Evaluation of selected underutilized flowers of Kerala for commercial exploitation

by

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THESIS

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DECLARATION

I, hereby declare that the thesis entitled **"Evaluation of selected underutilized flowers of Kerala for commercial exploitation"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

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EXTERNAL EXAMINER

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Introduction

1. INTRODUCTION

Floriculture is an important multibillion dollar industry not only dealing with thousands of species and varieties of ornamental plants in cultivation and the wild but also ready to offer anything or vogue, the world wants from it; Even it is not exaggerate to say that high volt provogue fashion industry is nothing but imitation and admiration of nature particularly flowers and their own forms. In addition, it also provides an important livelihood option for several poor, especially in periurban areas. It is recognized that the wealth of ornamental plant diversity can bring happiness and health to humankind.

Floriculture industry is unique among agricultural industries where novelty is an important attribute. World floriculture is expanding rapidly and new innovations and introductions are in great demand to feed ever hungry market needs. It is nevertheless to say that high perishable nature of flowers is the main factor which is pushing itself hard as well as the consumers to always look for a new fresh thing. It is in this interest that neglected or underutilized flower crop species (NUS) comes to the picture from which we could identify and develop diversified uses of floriculture. Even the present day top charactered crops of the industry are nothing but just derived and developed only from their wild germplasm resources, the most prominent among them being rose, chrysanthemum, carnation, gerbera and what not like orchids and anthurium. In this context, no one would ever think to defend against the biodiversity wealth of the great Himalayas only next to this is the Western Ghats of God's own Kerala. Kerala is bestowed with rich wealth of biodiversity of flora as well as fauna due to its diverse agroclimatic and regional topography. As such there are numerous ornamental flowers which may have great potential, but people are not aware of their existence or true value, as they may exist in the wild or by road sides or conserved *in situ* in the forests or nature parks. We can commercialize such ornamental wild flowers in which we may have natural lead in the floricultural trade.

Any new crop cannot be harvested directly from natural resources for commercial exploitation as this creates threat to the nature. For domestication and successful utilization of any native ornamental species, the correct knowledge of the different purposes for which we can exploit them is highly essential. Dehydration of flowers is

an ancient practice. However in India, dry flower industry has gained momentum only a decade ago. In international and domestic markets, demand for dry flower is increasing day by day. Major part of the raw materials for dry flower industry are obtained from underutilised and wild ornamentals. Quality of dry flower mainly depends on flower structure, moisture content, stage of harvest, time of harvest and drying methods.

Use of synthetic pigments in food and textile industries has dangerous impacts on human health. Researches are focussed to replace these dangerous synthetic dyes with natural ones. *Pigments* from flowers are safe to use and ecofriendly.

Essential oils are source of fragrance in flowers. Perfumery industries are exploiting only a few flowers like rose, jasmine and tuberose. Essential oils from underutilized flowers like *Plumeria* and *Gardenia jasminoides* have great demand in market. Method of extraction has great role in determining the quality and yield of essential oil.

The study is planned to explore underutilized native ornamental flowers for their suitability for cut flowers, dry flowers and for extraction of oils and pigments. This will help to conserve the flora, diversify floriculture and promote regional development and value to local flora. The objectives of the study is to assess the suitability of underutilized native flowers of Kerala as cut flowers, dry flowers and for oil and pigment extraction.

Review of literature

2. REVIEW OF LITERATURE

Kerala is bestowed with rich wealth of biodiversity of ornamental plants due to diverse agro-climatic and regional topography. There are numerous ornamental flowers which may have great potential, but people are not aware of their existence or true value, as they may exist in the wild or by the way sides or conserved *in situ* in the forests or nature parks. Many of these underutilized flowers can be used as cut flower, dry flower, loose flower and also for extraction of pigments and essential oils. We can commercialize such ornamental wild flowers in which we may have natural lead in the floriculture trade. The study is planned to acces underutilized native ornamental flowers for their suitability for cut flowers, dry flowers and for extraction of oil and pigments. This will help to conserve and add value to local flora.

2.1. EVALUATION OF UNDERUTILIZED FLOWERS AS CUT FLOWERS

Cut flowers are flowers having long stem and more post harvest life and have been cut from the plant bearing it for decorative purposes. Post harvest techniques like pulsing, hardening, precooling etc. can increase the vase life of cut flowers.

2.1.1. POST HARVEST LONGEVITY

Senescence of cut flowers is generally attributed to the depletion of food and water, however, in ethylene insensitive flowers, oxidative stress has also been suspected as one of the major cause of senescence. Post harvest senescence of many cut flowers can be delayed by harvesting the flowers at proper stage and by providing them with sugars and other biocides through pulsing or holding treatments. However, the stage of harvest and optimum concentration of pulsing treatments differ widely among the species (Jeevitha *et al.*, 2013). Unemoto *et al.* (2011) reported that the abscission and senescence processes may be accelerated by the increase of the ethylene yield which exerts influence upon the tissue turgidity, accelerating the flower wilt.The vase life of vacuum cooled flowers with and without cold storage was studied by Sun and Brosnan(1999). The results show that vacuum cooling can significantly extend the vase life of the flowers with and without cold storage and it is a very effective pre-cooling technique for cut flowers (Sun and Brosnan, 1999). Increasing storage temperature from 2 to 4°C or 7°C decreased vase life for *Echinacea* and *Helianthus*.

2.1.2 FLORAL PRESERVATIVES AND PRECOOLING TREATMENTS

Kobayashi *et al.* (2007) reported that postharvest life is increased by use of floral preservatives containing 2 percent sucrose and 8-HQC (8 hydroxyquinoline citrate), antitranspirants, or simply recutting the stems. Soap can be used to clean the flowers and kill the insects. They found that hot water treatment of red ginger at 120–122°F for 12–15 minutes extended postharvest life, killed most of the pests that infested red ginger, and reduced the geotropic response. Silva *et al.* (2009) studied the effect of silver thiosulphate and calcium sulphate on the vase life of ginger flowers and found thatsilver thiosulphate applied in pulsing for 60 minutes or more led to stem dehydration, whereas calcium sulphate improved both stem hydration and commercial durability. Even in the absence of exogenous ethylene, the life of the flowers was significantly increased by inhibiting ethylene action using pretreatment with silver thiosulphate (STS) or 1-MCP. STS was more effective than 1-MCP in maintaining flower quality (Ceilikal and Ried, 2002). Study conducted by Unemoto *et al.* (2011) showed that the association between the 1-MCP and Florissant® had promoted greater longevity and greater quality in the postharvest conservation of torch ginger for additional 3 days when compared to those kept in water only. It was reported by Prasongchan *et al.,* (2009) that 20 percent sucrose vase solution exhibited the good post harvest quality of inflorescence by delaying peduncle and bract browning, and prolonged vase life up to 7 days. Pulsing in 500 mg/l 8-HQC decreased vase life of *Achillea* but increased vase life of *Helianthus* and *Weigela.* Increasing sucrose concentration from zero to 4 or 8 percent decreased vase life of *Celosia* and *Helianthus*, while zero or 8 percent sucrose was optimum for *Achillea.* According to Emongeor (2004) gerbera flowers held in different concentraction of gibberlic acid(GA_3) had increased flower quality after 14 days of holding compared to distilled water. As per Criley (2001), BA treatments were only slightly more successful on stimulating bud break compared to control. Ieamtim *et al.* (2008) reported that vase life of the flowers treated with ascorbic acid was significantly longer than that of untreated (control) flowers. Flowers held in 0.1percent ascorbic acid had the longest vase life (11.6 days) while that of control was the shortest. Once cut, the inflorescence was not as long lasting as those of the cone gingers, but we can

peel off the outer bract layers as the flower ages to extend its useful life.Chantrachit and Paull (1998) suggested that preconditioning at 40°C for 15 min, standing in a bucket of water at room temperature (22±2°C) for 1 h, and then a hot water treatment at 50°C for 12–15 min increased the vase life of flowers.

2.2 EVALUATION OF UNDERUTILIZED FLOWERS AS DRY FLOWERS

Cut flowers are one of the main components of floriculture trade. The demand for fresh cut flowers is increasing day by day and their prices have shot up considerably. The shelf life of fresh cut flowers is limited, In spite of using best chemicals for improvement of keeping quality and enhancement of vase life. Hence, the fresh cut flowers cannot be stored for a long time. Non availability of flowers at times and places where one wants them very much is an additional problem. Efforts are being made since centuries to find alternatives for fresh flowers. For these efforts, dried flowers hold an economic and eco friendly answer. Dried flower demand in the domestic as well as in the international market is increasing at the annual rate of 15 per cent. Dried flower quality greatly depends on flower structure, moisture content, stage of harvest, time of harvest and drying methods. Flower drying offer excellent prospects, particularly for the Indian entrepreneurs. The country is blessed with a wide range of flora that act as the raw materials. The industry also enjoys the benefit of the cheap labour and favourable climate as against other countries (Gurumurti, 1997). Dried flowers are long lasting and can be used for extended period. When the flowers were dried, one can take them apart and store for future use (Conder *et al.*, 1993). In India, dried flower industry is as old as 40 years. But it is only the last decade that brought in a lot of changes and widened the scope for this industry. The momentum of growth was surprisingly high during the past 10 years (Singhvi, 2001).The life of dried flowers varies with different flowers according to the species, texture of their petals and total consistency of flowers (Deborah,1992). The time of harvest, stage of harvest, pre-drying treatments, method of drying, type of desiccant used are a few to mention among the many factors that decide the final quality of dried flowers. Virtually all the species can be dried, but certain considerations have to be kept in mind before selecting the material. Foremost is that the material should have less moisture and fibrous tissues, secondly, the fluffy and open flowers are difficult to be dried as they lose their shape during drying process (Kaur,1999).

Drying flowers is an exotic physical process with the unique ability to preserve a live appearance and colour in beautiful blooms. Floral dehydration and drying technique is a way to preserve the beauty of fresh flowers. The drying period is affected by various biological factors, out of which, water content in a flower influences themost.Dried flowers have a great potential as substitute of fresh flowers (Dhatt, *et al.* 2007). Drying means decreasing the moisture content to preserve the product for extended shelf life (Muller and Heindl, 2006). For making decorative floral craft items, interior decoration andcommercial exploitation, dry flower technology is preferred (Ranjan and Misra, 2002).

2.2.1 METHODS OF DRYING

Many workers have studied varied approaches or methods to dehydrate flowers and other ornamental plant parts (Bhutani, 1995; Dubois and, Joyce, 1989; Westland, 1995). It is the most common and fundamental method for post-harvest preservation of plants because it allows for quick conservation of the plant material qualities in an uncomplicated manner. To produce best quality of decorative items and value added products, standardization of drying period of different flowers is necessary. The life of the dried flower varies according to species, texture of their petal and total consistency of flower. At 46^0C, flowers get dried without affecting the structural integrity (texture) of flowers due to the removal of moisture in a steady state and the papery structure of flower and low moisture content were the factors affect the drying rate (Safeena and Patil, 2013). The moisture content in dried flower influenced the longevity and ultimately their quality as it was observed that the moisture content is inversely proportional to longevity (Pandey, 2002). Chen *et al.* (2000) reported that stronger and stiffer petal in dried flowers have low moisture content as their enhanced quality.

2.2.2 TEMPERATURE OF DRYING

According to Safeena and Patil (2013) the quality of dried flower of rose cultivar gave best result at 40^0C. Mullar and Haindl (2006) stated that in case of *Salvia* the optimum drying temperature was 50^0C as quality reduction due to discoloration may occur at high temperature. Mishra *et al.,* (2014) observed that the slow rise in temperature up to 46^0C was optimum and uniform for all the plants

selected. The temperature between 40^0C - 50^0C was suitable for drying and also suited the thermostatic quality of hot air oven as well as the natural weather. The desiccant silica gel showed good results in *Chrysanthemum* at 40^0C (Nair and Singh, 2011) and also at 50^0C (Dahiya, 2003).

2.3 PIGMENTS FROM FLOWERS

According to Vargas *et al.*, (2000) pigments are substances present in all living matter which provide attractive colour and play basic roles in the development of organisms. Floral pigment is an important component that give colour to the ornamental plant species. Colour of the flower is influenced by a combination of factors i.e. the type of pigments present in the flower, the translocation of such pigments from site of production and pH of the cell. Natural pigments includes anthocyanins, betalains, carotenoids, chlorophylls and other pigments found in the plants (Grotewold, 2006). Pigments found in plants have been used for centuries for colouring materials. Anthocyanins are normally found dissolved uniformly in the vacuolar solution of epidermal cells and are responsible for majority of red, blue and yellow pigments (Kalia and Saha, 2011)

2.3.1. NATURAL PIGMENTS AND ITS EXTRACTION

Vargen and Lopes (1996) evaluatedcarotenoid content in fresh marigold and found significant differences between control (without enzyme) and enzymatically treated samples. Anthocyanins are naturally occurring compounds that impart colour to fruits, vegetables, and plants. They are probably the most important group of visible plant pigments besides chlorophyll. Apart from imparting colour to plants, anthocyanins also have an array of health-promoting benefits, as they can protect against a variety of oxidants through a various number of mechanisms. They belong to the widespread class of phenolic compounds collectively named flavonoids. They are glycosides of polyhydroxy and polymethoxy derivatives of 2-phenylbenzopyrylium or flavylium salts (Kong *et al.*, 2003). Dev and Ledvani opinioned that besides the pharmacological application, anthroquinones are also important as redox mediator in bio recolorisation of dyes and has potential to replace the synthetic organic compounds in insecticides and pesticides. The distribution of the six most common anthocyanidins in the edible parts of plants is cyanidin (50%),

pelargonidin (12%), peonidin (12%), delphinidin (12%), petunidin (7%), and malvidin (7%). The following four classes of anthocyanidin glycosides are common: 3-monosides, 3-biosides, 3,5-diglycosides and 3,7-diglycosides. 3-glycosides occur about two and half times more frequently than 3,5-diglycosides. So, the most widespread anthocyanin is cyanidin 3-glucoside. Joseph *et al.,* (1999) found that fruit extracts including anthocyanins were effective in reversing age-related deficits in several neural and behavioural parameters, e.g. oxotremorine enhancement of a K1-evoked release of dopamine from striatal slices, carbachol- stimulated GTPase activity, striatal Ca buffering in striatal synaptosomes, motor behavioral performance on the rod walking and accelerod tasks, and Morris water maze performance. The crude anthocyanin extracts of Vaccinium myrtillus have been given orally and by intravenal or intramuscular injection to reduce capillary permeability and fragility. Obi *et al.,* (1998) examined the ability of anthocyanin obtained from the petals of *Hibiscus rosasinensis* to prevent carbon tetrachloride-induced acute liver damage in rats. The YHR pigments have been reported to invigoratecardiovascular and central nervous systems, and act as antioxidants, anti-free radicals, anti-tumour, and anti-inflammation productsand also as antibiotics, and for the alleviation of bloodpressure (Wu *et al.,* 2005). Eugster *et al.,* (1991) found that the red colour of rose is attributed to the presence of anthocyanins and carotenoids. Anthocyanins and carotenoids which are distinct pigment found in plants are also used for their value in food, nutritional and pharmaceutical preparations especially due to their low toxicity (Daugalla *et al.,* 1998). Ersus and Yurdagel (2007) has reportedmicroencapsulation of anthocyanin pigments of black carrot,which has similar physicochemical properties as RRP.

Tan *et al.* (2014) found that total anthocyanin content of six different orchids' petals was determined spectrophotometrically and the value ranged from 0 mg/g (in *Dendrobium* Shavin white) to 2.128 mg/g (in *Mokara* Aranda). Total anthocyanin content was found to be the highest when compared to β-carotene and chlorophyll content.

Carotenoids comprise a diverse class of natural pigments that are of interest for pharmaceuticals, colouring food and animal feed and nutrient supplements (Schmidt-Dannert *et al.*, 2000) due to their high antioxidant activity. Bartley and Scolnik (1995) suggested that plant carotenoids are red, orange and yellow lipid-soluble pigments found embedded in the membranes of chloroplasts and chromoplasts. Their color is masked by chlorophyll in photosynthetic tissues, but in later stages of plant development these pigments contribute to the bright colors of many flowers and fruits and the carrot root. Dietary carotenoids have been studied as agents of prevention and treatment of several illnesses such as cancer and photosensitivity diseases.

