



A survey of plants responsible for causing irritant contact dermatitis in the Amathole district, eastern cape, South Africa



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ABSTRACT

Ethnopharmacological relevance: Potentially harmful plants grow almost everywhere, hence, it is not practical to eradicate them all. However, a basic understanding of adverse cutaneous reactions and the common plants that cause each type can enable vulnerable individuals to discover the source of their dermatitis and thus prevent re-exposure. The aim of this study therefore, was to document the plants responsible for irritant contact dermatitis (ICD) in the Eastern Cape, along with their respective irritants and clinical presentations.

Materials and methods: Study participants (161) in 12 locations were selected by convenient sampling with particular focus on local people who regularly interact with plants or plant products. Interview questions were focused on the local names of plants that contain irritating chemicals and physical characteristics that cause ICD.

Results: Forty four plant species distributed in 24 families and 34 genera were reported as causative agents of irritant contact dermatitis. Herbs constituted 67.35%, trees 24.49% and shrubs 8.16%. Mechanical ICD was reported to be caused by 23 species, closely followed by chemical ICD (20 species) and mechanico-chemical ICD (6 species). Species with the highest frequency of citations were *Allium cepa*, *Acacia karroo*, *Capsicum annum*, *Citrus limon* and *Zea mays*. The most representative families were Euphorbiaceae (for chemical ICD), Urticaceae (for mechanico-chemical ICD), Fabaceae and Rutaceae for mechanical ICD. Most of the classes of chemical compounds identified as being responsible for chemical ICD were restricted to plants of specific genera such as the diterpenes in *Euphorbia* spp., disulphides in *Allium* spp., terpenes in *Citrus* spp. and isothiocyanates in *Brassica* spp.

Thorns and hairs were reported for causing Mechanical ICD in 6 plant species each, including widely cultivated plants such as *Acacia karroo* and *Citrus reticulata*.

Conclusion: Irritant contact dermatitis is a common cutaneous disorder in individuals exposed to plants in the Eastern Cape, especially among workers of the food and flower industries. Health practitioners should therefore consider the possible work-related causes of dermatitis, especially in cases associated with a clear history of symptoms.

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1. Introduction

Plants are of relevance to dermatology both for their adverse and beneficial effects on the skin. Beneficial aspects of medicinal plants on the skin include: healing of wounds and treatment of skin infections such as acne, herpes and scabies and against inflammatory disorders affecting the skin such as psoriasis (Mantle et al., 2001). Adverse effects due to plants are common in South Africa since harmful plants grow in almost every garden and form part of the indigenous flora. Cutaneous adverse effects induced by plants

include: irritant contact dermatitis due to mechanical injury or by irritant chemicals in the plant sap, phytophotodermatitis resulting from skin contamination by plants containing furocoumarins following subsequent exposure to UV light and immediate (type I) or delayed hypersensitivity contact reactions mediated by the immune system in individuals sensitised to plants or plant products e.g. peanut (*Arachis hypogaea*) allergy and poison ivy (*Toxicodendron radicans*) poisoning.

Touching certain plant species can be a serious health hazard. Hence, numerous occupations such as food handlers, caterers, gardeners, farmers, agricultural workers, florists, nursery workers, landscapers, forestry workers and loggers are associated with the risk of developing adverse cutaneous reactions to plants and woods. For example, it is estimated that 50% of all occupational skin diseases among agricultural workers is due to plants (Modi et al., 2009) while reactions to pesticides and chemicals account

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for less than 20%. Poison control centres, physicians, botanists, and toxicologists are frequently confronted by situations in which a plant is implicated in the formation of a rash, suggesting that the ability to recognise plant-induced dermatitis is important for all.

Skin-associated complaints are the most frequent type of plant poisoning reported to poison control centres and are managed by primary care physician or dermatologists. However, South Africa suffers from a scarcity of dermatologists, compounded by the fact that most dermatologists are centred near urban areas, not accessible to 70% of the rural population (Carruthers (2013)). The majority of specialist care, including dermatology, is only available in the major hospitals. There are currently 167 members in the Dermatology Society of South Africa (110 of whom are exclusively in the private sector) serving a population of about 50 million (Carruthers (2013)). Many health care centres in the Eastern Cape are often run by clinical officers or nurses, rather than physicians, who act as the primary care workers but have very limited training in diagnosing dermatologic conditions (Hay and Marks, 2004). Hence, skin diseases such as dermatitis, prurigo, scabies, and papular urticaria are either untreated or over-treated with strong topical steroids or antibiotics which have been found to cause considerable disability (Njoronge and Bussmann, 2007).

The Eastern Cape is one of the poorest regions of South Africa and it is particularly known for its richness in plant species (Phillipson, 1987). The Xhosas are the major inhabitants of this province and they live primarily in the areas called Ciskei and Transkei. They are divided into a number of subgroups with their own distinct but related heritages. One of these subgroups is called Xhosa as well. The other main subgroups are the Bhaca, Bomvana, Mfengu, Mpondo, Mpondomise, Xesibe and Thembu.

In the Eastern Cape, various floral habitats meet. Rolling grasslands dominate the eastern interior of the province, while the western central plateau is savanna bushveld. The northern inland is home to the aromatic, succulent-rich Karoo habitat (Phillipson, 1987). As a result of the myriad of previous ethnobotanical studies carried out in the Eastern Cape, many plants have been grouped according to their use-categories and/or use-values and some of the phytochemicals responsible for their curative and nutritional values have been elucidated. However, because of the relatively little data available in the scientific literature with regard to the adverse effects of plants in the Eastern Cape, the aim of this study therefore, was to document the plants responsible for irritant contact dermatitis (ICD) in the Eastern Cape, along with their respective irritants and to describe the clinical presentations observed in plant-induced ICD.

Since harmful plants grow everywhere, it is not practical to eradicate them all. The most we can do is to learn to identify them and to raise awareness in the general public on the dangers of

these plants. With a basic understanding of the types of reaction and the common plants that cause each type, physicians can help patients discover the source of the dermatitis and thus prevent re-exposure.

