (1973)			
<i>Helichrysum gymnocomum</i> DC. <sup>c</sup> Roots and aerial parts	4																						XX	X	Bohlmann and Mahanta (1979) ( <i>Helichrysum gymnoconum</i> DC. <sup>d</sup> )		
<i>Helichrysum gymnocomum</i> DC. <sup>c</sup> Flowers	4	X	X																				X	Drewes and Van Vuuren (2008)			
<i>Helichrysum herbaceum</i> (Andrews) Sweet <sup>c</sup> Aerial parts	29	X																					XX	X	Bohlmann et al. (1979a)		
<i>Helichrysum heterolasium</i> Hilliard Aerial parts	30		X		X																		XX	XX	X	Bohlmann and Abraham (1979a)	
<i>Helichrysum hypophyllum</i> Hilliard Aerial parts and roots	27	XX																					X	X	Bohlmann and Abraham (1979d) ( <i>Helichrysum hypocephalum</i> Hilliard <sup>d</sup> )		
<i>Helichrysum indicum</i> (L.) Grierson <sup>c</sup> Aerial parts	15																							X	Jakupovic et al. (1989)		
<i>Helichrysum infaustum</i> J.M. Wood. and M.S. Evans Aerial parts	4																							X	X	Bohlmann and Suwita (1979)	
<i>Helichrysum kraussii</i> Sch. Bip. <sup>c</sup> Aerial parts, flowers and roots	8		X		X	X																	X	XX	Jakupovic et al. (1989), Bremner and Meyer (2000), Candy et al. (1975), Candy and Wright (1975)		
<i>Helichrysum krebsianum</i> Less. Aerial parts	23																							X	Bohlmann et al. (1980a)		
<i>Helichrysum krookii</i> Moeser Roots and aerial parts	5																							XX	X	X	Bohlmann et al. (1980a)
<i>Helichrysum lepidissimum</i> S. Moore Aerial parts	19	X																					X		X	Jakupovic et al. (1989)	
<i>Helichrysum litorale</i> Bolus <sup>c</sup> (= <i>Leontonyx angustifolius</i> DC., = <i>Leontonyx spathulatus</i> Less.)	14																							XX	X	Bohlmann and Suwita (1978) ( <i>Leontonyx spathulatus</i> Less. <sup>d</sup> )	

Table 2 (Continued)

Species	Morphologic group	Flavonoid derivatives <sup>a,b</sup>						Phloroglucinols <sup>b</sup>	Pyrones <sup>b</sup>	Diterpenes <sup>b</sup>	Terpenes <sup>b</sup>	Other <sup>b</sup>	Reference
		A	B	C	D	E	F						
<i>Helichrysum melanacme</i> (DC.) Harv. <sup>c</sup> Shoots	8		X		X								Lall et al. (2006)
<i>Helichrysum miconiifolium</i> DC. <sup>c</sup> Roots	23								X				Bohlmann et al. (1980a)
<i>Helichrysum mimetes</i> S. Moore Aerial parts	19					X			X	X	XX		Jakupovic et al. (1986)
<i>Helichrysum mixtum</i> (Kuntze.) Moeser Roots	24							XX	XX				Jakupovic et al. (1986)
<i>Helichrysum moeserianum</i> Thell. Aerial parts	22							X		X			Jakupovic et al. (1989)
<i>Helichrysum monticola</i> Hilliard Aerial parts and roots	28				X			XX			X		Jakupovic et al. (1989), Bohlmann and Zdero (1980a)
<i>Helichrysum mundtii</i> Harv. <sup>c</sup> (= <i>Helichrysum mundii</i> Harv.) <sup>d</sup> Roots and aerial parts	23				X		X			X	X		Bohlmann et al. (1978b), Bohlmann et al. (1980a)
<i>Helichrysum nanum</i> Klatt Aerial parts	6							X		X	X		Bohlmann and Suwita (1979)
<i>Helichrysum natalitium</i> DC. <sup>c</sup> Aerial parts and roots	3							XX			X	X	Bohlmann and Zdero (1979a)
<i>Helichrysum nudifolium</i> L. Less. var. <i>nudifolium</i> <sup>c</sup> Aerial parts and roots	23							XX		X	XXX	X	Jakupovic et al. (1986), Bohlmann et al. (1978a) ( <i>Helichrysum nudifolium</i> L. Less. <sup>d</sup> ) Bohlmann and Zdero (1973) ( <i>Helichrysum nudifolium</i> L. Less. <sup>d</sup> ) Bohlmann et al. (1980a) ( <i>Helichrysum oxyphyllum</i> Klatt <sup>d</sup> )
<i>Helichrysum nudifolium</i> var. <i>oxyphyllum</i> (= <i>Helichrysum oxyphyllum</i> DC.) <sup>c</sup> Aerial parts	23		X	X						X	X		
<i>Helichrysum nudifolium</i> var. <i>pilosellum</i> (= <i>Helichrysum latifolium</i> Less.) <sup>c</sup>	23											X	Bohlmann and Zdero (1973) ( <i>Helichrysum latifolium</i> Less. <sup>d</sup> )
<i>Helichrysum nudifolium</i> var. <i>pilosellum</i> (= <i>Helichrysum pilosellum</i> (L.f.) Less.) Roots	23									XX			Jakupovic et al. (1986) ( <i>Helichrysum pilosellum</i> (L.f.) Less. <sup>d</sup> )
<i>Helichrysum odoratissimum</i> (L.) Sweet <sup>c</sup> Aerial parts and roots	4			X		X		XX	X	X		X	Van Puyvelde et al. (1989), Hänsel et al. (1980), Bohlmann and Zdero (1973)
<i>Helichrysum oreophilum</i> Klatt. Aerial parts	21		X	X				X		X	X		Jakupovic et al. (1986), Bohlmann et al. (1980a)
<i>Helichrysum pagophilum</i> M.D. Hend. Aerial parts	27					X							Bohlmann et al. (1980a)