In plants, carotenoids have photoprotective functions during photosynthesis and act as precursors for the biosynthesis of the phytohormone abscisic acid ABA (Cunningham and Game, 2005). According to Fraser and Bramley (2004),carotenoids are also very significant nutraceutical components of the animal diet, serving, for example, as precursors for vitamin A, and as antioxidants. Astaxanthin type of carotenoids gives bluish colour to the lobster shells; the bathochromic shift from red to blue is the result of binding of these carotenoid to the crustacyanin macromolecular complex (Cianci *et al.*, 2002).

Carotenoids have essential biological activities, as well as recognized as flower pigments. Carotenoids give most of the yellow to orange flower colours in ornamentals like marigold (*Tagetes* sp), daffodil (*Narcissus* sp), *Freesia, Gerbera, Rosa, Lilium* and *Calendula.* According to Jothi (2008) African marigold (*Tagetes erecta L.*) used as a major source of Lutein carotenoid family . Forkmann (1991) suggested that the ability of carotenoids is to coexist with red or purple anthocyanins, resulting in brown and bronze hues that neither pigment would be able to provide in real. Most of the enzymes in the carotenoid biosynthetic pathway have been identified by Cunningham and Game (2005); Fraser and Bramley (2004). Mathews (1982) found that carotenoid pigments have the ability in slowing down the growth of induced skin tumours, treating dermatological diseases and reducing the overall risk of cancer in human beings.

2.3.2. PIGMENTS FROM UNDERUTILISED FLOWERS

According to Goswami and Gogoi (2015) dye extracted from *Caesalpinia pulcherima* can be used **as** low cost sensitizer for dye sensitized solar cell (DSSC) in order to replace the rare and expensive inorganic and organic sensitizers. According to Dave and Ledwani (2012) Cassia species are rich sources of anthraquinones which are well sources of natural dyes and plant extract containing anthraquinones have wide spread application in food, dye, cosmetics and pharmaceuticals. Campas *et al.,* (2008), Chirinus *et al.,* (2007) and Neuhgnapa (2008) opinionned that red flowers contain Beta - carotene. Beta – carotene form the major hydrocarbon in *Delonix regia* and the carotenoids of different floral parts of *Delonixregia* were first reported by Jungalwala *et al.* (1962). Saleh *et al.* (1976) reported the presence of two anthocyanins cyanide in Delonix regia, n-3-glucoside and cyanidin-3-gentiobioside in the flowers. According to Veigas *et al.* (2012) anthocyanin content of 5.8 mg/g (dw) were recorded in the floral petals of *D. regia* where the anthocyanins contributed to one third of the total phenolics of the petals and total carotenoid content in *Delonix regia* petals was found to be 694 µg/g on a dry weight basis (dw) of which about 367 µg/g was β-carotene. Adje *et al.* (2008) identified three major anthocyanins, cyanidin 3-*O*-glucoside, cyanidin 3-*O* rutinoside, and pelargonidin 3-*O*-rutinoside in *Delonix regia.*

2.4. ESSENTIAl OIL EXTRACTION FROM FLOWERS

Natural perfumery industry mostly uses few flowers like rose, jasmine and tuberose. Now researchers are also focused on certain new under exploited crops in natural perfumery. India is suitable for growing an array of different flower crops, which can be exploited for the extraction of aromatic products. Floral oil is a vital area, which will open up new vistas of flower crops, which can be well substituted to the present conventional cut flower and loose flower industry of the world (Rajamani, 2006).

2.4.1. DEFINITION AND USES OF ESSENTIAL OILS

Floral oils are concentrated volatile aromatic compounds produced by plants. These are easily evaporated essences of plants responsible for the pleasant aroma. Each of these complex precious liquids is extracted from a particular species of

plant.According to Varshey(2012) essential oil are the secondary metabolites produced by the plant to defend them from abnormal severe changes in climate and also invasion of insects and animals. It acts as the defending forces of plants and can be called as plants immune system boosters. Essential oils are studied by different scientists.

Essential oils are volatile, fragrant oils that occur in plants and in general contribute to their characteristic odours, flavours, or other such properties (Heravi, 2006). According to Joy *et al.* (2001) odorous volatile chemical compounds which contain the true essence of flowers are called floral oils.

According to Skaria *et al.* (2011) that application of essential oils in agriculture as antifeedents, repellents, botanical insecticides, natural herbicides and growth boosters are still open to fascinating realms of research. Frangipani essential oil is used for several purpose such as an ingredient in cosmetics, excellent for aromatherapy uses, for example, scented candles, freshen potpourri, massage oils, and of course as a perfume to smell just truly great.(Woodspirits Natures Essentials., 2003; Aromatic Ltd. 2001-2008).

2.4.2. CONSTITUENTS OF ESSENTIAL OILS OF FLOWERS

Raguso and Pichersky (1995) found that in *Clarkia breweri* and *C. concinna,* linalool and linalool oxide (pyran form) were the most abundant monoterpenoids, while linalool oxide (furan form) was present at lower concentrations. Of the aromatic compounds detected, benzyl acetate was most abundant, whereas benzyl benzoate, eugenol, methyl salicylate, and vanillin were present as minor constituents in all floral samples. Zaheer *et al.* (2010) suggested that *Plumeria rubra* was used for the treatment of venereal disease and also used in the indigenous system of medicine for the treatment of rheumatism, diarrhoea, blennorrhea and leprosy. The pink flowered*P. rubra* oil was similar to *P. acuminata* oil in that it was also devoid of benzyl salicylate and benzyl benzoate and rich in alkanoic acids but linoleic acid was absent in the oil of the former (Toher *et al.,* 2006). According to Baretto *et al.* (2014) of the three varieties, (*P. rubra typica* form, *Q. rubra L. lutea* form (R & P) Woodson, *Prubra L.* acutifolia shape and *P rubra* form tricolor (R & P) Woodson, oils from flowers of typica form was presented the highest number of hydrocarbons and sesquiterpenes and low concentrations in oil from tricolor (R & D) Woodson.

Lawal *et al.* (2015) analysed the quantitative significant compounds of the flowers oil of *Plumeria rubra* were (*E*)-non-2-en-1-ol (15.7%), limonene (10.8%), phenyl acetaldehyde (9.0%), *n*-tetradecanal (8.8%), γ-elemene (6.5%) and (*E,E*)-α-farnesene (6.1%). Pitpiangchan., (2009) showed percentage yields of the extracts of *Plumeria* spp. were 0.0167, 0.0045, 0.0342, 0.4170, 0.3510, 0.3969 and 12.2400%, respectively. Main chemical component of essential oil from three distillation methods and absolutes of both solvent was benzyl salicylate, from cold enfleurage absolute was linalool and from hot enfleurage absolute was n-undecanoic acid.

2.5 IDENTIFICATION OF COMPONENTS USING GAS CHROMATOGRAPHY- MASS SPECTROMETRY

Gas Chromatography-Mass Spectrometry (GC-MS) is defined as a method that combines the features of gas-liquid chromatography and mass spectrometry to identify different constituents and also it is used to identify trace elements in materials that were previously thought to have disintegrated beyond identification. Chaichana *et al.,* 2009used Shimadzu GCMS-QP 2010 Plus system, with a mass-selective detector with electron impact ionization for identifying the essential oil components of *Gardenia jasminoides.* Major chemical constituents of the essential oil, absolute and fresh flowers of *G.jasminoides* were linalool, *alpha*-farnesene, *z*-3-hexenyl tiglate and *trans-beta*-ocimene. The essential oil and absolute possessed antimicrobial activities against *Staphylococcusaureus* and *Staphylococcus. epidermidis*, the activity towards *Escherichia coli* presented for only essential oil and the activity against *Candida albicans* appeared for only absolute.

The essential oil from *Gardenia jasminoide*s flower was obtained by hydrodistillation and analyzed by Gas Chromatography (GC). Fifty-four components were characterized, representing 100% of the totalcomponents detected. The oil is composed mainly of sesquiterpenes (49.01%) and monoterpene (44.33%) (Obuzor and Nwaokolo, 2010). Victorio *et al.* (2010) identified the components in fresh leaves of *Alpinia zerumbet* and *A. purpurata* (Zingiberaceae) by GC-MS, terpinen-4-ol (29.4%) and 1,8-cineole (23.1%). Leaf oil of *A. purpurata* was rich in ß-pinene (34.7%) and a-pinene (11.8%). Limonene was the only major constituent present in the oil samples from *C. lemon* with the highest percentage (78.28%).

Raguso and Pichersky, (1995) After floral scent collection, adsorbent columns were eluted with 2.4 ml of HPLC-grade hexane and the eluant stored in teflon-capped glass vials at - 20 °C. Samples were prepared for GC-MS by concentrating to 75/g with a stream of purified air at ambient temperature. The flower oils of four *Plumeria* species; *P. obtusa* L., *P. acuminata* (yellow flower), *P. rubra* L. (pink flower) and *P. rubra* (orange flower) hydrodistilled from samples grown on peninsular Malaysia, were analyzed by gas chromatography on two columns of different polarity and GC/MS and found that the orange flowered cultivar had the highest concentration of (E)-nerolidol (14.4%) and geraniol (4.1%) among the species studied (Tohar, 2006). The compounds of these extracts are identified by GC/MS and percentage compositions are determined by GC-FID.The major components detected in the extracts are E- and Z-linalool oxides (furanoid form), 2,2,6-trimethyl-6-vinyl-3-keto-tetrahydropyran, 2,2,6-trimethyl-6-vinyl-3-hydroxy-tetrahydropyran (linalool oxide pyranoid form), (E,E)-α-farnesene, Z-3-hexenyl benzoate and benzyl benzoate and a tentatively identified compound quinoline carbonitrile along with some waxy components (Rout and Naik, 2006).

Extract of *Calliandra portoricensis* by GC-MS revealed 14 – methyl esters detected were hexadecanoic acid, methylhexadecanooate, 9–oxo– methyl nonanoate and some other minor components and extract was investigated for preliminary antimicrobial activity using the following pathogenic bacteria *Escherichia coli, Staphyloccocus aureus*, *Salmone* (Orishadipe *et al.* 2010). Sousa *et al.* (2010) studied the GC-MS phytochemical profile of the essential oil present in the leaves of *Lantana camera* and found that germacrene-D (24.50-6.15%), biciclogermacrene (33.32-14.27%), spathulenol (25.04- 1.06%), eremophilene (20.64-1.93%), valecene (33.70-0.84%), viridiflorene (19.46%) and 1,10-di-epi-cubenol (27.93-21.32) are present. Pratheesh *et al.* (2009) observed that chromatographic separations of saponified oleoresin were performed and Trans-Lutein identified as the major constituent. Sarkar *et al.* (2012) indicated that different solvents ranging from organic to aqueous and their mixture were used to achieve the maximum extractability of total carotenoids. The extracted total carotenoids were estimated using UV- visible spectrophotometer.

Materials and methods

3. MATERIALS AND METHODS

Evaluation of selected underutilized flowers of Kerala for commercial exploitation was carried out during 2013-2015 at the Department of Pomology and Floriculture, College of Horticulture,Vellanikkara. The investigations were carried out as five different experiments, viz., evaluation of 10 underutilized species of Kerala for use as cut flower, evaluation of five species for use as dry flower, essential oil extraction of three species, pigment extraction of four species and identification of components of floral oil and pigments using chromatographic and spectrometric methods.

3.1. Location

Geographically Vellanikkara is situated at latitude of 10° 31'N and longitude of 76° 13'E and lies 22-25m above mean sea level.

3.2. Climate

The climate is humid tropical.

3.3 Evaluation for use as cut flower

Table 1.List of flowers selected for cut flower evaluation

Sl. No	Common name	Scientific name	Family
1	Coral vine	*Antigonon leptopus*Hook. and Arn.	*Polygonaceae*
2	White orchid tree	*Bauhinia acuminata* L.	Fabaceae
3	Peacock flower	*Caesalpinia pulcherrima* (L)Sw.	Fabaceae
4	Paper flower climber	*Calicopteris floribunda* (Roxb.) Lam. ex Poir	Combretaceae
5	Candle brush	*Cassia alata* (L.) Roxb.	Fabaceae
6	Golden shower tree	*Cassia fistula* L.	Fabaceae

7	Glory tree / stick bush	*Clerodendrum fragrans* Vent.	Lamiaceae
8	Pagoda flower	*Clerodendrum paniculatum* L.	Lamiaceae
9	Cape jasmine	*Gardenia jasminoides* Ellis.	Rubiaceae
10	Temple tree	*Plumeria alba* L.	Apocynaceae

The above flowering plants were located in different parts of the campus and labelled. Then the following observations were recorded.

3.3.1 Floral characters

3.3.1.1Flower type

The type of flower on the plant whether single or in inflorescence was observed and recorded

3.3.1.2 Size of flower

The total width of flower or inflorescence in east-west and north -south directions was measured and recorded

3.3.1.3 Length of stalk (cm.)

The length of stalk was expressed as pedicel length and peduncle length. The length from the point of emergence to the point of attachment of inflorescence was measured and expressed as the peducle length in centimeters. The length of stalk of a flower is expressed as pedicel length.

3.3.1.4 Interval of flower production (days)

Blooming period was noted for all the species and expressed in months.

3.3.1.5 Number of flowers produced

The total number of inflorescence or flowers produced per plant per season was recorded.

3.3.1.6 Colour of flower

The flower colour was noted.

3.3.1.7 Fragrance

Noted whether the flower hadfragrance or not.

3.3.1.8 Flower longevity on the plant

Number of days taken for the emergence of flower till necrosis appeared on it was observed and recorded

3.3.1.9 Visual scoring

Visual scoring was done based on flower colour, shape, size, arrangement of flower on spike and texture. The flowers were visually scored by 15 individuals. The grades ranged from 1 to 10 for each character totalling to 50 for each species.

3.3.2 Post harvest studies

Flowers were harvested at different stages (25%, 50% and fully opened) of development on the morning, A slanting cut is given at the end of the stalk of harvested flowers and kept in water and their post harvest longevity was recorded in days to access the correct stage of harvest for use as cut flower.

3.3.2.1 Fresh weight of flower

Weight of flower just after harvest was recorded.

3.3.2.2 Physiological loss in weight

Physiological loss in weight of flower was calculated by taking the difference between the weight of flower before putting it into vase solution and weight at the end of the experiment.

3.3.2.3 Water uptake

Water uptake was calculated by taking the difference between the initial quantity of water in the vase and final amount remained in vase after the experiment. Total uptake was worked out and expressed in ml.

3.3.2.4 Vase life

The vase life was expressed as the days taken for the appearance of symptoms like shrivelling/ colour fading/ blackening of the flowers from the day of harvest.

3.3.2.5 EC and pHof vase solution

pH values of the treatment solution were read using the pHmeter both at the beginning and at the end of the experiment and the change in pH was expressed. Electrical conductivity of the solution was noted as Sm^{-1}or dSm^{-1}per meter using a salinity meter.

3.4 Evaluation for use as dry flower

Flowers of five plant species were selected for the study. Each species were dried by different drying methods. Suitable drying methods and time taken for drying were standardised for these flowers.

Table 2. List of flowers selected for their suitability as dry flower evaluation

Sl. No	Common name	Scientific name	Family
1	Coral vine	*Antigonon leptopus*	*Polygonaceae*
2	Bush violet	*Barleria obtusa* Nees.	Acanthaceae
3	Paper flower climber	*Calicopteris floribunda*	Combretacea
4	Golden shower	*Cassia fistula*	Fabaceae
5	Pagoda flower	*Clerodendron paniculatum*	Lamiaceae

3.4.1 Time taken for drying

Time required to dry the flower was noted.

3.4.2 Visual scoring

Scoring was done based on brightness, brittleness, colour change and visual appearance

3.4.3 Drying methods

Selected flowers were dried using different drying methods like shade drying, embedded drying, microwave oven drying, hot air oven drying and press drying.