1.1. The skin

The skin is our primary interface with the external environment and in general, performs quite efficiently as a barrier against noxious chemicals or living organisms. Other functions of the skin include protection, percutaneous absorption, temperature regulation, fluid maintenance, sensory and disease control (Abbasi et al., 2010). However, since the range of human activities is extremely diversified, numerous occupations can lead to break down of the epidermal barrier, with subsequent development of work-related dermatoses (Mathias 1988). Although mortality rates for skin disorders are relatively low (Njoronge and Bussmann, 2007), skin ailments present a major health concern because they occur worldwide and amount to approximately 34% of all occupational diseases encountered (Spiewak, 2000) and because of their highly visible symptoms, they impact significantly on the quality of life, are often persistent and difficult to treat.

1.2. Irritant contact dermatitis (ICD)

The term “irritant contact dermatitis” (ICD) is used to describe a cutaneous inflammatory response to physical or chemical injury, characterised by the absence of antigen-specific immunoglobulins. Only innate immune response mechanisms are involved in ICD and unlike in the case of allergic contact dermatitis, anyone exposed to a cutaneous irritant can potentially be affected and the effect is usually restricted to areas of skin contact (Modi et al., 2009). Irritant contact dermatitis is caused by the direct cytotoxic action of the offending agent on the cells of the epidermis and dermis. Visible skin changes are the result of alterations in the epidermal barrier, cellular destruction, trans-epidermal water loss, and inflammation secondary to non-immunologic release of vasoactive peptides and pro-inflammatory cytokines (Adams, 1988). Although itch is a frequent complaint, the main symptoms are pain or a burning sensation, and the dermatitis presents as subacute to chronic eczema. ICD is the most common type of occupational skin disorder, traditionally held accountable for approximately 80% of all contact dermatitis reactions and the majority of occupational and plant dermatoses (Adams, 1988, Ricks et al., 1994).

Table 1

Physical structures in plants responsible for mechanical irritant contact dermatitis (Adapted from Modi et al. (2009)).

Type of irritant	Characteristics	Mode of action	Clinical presentation/effect on skin	Example of plants
Spinose apical process	Sharp, stiff, and spinelike leaf apex, generally an extension of the mid-vein	Scratch, impale, or lacerate the skin	Vesicular, pruritic, pains, wounds and excoriations	Agave and Aloe spp.
Thorns	A branch with a sharp tip	Scratch, impale, or lacerate the skin	Vesicular, pruritic, pains, wounds and excoriations	Citrus and Acacia spp.
Spines	Modified leaves, stipules, or parts of leaves, such as extensions of leaf veins	Scratch, impale, or lacerate the skin	Vesicular, pruritic, pains, wounds and excoriations	Opuntia spp.
Glochids	Hair-like spines or short prickles, generally barbed, found on the areoles of cacti	Easily detach from the plant and lodge in the skin	Cause irritation upon contact. extremely pruritic, papular eruption called sabra dermatitis	Opuntia spp.
Trichomes	Very fine outgrowths (hairs) on plants	Rub against the skin	Skin irritation, rashes	Capsicum pubescens
Prickles	Spinose structure with sharp end derived from the epidermis and don't have vascular bundles	Scratch, impale, or lacerate the skin	Vesicular, pruritic, pains, wounds and excoriations	Rosa spp.

1.2.1. Types of irritant contact dermatitis

Based on the nature of the irritant, ICD can be divided into mechanical irritant contact dermatitis (MICD) and chemical irritant contact dermatitis (CICD). MICD is caused by plants with obvious physical characteristics (Table 1, Fig. 2) such as thorns, spines and hairy appendages that directly injure the skin, causing cuts, abrasions and punctures which may become secondarily infected with bacteria or fungi (Modi et al., 2009). Chemical ICD develops when the skin comes in contact with an irritating chemical present in the plant sap. The vast majority of CICD are caused by one of seven basic irritant groups: calcium oxalate, protoanemonin, isothiocyanates, diterpene esters, bromelain, and alkaloids (Table 2, Fig. 1). Mustards, chile peppers, pineapple, mayweed, cowhage and yarrow are examples of plants that contain irritating chemicals that can injure the skin (Modi et al., 2009). In mechanico-chemical ICD (MCICD), there is, however, a frequent overlap in which some plants penetrate the skin of the victim mechanically and then introduce a poisonous chemical. Under an electron microscope, fragile hollow needles are visible, with nettle cells at the base, filled with liquid poison. When touched, a needle breaks off, leaving an oblique tip, which can

enter the human skin like a syringe and release the poison. For example physical microtrauma from handling *Narcissus* bulbs may enhance the cutaneous penetration and effects of chemical irritant calcium oxalate crystals (Lovell, 1997).

2. Materials and methods

2.1. Description of the study area

This study was carried out in the Amatole District (Fig. 1) of the Eastern Cape Province, South Africa. The Eastern Cape Province is one of the 9 provinces of South Africa and it falls within the latitudes 30°00' to 34°15'S and longitudes 22°45' to 30°15'E (Grierson and Afolayan, 1999). It is bounded by the sea in the East and the drier Karroo (semi-desert vegetation) in the west. The Amatole District Municipality is situated within the Eastern Cape Province, between Port Alfred and Port St John, and includes the city of East London. The climate is highly varied; the west is dry with sparse rain during winter or summer, with frosty winters and hot summers. Mean maximum temperature in January has been



Fig. 1. Map of Amatole District Municipality. Source: Urban-Econ, Eastern Cape, 2011.

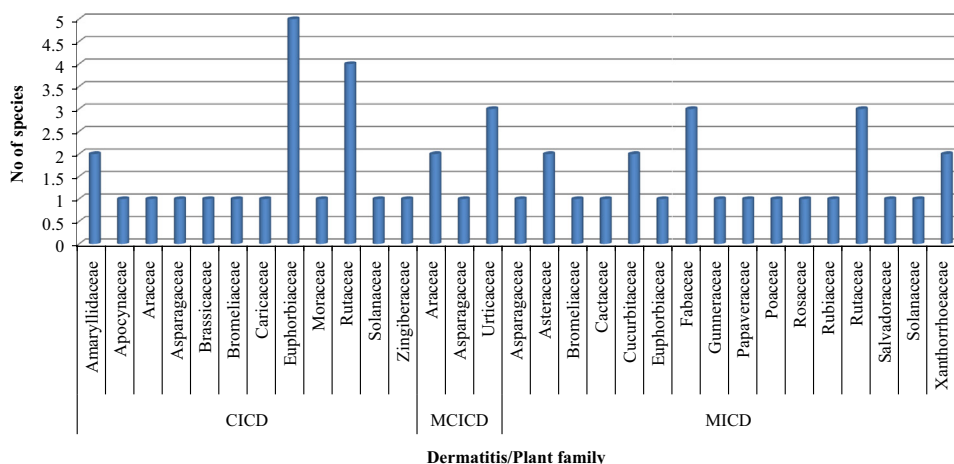


Fig. 2. Distribution of plant families according to number species and type of irritant contact dermatitis.

