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Counselling interventions for Households on the Dangers of the Houseplant, Dieffenbachia spp. (Floristic Dumb cane), in Calabar

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Abstract
Diffenbachia species commonly called dumb cane is a houseplant found in homes, offices, banks and landscape premises as ornamental plants. Ingestion of dieffenbachia sap or plant parts leads to stinging and burning sensations to the mouth and throat, irritates the mucousal membranes, swelling of the mouth and throat, hoarse voice, nausea, vomiting and blindness if sap is in contact with the eyes. This family of plants has shown high levels of acute and chronic toxicities with high mutagenic, carcinogenic, genotoxic potentials. Results of the phytochemicals – proteins interactions in biological systems revealed that oxalates impair and inhibit the formation and functionality of essential amino acids due to complex formations of alanine glycoxylatetransferase (GRHPR), Chromobox homolog 5 chromosome (CBX5), alpha ketaglutarate dehydrogenase (AGXT) and glyoxylatereductase (OGDH). The glycosides on the other hand affect and interact with cytosolic beta glucosidase (GBA3) while saponin interacts with neurotransmitter proteins, alpha L rhamo, sephadex and FOXB proteins which together manifest in the associated symptoms and toxicity earlier stated. There is need to create awareness on the dangers and toxicity of this houseplant especially here in Nigeria, Cross River State and Calabar where the use of this supposed ornamental plant is on the increase.
Keywords: domestic, flower, dumb cane, counselling, sap, toxicity

Introduction

Plants are known to have ornamental, nutritional, industrial and medicinal properties which enable them to be utilized in the decoration of residence, generation of staple food, raw materials for industries (Dutta, 2002), and in the prevention and treatment of diseases and ailment such as flu, typhoid, malaria, hypertension and diabetes mellitus etc. This knowledge has been passed down from one generation to another using various forms of documentation (Cragg et al., 1997). The word candidate or crude drug derived from natural sources has also been used by researchers to describe whole plants or parts of plants which have medicinal attributes. Naturally occurring compounds of plant and animal origin exist in different forms as saponins, flavonoids, resins, terpenoids, alkaloids, glycosides, tannins (Cloutier et al., 2015), amongst others and have been used primarily as sources of medicinal therapy from time immemorial (Burkill, 1985). Some of these naturally occurring compounds in plants are toxic at low or high concentrations to humans and animals and some of these plants have also been used in indoor ornamental decorations in most exotic homes, offices, banks, school premises and relaxation centres by people grossly ignorant of their grave dangers (Blessing et al., 2009).

The indoor houseplant and floristic Dumb cane (*Dieffenbachia species)* is a monocot which is commonly cultivated as a house plant, for its decorative leaves (Bors and Saran, 1991). It is a very popular and hardy shade loving plant. The plant has large leaves that are oblong in shape and greenish with tinted cream or light yellow deep spots and stripes in bands along the veins and border. The genus Dieffenbachia has many species some of which include *D. amoena, D. sesuines, D. picta and D.maculata* amongst others. They are very poisonous to humans and animals and are a grave danger to children who play ignorantly around with it at homes (Groombridge, 1992). The latex sap is a very toxic liquid and has the capacity to cause permanent dumbness and eventual death.

The name dumb cane is derived from a temporary speechlessness after chewing a piece of the stem. Juices or sap from the stem contains oxalates and other substances which irritate the mucousal membranes and cause rapid swelling and inflammation of the tongue and throat. Ingestion of dieffenbachia sap or plant parts can lead to stinging and burning sensations to the mouth and throat, swelling of the mouth and throat, hoarse voice, nausea, vomiting, and blindness if sap is in contact with the eyes (Jiri et al., 2005). This family of plants has shown high levels of acute and chronic toxicities with high mutagenic, carcinogenic, genotoxic potentials.