3.4.3.1 Shade drying

Flowers were hanged and spread on a slab under shade and time taken for proper drying was recorded.

3.4.3.2 Embedded drying

Flowers were embeded in clean sieved fine sand taken in plastic trays and kept in a well ventilated room for drying. Time taken for proper drying was recorded.

3.4.3.3 Microwave-oven drying

Flowers were dried in micro-wave oven by embedding in clean sieved fine sand taken in microwave oven safe containers. After proper drying, containers were taken out of the oven and kept at room temperature. Time taken for drying was recorded.

3.4.3.4 Hot air oven drying

Flowers were kept in hot air oven at a temperature of 50 – 55°C and time taken for proper drying was recorded

3.4.3.5 Press drying

Fresh flowers were carefully kept between folds of blotting sheets and placed one above the other and then placed in a plant press. The plant press was tightened regularly. Time taken for proper drying was recorded.

3.5 Evaluation of underutilized ornamentals for essential oils

Suitability of these selected underutilized ornamentals for essential oil extraction was studied.

Table 3. List of flowers selected for essential oil extraction

Sl.No	Common name	Scientific name	Family
1	*Cape jasmine*	*Gardenia jasminoides*	*Rubiaceae*
2	*Temple tree*	*Plumeria sp.*	*Apocynaceae*
3	*Rangoon creeper*	*Quisqualis indica* L.	*Combretaceae*

3.5.1 Method of extraction

Solvent extraction method using a soxhlet apparatus was followed for essential oil extraction. Food grade hexane was used as solvent and flower to solvent ratio was 1:2. Fully opened flowers were harvested at 7.00 am and soaked uniformly for two hours in the solvent. Concentrate was extracted using the procedure developed by Guenther (1952). Soxhelet apparatus consisted of soxhelet extractor,

round bottom flasks and condensor. 100g of soaked flower petals were taken in the soxhlet extractor and fitted to a round bottom flask. The temperature of the heater was maintained at 40°C and the flowers were continuously washed with solvent. Essential oil dissolved into the solvent by the penetration of solvent into the flower during washing. The solution was passed through the condenser after which it was kept for evaporation at room temperature. After completeevaporation of solvent, the concentrated flower extract (concrete) was obtained.

3.6 Pigment extraction

Flowers of four plant species were selected for pigment extraction

Table 4. List of flowers selected for pigment extraction

Sl, No	Common name	Scientific name	Family
1	Peacock flower	*Caesalpinia pulcherrima*	Fabaceae
2	Golden shower	*Cassia fistula*	Fabaceae
3	Pagoda flower	*Clerodendrum paniculatum*	Lamiaceae
4	Gulmohar	*Delonix regia* (Bojer ex Hook.) Raf.	Fabaceae

3.6.1. Method of pigment extraction

3.6.1.1 Solvent extraction with solid state fermentation

Pigment extraction was done after fermentation as suggested by Sreevidya, 2008. After harvest, petals were seperated and heaped on a 300 guage polythene sheets and was covered with another 150 guage polythene sheet and kept for a week in a closed yard under ambient conditions. After a week of fermentation, moisture content was reduced to about 8% using a cabinet drier at 60°C. Then it was powdered to a size of 0.5mm. Concentrate was extracted in a batch process using analytical grade solvents from powdered flower petal. Soxhelet apparatus was used for the extraction. The batch extractors were loaded with 5g sample in a filter paper packet. Solvent used for extraction was hexane: acetone mixture (7:3) and it was heated to 100°C in a heater for 2 hours. At saturation, the solvent turned colourless. After

extraction the extracts were collected in a petri dish and the solvent was evaporated by drying in a hot air oven to get free oleoresin.

3.6.1.2 Solvent extraction with pretreatment

Pretreatment was done as per the method suggested by Sowbhagya *et al* (2011). NaOH 0.5% (0.125M, pH 8.5) solution was used for pretreatment. Fresh flower petals were soaked in NaOH solution for 48 hours at room temperature. Flower to solution ratio was 1:1. Samples were manually mixed at every one hour interval. After pretreatment, the samples were dried in hot air oven at a temperature of about 45±2°C. Then the dried samples were powdered. This powdered flower samples were used for the extraction

3.7 Identification of major components in floral oils and pigments

GCMS and spectrophotometry was used to find the components of essential oils and pigments.

3.7.1 Component identification of floral oil by GC-MS (Gas Chromatography-Mass spectrometry)

GC-MS analysis of all extracts was performed on 60 mm × 0. 25 mm DB–5 capillary columns of GC-MS QP 5050A Shimadzu using a temperature programme rate of 60-250°C. Operating conditions were 57 minutes of total time and a solvent cut time of five minutes and 40 to 400 m/z of mass range using 1 µl of injector volume. Carrier gas used was Helium. By comparing with mass spectral data from standard library (TUTOR.LIB, NIST12.LIB and NIST62.LIB) and literature data (Adam, 2007) the components of extracts were identified.

3.7.2 Identification of carotenoids and anthocyanins

Identification of carotenoids and anthocyanins was done by spectrophotometer from the extracted samples.

3.7.2.1 Estimation of carotenoid

AOAC method was followed to estimate the total carotenoid content. Fresh petals were dried at a temperature of58±2°C. Dried samples were powdered and used for estimation. One g of the powdered sample was taken in a round bottom flask

along with 2 ml of 40% methonolic KOH and refluxed in a water bath at 56 °C for 20 min. Then, the flask was cooled under tap water. 30 ml of hexane was added to the cooled content and kept in dark for 2h. Top layer of separated hexane was diluted appropriately with hexane. Spectrophotometer was used to read the absorbance at 474nm. Total carotenoid content was calculated in terms of lutein using $E^{1\%}$ 1cm value of trans lutein. The specific absortivity of trans lutein is 2360.

$$\text{Total carotenoids (g/kg)} = \frac{\text{Absorbance at 474nm x Dilution factor}}{\text{Sample weight x } 236}$$

3.7.2.2 Estimation of anthocyanin

Anthocyanin content of the extract was determined colourimetrically using the method standardised by Selim *et al.*, 2008. Powdered flower sample of 1 gwas extracted with 1.5N HCl. The method suggested by Elbe and Schwartz (1996) was used to find the absorption spectrum of the anthocyanins. For this 1 ml of the pigment extract was mixed with 9ml of buffer solution with a pH of 1.5.

3.7.2.3 Total pigment content

A known volume of the filtered extract was diluted to 100ml in the extracting solvent. The colour intensity at 520 nm was measured using Spectronic 2000 spectrophotometer. The total anthocyanin content referred to delphenidin-3,5-sumboside, was calculated using the following equation

$$\text{Total anthocyanins (100 mg)} = \frac{\text{Absorbance at 520nm x dilution factor}}{\text{Sample weight x } 55.9} \times 100$$

3.4. Statistical analysis

Statistical analysis of the data collected was done by adopting the standard procedure of Panse and Sukhatme (1985) and interpreted the results. The critical difference was worked out at five per cent (0.05) probability.

Results

4. RESULTS

The result of the investigation on "Evaluation of selected underutilized flowers of Kerala for commercial exploitation" carried out in the department of Pomology and Floriculture, College of Horticulture,Vellanikkara are presented in this chapter. The investigation were carried out as five different experiments, viz.

1. Evaluation of 10 underutilized species of Kerala for use as cut flower
2. Evaluation of five species for use as dry flower
3. Essential oil extraction from three species
4. Pigment extraction from four species
5. Identification of components of floral oil and pigments using chromatographic and spectrometric methods

4.1.1 Field evaluation

The selected underutilized ornamental plants were studied for various purposes and depicted in plates 1. The results are presented in tables 5.

4.1.1.1 Flower type

The evaluated species produced solitary flower at its apex (terminal) and also a collection of flowers (inflorescence). Inflorescence was observed in *Antigonon leptopus, Caesalpinia pulcherrima, Calicopteris floribunda, Cassia alata, Cassia fistula, Clerodendrum fragrans, Clerodendrum paniculatum, Delonix regia, Plumeria* spp. *and Quisqualis indica* whereas solitary flowers were observed in *Barleria obtusa, Bauhinia acuminata and Gardenia jasminoides.*

4.1.2 Size of flower

Considerable variation was noticed among the evaluated plant species. Among the solitary flowers, maximum flower size (3.5 x 5.4 cm) was noticed in*Gardenia jasminoides* followed by *Bauhinia acuminata* (2.0 x 6.5cm) and *Barleria obtusa* (4.0 x 2.4cm). Flower size also varied among plants bearing flower as inflorescense. *Delonix regia* recorded the maximum (3.2 x 8.02cm) followed by *Plumeria spp* (3.2 x 4.2cm), *Quisqualis indica* (5 x 2.4cm), and *Caesalpinia pulcherrima* (1.8x3.0 cm). Minimum flower size was observed in *Antigonon leptopus* (0.8 x 0.5 cm). Largest inflorescence size was observed in *Clerodendrum*

paniculatum (48.0 x 19.2)and smallest inflorescence was observed in *Antigonon leptopus* (7.2 x 4.0).

4.1.3 Length of stalk

Delonix regia recorded the maximum peduncle length (5.0cm) followed by *Quisqualis indica* (4.0cm). Minimum peducle length was observed in *Clerodendrum paniculatum* (1.0). *Caesalpinia pulcherrima*had maximum pedicel length of 7.2 cm and *Antigonon leptopus* had minimum length of pedicel (1.0 cm).

4.1.4 Blooming period (months)

Bauhinia acuminata took longest blooming period of 10 months, followed by *Caesalpinia pulcherrima* of nine months. Shortest blooming period were recorded for *Clerodendrum paniculatum* and *Cassia fistula* (2 months). Blooming period of *Antigonon leptopus* was five to seven months, *Barleria obtusa* was 4 months, *Delonix regia*wastwo to three months, *Gardenia jasminoides* was four months, *Plumeria* spp.was six months and *Quisqualis indica* was five months. Three months of blooming period was observed in *Calicopteris floribunda, Cassia alata* and *Clerodendrum fragrans.*.

4.1.5 Number of flowers produced

Plants were grouped based on their habitat for comparing the number of flowers produced. For large trees, inflorescence produced at 50 cm^2 of tree canopy was recorded and maximum number of flowers were produced by *Cassia fistula* (28 flowers/50 m^2) and minimum in *Delonix regia*(18 flowers/50 cm^2). Among shrubs producingsolitary flowers, *Barleria obtusa* (35 flowers/ plant) yielded maximum number of flowers and minimum was recorded for *Gardenia jasminoides* (10 flowers/plant). In shrubs producing inflorescence, maximum number of inflorescence was produced by *Calicopteris floribunda* (7 inflorescence/50 cm^2) and minimum was recorded in *Clerodendrum paniculatum* (3 inflorescence per plant). Among the climbers maximum number was observed in *Antigonon leptopus* (12 inflorescence/50 cm^2) and minimum was noted in *Quisqualis indica* (7 inflorescence/50 cm^2).

4.1.6 Colour of flower

The colour of flower was noticed. *Antigonon leptopus* produces pink coloured inflorescence. Flower colour of *Barleria obtusa* is light violet colour. White

coloured flower was produced by *Bauhinia acuminate.Caesalpinia pulcherrima* produces inflorescence with combination of yellow, red and orange coloured flowers. Flower colour of *Calicopteris floribunda*was green in colour. Inflorescence colour of *Cassia alata*was yellow. *Cassia fistula* produces inflorescence with yellow flowers. White flowers with violet tinges was the flower colour of *Clerodendrum fragrans*. Flower colour of *Clerodendrum paniculatum* was of light red. Red coloured flowers were produced by *Delonix regia.Gardenia jasminoides* produces cream coloured flowers. *Plumeria alba* produces white coloured flowers with yellow tinges where as *Plumaria rubra* produces red coloured flowers with yellow tinges on inner side of the flowers. In *Quisqualis indica* flower colour was white at the day of opening later it turns in to pink.

4.1.7 Fragrance

Among the underutilized flower species evaluated *Gardenia jasminoides, Plumeria* spp., *Quisqualis indica, Bauhinia acuminata*and *Clerodendrum fragrans*were fragrant.

4.1.8 Flower longivity on plants (days)

Gardenia jasminoides had the maximum flower longivity of 5 days, followed by *Quisqualis indica* (4 days), followed by *Calicopteris floribunda,Caesalpinia pulcherrima*and *Clerodendrum fragrans* (3 days). *Plumeria* spp. had two days of flower longevity. Minimum flower longevity was observed in *Cassia alata, Barleria obtusa, Bauhinia acuminata, Antigonon leptopus, Cassia fistula and Clerodendrum paniculatum* (1 day).

4.1.9 Scoring of flowers

Scoring of flowers based on floral characters like flower colour, shape, size, arrangement of flower on spike and texture was done (Tables 6 & 7). Among inflorescence, it was observed that *Caesalpinia pulcherrima* had the maximum score of 46.2 followed by *Clerodendrum fragrans* (45.5), and minimum score was observed in *Cassia fistula.* In solitary flowers, *Barleria obtusa*recorded maximum score (39.8) and minimum was recorded in *Bauhinia acuminata*(30.6).

Table 5. Floral characters of plant species selected for the study

Name of flower	Flower type	Flower Size (l x b) cm.	Inflorescence Size (l x b) cm.	Peduncle length (cm.)	Pedicel length (cm.)	Number of flowers produced per plant or 50 cm^2	Flower Colour	Flower longevity on plant (days)	Presence of Fragrance	Blooming period (months)
Antigonon leptopus	Inflorescence	0.8 x 0.5	7.2 x 4.0	1.7	1.0	12inflorescence /50 cm^2	Pink	1	Absent	5 - 7
Barleria obtusa	Solitary	4.0 x 2.4	-	1.5	-	35 flowers/ plant	Light Violet	1	Absent	4
Bauhinia acuminata	Solitary	2.0 x 6.5	-	2.0	-	22 flowers/ plant	White	1	Present	10
Caesalpinia pulcherrima	Inflorescence	1.8 x 2.5	20.0 x 9.0	3.1	7.2	5 inflorescence/ 50 cm^2plant	Reddish yellow	3	Absent	9
Calicopteris floribunda	Inflorescence	2.5 x 1.8	30.0 x 10.0	2.0	4.8	7 inflorescence / 50 cm^2	Green colour	3	Absent	3

Cassia alata	Inflorescence	2.3 x 2.8	18.0 x 4.8	-	7.3	7 inflorescence / plant	Yellow	1	Absent	3
Cassia fistula	Inflorescence	1.5 x 4.8	46.0 x 16.0	2.4	3.5	28 flowers / 50 cm^2	Yellow	1	Absent	2
Clerodendrum fragrans	Inflorescence	1.8 x 3.0	10.6 x 5.4	1.2	3.0	4 inflorescence / plant	White flowers with tinges	3	Present	3
Clerodendrum paniculatum	Inflorescence	2.4 x 1.0	48.0 x 19.2	1.0 (Corolla tubular)	3.2	3 inflorescence / plant	Light red	1	Absent	2
Delonix regia	Inflorescence	3.2 x 8.02	19.0 x 15.0	5.0	4.4	18 flowers /50 cm^2	Red	1	Present	2 - 3
Gardenia jasminoides	Solitary	3.5 x 5.4	-	1.8	-	10 flowers/ plant	Cream colour	5	Present	4
Plumeria spp.	Inflorescence	3.2 x 4.2	18. 0 x 14.2	3.6	8.4	4inflorescence / 50 cm^2	Cream colour with yellow tinges	2	Present	6
Quisqualis indica	Inflorescence	5 x 2.4	15.0 x 12.0	4.0	2.0	6 inflorescence / 50 cm^2	White and Pink	4	Present	5