Table 2Chemical compounds in plants responsible for chemical irritant contact dermatitis (Adapted from [Modi et al. \(2009\)](#)).

Type of irritant	Characteristics	Mode of action	Clinical presentation/effect on skin	Example of plants
Protoanemonin (ranunculol)	A toxin found in all plants of the buttercup family (Ranunculaceae), produced by an enzymatic process from the glucosideranunculin when the plant is wounded	Disrupt disulphide bonds, resulting in sub-epidermal dysjunction	Irritating odour, conjunctival irritation, and irritation of the nasal airway. Contact with the skin results in warmth, burning, irritation and erythema	Buttercups (<i>Ranunculus</i> spp.)
Isothiocyanates (Mustard oils)	Principal irritant constituents of the mustard oils found in many members of Brassicaceae	React readily with the amino-groups of proteins on human skin and mucosal surfaces	Short-lived burning, erythema, and urticaria, contact with the eyes results in burning, and irritation	Cabbage, cauliflower, radish and papaya
Diterpene Esters	Phorbol esters are tetracyclic diterpenoids generally known for their tumour promoting activity. They are among the most irritant of plant-derived chemicals	Their primary action is on biological membranes. They bind to phospholipid membrane receptors. Proteolytic activity	Pain, erythema, oedema, blistering, conjunctivitis, and even blindness	<i>Croton texensis</i> , <i>Ricinus communis</i>
Bromelain	A plant-derived enzyme originally extracted from the pineapple plant		Cutaneous irritation.	<i>Ananas comosus</i>
Capsaicin	An alkaloid derived from members of the Solanaceae family	Binds to vanilloid receptors on sensory neurons resulting in the sensation of heat and pain	Cutaneous burning and erythema	<i>Capsicum</i> spp.
Nicotine	An alkaloid derived from tobacco plant	Antagonist to nicotinic receptors in the peripheral and central nervous system	Cutaneous irritation	<i>Nicotiana tabacum</i>

recorded as 26 °C and mean minimum as 10 °C in July. The main tribes of the area are Xhosa-speaking peoples who are divided into several tribes with related but distinct heritages.

2.2. Survey of plants that cause irritant contact dermatitis

The study was carried out by interviewing 161 respondents in 12 locations (Tyahli, Ngwenya, Dyamala, Gxwadera, Roxeni, Mhehelo, Sheshegu, Alice, Mavuso, Chwaru, Gaga and Fort cox) in the Amathole District of the Eastern Cape. High poverty levels, lack of modern health facilities and the extensive use of medicinal plants are characteristic of the selected locations. Study participants were selected by convenient sampling with particular focus on local people who regularly interact with plants or plant products such as food handlers, caterers, cooks, chefs, gardeners, farmers, agricultural workers, florists, herbalists and nursery workers. The survey was conducted from April to June 2014, through interviews and discussions which were conducted in Xhosa, the local language of the informants and were facilitated by a local field assistant who is fluent in both Xhosa and English. The interviews included questions targeted the local names of plants that contain irritating chemicals and physical characteristics (such as thorns, spines and hairy appendages) that directly induce adverse cutaneous reactions. The symptomatology and aetiology of various plant-induced ICD and their chemical and physical causative agents (Tables 1 and 2, Fig. 1) were described to the informants so as to enable them state the appropriate culprit plant species. The plant parts implicated and the life forms of the reported plants were also recorded. The acquired data were cross-checked in different locations either by showing the plant specimen or telling the local names of plants to other informants in order to verify the authenticity of claims ([Abbasi et al., 2010](#)). The type of dermatitis attributed to each plant species was validated when the answers of at least two informers coincided to an identical adverse cutaneous reaction for the same part of a plant ([Martínez and Barboza, 2010](#)).

2.3. Preservation and identification of the plants that induce ICD

Collection of plants reported as having adverse cutaneous reactions was assisted by the informants in order to ensure that the correct plants have been collected. The fresh plant materials were pressed and mounted on herbarium sheets and were later transported to the University of Fort Hare's herbarium where identification

of the collected plant specimens was done in the Department of Botany with the help of floristic works of South Africa ([Bhat and Jacobs, 1995](#); [Van Wyk et al., 1997](#) and [Dold and Cocks, 2000](#)) and the Plant List (www.theplantlist.org/). Voucher specimens were deposited in the Griffin Herbarium of the University of Fort Hare.

2.4. Data analysis

The harm-value, modified from [Phillips et al. \(1994\)](#) was used as a quantitative index that weighs the relative local significance of a plant species as a causative agent of irritant contact dermatitis was calculated as follows:

$$HV = \sum U/n$$

where: UV = harm-value of a species; U = number of citations per species; n = number of informants.

2.5. Intellectual property agreement

The survey was carried out with the full consent of all participants, with further verbal agreement and understanding that this research shall not be used for commercial purposes, but shall serve as enlightenment and as a means of preservation of the indigenous knowledge as regards plant-induced ICD in the Eastern Cape, South Africa. Ethical approval for the study was granted by the Ethics Committee of the University of Fort Hare.

3. Results and discussion

3.1. Socio-demographic information

A total of 161 informants, aged between 19 and 76 years with a mean age of 35.1 ± 14.2 participated in the study, including 62 (39%) males and 99 (61%) female. The variability among the informants in terms of gender can be traced to some principal occupations which are more vulnerable to plant-induced ICD. Women disproportionately fill such occupations where contact dermatitis is more prevalent. For example, food handlers, professional cooks and chefs are mostly females and majority of plants (37.3%) reported for ICD in this study were mainly used as foods also (Table 3).