Araceae is a family of perennial herbaceous plant that grows in a wet land or terrestrial environment (Jang et al., 2013). This family of plant has 105 genera with more than 3300 species and can be found nearly in all the continents of the world especially in

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the tropical regions. *Dieffenbachia amoena* (Dumb cane), is an ornamental cultivar, perennial and common household plant belonging to the Araceae family (Koneman et al., 1997; Joshi et al, 2013). The plant is native to tropical America and the West Indies, especially Costa-Rica and Colombia but presently it can be found in many tropical and subtropical climates, including Africa, Nigeria, Cross River State, Calabar and Esierebom. But its toxicity has not been known even as at the time of the report in Esierebom and thus the need for the counseling intervention in the area to prevent further damage and deaths arising from the continuous use of these plant species as houseplant or ornament in homes, offices and premises in the area (Fronhne & Pfander, 1984). Phytochemical studies conducted on *Dieffenbachia* plant species have implicated some of the phytochemicals such as alkaloids, saponin, glycocides and oxalates to be responsible for the acute and fatal toxicities associated with the whitish liquid sap of the plant species (Dvorack et al., 1999).

Thus this paper seeks to highlight and create the desired awareness and enlightenment to the people of Nigeria, Cross River State and Esierebom in particular on the dangers of this ornamental plant Dieffenbachia species with a view to save lives and humanity.

Methodology

Plate 1: showing diverse species of Dieffenbachia in the study area

Dieffenbachia sap poisoning can be a problem, especially if one has children or pets. It is toxic if ingested and poisoning can result in many symptoms.

Determination of tannin

Tannin was determined from the dumb cane plantusing methods described by AOAC (2016). This method was however slightly modified. About 2g of the leaf sample was defatted with petroleum ether for 2 hours using soxhlet extraction apparatus. The residue was dried in oven for 3 hours at 80^0C, boiled with 300ml of distilled water, diluted to 500ml in standard volumetric flask and filtered through non-absorbent cotton wool. A volume of 25ml of the infusion was measured into 2 litre porcelain dish and titrated with 0.1N potassium permanganate (0.1N potassium permanganate was standardized against 0.1N oxalic acid) until blue solution change green; the few drops of 0.1N potassium permanganate was added. The difference between the two titrations was multiplied by 0.006235 to obtain the amount of tannin in the sample using equation:

0.1N oxalic acid=0.006235g tannin

Determination of oxalate

The total acid of the powdered sample was determined by a modified method of AOAC (2016). About 2g aliquot of the plant material was weighed into a 250 ml flask; 190 ml distilled water and 10ml of 6M hydrochloric acid were added. The mixture was digested for 1 hour on boiling water bath, cooled, transferred into a 250 ml volumetric flask, diluted to volume and filtered. Four drops of methyl red indicator were added followed by concentrated ammonia until the solution turned faint yellow. It was then heated to 100^0C, allowed to cool and filtered to remove precipitate containing ferric ions. The filtrate was boiled, 10 ml of 5% calcium chloride added with constant stirring and was allowed to stand overnight. The mixture was filtered through whatman No. 40 filter paper. The precipitate was washed several times with distilled water. The precipitate was transferred quantitatively to a beaker and 5ml of 25% sulphuric acid was added to dissolve the precipitate. The resultant solution was maintained at 80^0C and titrated against 0.5% potassium permanganate until the pink colour persisted for approximately one minute. A blank was also run for the test sample. From the amount of potassium permanganate used, the oxalate content of the unknown sample was calculated using equation:

1ml of $KMnO_4$ = 2.2mg oxalates

Determination of cyanogenic glycosides

The alkaline titration method was used. About 10-20g sample (ground to pass through No. 20 sieve) was placed in 800ml Kjeldahl flask. Approximately 200ml of water was added and allowed to stand for 2-4hrs. About 160ml distillate from steam distillation was collected in NaOH solution (0.5g in 20ml H_2O), and diluted to a definite volume. To 100ml distillate, 8ml 6N NH_4OH and 2ml 5% potassium Iodide solution were added and titrated with 0.02N $AgNO_3$ using a micro burette. Amount of hydrocyanic acid was calculated using the equation:

1ml 0.02N $AgNO_3$=1.08mg HCN

Determination of alkaloids

The gravimetric method was adopted for this analysis. About 5g of sample was weighed and dispersed into 50 ml of 10% acetic solution in ethanol. The mixture well agitated and allowed to stand for 4hours before filtering. The filtrate was evaporated to one quarter (1/4) of its original volume and concentrated NH_4OH was added dropwise to precipitate the alkaloid. The precipitate was filtered with a weighed filter paper and washed with 1% NH_4OH solution. Precipitate was dried in the oven at 600ºC for 30minutes and reweighed. By weight difference, the weight of alkaloid was determined and expressed as a percentage of the sample weight analyzed. Given by the formula:

% Alkaloids = $\frac{W2-W1}{W}$x 100

Where:

W = weight of sample

W1 = weight of empty filter paper

W2 = weight of paper plus precipitate

Determination and implications of phytochemicals in dumb cane toxicity

Several research and reports carried out on Dieffenbachia species has implicated the following phytochemicals and antioxidant as responsible for the toxicity.

1. Saponins
2. Glycosides
3. Oxalates

The European molecular Chemical – proteins interaction network analysis (STITCH) online interactive programme was used to identify each of the phytochemicals in Dieffenbachia sap and the proteins they interact with in the human biological systems to identify possible effects and damages on humans and animal biological systems (Johnson, 1995; Jacob *et al*., 2013).

Presentation of results

Confirmatory test for presence of Saponins in dumb cane

In order to determine the saponin content, 5ml of the leaf sap extract was added to 5ml of distilled water in a test tube and boiled for 10minutes then filtered using whatmann filter paper (125mm), the solution was vigorously agitated and observed. The formation of stable persistent froth (a creamy mass of small bubbles) indicated the presence of saponins (AOAC, 2005).

Confirmatory test for presence of Alkaloids in dumb cane
To check for the alkaloids in the leaf sap extract, 5ml of the extracts was diluted in10ml alcohol, boiled and filtered, 5ml of the filtrate was added to 2ml of ammonia, 5ml of chloroform was then added and shaken gently after which 10ml of acetic acid was added. Finally, the Wagner's reagent was also added. A reddish-brown precipitate appeared to indicate the presence of alkaloids (AOAC, 2005).

Confirmatory test for presence of Glycosides in dumb cane
Liebermann's Test 2.0ml of acetic acid and 2ml of chloroform was added to the whole aqueous plant crude extract. The mixture was then cooled and concentrated H_2SO_4 was added. A Green colour revealed the presence of a glycone, which is a steroidal part of glycosides.

Confirmatory test for presence of Tannins in dumb cane
Two (2) grams of the powdered plant leaves sample was weighed into a beaker and 10ml of distilled water was added. The mixture was boiled for five minutes. Two drops of 5% $FeCl_3$ was then added. Production of a greenish precipitate indicated the presence of tannins.

Oxalates phytochemicals and protein interactions in biological systems

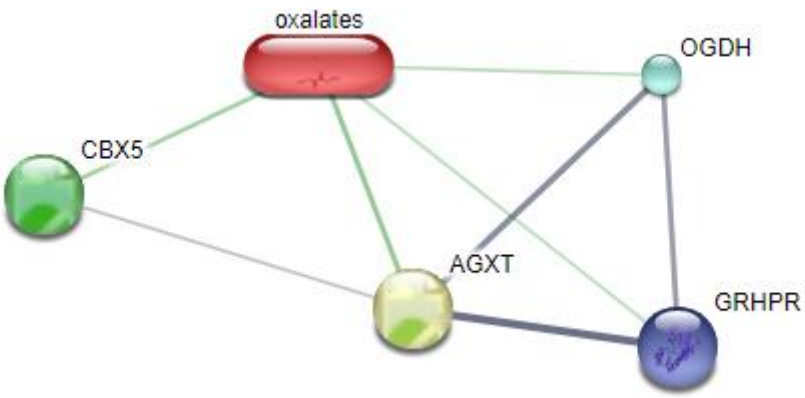

Fig.1: Oxalate – proteins interactions in biological systems

Oxalates (fig.2) are naturally occurring molecules found in abundance in dieffenbachia species and many other plant species especially edible ones. It leads to kidney stone in humans and animals.