<i>Helichrysum pallidum</i> DC. <sup>c</sup> Aerial parts and roots	23								XX	X	Bohlmann et al. (1980a)
<i>Helichrysum panduratum</i> O.Hoffm. <sup>c</sup> Aerial parts	18									X	Bohlmann and Abraham (1979b)
<i>Helichrysum patulum</i> (L.) D. Don. <sup>c</sup> (= <i>Helichrysum crispum</i> Less.) Aerial parts	18							XX		X	Bohlmann and Suwita (1979) ( <i>Helichrysum crispum</i> Less. <sup>d</sup> )
<i>Helichrysum pedunculatum</i> Hilliard and Burt <sup>c</sup> Leaves	23										X Dilika et al. (2000)
<i>Helichrysum petiolare</i> Hilliard and B.L. Burt <sup>c</sup> Aerial parts	18		X			X		X	X	XX	X Jakupovic et al. (1989), Bohlmann and Zdero (1973) ( <i>Helichrysum petiolatum</i> DC. <sup>d</sup> )
<i>Helichrysum platypterum</i> DC. <sup>c</sup> Aerial parts and roots	20				X	X	X	XXX		X	X Jakupovic et al. (1986), Bohlmann et al. (1980a), Bohlmann and Zdero (1979a), Jakupovic et al., 1987
<i>Helichrysum polycladum</i> Klatt Aerial parts and roots	8	X	X	X				X			X Bohlmann et al. (1980a)
<i>Helichrysum populifolium</i> DC. Roots	16										X Bohlmann et al. (1980a)
<i>Helichrysum reflexum</i> N. E. Br. Aerial parts	29									XX	XX Bohlmann et al. (1985) ( <i>Helichrysum reflexum</i> N. E. Br. <sup>d</sup> )
<i>Helichrysum revolutum</i> (Thunb.) Less. Aerial parts	9		X			X		X			Jakupovic et al. (1989)
<i>Helichrysum retortoides</i> N.E. Br. Aerial parts	26										X Bohlmann et al. (1980a)
<i>Helichrysum rosum</i> (Berg.) Less. Aerial parts	9							X			X Jakupovic et al. (1989)
<i>Helichrysum nudifolium</i> L. Less. var. <i>nudifolium</i> (= <i>Helichrysum coriaceum</i> Harv.) Roots	23									XX	X Bohlmann et al. (1984a) ( <i>Helichrysum coriaceum</i> Harv. <sup>d</sup> )
<i>Helichrysum ruderale</i> Hilliard and B.L. Burt <sup>c</sup> Aerial parts	30									X	Bohlmann et al. (1980a)
<i>Helichrysum rugulosum</i> Less. <sup>c</sup> Aerial parts and roots	9	XX	XX								Bohlmann and Misra (1984)
<i>Helichrysum scabrum</i> (Thunb.) Less. Aerial parts	9		X					X			Jakupovic et al. (1989)
<i>Helichrysum setosum</i> Harv. <sup>c</sup> Aerial parts	30									XX	Jakupovic et al. (1986)
<i>Helichrysum spiralepis</i> Hilliard and Burt <sup>c</sup> . (= <i>Leontonyx squarrosus</i> )	14							XX			X Bohlmann and Suwita (1978) ( <i>Leontonyx squarrosus</i> <sup>d</sup> )