Table 3

Plants responsible for causing irritant contact dermatitis.

Family Scientific name Local/common name	Habit	Type of dermatitis	Irritants	Clinical presentation	Frequency of citation	Principal use
Amaryllidaceae <i>Allium sativum</i> L. Ivimbampunzi (garlic)	Herb	CICD	Disulphides	Burning, erythematic, malodorous breath or body odour and irritation of the nasal airway	24	Food
Amaryllidaceae <i>Allium cepa</i> L. Itswele	Herb	CICD	Disulphides	Conjunctival irritation, malodorous breath or body odour	5	Food
Apocynaceae <i>Catharanthus roseus</i> (L.) G. Don Periwinkle	Herb	CICD	Alkaloid	Conjunctival damage, skin irritation	4	Ornamental
Araceae <i>Alocasia macrorrhizos</i> (L.) G. Don Alocasia	Herb	CICD	Calcium oxalate	Irritation of mucous membranes, mouth and eyes, burning sensation, extreme pain	3	Ornamental
Araceae <i>Colocasia esculenta</i> (L.) Schott Idunbe	Herb	MCICD	Calcium oxalate	Irritation of the mouth, burning sensation, rashes	4	Food
Araceae <i>Dieffenbachia maculata</i> (Lodd.) Sweet Dumb Cane	Herb	MCICD	Calcium oxalate/ saponin	Pruritis, erythema, irritation of mucous membranes, burning sensation, rashes, extreme pain	5	Ornamental
Asparagaceae <i>Albuca setosa</i> Jacq. Inqwweba	Herb	CICD	Not determined	Severe irritation, rashes, and reddening	6	Medicinal
Asparagaceae <i>Agave americana</i> L. Ikhamanga	Herb	MCICD	Calcium oxalate/ saponin	Marked pruritus and stinging	5	Ornamental
		MICD	Spinose apical process	Wound, pain and redening	5	
Asteraceae <i>Bidens pilosa</i> L. Ugcadolo	Herb	MICD	Bristles	Wounds, pain and redness	3	Medicine
Asteraceae <i>Arctotheca calendula</i> (L.) Levyns Isiqwashumbe (Cape dandelion)	Herb	MICD	Hairs	Irritation of the skin, itches and rashes	3	Weed
Brassicaceae <i>Brassica oleracea</i> L. Cabbage	Herb	CICD	Isothiocyanates	Conjunctival irritation, pungent odour, erythema, and urticaria	5	Food
Bromeliaceae <i>Ananas comosus</i> (L.) Merr. Pineapple	Herb	MICD	Spines	Wounds, pain and redness	9	Food
		CICD	Proteolytic enzyme	Cutaneous irritation	5	
Cactaceae <i>Opuntia aurantiaca</i> Lindl. Ikati (Jointed cactus)	Herb	MICD	Spines	Wound, pain and reddening	9	Ornamental
Caricaceae <i>Carica papaya</i> L. Pawpaw	Tree	CICD	Isothiocyanates	Pain, erythema, severe conjunctival irritation	4	Food
Cucurbitaceae <i>Cucurbita pepo</i> L. Usenga	Herb	MICD	Hairs	Irritation of the skin, itches and rashes	3	Food
Cucurbitaceae <i>Cucumis africanus</i> L.F Ithangazana (wild cucumber)	Herb	MICD	Hairs	Irritation of the skin, itches and rashes	8	Weed
Euphorbiaceae <i>Euphorbia tirucalli</i> L. Umhlontlo	Shrub	CICD	Diterpene esters	Severe irritation, redness, burning sensation, conjunctivitis	5	Ornamental
Euphorbiaceae <i>Euphorbia ingens</i> E.Mey. ex Boiss. Intsema	Herb	CICD	Diterpene esters	Conjunctival damage, skin irritation	3	Ornamental

Table 3 (continued)

Family Scientific name Local/common name	Habit	Type of dermatitis	Irritants	Clinical presentation	Frequency of citation	Principal use
Euphorbiaceae <i>Synadenium cupulare</i> L.C. Wheeler Dead-man's tree	Shrub	CICD	Diterpene esters	Severe burning and itching of the skin, eyelids and nostrils that last for several hours	3	Medicinal
Euphorbiaceae <i>Euphorbia virosa</i> Willd. poison tree	Herb	CICD	Diterpene esters	Conjunctival damage, irritation and blistering of skin	3	Ornamental
		MICD	Diterpene esters	Wound, pain and reddening, conjunctival damage, irritation and blistering of skin	3	
Euphorbiaceae <i>Euphorbia tirucalli</i> L. Umhlontlo	Herb	CICD	Diterpene esters	Conjunctival damage, irritation and blistering of skin	3	Ornamental
Fabaceae	Tree	MICD	Spines	Wounds, pain and redness	14	Ornamental
<i>Acacia karroo</i> Hayne umuNga	Tree	MICD	Thorns	Wound, pain and reddening	3	Medicinal
Fabaceae <i>Caesalpinia decapetala</i> (Roth) Alston Ubobo	Tree	MICD	Hairs	Wounds, pain and redness	3	Weed
Gunneraceae <i>Gunnera perpensa</i> L. Upuzi	Herb	MICD	Hairs	Irritation of the skin, itches and rashes	4	Medicinal
Moraceae <i>Ficus natalensis</i> Hochst. Umthombe	Tree	CICD	Proteolytic enzyme	Severe irritation, redness and burning sensation	3	Food
Papaveraceae <i>Argemone ochroleuca</i> Sweet Ikritsi (Mexican poppy)	Herb	MICD	Spinose apical process	Wound, pain, redness	5	Weed
Poaceae <i>Zea mays</i> L. Unbone	Herb	MICD	Hairs	Irritation of the skin, itches and rashes	10	Food
Rosaceae <i>Rosa rubiginosa</i> L. Rose	Herb	MICD	Prickles	Wound, pain, redness	3	Ornamental
Rubiaceae <i>Canthium inerme</i> (L.f.) Kuntze Isiphingo	Tree	MICD	Thorns	Wound, pain and redness	3	Medicinal
Rutaceae <i>Citrus reticulata</i> Blanco Tangerine	Tree	MICD	Thorns	Wounds, pain and redness	7	Food
		CICD	Terpenes	Pungent smell, rash and blisters, or irritation around the mouth	8	
Rutaceae <i>Citrus sinensis</i> (L.) Osbeck Orange	Tree	MICD	Thorns	Wounds, pain and redness	9	Food
		CICD	Terpenes	Pungent smell, rash and blisters, or irritation around the mouth	9	
Rutaceae <i>Citrus limon</i> (L.) Osbeck Lemon	Tree	MICD	Thorns	Wounds, pain and redness	12	Food
		CICD	Terpenes	Pungent smell, rash and blisters, or irritation around the mouth	8	
Rutaceae <i>Clausena anisata</i> (Willd.) Hook.f. ex Benth. Iperepesi	Shrub	CICD	Alkaloid	Body odour, irritation of nasal membrane	3	Medicinal
Salvadoraceae <i>Azima tetracantha</i> Lam Igcegeceleya	Shrub	MICD	Thorns	Wound, pain and redness	5	Medicinal
Solanaceae <i>Capsicum annuum</i> L. Itshilisi	Herb	CICD	Alkaloid	Burning sensation, pain and heat	12	Food
Solanaceae <i>Datura stramonium</i> L. Ijoyi	Herb	MICD	Prickles	Wound, pain and redness	5	Medicinal
Urticaceae <i>Laportea grossa</i> (Wedd.) Chew Ububasa	Herb	MCICD	Stinging hairs	Sharp burning sting and redness	3	Weed
Urticaceae	Herb	MCICD	Stinging hairs	Sharp burning sting and redness	5	Weed