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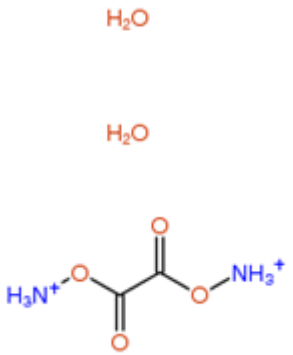

Fig. 2: Oxalate chemical structure

AGXT (Fig. 3) is alanine – glyoxylate aminotransferase protein that processes essential amino acids production in the cells and their further metabolism. These enzymes are disrupted by oxalates as antioxidants and interrupt the processing and production of essential amino acids in the human and animal biological systems.

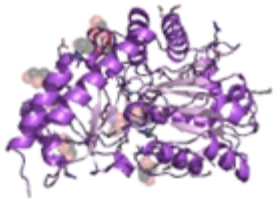

Fig. 3: Alanine glyoxlate aminotransferase protein

CBX5 (Fig. 4) is the chromobox homologue 5 which is a component of heterochromatin that recognizes and binds histone H3 proteins tail which has been methylated at Lysine 9 (H3K9me), leading to epigenetic repression. Oxalates interact with the CBX5 and lamin-B receptor and disrupt and inhibit the possible complex association of the heterochromatin and the inner membrane which together take part in formation of functional kinetochore by further interacting with MIS12 complex proteins.

Fig. 4: Chromobox homolog 5 protein

OGDH (Fig. 5) is the oxoglutarate (also called alpha – ketoglutarate) dehydrogenase (lipoamide). This oxalate glutarate complex catalyzes the overall conversion of the oxalate glutamine complex to succinyl-COA and CO2, revealing multiple copies of three enzymatic components which interrupts with protein metabolism.

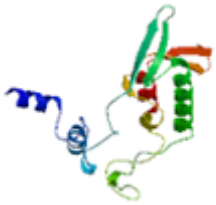

Fig. 5: Alpha ketaglutarate dehydrogenase protein

GRHPR (Fig.6) is glyoxylatereductase which inhibits the processing and reduces hydroxypyruvate to D-glycerateglyoxylate and vice versa.

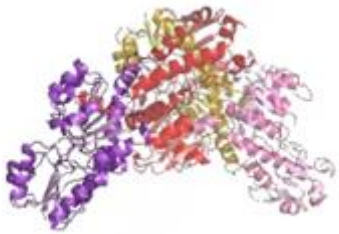

Fig 6: Glyoxylatereductase protein

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Glycosides phytochemical and protein interactions in biological systems