Table 6. Visual scoring of inflorescence based on floral characters

Sl. No.	Name of flower	Flower colour (10.0)	Shape (10.0)	Size (10.0)	Texture (10.0)	Arrangement of flower (10.0)	Total (50.0)
1	*Antigonon leptopus*	8.6	8.4	8.8	9	9	43.8
2	*Caesalpinia pulcherrima*	9.4	9.2	9.4	9	9.2	46.2
3	*Calicopteris floribunda*	8	8	8.4	9	7.8	41.2
4	*Cassia alata*	9.2	9.6	9.3	8	9.4	45.5
5	*Cassia fistula*	8.8	8	7.4	7.1	7.4	38.7
6	*Clerodendrum fragrans*	8.2	9.5	9.3	9.6	9.3	45.9
7	*Clerodendrum paniculatum*	7.2	9	8.6	7.5	8.4	40.7
8	*Plumeria spp.*	8.2	7.4	7.8	9	7.5	39.4
9	*Quisqualis indica*	8	8.2	8	8.4	7.2	39.8
10	*Delonix regia*	9.2	7.8	8.4	8	8	41.4

Table 7. Visual scoring of solitary flowers based on floral characters

Sl. No.	Name of flower	Flower colour (10.0)	Shape (10.0)	Size (10.0)	Texture (10.0)	Total (40.0)
1	*Bauhinia acuminata*	7	7.4	8.2	8	30.6
2	*Barleria obtusa*	8	8.2	8	8.4	39.8
3	*Gardenia jasminoides*	7.2	8	8.2	8.3	31.7

4.2. Post harvest studies

4.2.1 Evaluation of underutilized native flowers for use as cut flowers

Flowers were harvested at different stages of flower opening (25 % of flower opening, 50 % of flower opening and 75 % of flower opening) and evaluated for use as cut flower.The results of the studies are given in table 8 and plate 2.None of flowerswere found not suitable for use as cut flower, since in many of them water uptake was almost nil for many reasons like woody stem, latex exudation etc.(Table 8)

Table 8. Evaluation of underutilized native flowers for use as cut flowers

Sl. No	Name of the flower	Stage of harvest	Fresh weight of flower (g)	Remarks
1.	*Antigonon leptopus*	25 percentage of opening	2.320	Pedicel too short, no water uptake, drooping of flowers at the first day of harvest itself.
		50 percentage of opening	3.084	
		75 percentage of opening	2.992	
	CD Value	0.280		
2.	*Bauhinia acuminate*	25 percentage of opening	11.692	No water uptake Flowers droop at the first day of harvest
		50 percentage of opening	10.416	
		75 percentage of opening	8.328	
	CD Value	1.87		
3.	*Caesalpinia*	25 percentage of	9.068	No water

	pulcherrima	opening		uptake due to woody stem
		50 percentage of opening	10.428	
		75 percentage of opening	7.834	
	CD Value	1.973		
4.	*Calicopteris floribunda*	25 percentage of opening	8.796	No water uptake due to woody stem
		50 percentage of opening	10.020	
		75 percentage of opening	12.516	
	CD Value	1.618		
5.	*Cassia alata*	25 percentage of opening	19.7	Petals fall off at the first day of harvest
		50 percentage of opening	27.808	
		75 percentage of opening	20.764	
	CD Value	2.781		
6.	*Cassia fistula*	25 percentage of opening	16.216	Petals falls off at the first day of harvest
		50 percentage of opening	17.940	
		75 percentage of opening	12.564	
	CD Value	3.195		
7.	*Clerodendrum fragrans*	25 percentage of opening	16.378	No water uptake due to woody stem
		50 percentage of	20.912	

		opening		Pedicel length very short
		75 percentage of opening	19.612	
	CD Value	2.996		
8.	*Clerodendrum paniculatum*	25 percentage of opening	43.632	Flowers falls off at the first day itself No water uptake due to woody stem
		50 percentage of opening	84.796	
		75 percentage of opening	62.216	
	CD Value	15.816		
9.	*Gardenia jasminoides*	25 percentage of opening	1.928	No water uptake due to woody stem
		50 percentage of opening	2.696	
		75 percentage of opening	3.108	
	CD Value	0.508		
	Plumeria spp.	25 percentage of opening	23.732	There is no water uptake due to latex exudation from the stem
10.		50 percentage of opening	27.816	
		75 percentage of opening	20.416	
	CD Value	4.665		

Plate 1. List of plants selected for the study

Quisqualis indica *Cassia alata* *Bauhinia acuminata*



Caesalpinia pulcherrima *Plumeria alba* *Gardenia jasminoide* *Calicopteris floribunda*




Cassia fistula *Delonix regia* *Antigonon leptopus*



Caesalpinia pulcherrima *Clerodendrum fragrans* *Barleria obtusa*

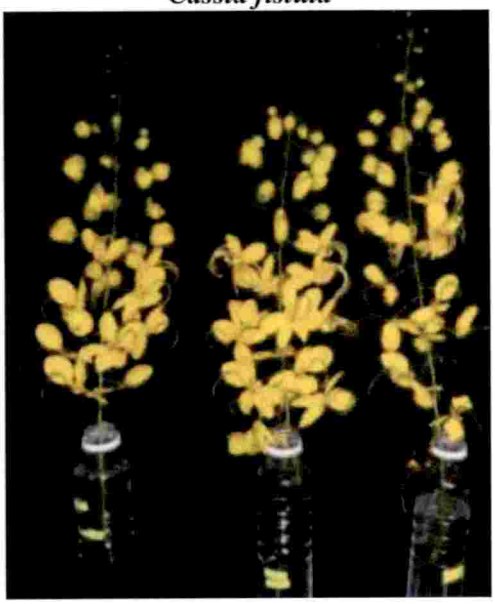


Plate 2. Evaluation of the flowers of the selected plant species for use as cut flowers

Antigonon leptopus

Bauhinia acuminata

Cassia fistula

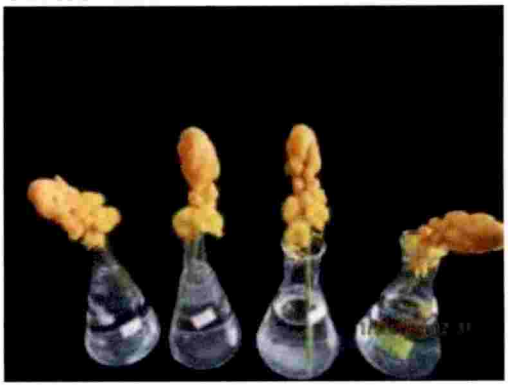


Caesalpinia pulcherrima

Plate 3 . Evaluation of the flowers of the selected plant species for use as cut flowers (contd..)

Calicopteris floribunda

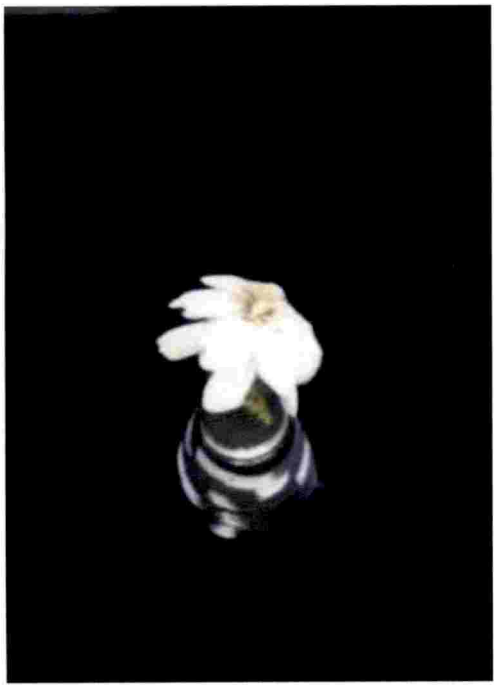
Cassia alata



Clerodendrum fragrans

Clerodendrum paniculatum

Gardenia jasminoides



***Plumeria* spp.**

4.3 EVALUATION OF SELECTED UNDERUTILIZED FLOWERS FOR USE AS DRY FLOWER

Flowers of five plant species were selected for the study. Each species were dried by different drying methods. The drying methods used were shade drying, embedded drying, microwave oven drying, hot air oven drying and press drying.Suitable drying methods and time taken for drying were standardised for these flowers by visual scoring. Scoring was done based on brightness, brittleness and colour change and visual appearance.

4.3.1. Scoring of dried flowers for standardization of drying methods based on aesthetic parameters

All the flowers were scored based on aesthetic and visual quality characters namely brightness, colour change,brittleness and visual appearance after drying and the best method of drying was selected. (Table.9)

4.3.1.1 Aesthetic parameters

4.3.1.1.1 Brightness

In *Antigonon leptopus* under shade drying brightness was scored as medium (1.74). It was good under microwave oven drying (3.06) and poorafter embedded drying (0.54), press drying (1.2) and hot air oven drying (0.94).

In *Barleria obtusa* for shade drying brightness was scored as very poor (0.18), medium in microwave oven and embedded drying, good in press drying and very poor in hot air oven drying.

In *Calicopteris floribunda* brightness was scored as poor in shade drying, embedded drying and hot air oven drying. It was medium in microwave oven drying and good in press drying.

In *Cassia fistula* brightness was scored as medium in shade and hot air oven drying, good in microwave oven drying and excellent in embedded and press drying.

In *Clerodendrum paniculatum* brightness was scored as very poor in all the five methods of drying.

4.3.1.1.2 Colour change

In *Antigonon leptopus*colour change was scored as medium for shade drying, press drying and hot air oven drying. The score waslow for microwave oven drying and high for embedded drying.

In *Barleria obtusa* colour change was scored as complete in shade drying, medium in microwave oven and embedded drying, low in press drying and high in hot air oven drying.

In *Calicopteris floribunda* colour change was scored as poor in shade drying, medium in microwave oven drying, embedded drying and press drying and high in hot air oven drying.

In *Cassia fistula* colour change was scored as medium in shade drying and hot air oven drying, low in microwave oven drying,embedded drying and press drying.

In *Clerodendrum paniculatum*colour change was scored as high in shade, press drying and hot air oven drying, medium in microwave oven and embedded drying.

4.3.1.1.3 Brittleness

In *Antigonon leptopus*brittleness was scored as very low for shade drying, moderate in microwave oven and press drying, low in hot air oven drying and embedded drying.

In *Barleria obtusa* brittlenesswas scored very low in shade drying and hot air oven drying, low in microwave oven drying and embedded drying, moderate in press drying.

In *Calicopteris floribunda* brittlenesswas scored as moderate in all the five methods of drying.

In *Cassia fistula* brittlenesswas scored as low in shade drying,moderate in microwave oven drying, embedded drying, press drying and hot air oven drying.

In *Clerodendrum paniculatum*brittlenesswas scored as low in shade and press drying and moderate in hot air oven drying, microwave oven drying and embedded drying.

4.3.1.1.4 Visual appearance

In *Antigonon leptopus*visual appearance was scored as poor for shade drying, very good for microwave oven drying , average for embedded drying, good forpress drying and hot air oven drying.

In *Barleria obtusa* visual appearance was scored as poorfor shade drying, good in microwave oven and embedded drying, very good for press drying and very low for hot air oven drying.

In *Calicopteris floribunda* visual appearance was scored as average in shade drying and hot air oven drying, good in microwave oven drying and embedded drying, very good in press drying.

In *Cassia fistula* visual appearance was scored as poor in shade drying,high in microwave oven drying, excellent in embedded drying and press drying and average in hot air oven drying.

In *Clerodendrum paniculatum*visual appearance was scored as poor in all the five drying methods.

Data pertaining to the scores of aesthetic parameters and visual qualityof*Antigonon leptopus* under different methods of drying were presented in Table(9). In shade drying scores for brittlenesMicrowave oven drying got highest cumulative score of 11.64. Lowest score was for embedded drying (3.14). microwave oven dried flower secured Microwave oven dried flower retains the colour and brightness. It had low brittleness.

Scoring of *Barleria obtusa* for standardization of drying methods was presented in table (9). Highest cumulative score was for press drying (10.28). Lowest cumulative score was for shade drying(1.06). Press dried flowers secured high score under visual appearance (3.48).Among different drying methods, press drying had the highest cumulative score (10.22) and microwave oven drying has the lowest (7.6). Press dried flowers are less brittle (2.12). Compared to other flowers it was highly brittle.

In *Cassia fistula* highest cumulative score was obtained for embeded drying (12.84). Lowest cumulative score was obtained for shade drying(4.58). In embeded dried flowers flowers, colour change (3.36) was minimum and it maintain the brightness(3.64).

Data pertaining the scores of *Clerodendrum paniculatum* under differentdrying methods was presented in table 9. Cumulative score was highest for microwave oven drying(4.12) and lowest was obtained for press drying(2.38). In all method of drying colour change was high and brightness was very low compared to other flowers.

Plate 4. Evalauation of the flowers of the selected plant species for use as dry flowers

Calicopteris floribunda

Fresh flower ***Dried flower***

Clerodendrum paniculatum

Fresh flower ***Dried flower***

Plate 5. Evalauation of the flowers of the selected plant species for use as dry flowers (contd..)

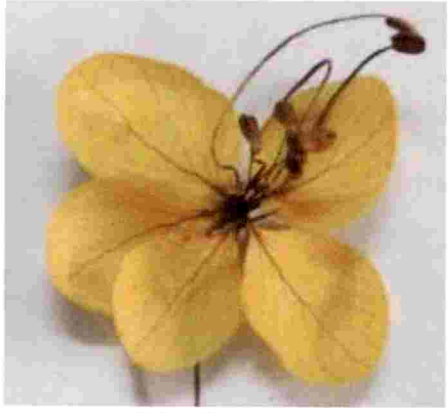
Antigonon leptopus

Fresh flower

Dried flower

Cassia fistula

Fresh flower



Dried flower

Barleria obtusa

Fresh flower

Dried flower

4.3.1.1.5 Cumulative score

Among the five flowers cumulative score was high for *Cassia fistula* (embedded drying-12.84) followed by *Antigonon leptopus* (microwave oven drying-11.64), *Barleria obtusa* (Press drying - 10.28) and *Calicopteris floribunda* (Press drying – 10.22). Least cumulative score was obtained for *Clerodendrum paniculatum.*

Table 9. Scoring of aesthetic parameters of dry flowers obtained from different drying methods

Name of flowers	Drying methods	Aesthetic parameters				Cumulative score (20.0)
		Brightness (5.0)	Colour change (5.0)	Brittleness (5.0)	Visual appearance (5.0)	
Antigonon leptopus	Shade drying	1.74	2.28	0.76	0.34	5.12
	Microwave oven drying	3.06	3.02	2.18	3.38	11.64
	Embedded drying	0.54	1.06	0.7	0.84	3.14
	Press drying	1.2	1.92	1.54	2	6.66
	Hot air drying	0.94	1.66	1.32	1.48	5.4
Barleria obtusa	Shade drying	0.18	0.46	0.22	0.2	1.06
	Microwave oven drying	1.58	1.46	0.9	1.68	5.62
	Embedded drying	1.66	1.64	1.06	1.7	6.06
	Press drying	2.58	2.5	1.72	3.48	10.28
	Hot air drying	0.22	0.48	0.22	0.24	1.16
Calicopteris floribunda	Shade drying	0.88	1.58	1.56	0.5	4.52
	Microwave	1.46	1.8	1.94	2.4	7.6

	oven drying					
	Embedded drying	1.32	1.54	1.46	1.44	5.76
	Press drying	2.52	2.36	2.12	3.22	10.22
	Hot air drying	0.66	1.06	1.48	0.56	3.76
Cassia fistula	Shade drying	1.62	1.62	0.74	0.32	4.58
	Microwave oven drying	2.72	2.78	1.68	2.8	9.98
	Embedded drying	3.64	3.36	2.16	3.68	12.84
	Press drying	3.5	3.3	2.04	3.56	12.4
	Hot air drying	1.68	1.72	1.5	0.94	5.84
Clerodendrum paniculatum	Shade drying	0.24	1.06	1.22	0.3	2.82
	Microwave oven drying	0.3	1.64	1.8	0.38	4.12
	Embedded drying	0.26	1.56	1.78	0.36	3.96
	Press drying	0.14	0.58	1.46	0.2	2.38
	Hot air drying	0.2	0.62	1.74	0.36	2.92

	Scores				
Character	0.0-0.4	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.0
Brightness	Very poor	Poor	Medium	Good	Excellent
Colour change	Complete	High	Medium	Low	No change
Brittleness	Very low	Low	Moderate	High	Very high
Visual appearance	Poor	Average	Good	Very good	Excellent

4.3.2.2. Weight loss

The weight loss of flowers during the drying process at different time intervals were given in the Table 10.