Table 3 (continued)

Family Scientific name Local/common name	Habit	Type of dermatitis	Irritants	Clinical presentation	Frequency of citation	Principal use
<i>Laportea peduncularis</i> (Wedd.) Chew Ububasa						
Urticaceae <i>Laportea alatis</i> Hook.f. Ubazi	Herb	MCICD	Stinging hairs	Sharp, burning sting, redness	2	Weed
Xanthorrhoeaceae <i>Gasteria obliqua</i> (Aiton) Duval Intelezi	Herb	MICD	Spinose apical process	Wound, pain and redness	2	Medicinal
Xanthorrhoeaceae <i>Aloe ferox</i> Mill. Umhlaba	Herb	MICD	Spinose apical process	Wound, pain and redness	4	Medicinal
Zingiberaceae <i>Zingiber officinale</i> Roscoe Ginger	Herb	CICD	Phenol	Conjunctival irritation, pungent odour, burning and blistering	5	Food

3.2. Diversity of medicinal plants that cause irritant contact dermatitis

Results of the present investigation are presented in Table 3. In this study, 44 plant species distributed in 24 families and 34 genera were reported as causative agents of ICD. Herbs constituted 67.35%, trees 24.49% and shrubs 8.16%. Mechanical ICD was reported to be caused by 23 species, closely followed by chemical ICD (20 species) and mechanico-chemical ICD (6 species). The species with the highest frequency of citations were *Allium cepa* (24 citations), *Acacia karroo* (14 citations) *Capsicum annum*, *Citrus limon* and *Zea mays* (12 citations each). The most representative families were Euphorbiaceae (for chemical ICD), Urticaceae (for mechanico-chemical ICD), Fabaceae and Rutaceae (for mechanical ICD) (Fig. 4). Hard data on the incidence of ICD are still very limited and the clinical picture is extremely variable and ranges from chemical burns to chronic irritant forms, often indistinguishable from allergic contact dermatitis. In Heidelberg, Germany, a retrospective study of 190 cases of hand dermatitis revealed the following distribution of diagnoses: atopic dermatitis 40%, chronic irritant contact dermatitis 27%, allergic contact dermatitis 23%, and various other diseases 10% (John and Uter, 2005). Paulsen et al. (1998) studied 253 gardeners in Odense (Denmark) and found irritant occupational contact dermatitis in 59%. Plants were the most commonly involved irritants (Compositae, Primulaceae, Araceae, Euphorbiaceae, Eraliaceae and Geraniaceae).

3.3. Irritant chemicals responsible for plant-induced chemical ICD

Based on literature searches, proteolytic enzymes and 9 classes of chemical compounds were identified as being responsible for the plant-induced ICD (Fig. 3). Most of the classes of chemical compounds were restricted to plants of specific genera such as the diterpenes in *Euphorbia* spp., disulphides in *Allium* spp., terpenes in *Citrus* spp. and isothiocyanates in *Brassica* spp. (Table 4). Calcium oxalate on the other hand had the widest distribution, implicated in 5 genera.

3.3.1. Calcium oxalate

In the current study, the cited examples of calcium oxalate-induced CICD were caused by *Dieffenbachia maculata*, *Alocasia macrorrhizos*, *Colocasia esculenta*, *Ananas comosus* and *Agave americana* (Tables 3 and 4). Freshly cut parts of *Dieffenbachia* spp. were

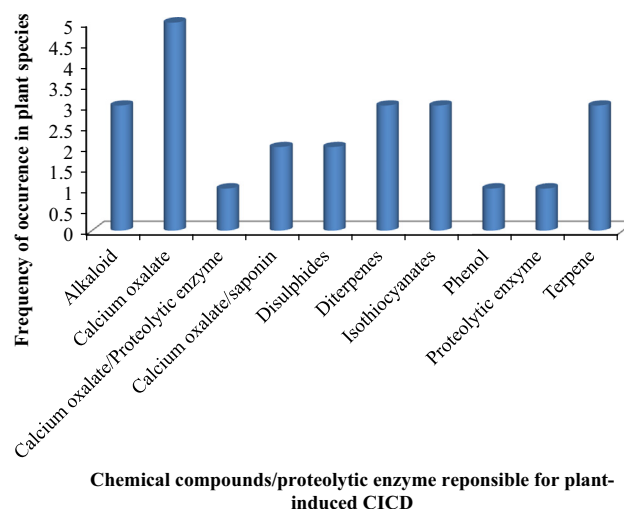


Fig. 3. Classes of chemical compounds responsible for plant-induced chemical ICD.