Table 2 (Continued)

Species	Morphologic group	Flavonoid derivatives <sup>a,b</sup>						Phloroglucinols <sup>b</sup>	Pyrones <sup>b</sup>	Diterpenes <sup>b</sup>	Terpenes <sup>b</sup>	Other <sup>b</sup>	Reference
		A	B	C	D	E	F						
<i>Helichrysum splendidum</i> (Thunb.) Less. <sup>c</sup> Aerial parts and roots	22			X	X					XXX	X	Bohlmann and Suwita (1979a), Jakupovic et al. (1989)	
<i>Helichrysum subfalcatum</i> Hilliard Aerial parts	6								X	X		Bohlmann et al. (1980a)	
<i>Helichrysum subglomeratum</i> Less. <sup>c</sup> Aerial parts	6		X	X						X		Jakupovic et al. (1989)	
<i>Helichrysum sutherlandii</i> Harv. (= <i>Helichrysum sutherlandii</i> Harv.) <sup>c</sup> Aerial parts and roots	17		X	X					X		X	Bohlmann et al. (1978b), Bohlmann et al. (1980a)	
<i>Helichrysum swynnertonii</i> S. Moore Aerial parts and roots	25										X	Bohlmann et al. (1980a)	
<i>Helichrysum tenax</i> var. <i>tenax</i> M.D. Hend. Leaves	30								XX			Drewes et al. (2006)	
<i>Helichrysum tenuiculum</i> DC. Aerial parts and roots	8	X	X	X						X		Bohlmann et al. (1979b)	
<i>Helichrysum tenuifolium</i> Killick. Aerial parts and roots	22	X		X	X	X	X			X	XX	Bohlmann and Abraham (1979b)	
<i>Helichrysum thapsus</i> (O. Kuntze) Mooser Aerial parts	23	X										Bohlmann and Zdero (1983)	
<i>Helichrysum tomentosulum</i> Klatt. Merxm subsp. <i>aromaticum</i> (Dinter) Merxm. <sup>c</sup> Aerial parts	1		X		X							Jakupovic et al. (1989)	
<i>Helichrysum tricostatum</i> (Thunb.) Less. Aerial parts	11				X							Jakupovic et al. (1989)	
<i>Helichrysum trilineatum</i> DC. Shoots and roots	22									X	X	Bremner and Meyer (1998), Bohlmann et al. (1980a)	
<i>Helichrysum umbraculigerum</i> Less. Aerial parts	5		X							X	XXX	Bohlmann and Hoffmann (1979)	
<i>Helichrysum vernum</i> Hilliard Roots	28								X	X		Bohlmann et al. (1980a)	
<i>Helichrysum zeyheri</i> Less. Aerial parts	1							X	X	X		Jakupovic et al. (1986)	

<sup>a</sup> A = flavanone, B = chalcone, C = dihydrochalcone, D = flavonol, E = flavone, F = other flavonoids.

<sup>b</sup> X = 3 or less compounds isolated; XX = 4–9 compounds isolated; XXX = 10 or more compounds isolated, XXXX = more than 20 compounds isolated.

<sup>c</sup> Used in traditional medicine.

<sup>d</sup> Name as used in reference.