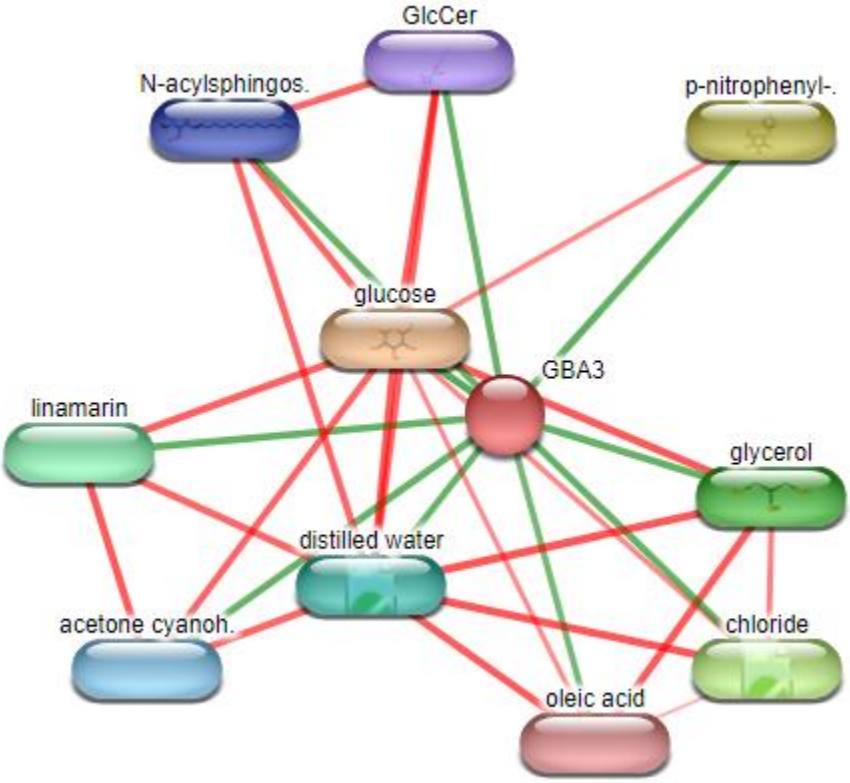
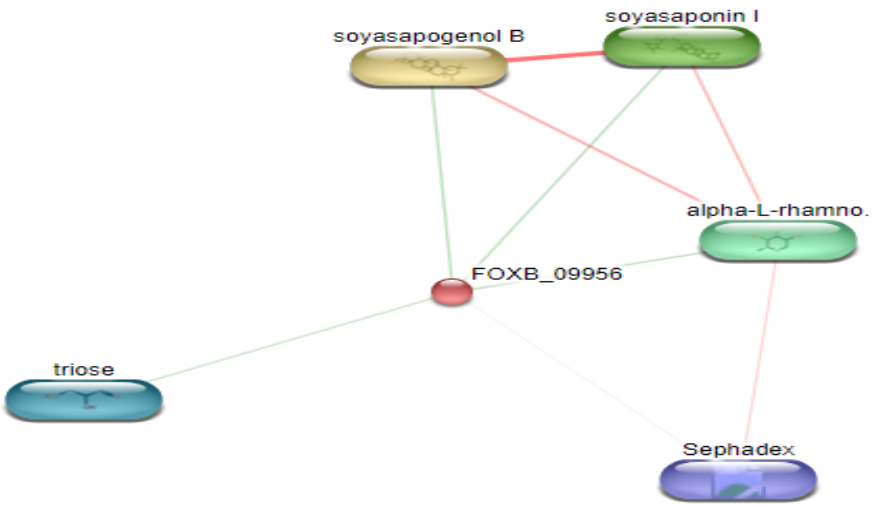


Fig. 7: Glycoside – protein interactions in biological systems

GBA3 is Cytosolic beta-glucosidase. Glycosidase is an enzyme primarily involved in the intestinal absorption and metabolism of dietary flavonoid glycosides and is able to hydrolyze a broad variety of glycosides including phytoestrogens, flavonols, flavones, flavanones and cyanogens. It possesses beta- glycosylceramidase activity and may be involved in a nonlysosomal catabolic pathway of glycosylceramide. GBA3 reacts with linamarin which is a cyanogenicglucoside found in the leaves and roots of plants such as Dieffenbachia, cassava, lima beans, and flax. It is a glucoside of acetone cyanohydrin. Upon exposure to enzymes and gut flora in the human intestine, linamarin and its methylated relative lotaustralin can decompose to the toxic chemical hydrogen cyanide; hence food uses of plants that contain significant quantities of linamarin require extensive preparation and detoxification. Ingested and absorbed linamarin is rapidly excreted in the urine and the glucoside itself does not appear to be acutely toxic. Consumption of some crops like cassava with low levels of linamarin is widespread in the low-land tropics. Ingestion of food prepared from insufficiently

processed cassava roots with high linamarin levels has been associated with dietary toxicity, particularly with the upper motor neuron disease known as konzo to the African populations in which it was first described by Trolli and later through the research network initiated by Hans Rosling. However, the toxicity is believed to be induced by ingestion of acetone cyanohydrin, the breakdown product of linamarin. Dietary exposure to linamarin has also been reported as a risk factor in developing glucose intolerance and diabetes, although studies in experimental animals have been inconsistent in reproducing this effect and may indicate that the primary effect is in aggravating existing conditions rather than inducing diabetes on its own.