Table 10. Weight loss during drying of flowers

Name of flower	Drying method	Time taken for drying					
		1 day	**2 day**	**3 day**			
Barleria obtusa	Shade drying	60.975[b]	71.353[a]	72.775[a]			
	Microwave oven drying	**1 min**	**2 min**	**3 min**	**4 min**	**5 min**	
		47.815[d]	57.215[c]	66.645[b]	72.790[a]	74.000[a]	
	Embedded drying	**1 day**	**2 day**	**3 day**	**4 day**		
		52.735[c]	65.783[b]	75.538[a]	76.795[a]		
	Press drying	**1 day**	**2 day**	**3 day**	**4 day**	**5day**	**6 day**
		26.733[e]	42.205[d]	58.57[c]	65.230[b]	73.345[a]	75.105[a]
	Hot air oven	1 hr	**2 hr**	**3 hr**			
		51.285[b]	76.590[a]	77.133[a]			
Calicopteris floribunda	Shade drying	**1 day**	**2 day**	**3 day**			
		66.215[b]	76.970[a]	77.620[a]			
	Microwave oven drying	**1 min**	**2 min**	**3 min**			
		43.695b	73.988[a]	75.23[a]			
	Embedded drying	**1 day**	**2 day**	**3 day**			
		47.410[b]	70.230[a]	71.240[a]			
	Press drying	**1 day**	**2 day**	**3 day**	**4 day**	**5day**	
		36.025[d]	56.055[c]	67.980[b]	76.310[a]	77.160[a]	
	Hot air oven drying	**1 hr**	**2 hr**	**3 hr**			
		47.410[b]	70.230[a]	71.240[a]			
Cassia fistula	Shade drying	**1 day**	**2 day**	**3 day**	**4 day**	**5 day**	
		47.005[d]	60.643[c]	67.010[b]	71.470[a]	72.698[a]	
	Microwave oven drying	**1 min**	**2 min**	**3 min**	**4 min**	**5 min**	
		35.743[d]	46.623[c]	56.76[b]	67.09[a]	67.67[a]	
	Embedded drying	**1 day**	**2 day**	**3 day**	**4 day**	**5 day**	**6 day**	**7 day**
		37.513[f]	49.815[e]	59.800[d]	67.210[c]	72.110[b]	74.725[a]	75.395[a]
	Press drying	**1 day**	**2 day**	**3 day**	**4 day**	**5 day**	**6day**	**7day**
		29.880[f]	43.255[e]	53.243[d]	61.245[c]	67.268[b]	70.572[a]	71.415[a]
	Hot air oven drying	**2hr**	**4 hr**	**6 hr**				
		41.403[b]	69.510[a]	70.535[a]				

Clerodendrum paniculatum	Shade drying	**1 day**	**2 day**	**3 day**	**4 day**	**5 day**		
		5353.243[d]	64.456[c]	70.321[b]	75.122[a]	75.845[a]		
	Microwave oven drying	**1 min**	**2 min**	**3 min**	**4 min**	**5 min**		
		44.283[d]	59.346[c]	68.422[b]	72.213[a]	72.542[a]		
	Embedded drying	4 day	**5 day**	**6 day**	**7 day**			
		59.675[c]	65.795[b]	70.545[a]	71.455[a]			
	Press drying	**1 day**	**2 day**	**3 day**	**4 day**	**5 day**	**6 day**	**7 day**
		24.985[f]	43.590[e]	55.544[d]	65.570[c]	73.575[b]	76.585[a]	76.995[a]
	Hot air oven drying	**2hr**	**4 hr**	**6 hr**	**8 hr**			
		32.230[b]	56.150[b]	68.885[a]	70.775[a]			
Antigonon leptopus	Shade drying	**1 day**	**2 day**	**3 day**	**4 day**			
		43.220[c]	55.555[b]	70.143[a]	72.010[a]			
	Microwave oven drying	1 min	2 min	3 min	**4 min**	**5 min**		
		26.100[d]	44.000[c]	55.503[b]	65.663[a]	66.715[a]		
	Embedded drying	**1 day**	**2 day**	**3day**	**4 day**	**5 day**		
		49.945[d]	61.070[c]	68.375[b]	73.778[a]	75.185[a]		
	Press drying	**1 day**	**2 day**	**3 day**	**4 day**	**5 day**	**6 day**	
		29.183[e]	39.003[d]	48.380[c]	63.905[b]	72.710[a]	73.818[a]	
	Hot air oven drying	**2 hr**	**4 hr**	**6 hr**				
		44.800[b]	70.045[a]	71.705[a]				

4.3.2.2.1 *Antigonon leptopus*

At shade drying maximum weight loss was observed on the 4th day of drying which was on par with 3rd day of drying.For microwave oven drying maximum weight loss was observed at 5 minutes of drying and was on par with 4 minutes. The weight loss for embedded drying was statistically on par at 4th and 5th day of drying. For press drying, 5th and 6th day of drying were statistically on par. Maximum weight loss for hot air oven drying was observed for 6 hoursof drying and it was statistically on par with 4 hours of drying.

4.3.2.2.2 *Barleria obtusa*

At shade drying maximum weight loss was observed on the 3rd day of drying which was on par with 2nd day of drying. For microwave oven drying maximum weight loss was observed after 5 minutes of drying and was on par with 4 minutes of drying. The weight loss for embedded drying was statistically on par at 3rd and 4th day of

drying. For press drying, 5th and 6th day of drying were statistically on par. Maximum weight loss for hot air oven drying was observed for 6 hoursafter drying and it was statistically on par with 4 hoursafter drying.

4.3.2.2.3 *Calicopteris floribunda*

At shade drying maximum weight loss was observed on 3rdday of drying which was on par with 2nd day of drying. For microwave oven drying maximum weight loss was observed after 3 minutes of drying andit was on par with 2 minutes of drying. The weight loss for embedded drying was statistically on par at 2nd and 3rdday of drying. For press drying, 4thand 5th day of drying were statistically on par. Maximum weight loss for hot air oven drying was observed for4 hoursafter drying and it was statistically on par with 2hoursafter drying

4.3.2.2.4 *Cassia fistula*

At shade drying maximum weight loss was observed on 5th day of dryingwhich was on par with 4th day. For microwave oven drying maximum weight loss was observed 5 minutesafter drying and itwas on par with 4 minutes of drying. The weight loss for embedded drying was statistically on par at 6th and7thday of drying. For press drying, 6th and7th day of drying were statistically on par. Maximum weight loss for hot air oven was observed for 6 hoursafter drying and it was statistically on par with 4 hours of drying.

4.3.2.2.5 *Clerodendrum paniculatum*

At shade drying maximum weight loss was observed on 6th day of drying which was on par with 5th day of drying. For microwave oven drying maximum weight loss was observed 6 minutesafter drying and was on par with 5 minutes of drying. The weight loss for embedded drying was statistically on par at 6th and 7th day of drying. For press drying, 6th and 7th day of drying were statistically on par. Maximum weight loss for hot air oven was observed for 8 hoursafter drying and it was statistically on par with 6 hoursof drying.

Table 11. Time taken for proper drying of flowers in different drying methods

Name of plants	Shade drying (Days)	Microwave oven drying (Minutes)	Embedded drying (Days)	Press drying (Days)	Hot air oven (Hours)
Antigonon leptopus	3	4	4	5	4
Barleria obtusa	2	4	3	5	2
Calicopteris floribunda	2	2	2	4	2
Cassia fistula	4	4	6	6	4
Clerodendrum paniculatum	5	5	6	6	6

4.3.3 Drying time

Data pertaining to the time of drying is given the Table. (11). Perfect time of drying of flowers were standardised based on weight loss during drying. Time taken for perfect drying of flowers varied with method of drying. For *Antigonon leptopus,*time for perfect drying was standardised as 3 days for shade drying, 4minutes for microwave oven drying, 4 days for embeded drying, 5 days for press drying and 4 hours for hot air oven drying. *Barleria obtusa*took two days for shade drying, 4 minutes for microwave oven drying, 3 days for embeded drying, 5 days for press drying and 2 hours for hot air oven. For shade drying and embedded drying it took two days each, 2 minutes for microwave oven drying, four days for press drying and 2 hours for hot air oven drying. *Cassia fistula*took four days for shade drying, four mintes for microwave oven drying, six days each for embedded and press drying and four hours for hot air oven drying. Perfect drying time for *Clerodendrum paniculatum* standardized as 5 days for shade drying, five minutes for microwave oven drying, 6 days each for embedded and press drying and 6 hours for hot air oven drying.

4.4. EVALUATION OF SELECTED UNDERUTILIZED FLOWERS FOR OIL EXTRACTION

The fragrant flowers selected for extraction of essential oils were *Gardenia jasminoides, Plumeria* spp. and *Quisqualis indica.* The selected flowers were evaluated for the suitability for extraction of essential oils. All species were found to be suitable for oil extraction.

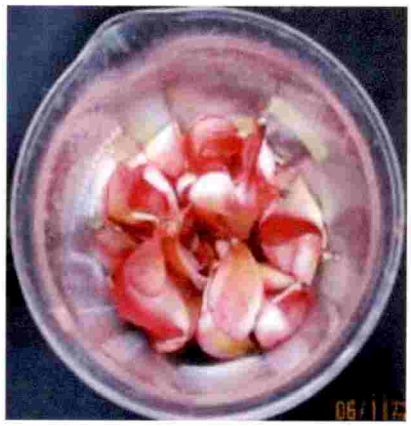
4.4.1Yield of concrete from flowers

The percentage yield of concrete extracted from flowers are presented in Table 12.Highest concrete yield was obtained from*Gardenia jasminoides* and the yield is significantly higher than the other two flowers. The lowest yield was recorded in *Quisqualis indica.* Colour of concrete obtained from *Gardenia jasminoides* was yellow, Whereas light brown in *Plumeria* spp.and dark brown in *Quisqualis indica.*

Tabel 12. Yield of concrete from flowers

Name of flower	Fresh weight (g)	Concrete yield g/100 g petal weight	Concrete yield (percentage)
Gardenia jasminoides	100	0.618	0.61
Plumeria spp	100	0.410	0.408
Quisqualis indica	100	0.403	0.402
C.D. value at 0.05%	0.043		
C.V value ar 0.05%	0.014		

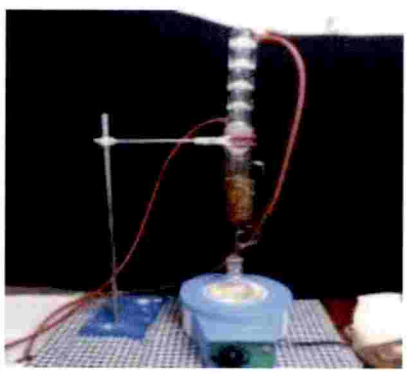
Plate 6. Flow chart showing the method of solvent extraction for concrete from flowers



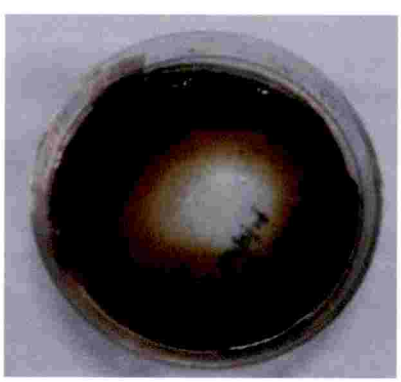
Petals

Soaked in solvent

Extraction



Oleoresin



Gardenia jasminoides

***Plumeria* spp.**

Plate 7. Flow chart showing the method of solvent extraction for concrete from flowers *Quisqualis indica*

Petals

Extraction

Oleoresin

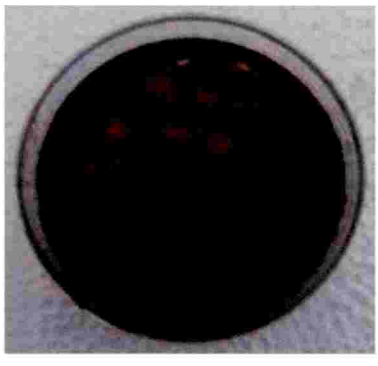


Table 13. Components identified in concrete of*Gardenia jasminoides.*

Sl. No	Retention time (min)	Name of compound	% of total area
1.	30.05	Ascalbin	0.74
2.	32.79	Nonadecane	0.80
3.	25.67	Dendaralasine	0.96
4.	23.66	Alpha famesene	1.12
5.	12.55	Linalool	1.38
6.	22.72	Beta famesene	2.75
7.	24.02	Famesene	3.04
8.	36.66	Henecosane	5.26
9.	40.17	n-Tricosane	6.91
10.	46.43	n-octacosane	10.43
11.	43.44	Pentacosane	13.19
12.	43.94	Monoethylhexyl phthalate	44.74

Table 14. Components identified in concrete of*Plumeria* spp.

Sl. No	Retention time (min)	Name of compound	% of total area
1.	24	α-Farnesene	1.02
2.	42.2	Benzoic acid, [(E,E)-3,7,11-trimethyl-2,6,10-dodecatrien-1-yl] ester	1.08
3.	22.70	1,6,10-Dodecatriene, 7,11-dimethyl-3-methylene-, (E)-	1.17
4.	18.72	Cyclohexasiloxane, dodecamethyl	1.92
5.	12.92	Phenylethyl alcohol	2.20
6.	23.10	1,3,6,10-Dodecatetraene, 3,7,11-trimethyl-, (Z,E)-	2.93
7.	39.4	Oxalic acid, decyl 2-phenylethyl ester	4.3
8.	41.5	Triphenyl phosphate	4.3
9.	46.38	Heptacosane	6.32
10.	49.19	Nonacosane	6.40
11.	48.87	Z-14-Nonacosane	11.65

Table 15. Components identified in concrete of *Quisqualis indica*.

Sl. No	Retention time (min)	Name of compound	% of total area
1	15.5	2H-Pyran-3-ol, 6-ethenyltetrahydro-2,2,6-trimethyl	1.24
2	46.5	Heptacosane	1.44
3	9.8	Cyclotetrasiloxane, octamethyl	1.95
4	42.1	Triphenyl phosphate	2.30
5	49.2	Nonacosane	2.89
6	23	5-Isoquinolinecarbonitr	12.57

4.4.2 Oil component analysis

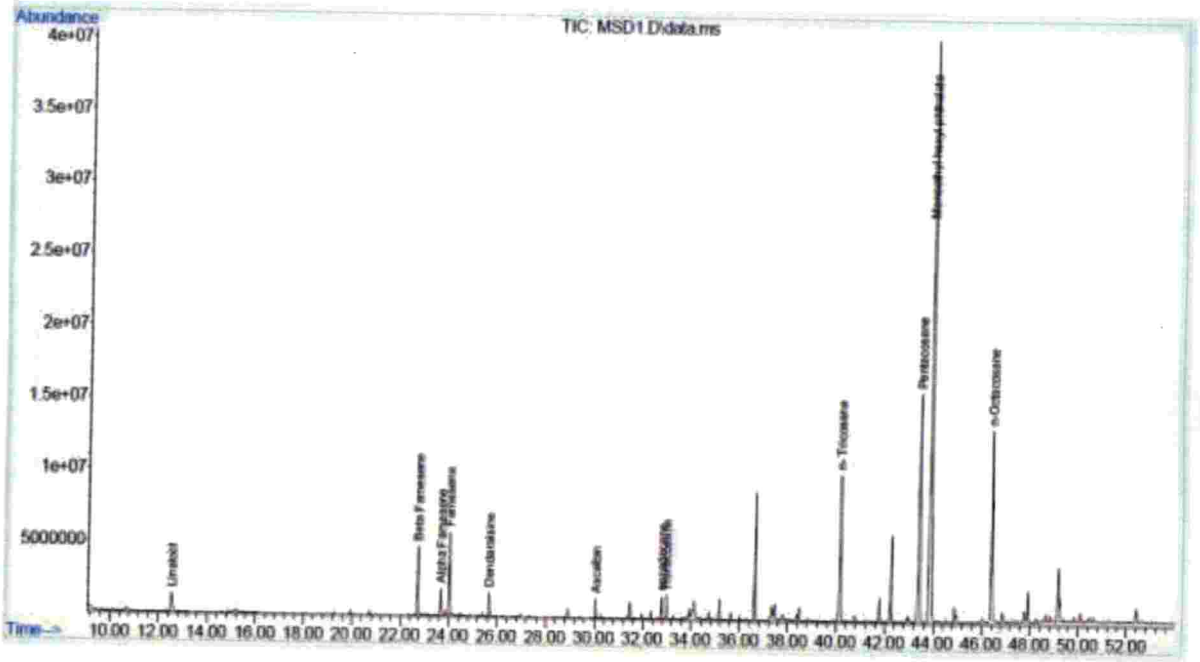
The component identification of all the samples were done by gas chromatography and mass spectrometry. In *Gardenia jasminoides* the components identified were Ascalbin (0.7%), Nonadecane (0.80%), Dendaralasine (0.96%), Alpha famesene (1.12%), Linalool (1.38%), Beta famesene (2.75%), Famesene (3.04%), Henecosane (5.26 %), n-Tricosane (6.91%), n-octacosane (10.43%), Pentacosane (13.19%), Monoethylhexyl phthalate (44.74 %).