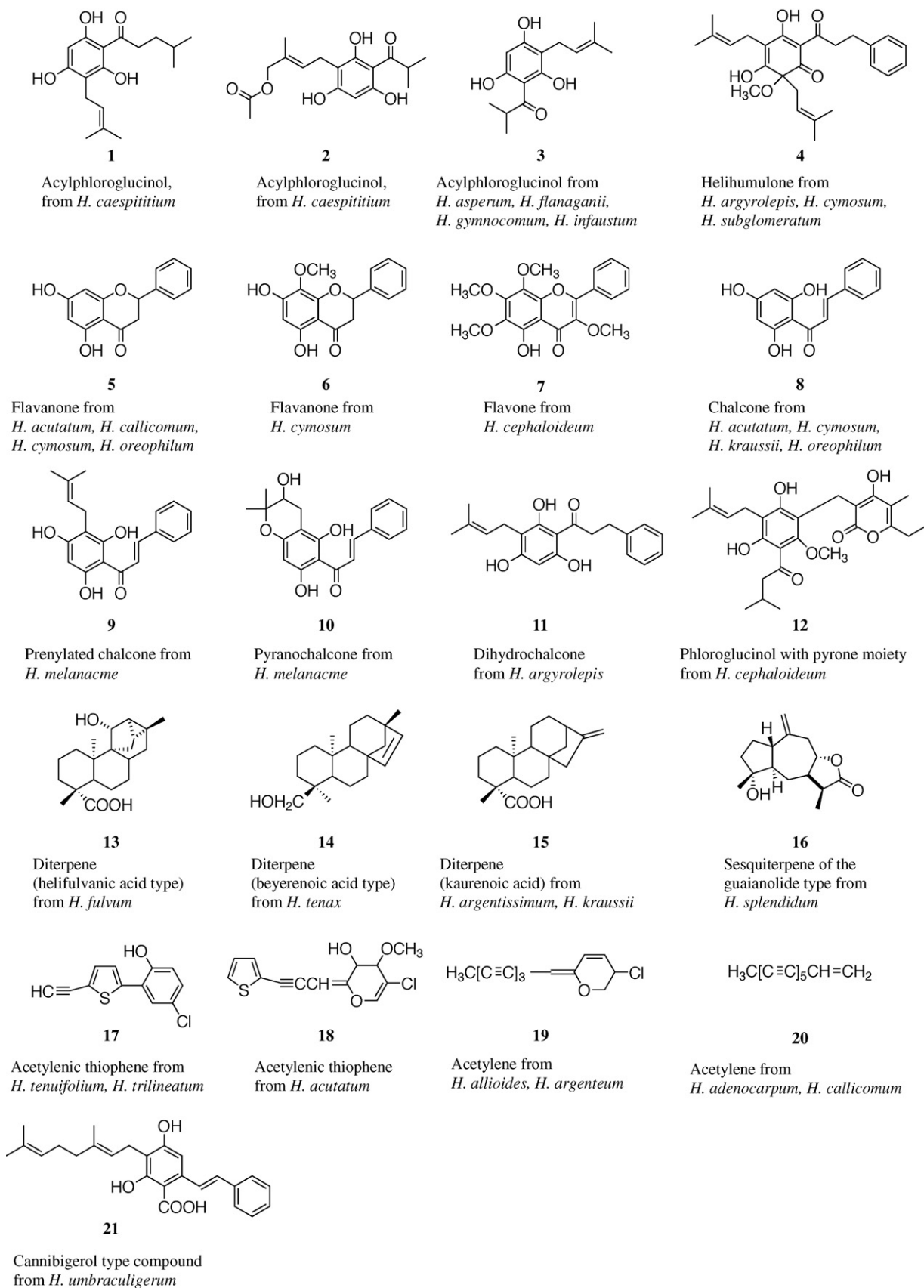


Fig. 1. Compounds isolated from South African *Helichrysum* species.

activity was the acetone extract of *Helichrysum odoratissimum* with an MIC of 0.016 mg/ml against *Staphylococcus aureus* (which correlates well with the values obtained by Mathekga and Meyer, 1998).

*Helichrysum* species are often used to treat respiratory conditions and tuberculosis (Table 1). Extracts of *Helichrysum odoratissimum* and *Helichrysum melanacme* showed activity against *Mycobacterium tuberculosis* at concentrations of 0.5 mg/ml (Lall and Meyer, 1999; Lall et al., 2006). The acetone extract of *Helichrysum caespitium* inhibited a drug sensitive-strain of *Mycobacterium tuberculosis* at a concentration of 0.5 mg/ml in the agar plate method and a MIC of 0.1 mg/ml was observed using the rapid radiometric method (Meyer et al., 2002). The water extract caused partial inhibition at the highest concentration of 5 mg/ml.