Saponins phytochemical and proteins interactions in biological systems



Dangers of *Dieffenbachia amoena* plant sap

1) The dumb cane is toxic to every part of the human body that the sap comes in contact with.
2) It is extremely dangerous to the five basic sense organs - eyes, skin, ear, nose and tongue.
3) It can induce permanent disability in children.
4) It causes dumbness.
5) It causes blindness if in direct contact with the eye balls.

6) It affects brain proteins and cause loss of memory as indicated in the Chromobox earlier.
7) It affects the reproductive gonads in adults if ingested.
8) It is carcinogenic.
9) It causes severe diarrhea.
10) It affects the electron transport chain impeding the release of energy to the cells and tissues which leads to coma.
11) The oxalates causes kidney stone.
12) The oxalates and other phytochemicals causes aberrations of the human chromosomes if ingested.
13) The oxalates cause epigenetic repression and non disjunction of chromosomes leading to genetic defects.
14) It impedes protein metabolism in humans if ingested.
15) Causes death of humans if urgent medical attention is not given.

Discussion of the findings

Araceae contain crystals of calcium oxalate, which are often cited (Simson & Ogonzaly, 1998) causing the intense irritation experienced when handling or consuming the raw plant tissue of many genera in the family. This supposition is contradicted by the fact that irritation generally is not produced by properly cooked plants (Meyer et al., 1982; Onwugbuta-Enyi, 2003), the crystals still remain after heating (Hewitt & Vincent 1989; Sofowora, 2008). Other compounds must therefore be involved which cause this reaction. Whether irritation is caused by enzymes or crystals, many genera of Araceae are included in the lists of poisonous plants (Tulachan et al, 2014; Potterat, 1997; Walter & Rhanna, 1971). The poisonous compounds in *D. amoena* might likely be present in the non-polar fraction of the plant. However, the ingestion of the polar fraction may not be harmful to the human body because of it is non-toxic.

Conclusion

Dumb cane causes speechlessness after chewing a piece of the stem. Juices or sap from the stem contains oxalates, saponin, glycosides, alkaloids, etc. which irritate the mucousal membranes and cause rapid swelling and inflammation of the tongue and throat. Ingestion of dieffenbachia sap or plant parts lead to stinging and burning sensations to the mouth and throat, swelling of the mouth and throat, hoarse voice, nausea, vomiting and blindness if sap is in contact with the eyes. Chemicals-proteins interactions had shown oxalates impair and inhibit the formation and functionality of essential amino acids due to complex formations of alanine glycoxylatetransferase (GRHPR), Chromobox homolog 5 histone chromosome (CBX5), alpha ketaglutarate dehydrogenase (AGXT) and glyoxylatereductase (OGDH). The glycoside interacts with cytosolic beta glucosidase (GBA3) and saponin affects neurotransmitter proteins

and the FOXB proteins in combination with alpha L rhamo, sephadex. All of these phytochemical proteins interactions are responsible for the observable associated symptoms and toxicity of D. *Sp*. Hence the urgent need to create awareness on the dangers and toxicity of this houseplant especially in rural areas where this plant is still utilized as ornamental plant.

Counseling intervention strategies on the dangers of *D. amoena* on public health

i. Counselling intervention should adopt the strategy of public enlightenment campaign in homes, offices, amusement parks and other places where this household plants is still being cherished as an ornamental floristic plants.

ii. Households should be encouraged to destroy all species of the plant used as ornament especially considering the fact that the plant does not have a nutritional or medicinal value in this part of the tropics. Alternative floristics plants like hisbicus flower should be advocated.

iii. Where the dumb cane plant must be allowed to grow in homes or offices, the plant should be isolated from the reach of children who are the most vulnerable due to ignorance on their part.

iv. Government, corporate organizations and individuals alike should join hands in creating awareness and help in sensitizing the public on the dangers of the household plant, *Dieffenbachia amoena.*

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