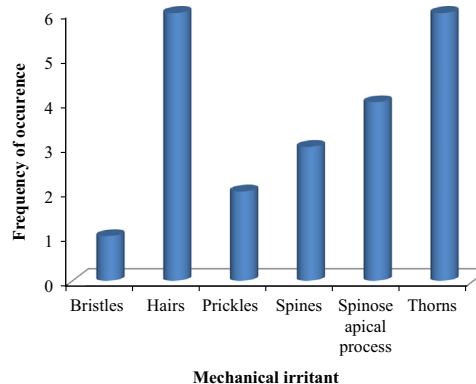


Fig. 4. Physical structures causing plant-induced mechanical ICD.

reported to be very skin irritating and inducing rashes, usually after one day (Table 3). Irreversible skin damage is possible. When brought into the eye, the sap can cause injury of the cornea. Calcium oxalate is a water-insoluble salt that forms bundles of needle-like crystals called raphides in many genera of plants. They enhance the penetration of known skin irritants, including bromelain in pineapples and saponins in *Dieffenbachia* (Table 4).

Table 4

Chemical cutaneous irritants previously isolated from the study plants.

Species	Irritant chemical	Isolated compounds	Reference
<i>Agave americana</i>	Calcium oxalate/saponin	Hecogenin-tetraglycoside	Rozas-Muñoz et al. (2012)
<i>Allium cepa</i>	Disulphides	Thiopropanal-s-oxide, diallyl disulphide	Valdivieso et al. (1994)
<i>Allium sativum</i>	Disulphides	Diallyldisulfide, allylpropyldisulfide and allacin.	Delaney and Donnelly (1996)
<i>Alocasia macrorrhizos</i>	Calcium oxalate		Modi et al. (2009)
<i>Brassica oleracea</i>	Isothiocyanates	2-Phenylethyl isothiocyanate	Rozas-Muñoz et al. (2012)
<i>Capsicum annum</i>	Alkaloid	8-methyl-N-vanillyl-6-nonenamide	Rozas-Muñoz et al., 2012
<i>Carica papaya</i>	Isothiocyanates	Benzyl isothiocyanate	Rozas-Muñoz et al. (2012)
<i>Catharanthus roseus</i>	Alkaloid	Vinblastine	van Wyk et al. (2002)
<i>Citrus limon</i>	Terpene	Geraniol, citral and d-limonene	Rozas-Muñoz et al. (2012)
<i>Citrus reticulata</i>	Terpene	Geraniol, citral and d-limonene	Rozas-Muñoz et al. (2012)
<i>Citrus sinensis</i>	Terpene	Geraniol, citral and d-limonene	Rozas-Muñoz et al. (2012)
<i>Clausena anisata</i>	Alkaloid	Girinimbine, murrayamine-A and ekeberginine	Songue et al. (2012)
<i>Colocasia esculenta</i>	Calcium oxalate		Modi et al. (2009)
<i>Dieffenbachia maculata</i>	Calcium oxalate/saponin	Not determined	Modi et al., 2009
<i>Euphorbia ingens</i>	Diterpenes	Phorbol 12, 13-diester, ingenol esters and euphorcinol	Eke et al. (2000)
<i>Euphorbia tirucalli</i>	Diterpenes	Phorbol 12, 13-diester, ingenol esters and euphorcinol	Eke et al. (2000)
<i>Euphorbia virosa</i>	Isothiocyanates	Phorbol 12, 13-diester	Eke et al. (2000)
<i>Ficus natalensis</i>	Proteolytic enzyme	Ficin	Huang et al. (2008)
<i>Synadenium cupulare</i>	Diterpenes	12-O-tigloyl-4-deoxyphorbol-13-isobutyrate	van Wyk et al. (2002)
<i>Zingiber officinale</i>	Phenol	Gingerol	Monge et al. (1976)
<i>Ananas comosus</i>	Calcium oxalate/Proteolytic enzyme	Bromelain	Modi et al. (2009)

Contact with moisture causes plant cells to eject the raphides which can then come into contact with skin or mucosal surfaces. Irritancy is mechanical in part due to the anatomically sharp structure of the crystals themselves and chemical mainly because they allow the penetration of other plant chemical toxins that may not normally breach the skin on contact (Modi et al., 2009).

Aroids (Araceae) make up the bulk of plant species most frequently encountered by poison control centres (Modi et al., 2009). A number of species and many hybrid cultivars are grown in gardens, used as pot plants, or displayed as freshly cut flowers. Dermatitis most commonly affects florist who strip off the leaves manually and are therefore exposed to broken plant parts with a high risk of ICD. Professional bulb growers, bulb collectors, sorters, and packers are particularly at risk of contact dermatitis due to aroids. Of particular concern are *Dieffenbachia* (dumb cane) and to a lesser degree, *Anthurium*, *Colocasia* (taro), and *Zantedeschia*. Their popularity as houseplants makes them especially accessible to very young children. They all contain oxalic acid, both free and as microscopic needle-like crystals of calcium oxalate (raphides), located in special mucilage containing cells (idioblasts). When the leaf/stem of an aroid is crushed (or chewed) the idioblast tips break off. On contact with sap from broken aroid stems, the released raphides can cause localized irritant dermatitis and eye injury. Another family of monocotyledons, Agavaceae (*Agave americana*) form six sided raphides and contain saponins (Rozas-Muñoz et al., 2012). Saponins can cause severe skin irritation by aggravating the mechanical damage inflicted by raphides.

3.3.2. Diterpene esters (mostly *euphorbia* spp.)

In the current study, latex of *Euphorbia* spp. (*E. tirucalli*, *E. ingens* and *E. virosa*) was reported to cause intense irritation, blistering of skin and eye injury. Ocular symptoms, such as burning or stinging pain, redness, and lacrimation, generally begin immediately on contact with the sap and may worsen in a few hours despite irrigation (Antcliff et al., 1994). The most likely irritant chemicals responsible for the production of ICD in *Euphorbia tirucalli* are a mixture of phorbol 12, 13-diester, ingenol esters and euphorcinol (Eke et al., 2000). Latex is also found in many members of the Moraceae. Edible fig (*Ficus carica*) latex contains a proteolytic enzyme (ficin, used to tenderise meat) that is responsible for irritant dermatitis (Table 4).