In some cases the antimicrobial activity of isolated compounds was determined. Flavonoids are generally one of the largest classes of antibacterial compounds (Gibbons, 2004). Galangin (3,5,7-trihydroxyflavone) isolated from *Helichrysum aureonitens* (Meyer and Afolayan, 1995), inhibited the growth of four Gram-positive bacteria (three *Bacillus* species and *Micrococcus kristinae*) as well as the Gram-negative *Enterobacter cloacae* (Afolayan and Meyer, 1997). The highest activity observed was against *Bacillus cereus*, *Micrococcus kristinae* and *Enterobacter cloacae* at 0.1 mg/ml. In other studies by Cushnie et al. (2003) and Cushnie and Lamb (2006), the activity of galangin was shown against six strains of  $\beta$ -lactam sensitive and resistant strains of *Staphylococcus aureus* and 16 strains of 4-quinolone resistant strains of the bacterium at MIC's of approximately 50  $\mu$ g/ml. Galangin also displays some antifungal activity against fungi such as *Aspergillus tamari* (35% growth inhibition at 0.5 mg/ml) (Afolayan and Meyer, 1997). These results support the use of *Helichrysum aureonitens* in the treatment of skin infections, often caused by *Staphylococcus aureus*.

Another flavonoid, 3-O-methylquercetin was isolated from *Helichrysum odoratissimum* and antimicrobial activity determined for a broad range of micro-organisms including Gram-negative bacteria such as *Salmonella typhimurium* (MIC = 50  $\mu$ g/ml), Gram-positive bacteria, such as *Staphylococcus aureus* (MIC = 6.25  $\mu$ g/ml) and fungi, for example *Candida albicans* (MIC = 12.5  $\mu$ g/ml), in the microdilution method (Van Puyvelde et al., 1989). Bremner and Meyer (1998) also reported on the anti-staphylococcal activity for pinocembrin chalcone (**8**, isolated from *Helichrysum trilineatum*), as well as pinocembrin (**5**) that was obtained as an artifact during the isolation procedure. Flavonoids isolated from the flowers of *Helichrysum gymnocomum* exhibited promising antimicrobial activity against a wide variety of Gram-positive and Gram-negative organisms as well as yeasts. An MIC of 8  $\mu$ g/ml was for example observed against *Cryptococcus neoformans* for 5,7-dibenzyloxyflavanone (Drewes and Van Vuuren, 2008). Two chalcones isolated from *Helichrysum melanacme* (**9**, **10**) exhibited MIC's of 0.05 mg/ml against the drug sensitive H37Rv strain of *Mycobacterium tuberculosis*. The activity of the chalcones was higher than that of the crude extract but a combination of the two chalcones did not result in an improved MIC (Lall et al., 2006).

There are also reports on the antimicrobial activity of compounds other than flavonoids. Activity against Gram-positive bacteria was observed for both linoleic and oleic acids, isolated from antibacterial extracts of *Helichrysum pedunculatum* (a plant used to treat circumcision wounds, Dilika et al., 2000). The MIC of both fatty acids was 1.0 mg/ml for *Staphylococcus aureus* and *Micrococcus kristinae* in the agar diffusion assay. The MIC's was 0.05 mg/ml of each fatty acid when they were administered at the same time (Dilika et al., 2000).

Kaurenoic acid (**15**, a diterpene), isolated from *Helichrysum kraussii*, exhibited a MIC as low as 1  $\mu$ g/ml against *Escherichia coli* and MIC's of 10  $\mu$ g/ml against *Bacillus cereus*, *Bacillus sub-*

*tilis*, *Staphylococcus aureus* and *Serratia marcescens* (Bremner and Meyer, 2000). Significant antimicrobial activity was also observed for monomeric (**14**) and dimeric diterpenes from *Helichrysum tenax* var. *tenax*. MIC values as low as 3.1 and 3.6  $\mu$ g/ml were determined against *Bacillus cereus* whereas MIC's as low as 41.5  $\mu$ g/ml were determined for a Gram-negative organism such as *Pseudomonas aeruginosa* (Drewes et al., 2006).