The volatile components identified in *Plumeria*spp. were α-Farnesene (1.08%), Benzoic acid, [(E,E)-3,7,11-trimethyl-2,6,10-dodecatrien-1-yl] ester (1.08%), 1,6,10-Dodecatriene, 7, 11- dimethyl- 3-methylene-E(1.17%), Cyclohexasiloxane, dodeca methyl (1.92%). Phenyl ethyl alcohol (2.20%), 1,3,6,10-Dodecatetraene, 3,7,11-trimethyl-(Z,E)(2.93%), Oxalic acid, decyl 2-phenyl ethyl ester (4.3%), Triphenyl phosphare (4.3%), Heptacosane (6.32%), Nonacosane(6.40%) and Z-14-Nonacosane (6.40%) and Z-14-Nonacosane(11.65%).

The components responsible for fragrance in *Quisqualis indica* were 2 H- Pyran-3-ol, 6-ethenyl tetra hydro-2,2,6-trimethyl(1.24%), Heptacosane (1.44%), Cyclotetra siloxane, octamethyl (1.95), Triphenyl phosphate (2.30%), Nonacosane(2.89%) and 5-Isoquinoline carbonitr (12.5%).

Plate 8. Result of GC-MS analysis of essential oils of *Gardenia jasminoides* and *Plumeria* spp.

Gardenia jasminoides



***Plumeria* spp.**

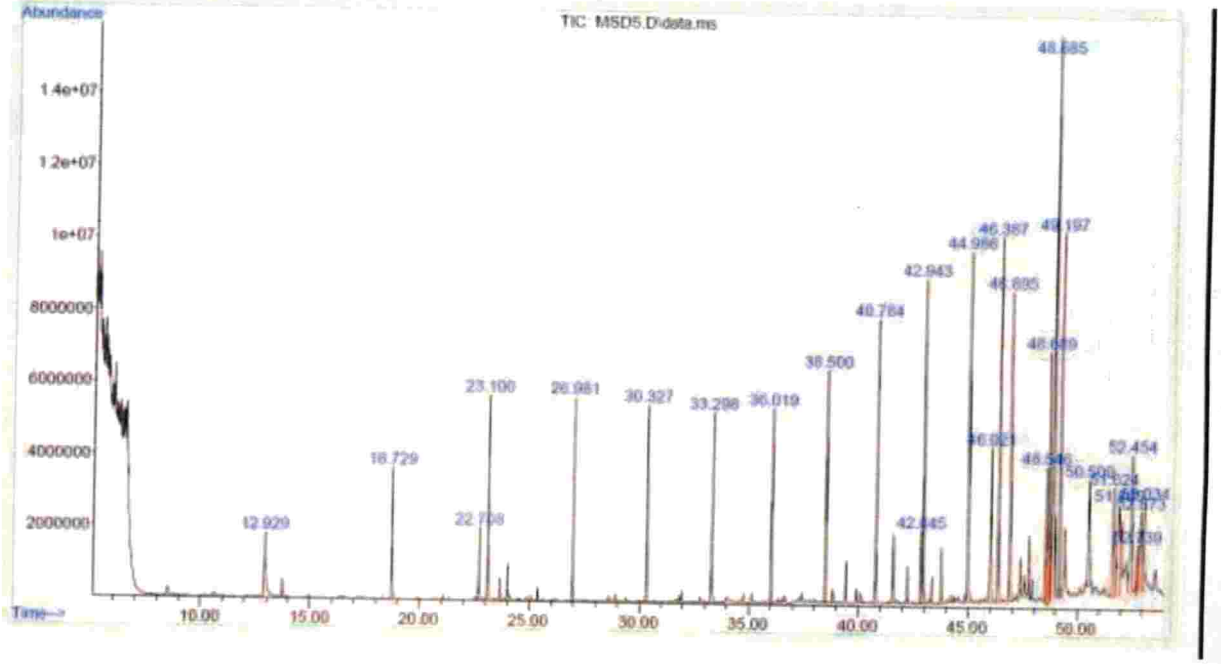
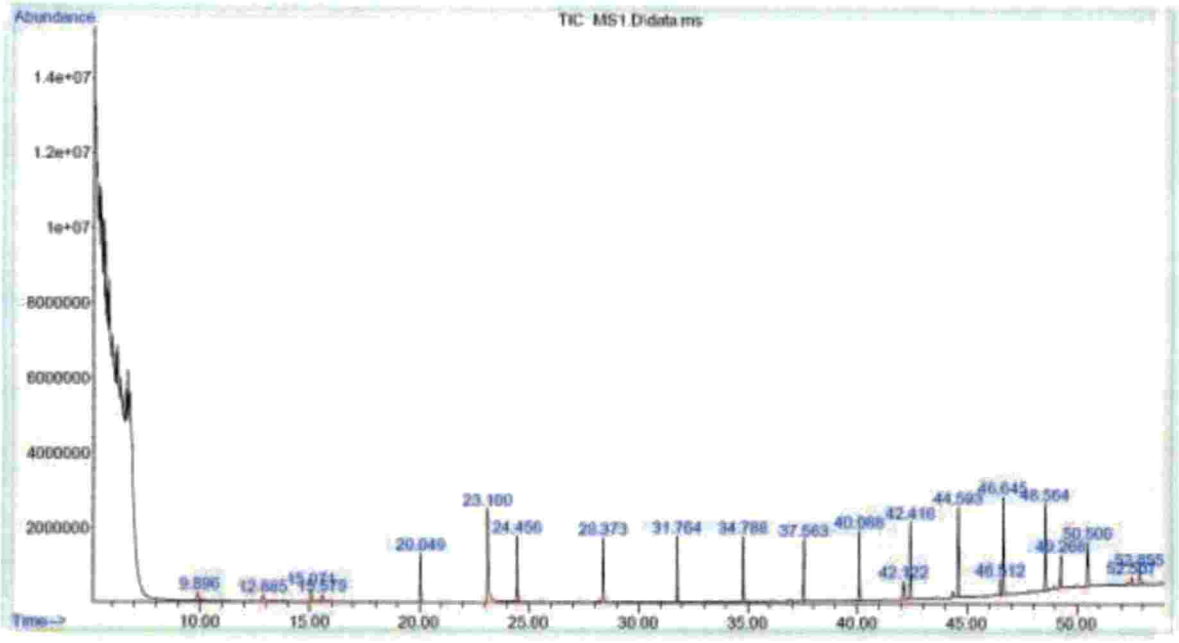


Plate 9. Result of GC-MS analysis of essential oils of *Quisqualis indica*



4.5 EVALUATION OF SELECTED UNDERUTILIZED FLOWERS FOR EXTRACTION OF PIGMENTS

The flowers selected for extraction of pigments were *Caesalpinia pulcherrima, Cassia fistula,Clerodendrum paniculatum, Delonix regia.* The details of plants presented in table 4.The fully opened flowers were selected for pigment extraction.

4.5.1 Method of pigment extraction

Two methods of extraction used in the study, solvent extraction after fermentation and solvent extraction after pretreatments with NaOH.

4.5.1.1Oleoresin yield under solventextraction after fermentation

Solvent extraction afterfermentation was done in all the samples and data pertaining fermentation was given in Table 16.It was observed that *Clerodendrum paniculatum* shows highest oleoresin yield (0.43g). This was followed by *Delonix regia*(0.4g), *Cassia fistula*(0.3g) and *Caesalpinia pulcherrima*(0.28g).

4.5.1.2 Oleoresin yield under solvent extraction after pretreatment

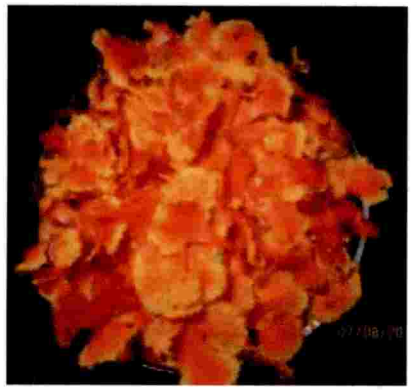
Result showing effects of fermentation and pretreatment on oleoresin yield are shown in table 16, figure 3 and plates3& 4. All flower samples were pretreated with NaOH for increasing oleoresin yield and compared with fermentation. It was observed that solvent extraction with pretreatment yielded more oleoresin than solvent extraction after fermentation.

Differential response of species to the treatment was observed as the interaction was significant (table 16). *Clerodendrum paniculatum* yielded maximum oleoresin under both condition. Under fermentation oleoresin yield of *Delonix regia* was on par with that of *Clerodendrum paniculatum.* Colour of the oleoresin obtained from *Caesalpinia pulcherrima* was reddish orange .Oleoresin obtained from *Cassia fistula* was light red in colour. Greenish yellow coloured oleoresin was obtained from *Clerodendrum paniculatum.* In *Delonix regia*, colour of oleoresin was dark orange

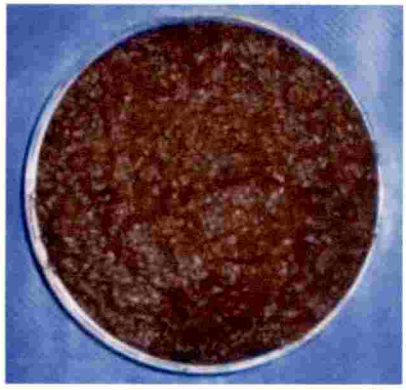
Highest oleoresin yield was observed in *Clerodendrum paniculatum* (0.60g), which is followed by *Delonix regia* (0.5g) and *Cassia fistula* (0.39). The lowest yield was observed in *Caesalpinia pulcherrima* (0.38g).

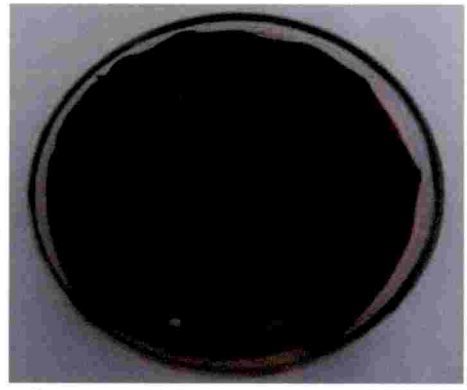
Plate 10. Flow chart of the method of solvent extraction for oleoresin from flowers

Caesalpinia pulcherrima *Cassia fistula*



Petals





Fermented petals

Dry powder

Plate 11.Flow chart of the method of solvent extraction for oleoresin from flowers(contd.)

Clerodendron paniculatum

Delonix regia

Petals

Fermented petals

Dry powder

Table 16. Oleoresin yield in different flowers after solvent extraction with fermentation and with pretreatment

Sl. No.	Name of flower	Weight of sample for extraction(g)	Dried flower petals (g/50g of fresh weight)		Oleoresin yield(g)		Oleoresin yield on dry weight basis (%)	
			Pretreatment	Fermentation	Pretreatment	Fermentation	Pretreatment	Fermentation
1	*Caesalpinia pulcherrima*	5	8.20	5.2	0.38	0.28	7.507	5.727
2	*Cassia fistula*	5	7.4	5	0.39	0.30	7.773	6.127
3	*Clerodendrum paniculatum*	5	12	6.3	0.60	0.43	11.373	9.107
4	*Delonix regia*	5	8.8	4.9	0.5	0.4	9.993	7.907
CD of value of species value at 0.05% Factor(A)					0.031		0.648	
CD of value of method of extraction at 0.05%Factor(B)					0.022		0.458	
CD value of interaction at 0.05 Factor(A XB)					0.044		NS	

4.3.2. Yield of pigments from oleoresin

Oleoresin extract from all flower samples were analysed using spectrophotometry and estimated the yield of anthocyanin and carotenoids. Highest carotenoid yield was observed in *Cassia fistula* (70.04mg/ 100 g) and highest anthocyanin yield in *Clerodendron paniculatum* (574.76mg/100g)). In *Caesalpinia pulcherrima* carotenoid content was recorded as 15.35mg and anthocyanin yield was 488.75. Anthocyanin yield of *Cassia fistula* was 0.35mg. *Clerodendrum paniculatum* recorded 2.98mg of carotenoid. *Delonix regia* recorded carotenoid and anthocyanin yield of 60.2 mg and 510 mg respectively. Results are presented in table 17.

Table 17. Yield of carotenoid and anthocyanin in the oleoresin from flowers

Sl. No.	Name of plant	Carotenoid mg/100gm	Anthocyanin mg/100gm
1	*Caesalpinia pulcherrima*	15.35	488.75
2	*Cassia fistula*	70.04	0.35
3	*Clerodendrum paniculatum*	2.98	574.76
4	*Delonix regia*	60.2	510

Discussion

5.DISCUSSION

5.1 Evaluation of selected underutilised flowers for use as cut flowers

In the present study none of flowers were found suitable for use as cut flower, since in many of them, water uptake was almost nil for many reasons like woody stem, latex exudation, etc.

5.2 Evaluation of selected underutilised flowers for use as dry flowers

Drying of flowers is an important post harvest technique for enhancing keeping quality and value.Drying means decreasing the moisture content to preserve the product for extended shelf life (Muller and Heindl, 2006). For making decorative floral craft items, interior decoration andcommercial exploitation, dry flower technology is preferred (Ranjan and Misra, 2002). According to Sing and Dhaduk, (2005) flower drying technique involves reducing moisture content of flowers to a point at which biochemical changes are minimised while maintaining cell structure, pigment level and flower shape.

5.2.1 Shade drying

For all the five flowers evaluated, shade drying was not found to be suitable. This is in line with the findings of Dhatt*et al.*, (2007) in which they found petals of flowers were shrinked due to inverted hanging in shade drying. *Antigonon leptopus* took 3 days, *Barleria obtusa* and *Calicopteris floribunda*took 2 days and*Clerodendrum paniculatum* took 5 days for perfect drying in shade drying method but in all the cases the petals shrinked and appearance was not acceptable.

5.2.2 Microwave oven drying

In *Antigonon leptopus and Clerodendrum paniculatum* microwave oven drying got the highest cumulative score of 11.64 in terms of aesthetic value. Microwave oven method was found to be suitable for drying in *Chrysanthemum grandiflorum,Gerbera jamesonii* and *Plumeria alba*with high overall acceptability (Jawaharlal, 2013). In microwave oven drying, drying was fast and it retained high

quality. These finding are in accordance with those of White *et al.*, (2002), Microwave drying, which takes only a few minutes in the oven, provides material that looks fresher and more colourful than that obtained by other methods.

For *Antigonon leptopus* drying time is 4 minutes whereas *Clerodendrum paniculatum* took 5 minutes in microwave oven drying. Similar results were observed in aster (4 minutes) and gerbera (6 minutes) flowers (Priyesh, 2003).