3.3.3. Isothiocyanates (mostly *brassica* spp.)

Plants cited in this study that produce mustard oils include cabbage, cauliflower and papaya. Contact dermatitis from these plants is characterised by immediate and short-lived burning, erythema and a pungent odour (Table 3), prominent among food handlers and those who cook. The eyes are particularly sensitive; thus, mustard oil was used as a component of tear gas in warfare (Modi et al., 2009). Isothiocyanates are a family of highly reactive, low molecular weight compounds identified by the number of nitrogen-carbon-oxygen (NCO) groups they contain (Rozas-Muñoz et al., 2012). They are the principal irritant constituents of the mustard oils found in many members of Brassicaceae and are not found in intact plants but are generated upon injury to the plant (Modi et al., 2009). The isothiocyanate components of mustard oils have recently gained attention because of their potential for inhibiting carcinogenesis and due to their spicy taste; they have been used for cooking for centuries.

3.3.4. Terpenes (mostly *citrus* spp.)

The reported cases of chemical ICD to *Citrus* fruits were rash, blisters, or irritation around the mouth induced by the essential oils from the peel of *Citrus limon*, *C. reticulata* and *C. sinensis*. Hand dermatitis to *Citrus* spp. was reported especially by food handlers. The terpenes represent a large class of hydrocarbon compounds produced by a wide variety of plants, are the main components of most essential oils and are composed biosynthetically of isoprene units. Irritant terpenes in the essential oils of *Citrus* peel include geraniol, citral and the hydroperoxide derivative of d-limonene which are usually included in fragrances. Limonene and its oxidation products are skin irritants, and limonene-1,2-oxide (formed by aerial oxidation) is a known skin sensitiser (Rozas-Muñoz et al., 2012). Citral is highly irritating to the skin can result in severe blistering. Besides its use in the food industry, *Citrus* spp. are used for aromatic oils in perfumery and in the manufacture of soaps and cosmetics.

3.3.5. Alkaloids (mostly *capsaicin*)

The juice of *Capsicum annum* fruit was reported to elicit a dose-related cutaneous burning, pain and erythema and irritation that are severe among those who frequently handle chili peppers such as cooks, chefs, housewives, food vendors and restaurants

workers (Table 3). The alkaloids as a chemical group are very diverse and include many of the commonly known bioactive compounds derived from plants, such as ephedrine, morphine, and quinolones (Modi et al., 2009). Capsaicin (8-methyl-N-vanillyl-6-nonenamide) is an alkaloid derived from members of the Solanaceae family and is responsible for the pungency of chili peppers (Williams et al., 1995). In humans, capsaicin binds to vanilloid receptors on sensory neurons, which can also be stimulated by heat and pain. The neuronal activation results in the sensation of heat (Modi et al., 2009). *Capsicum annum* is among the 5 spices most commonly associated to contact dermatitis in the USA. Irritation from chili peppers can be so strong that it is used in teargas (Williams et al., 1995; Burdzik, 2009). Nicotine (an alkaloid presumed to be the active irritating component of the tobacco plant) has also been reported to cause cutaneous irritation among workers in tobacco plantations (Modi et al., 2009).

3.3.6. Disulphides (mostly *allium* spp.)

The genus *Allium* includes many important vegetables such as garlic (*Allium sativum*) and onion (*Allium cepa*). All parts of garlic, when damaged, release the potentially irritating and allergenic sap. The possibility that garlic may cause irritant contact dermatitis (known as “garlic burns”) has been highlighted by a number of case reports both in infants and adults (Borrelli et al., 2007). Although garlic has enjoyed a long history of use in cooking and folk medicine; orally for its diuretic and antilipemic effects and topically to treat insect bites, boils, and skin infections (Delaney and Donnelly, 1996), on the other hand, it has long been recognised as an occupational hazard amongst chefs, housewives and those who practise herbal remedies. Many housewives (44 out of 53) and curry chefs who developed contact dermatitis on the fingerprints showed positive patch tests to garlic (Sinha et al., 1997). An experimental investigation evidenced that three sulphur-containing compounds of garlic (allylmercaptan, allylmethylsulphide, allylsulphide) are able to provoke acantholysis (a breakdown of a cell layer in the epidermis) of normal human skin cultured *in vitro* (Brenner et al., 1995). Because of its sensitising potential and the high degree of irritation, the use of garlic as a topical medicinal agent should be discouraged.

Garlic odour was the most reported adverse effect associated to garlic use (Table 3). The odour of garlic may pervade the breath and skin so much that even after several days of garlic ingestion; the odour is still perceived on the breath and skin (Borrelli et al., 2007). The volatile sulphur compounds (alliin, allicin, diallyldisulphide, ajoene and many others) have been reported to be responsible for the pungent smell of garlic (Lanzotti, 2006). Irritant contact dermatitis to onion was reported much less often than to garlic (Table 3). Cut onions release thiopropanal-s-oxide, an irritant sulphur compound also known as ‘lacrimatory factor’ because of its effects on tearing (Valdivieso et al., 1994).

3.4. Irritant structures responsible for plant-induced mechanical ICD

Six types of mechanical irritants were reported for causing plant-induced ICD (Fig. 4). Thorns and hairs were the most frequent, accounting for MICD in 6 plant species each, including widely cultivated plants such as *Acacia karoo* and *Citrus* spp. (Table 3). In the Eastern Cape, thorns of *Acacia* spp. are well-known due to their distinctive white thorns, so sharp that they are used as sewing needles and for pinning insect specimens.

Sharp-edged leaves of *Aloe ferox* and *Agave americana* and prickles of roses (*Rosa rubiginosa*) were reported to induce wounds and pains when in contact with the skin. Penetration of the skin by hairs (trichomes) of *Gunnera perpensa*, *Cucurbita pepo*, *Zea mays*

and *Cucumis africanus* was reported to produce a papular irritation of the skin, itches and rashes. Spines and glochids of *Opuntia* are well-known hazards in the study area (Table 3). Most cactuses are armed with thorns, but *Opuntia* is among the most unpleasant ones because its fine glochids break off after the lightest touch and penetrate the skin easily which can result in papules and pigment changes which disappear after several months. The symptom is named “Sabra” dermatitis and resembles scabies (Modi et al., 2009).