MIC's of 100  $\mu$ g/ml were observed for prenylated butyrylphloroglucinol (**3**) isolated from *Helichrysum kraussii* against *Bacillus cereus*, *Bacillus pumilis*, *Bacillus subtilis*, *Micrococcus kristinae*, *Staphylococcus aureus*, *Serratia marcescens* and *Escherichia coli* in an agar diffusion assay (Bremner and Meyer, 2000). The same phloroglucinol was isolated from *Helichrysum gymnocomum* and MIC's of below 100  $\mu$ g/ml (6–45  $\mu$ g/ml) were reported for *Enterococcus faecalis*, *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Bacillus cereus*, *Pseudomonas aeruginosa*, *Cryptococcus neoformans* and *Candida albicans* (Drewes and Van Vuuren, 2008). A difference in assays employed, inoculum size and possibly different strains of the same micro-organism used may account for the observed difference in activity. A structurally related phloroglucinol also exhibited promising antibacterial activity against *Enterococcus faecalis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Cryptococcus neoformans* (Drewes and Van Vuuren, 2008). Caespitin (**1**) and caespitate (**2**) (both phloroglucinols) exhibited antimicrobial activity against several bacteria as well as fungi (Dekker et al., 1983; Mathekga et al., 2000). Caespitin (**1**) was active against *Staphylococcus aureus*, *Streptococcus pyogenes*, *Cryptococcus neoformans*, *Trichophyton rubrum*, *Trichophyton mentagrophytes* and *Microsporum canis* although neither the method used nor the level of activity, are indicated in the relevant article (Dekker et al., 1983). Caespitate (**2**), exhibited antibacterial activity against the Gram-positive *Bacillus cereus*, *Bacillus pumilis*, *Bacillus subtilis*, *Micrococcus kristinae* and *Staphylococcus aureus* at concentrations of 0.5  $\mu$ g/ml in the agar dilution method (Mathekga et al., 2000). This compound also exhibited antifungal activity which ranged from 0.5 to 1.0  $\mu$ g/ml against *Aspergillus flavus*, *Aspergillus niger*, *Cladosporium cladosporioides*, *Cladosporium cucumerinum*, *Cladosporium sphaerospermum* and *Phytophthora capsici* (Mathekga et al., 2000). Caespitate (**2**) was also active against several *Mycobacterium tuberculosis* strains at a concentration of 0.1 mg/ml which was similar to the MIC observed for the crude extract of *Helichrysum caespitium* (Meyer et al., 2002).

Several caespitin derivatives were synthesised with MIC values as low as 2  $\mu$ g/ml against *Staphylococcus aureus* and *Streptococcus pyogenes*. These compounds also exhibit antifungal activity. The possible development of antimicrobial resistance was examined as well as the development of cross resistance with known antimicrobials (Van der Schyf et al., 1986). For helihumulone (**4**), a phloroglucinol of the humulone type, activity was exhibited for a broad range of micro-organisms with some promising results, for example 16  $\mu$ g/ml against *Pseudomonas aeruginosa*. The antimalarial activity of this compound was determined to be 15  $\mu$ g/ml (Van Vuuren et al., 2006). As previously mentioned, the South African *Helichrysums* contain a large amount of phloroglucinol derivatives and considering the promising antimicrobial activity observed for this type of compound, it seems a class well worth investigating.

Aqueous extracts of *Helichrysum aureonitens* exhibited antiviral activity against the *Herpes simplex virus* type I *in vitro* at a concentration of 1.35 mg/ml (Meyer et al., 1996). The flavone, galangin, isolated from this plant also exhibited antiviral activity against *Herpes simplex virus* type I and the *Coxsackie virus* at concentrations of 6  $\mu$ g/ml (Meyer et al., 1997). The antiviral activity was also determined for a crude ethanolic extract of *Helichrysum melanacme* and its isolated constituents. The activity of the isolated prenylated chalcone (**9**) and a pyranochalcone (**10**) was lower

(IC<sub>50</sub> = 0.1 mg/ml) against the *Influenza A* virus than that of the crude extract (0.01 mg/ml) although a combination of the two chalcones resulted in an improved IC<sub>50</sub> (0.01 mg/ml, Lall et al., 2006).

In summary, the crude extracts generally show some degree of antimicrobial activity, which is usually higher against Gram-positive organisms than against Gram-negative organisms. Although the antibacterial and antifungal activities of these plants are well documented, antimalarial, antimycobacterial and antiviral data are scarce. Isolated compounds sometimes exhibit more superior activity when compared to the crude extract, but often the crude extract has similar activity. Correct identification of plant material is crucial as misidentification of plant material can lead to incorrect reporting (Lourens et al., 2004). The selected range of concentrations is often on the high side (Gibbons, 2004, considered values of below 1 mg/ml for extracts and 64 µg/ml for single chemical entities as significant); for example a range of 10–100 mg/ml was used for *Helichrysum pedunculatum* extracts (Meyer and Dilika, 1996). Positive controls (antibiotics) are absent in some of the assays (Mathekga et al., 2000), making it difficult to comparatively assess the activity of a particular extract or compound. The fact that different assays are employed impairs comparison of data between different laboratories (assays relying on diffusion are especially suspect since a low rate of diffusion would present a low activity, which is not always a true representation). Microbial strains are often not referenced and the number of colony forming units not mentioned (Meyer and Afolayan, 1995). Extracts also often do not dissolve completely in the solvents used and as Cushnie illustrated with galangin (2003) this can have a profound effect on the MIC's observed (Cushnie et al., 2003). Chemical classes such as the flavonoids, acylphloroglucinols and diterpenes from South African *Helichrysum* species exhibit promising antimicrobial activity and plants that contain these compounds seems potential candidates for further study.