5.2.3 Embedded drying

Sand drying is the oldest method, least expensive and sand is the best desiccant. It should be dry, fine and washed several times with water to make it salt free (White, 2002). In *Cassia fistula* highest cumulative score was obtained for embeded drying (12.84). Embedded drying was also found suitable in Thuja leaves (18 days) (Jawaharlal, 2013) and *Helicrysum* (Gill *et al.*, 2002).

5.2.4 Press drying

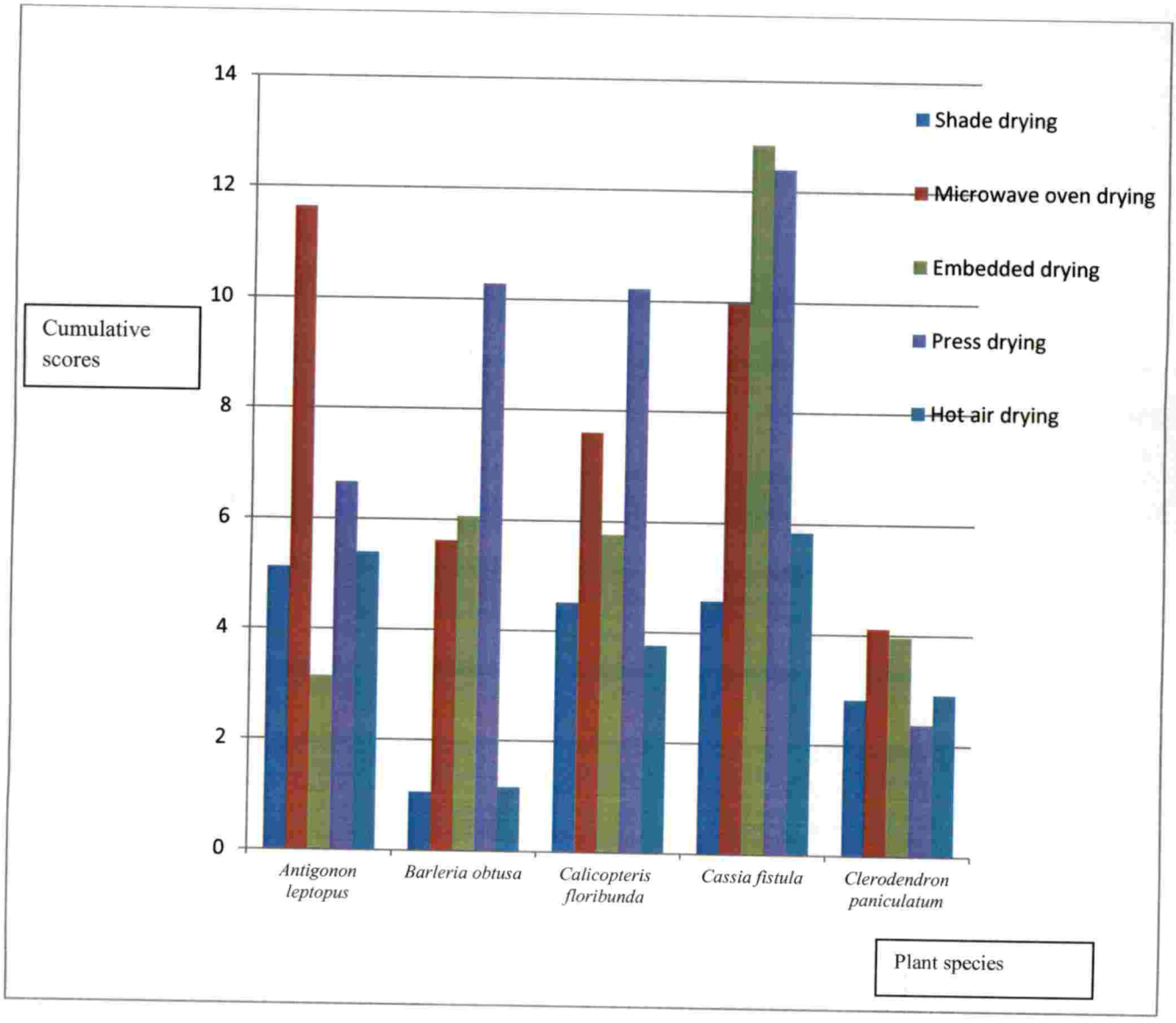
In *Barleria obtusa* and *Calicopteris floribunda*highest cumulative score was obtained for press drying (10.28). In *Helichrysum* and ferns for domestic purposes, press drying was most suitable and for ferns press drying for 60 hours were reported best for domestic purposes. (Gill, *et al.*, 2002). In *Barleria obtusa* and *Calicopteris floribunda*press drying took 5 days each. The papery structured flower and their low moisture content affect the drying rate (Safeena and Patil, 2013).

5.2.5 Hot air oven drying

Flowers of *Antigonon leptopus* and *Cassia fistula*took 4 hours, *Barleria obtuse* and*Calicopteris floribunda* took 2 hours and *Clerodendrum paniculatum* took6 hoursfor effective drying. In chrysanthemum time taken for perfect drying in hot air oven was 6 hours (Wilson, 2013). Priyesh (2003) reported that embedded flowers of *Celosia* and aster took 6 and 8 hours in hot air oven and *Celosia* took 6 hours for drying at 55- 60°C without embedding. Mishra *et al.*, (2014) observed that the slow rise in temperature up to 46^0C was optimum and uniform for all the plants selected. The temperature between 40^0C - 50^0C was

suitable for drying and also suited the thermostatic quality of hot air oven as well as the natural weather. This clearly indicates that the time of drying depended on the type of flower and the arrangement of petals on it.

Fig.1. Effect of drying methods on cumulativescores of aesthetic parameters of dry flowers



5.3 Evaluation of selected underutilized flowers for extraction of essential oils

Natural perfumery industry mostly uses few flowers like rose, jasmine and tuberose. Now researchers are also focused on certain new under exploited crops in natural perfumery. India is suitable for growing an array of different flower crops, which can be exploited for the extraction of aromatic products.

Essential oils are volatile, fragrant oils that occur in plants and in general contribute to their characteristic odours, flavours, or other such properties (Heravi, 2006). According to Joy *et al.* (2001) odorous volatile chemical compounds which contain the true essence of flowers are called floral oils.

Gardenia jasminoides essential oil is one of the most precious oils in the world. The aroma and fragrance are usually used as aromatherapy products. Absolute of gardenia is used extensively by the natural perfumery industry (Power, 2010). In this study it was found that maximum concrete yield was observed in *Gardenia jasminoides*. Yield of extracts in *Gardenia jasminoides* was found to be 0.618g/100 gm. Sukkatta *et al.* (2011) found that absolutes getting from cold enfleurage, hot enfleurage, and hexane and petroleum ether extractions of*Gardenia jasminoides* were 0.2438%, 12.5904%, 0.0600% and 0.0446%, respectively. Chaichana *et al.* (2009) found the percentage yield of the essential oil of *G. jasminoides* flowers as 0.02 % v/w (fresh weight).

In this study it was found that yield of extract from *Plumeria* spp. was found to be 0.408/100 gm. This is in line with the findings of Pitpiangchan., (2009) where percentage yields of the extracts of *Plumeria*spp. under hexane extraction was 0.4170%. Lowest yield of concrete extract was from *Quisqualis indica* (0.402g/100g). Femina (2013) found that concrete yield in *Michelia champaca* was 0.48g/100g, in*Pandanus odoratissimus,* 0.3g/100g, in *Artabotrys odoratissimu,s* 0.46g/100g and in *Mimusops elengi,*0.1g/100g. Shabbir *et al.* (2009) compared the chemical constituents in *Rosa centifolia* spp. and also found that concrete yield was 0.225% and absolute yield, 0.128%.

5.3.2 Identification of major components in floral oils

GC-MS analysis was used for the identification of major components in the floral oils. According to Croteau *et al.* (2000) the most fragrant compounds belonged to three major groups, viz; phenyl propanoids (benzenoids), fatty acid derivatives and terpenoids. In this study 12 major components were identified in the concrete from *Gardenia jasminoides* . The identified compounds were Ascalbin (0.7 %), Nonadecane (0.80 %), Dendaralasine (0.96 %), Alpha famesene (1.12 %), Linalool (1.38 %), Beta famesene (2.75 %), Famesene (3.04 %), Henecosane (5.26 %), n-Tricosane (6.91 %), n-octacosane (10.43 %), Pentacosane (13.19 %), Monoethylhexyl phthalate (44.74 %). This is in line with the findings of Sukkatta *et al.* (2011), who identified 10 major components, viz; methyl benzoate, Linalool, (Z)-3-hexenyl tiglate, 6-tridecanol, tetradecanol, 7-deceno-5-olide, 4-di-tert-butylphenol, (*Z*)-3-hexenyl benzoate, nonadecanol, octadecyl vinyl ether. The study conducted by Obuzor and Nwaokolo (2010) found thatthe oil is composed mainly of sesquiterpenes (49.01%) and monoterpene (44.33%). Themajor constituents of sesquiterpenes were identified as α-Farnesene (28.41%) and small amounts of Guaiol(5.89%), (z)-3-Hexenyl Tilgate (5.47%), Bulnesol (5.03%), cis-3-Hexenly Benzoate (4.21%). In the case ofmonoterpene, Linalool (22.05%) was the major constituent and trans-β-Ocimene (10.59%), α-Terpineol(9.03%) with Methyl Tiglate (2.66%) as the minor components, while Tetracosane (5.64%) was the onlyalkane.

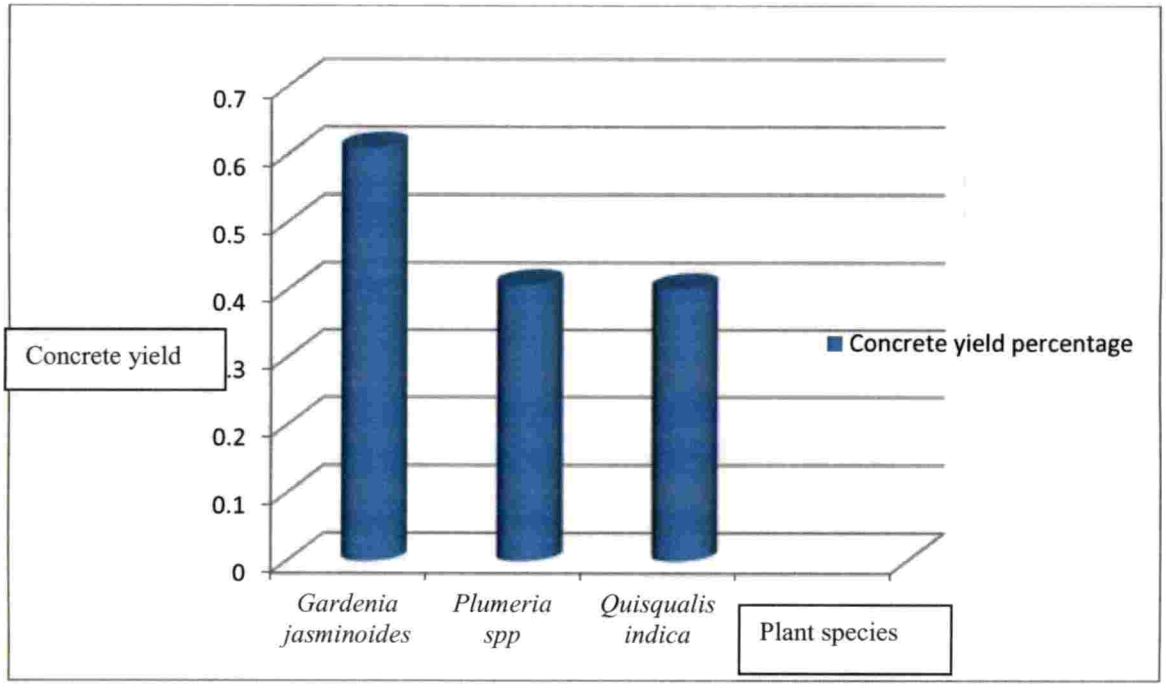
In this study, GC-MS analysis of the essential oils of *Plumeria* spp. revealed the presence of 11 compounds. The volatile components identified in *Plumeria* spp. were α-Farnesene (1.08 %), Benzoic acid, [(E,E)-3,7,11-trimethyl-2,6,10-dodecatrien-1-yl] ester (1.08 %), 1,6,10-Dodecatriene, 7,11-dimethyl-3-methylene-, (E) (1.17 %), Cyclohexasiloxane, dodecamethyl 1.92 %), Phenylethyl alcohol(2.20 %), 1,3,6,10-Dodecatetraene, 3,7,11-trimethyl-, (Z,E)-(2.93 %), Oxalic acid, decyl 2-phenylethyl ester(4.3 %), Triphenyl phosphate(4.3%), Heptacosane(6.32%), Nonacosane(6.40%), Z-14-Nonacosane (11.65 %). Lawal *et al.* (2015) analysed the quantitative significant compounds of

the flowers oil of *Plumeria rubra*as (*E*)-non-2-en-1-ol (15.7%), limonene (10.8%), phenyl acetaldehyde (9.0%), *n*-tetradecanal (8.8%), γ-elemene (6.5%) and (*E,E*)-α-farnesene (6.1%).

Piptpiangchan (2009) found thathexane extraction is the appropriate method to produce absolutes in pilot scale for use as perfume or cosmetic materials from *Plumeria* spp. because this method is cheaper and more convenient than enfleurage method and it gave higher percentage of yield than distillation method and the major components identified were, linalool, (Z)-geraniol, (E)-geraniol, (E)-geranylacetnoe, 2,4-di-t-butylphenol, (Z)-nerolidol, 1-hexadecene, (Z)-farnesol, (E)-farnesol, (E)-farnesal, benzyl benzoate, 1-octadecanol, benzyl salicylate, isoeicosane.

From the present study, components responsible for fragrance in *Quisqualisindica* were identified as 2H-Pyran-3-ol, 6-ethenyltetrahydro-2,2,6-trimethyl (1.24%), Heptacosane

Fig.2. Yield of concrete from flowers of selected plants



(1.44%), Cyclotetrasiloxane, octamethyl (1.95%), Triphenyl phosphate (2.30%), Nonacosane (2.89%), 5-Isoquinolinecarbonitr (12.5%). Sahu *et al.* (2012) studied the medicinal properties of phytoconstituents in *Quisqualisindica* and found the presence of polyphenol contents, rutin and pelargonidin-3-glucoside in flowers.

5.4 Evaluation of selected underutilized flowers for pigment extraction

Anthocyanins are naturally occurring compounds that impart colour to fruits, vegetables, and plants. They are probably the most important group of visible plant pigments besides chlorophyll. Anthocyanins are normally found dissolved uniformly in the vacular solution of epidermal cells and are responsible for majority of red, blue and yellow pigments (Kalia and Saha, 2011).

Carotenoids comprise of diverse class of natural pigments that are of interest for pharmaceuticals, colouring food and animal feed and nutrient supplements (Schmidt-Dannert *et al.*, 2000) due to their high antioxidant activity. Bartley and Scolnik (1995) suggested that plant carotenoids are red, orange and yellow lipid-soluble pigments found embedded in the membranes of chloroplasts and chromoplasts.

5.4.1 Method of pigment extraction

The simplest and easiest method of pigment extraction is solvent extraction after fermentation. Pretreatment with chemicals are found to be the cheapest method of pigment extraction (Femina, 2013). In this study chemical used for pretreatment is NaOH.

Solvent extraction after pretreatment with NaOH yield more oleoresin than solvent extraction after fermentation. These findings are in accordance with those of Femina, (2013). Pretreatment increases the oleoresin yield by degrading the cell wall component and decreasing the water holding capacity and there by increasing the mass transfer during extraction (Sowbhagya *et al.*, 2011). Pretreatment using sodium hydroxide and citric acid increases the permeability of

the tissues and increases the recovery percentage (Omowaye, 2001*et al.,*). Teran *et al.* (2001) also reported that pretreatment increases the yield of pigments from vanilla beans.