3.4.1. Granulomata and secondary infections

Beyond the initial mechanical ICD described above, mechanical irritants can cause or exacerbate granulomata or secondary infections by pathogens. Granulomata form when the immune system attempts to wall off substances that it perceives as foreign but is unable to eliminate. For example, if spines or thorns remains in situ and are not excised, granulomata may develop over the course of months and persist indefinitely (Modi et al., 2009). Chronic synovitis with granulomata containing foreign body giant cells have been reported following joint penetration by palm thorn (*Phoenix canarensis*) and blackthorn (*Prunus spinosa*) in different children. Surgical removal of the thorns resulted in a return to normal joint function in each case (Sugarman et al., 1997). An often overlooked comorbidity of mechanical dermatitis from plants is the introduction of infectious organisms into the skin and subcutaneous tissue (Modi et al., 2009). Bacteria such as *Clostridium tetani* may be introduced by spines and thorns and *Staphylococcus aureus* can be commonly found on blackthorns (*Prunus spinosa*) (Stromqvist et al., 1985). *Sporothrix schenckii* infection, a deep fungal infection, may result when the skin is pierced by rose prickles (Mehta et al., 2007). Infections by mycobacteria through mechanical injury by plants have been reported for *Mycobacterium kansasii*, *M. marinum* and *M. ulcerans* transmitted through contact with blackberry bushes, cactus spines and tropical vegetation respectively (van der Werf et al., 1999).

In contrast to contact allergy, the basic cellular and molecular inflammatory mechanisms of irritants have been less studied. However, some basic initial mechanisms seem to be fairly common to the early events in the elicitation of acute and chronic irritant contact dermatitis, e.g., the release of the pro-inflammatory mediators interleukin-1 (IL-1) and tumour necrosis factor alpha (TNF- α) following any kind of barrier perturbation, regardless of whether chemically or mechanically induced (Elias et al., 1999; Willis, 2002). There is good evidence so far that a thin and/or permeable stratum corneum plays a key role. Based on Fick's law of penetration, the thickness of the stratum corneum influences the flux of the penetrating chemical. The intercellular lipids of the stratum corneum play an important part in the barrier function of the skin, as has been shown by a number of investigators (Downing et al., 1987; Elias et al., 1999). Regional variations in irritability are related to differences in keratinization and to the density of transepidermal shunts allowing penetration (sweat ducts, hair follicles).

3.5. Plants responsible for mechanico-chemical ICD

Half of the plants reported for causing mechanico-chemical ICD belong to the Urticaceae family, 3 of which belong to the genus *Laportea*: *Laportea grossa* (spotted nettle), *Laportea alatis* (nettle) and *Laportea peduncularis* (river nettle) (Fig. 2). The stinging hairs of nettle which are widely distributed on the leaves and stems act like hypodermic needles, injecting histamine and other chemicals that produce a sharp, burning sting that lasts a while and can cause temporary redness on the skin. The nettle best known to

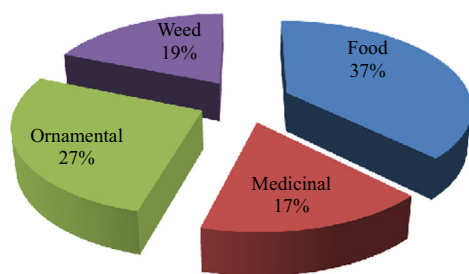


Fig. 5. Principal uses of plants reported for causing irritant contact dermatitis.

most people is the stinging nettle *Urtica dioica*, native to Europe but now distributed throughout the temperate areas of the world.

3.6. Principal uses of plants reported for causing irritant contact dermatitis

Out of the 44 plant species that were mentioned in the survey for causing ICD, 37% (18 species) are principally used as food, 27% (13 species) as ornamentals, followed by weed (19%) and medicine (17%) (Fig. 5). *Allium cepa* (onion), *Capsicum annum*, *Citrus limon* (sweet orange) and *Zea mays* (maize) are mainly used as food while *Acacia karroo* is used principally as an ornamental. These plants were the most frequently cited for causing irritant contact dermatitis during the survey (Table 3). The above findings imply that workers within the food and flower industries (such as florists, bakers, caterers, cooks, chefs etc) have a higher-than-average risk of contacting plant-induced ICD.

About 22 million people are employed in the food and drink industry globally (Burdzik, 2009) while the total number of persons employed in the food and beverage industry in South Africa at the end of June 2007 was 181 373 (SSA, 2012). Although the true prevalence of occupational contact dermatitis is unknown in the flower and food industries of South Africa, a high burden of occupational skin disease in these industries will definitely translates into large costs in terms of days lost from work and adjustments necessary in the workplace. Hence, early recognition of irritant contact dermatitis may lead to improved outcomes to both employees and employers. Therefore, health care practitioners need to be aware of possible occupational causes for all cases of ICD.

4. Conclusion

The current study was undertaken to investigate and document plants responsible for irritant contact dermatitis (ICD) in the Eastern Cape. Forty four plant species distributed in 24 families and 34 genera were reported as causative agents of ICD. Majority of the plants were herbs, followed by trees and shrubs. The species with the highest frequency of citations were *Allium cepa*, *Acacia karroo*, *Capsicum annum*, *Citrus limon* and *Zea mays*. The most representative families were Euphorbiaceae (for chemical ICD), Urticaceae (for mechanico-chemical ICD), Fabaceae and Rutaceae (for mechanical ICD). Most of the classes of chemical compounds identified as being responsible for plant-induced ICD were restricted to plants of specific genera such as the diterpenes in *Euphorbia* spp., disulphides in *Allium* spp., terpenes in *Citrus* spp. and isothiocyanates in *Brassica* spp., while calcium oxalate was implicated in 5 genera. Among the six types of mechanical irritants that were reported, thorns and hairs were the most cited, accounting for mechanical ICD in widely cultivated plants such as *Acacia karroo* and *Citrus* spp.. Spines and glochids of *Opuntia* are well-known hazards in the study area. Many of the plant species that were mentioned in the survey for causing ICD are principally

used as food and ornamentals, a finding which suggest that workers within the food and flower industries in the Eastern Cape have a higher-than-average risk of contacting plant-induced ICD. Hence, early recognition of irritant contact dermatitis may lead to improved outcomes to both employees and employers. Therefore, health care practitioners need to be aware of possible occupational causes for all cases of ICD.

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