#### 4.2. Other biological data

Unpublished work done by Noristan laboratories indicates that fractions of the extract of *Helichrysum caespititium* exhibits anti-inflammatory activity of up to 82% at 360 mg/kg in the carrageenan test done on rats and prevents platelet aggregation (Swanepoel, 1997). Ethanolic extracts of *Helichrysum subglomeratum* and *Helichrysum nudifolium* inhibited prostaglandin synthesis *in vitro* by 69 and 96% (50 µg of plant extract used), respectively (Jäger et al., 1996). The group at Noristan determined that fractions of a *Helichrysum nudifolium* extract also reduced edema in the carrageenan assay by approximately 30% at 300 mg/kg in rats (Swanepoel, 1997). These results indicate that *Helichrysum nudifolium* has both *in vitro* and *in vivo* anti-inflammatory activity, possibly due to the inhibition of the cyclooxygenase enzymes.

The group at Noristan observed that the second of three fractions obtained after gradient column chromatography (using petroleum ether, ethyl acetate and methanol) of a dichloromethane/methanol extract from *Helichrysum panduratum* showed a 79% reduction in pain experienced in the writhing pain test at 500 mg/kg. Edema was also reduced by 50% in the carrageenan test indicating that this plant has both anti-inflammatory and analgesic properties. It was also antihypertensive (a reduction of 6% in mean blood pressure was observed after administering a dose of 300 mg/kg) and weakly antimicrobial (Swanepoel, 1997). A fraction from a dichloromethane/methanol extract of *Helichrysum petiolare* investigated by the group from Noristan determined that administration of 300 mg/kg of extract to mice reduced mean blood pressure by 21% and resulted in a 6% reduction in heart rate (Swanepoel, 1997). Acetone extracts of *Helichrysum excisum* (IC<sub>50</sub> = 35 µg/ml) and *Helichrysum felinum* (IC<sub>50</sub> = 39 µg/ml)

inhibited the 5-lipoxygenase enzyme which also plays a role in inflammation. Antioxidant activity (as indicated with the DPPH assay) of acetone and methanol extracts of *Helichrysum odoratissimum*, *Helichrysum excisum*, *Helichrysum felinum* and *Helichrysum petiolare* was comparable to that of vitamin C, as expected for species rich in phenolic compounds (Lourens et al., 2004).

European research further highlights the antioxidant and anti-inflammatory effects displayed by plants from this genus. It is quite often the flowers that are investigated, a plant part that are seldom investigated in South African research (Drewes and Van Vuuren, 2008; Table 2). Antioxidant activity was reported for flower extracts from *Helichrysum stoechas* (Carini et al., 2001), *Helichrysum arenarium* (Czinner et al., 2000; Czinner et al., 2001) and *Helichrysum italicum* (Facino et al., 1990). *In vivo* (topical) anti-inflammatory activity comparable to that of the indomethacin standard was observed for an acetophenone derivative, gnaphaliin (a flavonoid) and ursolic acid isolated from *Helichrysum stoechas* (Recio et al., 1991). *In vivo* and *in vitro* anti-inflammatory activity was also observed for acetophenone glucosides, flavonoids and other compounds isolated from *Helichrysum italicum* (Sala et al., 2001, 2002, 2003a,b) as well as for extracts from *Helichrysum compactum* (Süzgeç et al., 2005). These promising results indicate that more research should be undertaken on the anti-inflammatory activity of South African species, as many similar compounds appear in the South African and European species.

As previously mentioned, *Helichrysum* species are often burnt as incense to invoke the goodwill of the ancestors, in protective and other charms and to induce trances. It is also used in the treatment of insanity, possession, used as a sedative to treat insomnia and as a protective cleanser (Table 1). Their traditional uses indicate that these plants may exhibit psychotropic effects. Stafford et al. (2005) determined the GABA-receptor binding effect of extracts from *Helichrysum argyrolepis*, *Helichrysum herbaceum*, *Helichrysum nudifolium*, *Helichrysum ruderales*, *Helichrysum rugulosum*, *Helichrysum simillimum* and *Helichrysum umbraculigerum* by using the <sup>3</sup>H-Ro 15-1788 binding assay. *Helichrysum ruderales* and *Helichrysum umbraculigerum* exhibited the most pronounced effects, while *Helichrysum herbaceum*, *Helichrysum rugulosum* and *Helichrysum simillimum* showed moderate to good dose dependant activity.

There appears to be a large divide between the rich chemical data available and biological testing on compounds isolated from the South African species. One chemical class, the α-pyrone will be discussed as an example. By our rough estimate, 28 different pyrones were isolated from South African *Helichrysum* species. The same type of compounds was isolated from European species and rather interesting biological activity was observed. Itaipyrone, plicatipyrene, a mixture of helipyrones and a mixture of homoarenol and arenol were all active against *Bacillus subtilis*, *Staphylococcus aureus*, *S. epidermidis* and *Mycobacterium phlei* using the agar diffusion method with the highest MIC being 25 µg/ml and the lowest 3 µg/ml (Ríos et al., 1991). Antifungal activity was also reported for α-pyrone isolated from *Helichrysum decumbens* (Tomás-Lorente et al., 1989). Pyrones (like arzanol and helipyrene) showed significant antioxidant activity and arzanol was not toxic at all concentrations tested (Rosa et al., 2007). Most interesting though is the findings by Appendino et al. (2007) that arzanol inhibits HIV-I replication in T-cells and inhibited NF-κB (IC<sub>50</sub> = 5 µg/ml) indicating that this group of compounds may exhibit both antiviral and anti-inflammatory properties. To our knowledge, none of the unique pyrones isolated from South African species were evaluated for biological activity.

Most concerning is the almost complete absence of toxicity data for the South African species of this genus. In very few cases, for example where antiviral and antimalarial activities were determined (Meyer et al., 1996, 1997; Lall et al., 2006; Van Vuuren

et al., 2006) toxicity is mentioned. Toxicity of the diterpenes is well known (for example IC<sub>50</sub> values of below 4 µg/ml was reported for three diterpene lactones from *Parinari capensis*; Uys et al., 2002), and several *Helichrysum* species contain high amounts of these compounds, to name but one example. Furthermore, Reid et al. (2006) screened 42 medicinal South African plants for mutagenicity, which included *Helichrysum herbaceum*, *Helichrysum nudifolium*, *Helichrysum ruderale*, *Helichrysum rugulosum*, *Helichrysum simillimum* and *Helichrysum umbraculigerum*. The only three plants that showed mutagenic activity were all *Helichrysums*, namely *Helichrysum herbaceum* (at 5 mg/ml), *Helichrysum rugulosum* (at 5 mg/ml) and *Helichrysum simillimum* (at 0.05 mg/ml). These results highlight both the need and importance of toxicity and safety data for plants of this genus. In general, there also seems to be a large need for *in vivo* validation of *in vitro* results since the effectiveness of these extracts and their compounds have not been validated in living organisms.

## 5. Conclusion

*Helichrysum* species are used extensively in ethnomedicine in South Africa and many of the uses are associated with the treatment of infections, e.g. it is used widely for treatment of respiratory diseases and wound dressing (Table 1). The large morphological diversity of the genus is complemented by chemical diversity as illustrated by the range of novel compounds isolated from the genus. Despite the extensive past and present traditional uses, the unrivalled botanical diversity, and the chemical complexity, it remains ironic that explorations of the biological activities of indigenous species are comparatively poorly studied. The genus is notoriously challenging from a taxonomic perspective and several examples have been highlighted to emphasise the importance of correct botanical identification when embarking on ethnopharmacological and phytochemical studies. There is an interesting relationship between the morphological classification and the classes of chemical compounds isolated from a specific morphological group and there are certain classes of compounds, e.g. diterpenes, guaianolides, acylated phloroglucinols and  $\alpha$ -pyrone derivatives, for which one can predict in which species they are most likely to occur. This may be important in the search of new plant-derived drugs, e.g. acylated phloroglucinols show potential as anti-staphylococcal drug leads (Gibbons, 2004) and  $\alpha$ -pyrone derivatives have anti-HIV properties (McGlacken and Fairlamb, 2005; Appendino et al., 2007). It is clear that *Helichrysum* is an interesting genus from an ethnobotanical, phytochemical and pharmacological perspective but that biological data to correlate the ethnobotany to the chemistry are often still lacking. To advance our knowledge on this fascinating genus a multidisciplinary approach involving botanists, chemists and ethnopharmacologists is required.

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