In this study it was observed that *Clerodendrum paniculatum* yielded maximum oleoresin under both extraction methods. In both the extraction methods, *Clerodendrum paniculatum* showed highest oleoresin yield (0.60g)followed by *Delonix regia* (0.5g),*Cassia fistula* (0.39) and*Caesalpinia pulcherrima* (0.38g). However the yield was more in solvent extraction after pretreatment with NaOH .This finding was in accordance with Femina (2013).

After fermentation, oleoresin yield of *Delonix regia* was on par with that of *Clerodendrum paniculatum.*

In solvent extraction after fermentation, it was observed that *Clerodendrum paniculatum* showed highest oleoresin yield (0.43g). This was followed by *Delonix regia* (0.4g), *Cassia fistula* (0.3g)and *Caesalpinia pulcherrima* (0.28g).

Oleoresin yield with pretreatment in *Bixasp* was 0.48g, 0.60g in *Nyctanthes arbour- tristis,* 0.38g in *Spathodea campanulata* and 0.32g in *Hibiscus rosasinensis*. Oleoresin yield in extraction after fermentation was 0.33 g in *Bixa sp*, 0.52g in *Nyctanthes arbour- tristis,* 0.26g in *Spathodea campanulata* and 0.23g in *Hibiscus rosasinensis* (Femina, 2013).

According to Prateesh *et al.* (2009) marigold flowers treated with lactic acid bacterial culture as pretreatment increases the yield of carotenoid pigment. Vargas and Lopez (1997) evaluatedcarotenoid content in fresh marigold and found significant differences between control (without enzyme) and enzymatically treated samples.

5.4.2 Identification of major components in pigments

Oleoresin extract from all flower samples were analysed using spectrophotometry and the yield of anthocyanin and carotenoids was estimated.

Highest carotenoid yield was observed in *Cassia fistula* (70.04mg/ 100 g) and highest anthocyanin yield in *Clerodendrum paniculatum* (574.76mg/100g)). In *Caesalpinia pulcherrima* carotenoid content was recorded as 15.35mg and anthocyanin yield was 488.75 mg/100g. Anthocyanin yield of *Cassia fistula* was 0.35mg/100g. *Clerodendrum paniculatum* recorded 2.98mg/100g of carotenoid. *Delonix regia* recorded carotenoid and anthocyanin yield of 60.2 mg/100g and 510 mg/100g respectively and this finding is in line with the findings of Veigas (2012). According to Veigas *et al.* (2012) anthocyanin content of 5.8 mg/g (dw) was recorded in the floral petals of *Delonix regia* where the anthocyanins contributed to one third of the total phenolics of the petals and total carotenoid content in *Delonix regia*petals was found to be 694 µg/g on a dry weight basis (dw) of which about 367 µg/g was β-carotene.

Eugster *et al.,* (1991) found that the red colour of rose is attributed to the presence of anthocyanins and carotenoids. Anthocyanins and carotenoids which are distinct pigment found in plants are also used for their value in food, nutritional and pharmaceutical preparations especially because of their low toxicity (Dougalla*et al.,* 1998). Tan *et al.* (2014) determined the total anthocyanin content of six different orchid's petals and found that value ranged from 0 mg/g in *Dendrobium* Shavin white to 2.128 mg/g in *Mokara* Aranda. Total anthocyanin content was found to be the highest when compared to β-carotene and chlorophyll content. Carotenoids give most of the yellow to orange flower colours in ornamentals like marigold (*Tagetes* sp), daffodil (*Narcissus* sp), *Freesia, Gerbera, Rosa, Lilium* and *Calendula.* Beta – carotene form the major hydrocarbon in *Delonix regia* and the carotenoids of different floral parts of *Delonixregia* were first reported by Jungalwala *et al.* (1962). Saleh *et al.* (1976) reported the presence of two anthocyanins in *Delonix regia* flowers viz; n-3-glucoside and cyanidin-3-gentiobioside.

Adje *et al.* (2008) identified three major anthocyanins viz; cyanidin 3-*O*-glucoside, cyanidin 3-*O* rutinoside, and pelargonidin 3-*O*-rutinoside in *Delonix regia.*According to Femina(2013), carotenoid and anthocyanin yield were6.04 and

82.24 mg/100g in*Nyctanthes arbour- tristis,* 10.80 and 73.55 mg/100g in *Spathodea campanulata*, 1789 and 1223.90 mg/100g in *Bixa* spp.and 3.70 and 203.54 mg/100g in *Hibiscus rosasinensis,*respectively.

Fig.3. Yield of oleoresin from flowers of selected plants (on dry weight basis)

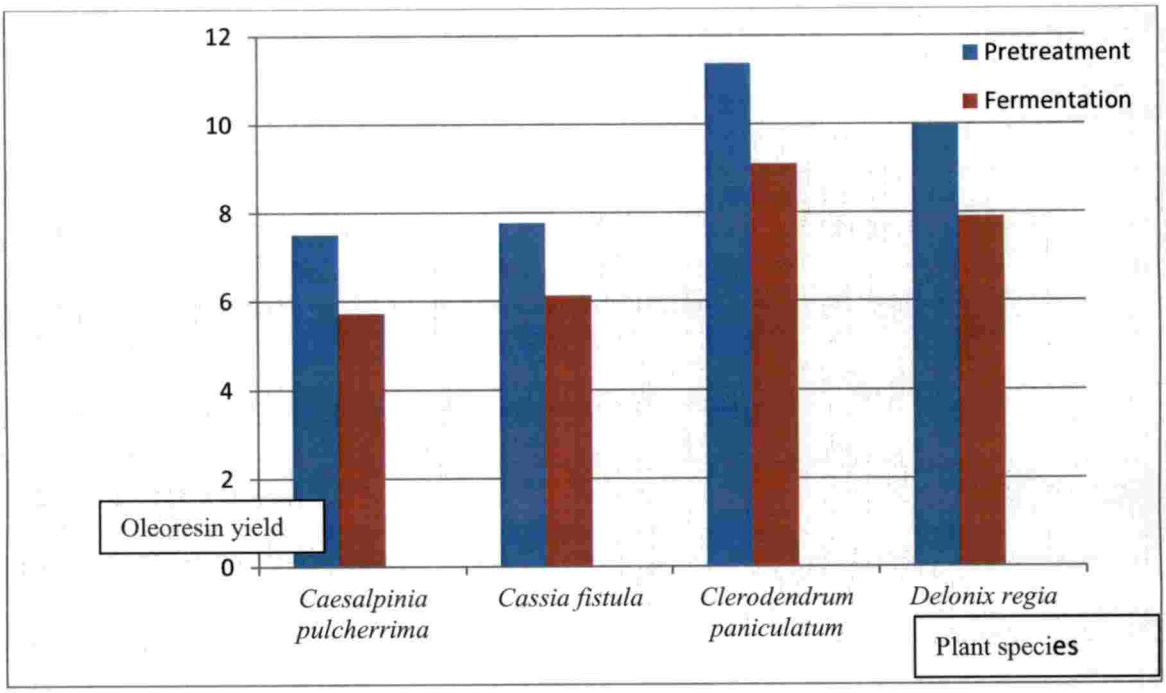
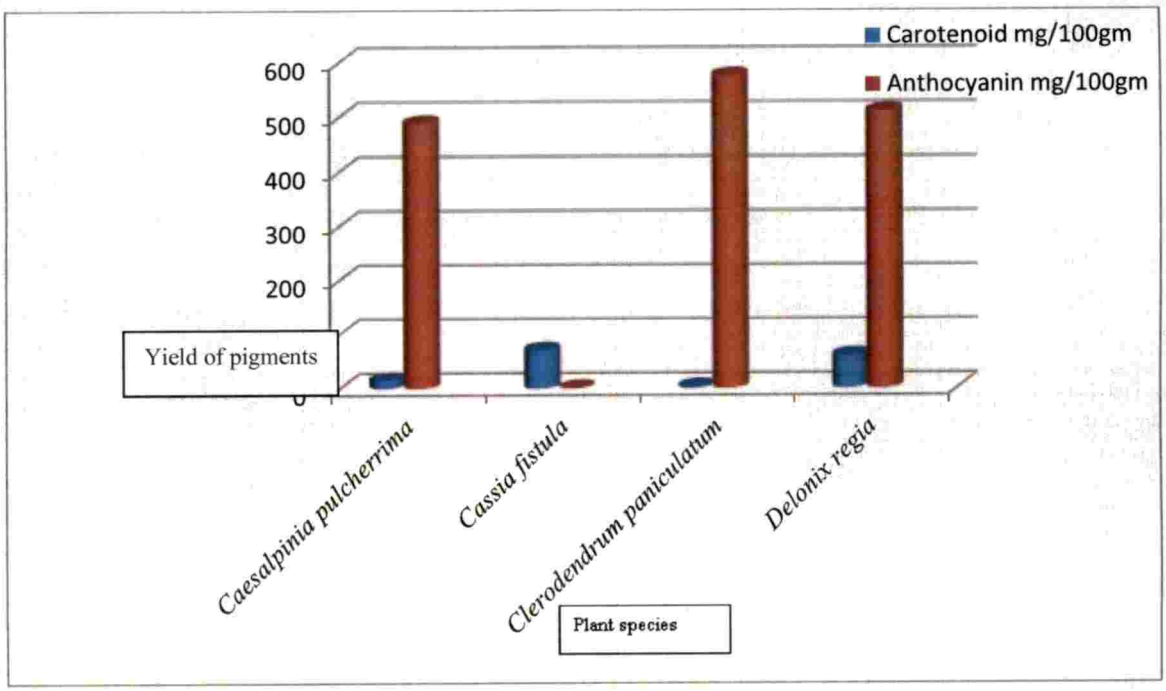


Fig.4.Yield of pigments from underutilized flowers



Summary

6.SUMMARY

The results of the investigation on "Evaluation of selected underutilized flowers of Kerala for commercial exploitation" carried out in the department of Pomology and Floriculture, College of Horticulture,Vellanikkara are summerised in this chapter. The investigation were carried out as five different experiments, viz.,

1. Evaluation of 10 selected underutilized species of Kerala for use as cut flower
2. Evaluation of five species selected for use as dry flower
3. Essential oil extraction from selected three species
4. Pigment extraction from selected four species
5. Identification of components of floral oils and pigments using chromatographic and spectrometric methods

Thirteen underexploited native ornamentals, in and around the Kerala Agricultural University campus were selected for the study. The flowers of these plants were critically evaluated based on their different characters. Among them ten plants were studied for their use as cut flowers and none of them were found to be suitable as cut flower. Five plants were selected for their possibility for use as dry flower. Among them, *Cassia fistula* got the highest cumulative score followed by*Antigonon leptopus*,*Calicopteris floribunda* and *Barleria obtusa.* Least cumulative score was obtained for *Clerodendrum paniculatum.* In *Antigonon leptopus* (11.64) and *Clerodendrum paniculatum*(4.12) best method of drying was found to be microwave oven drying. Press drying was the best drying method for *Barleria obtuse* (10.28)and *Calicopteris floribunda* (10.22). Embedded drying was the best method of drying in *Cassia fistula* (12.84).

Perfect time of drying of flowers were standardised based on weight loss during drying. Time taken for perfect drying of flowers varied with the method of drying. For *Antigonon leptopus,* time for perfect drying was standardised as 3 days for shade drying, 4 minutes for microwave oven drying, 4 days for embeded

drying, 5 days for press drying and 4 hours for hot air oven drying. *Barleria obtusa* took two days for shade drying, 4 minutes for microwave oven drying, 3 days for embeded drying, 5 days for press drying and 2 hours for hot air oven drying. For shade drying and embedded drying it took two days each, 2 minutes for microwave oven drying, four days for press drying and 2 hours for hot air oven drying. *Cassia fistula* took four days for shade drying, four minutes for microwave oven drying, six days each for embedded and press drying and four hours for hot air oven drying. Perfect drying time for *Clerodendrum paniculatum*was standardized as 5 days for shade drying, five minutes for microwave oven drying, 6 days each for embedded and press drying and 6 hours for hot air oven drying.

Extraction of essential oils weredone from fragrant flowers like *Gardenia jasminoides, Plumeria* spp. and *Quisqualis indica.*Maximum essential oil yield was obtained from *Gardenia jasminoides* (0.61%), followed by *Plumeria* spp. (0.408) and the minimum oil yield was in *Quisqualis indica* (0.402).

The components in the essential oils were identified by gas chromatography and mass spectrometry. In *Gardenia jasminoides* the components identified were Ascalbin (0.7%), Nonadecane (0.80%), Dendaralasine (0.96%), Alpha famesene (1.12%), Linalool (1.38%), Beta famesene (2.75%), Famesene (3.04%), Henecosane (5.26 %), n-Tricosane (6.91%), n-octacosane (10.43%), Pentacosane (13.19%), Monoethylhexyl phthalate (44.74 %). The volatile components identified in *Plumeria* were α-Farnesene (1.08%), Benzoic acid, [(E,E)-3,7,11-trimethyl-2,6,10-dodecatrien-1-yl] ester (1.08%), 1,6,10-Dodecatriene, 7, 11-dimethyl- 3-methylene-E(1.17%), Cyclohexasiloxane, dodeca methyl (1.92%). Phenyl ethyl alcohol (2.20%), 1,3,6,10-Dodecatetraene, 3,7,11-trimethyl-(Z,E)(2.93%), Oxalic acid, decyl 2-phenyl ethyl ester (4.3%), Triphenyl phosphare (4.3%), Heptacosane (6.32%), Nonacosane(6.40%) and Z-14-Nonacosane (6.40%) and Z-14-Nonacosane(11.65%). The components responsible for fragrance in *Quisqualis indica* were 2 H- Pyran-3-ol, 6-ethenyl tetra hydro-2,2,6-trimethyl(1.24%), Heptacosane (1.44%), Cyclotetra siloxane,

octamethyl (1.95), Triphenyl phosphate (2.30%), Nonacosane(2.89%) and 5-Isoquinoline carbonitr (12.5%).

The flowers selected for extraction of pigments were *Caesalpinia pulcherrima, Cassia fistula, Clerodendrum paniculatum and Delonix regia.* Two methods of extraction selected were solvent extraction after fermentation and solvent extraction after pretreatment with NaOH. In all the species, pigment yield was higher for solvent extraction after pretreatment. Highest oleoresin yield was in *Clerodendrum paniculatum* (0.60g), which was followed by *Delonix regia* (0.5g) and *Cassia fistula*(0.39). The lowest yield was observed in *Caesalpinia pulcherrima* (0.38g). After fermentation, *Clerodendrum paniculatum* gave highest oleoresin yield (0.43g) followed by *Delonix regia*(0.4g), *Cassia fistula*(0.3g) and *Caesalpinia pulcherrima*(0.28g). Highest carotenoid yield was obtained from *Cassia fistula* (70.04mg/ 100 g) and highest anthocyanin yield from *Clerodendrum paniculatum* (574.76mg/100g)). In *Caesalpinia pulcherrima* carotenoid content recorded was 15.35mg and anthocyanin, 488.75mg. Anthocyanin yield of *Cassia fistula* was 0.35mg. *Clerodendrum paniculatum* recorded a yield of 2.98mg of carotenoid. In *Delonix regia* the yield of carotenoid and anthocyanin was 60.2 mg and 510 mg, respectively.

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Evaluation of selected underutilized flowers of Kerala for commercial exploitation

by

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ABSTRACT OF A THESIS

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ABSTRACT

Floriculture industry is unique among agricultural industries where novelty is an important attribute. World floriculture is expanding rapidly and new innovations and introductions are in great demand to feed the ever hungry market needs. It is in this interest that neglected or underutilized flower crop species (NUS) comes to the picture from which we could identify and develop diversified uses of floriculture. Even the present day top charactered crops of the industry are nothing but just derived and developed only from wild germplasm resourses, the most prominent among them being rose, chrysanthemum, carnation, gerbera and what not, the orchids and anthurium.

Thirteen underutilized plants of Kerala were evaluated for use as cut flowers, dry flower, for essential oil extraction and pigment extraction and identification of components in their essential oils and pigments using GC-MS by conducting both field studies as well as postharvest studies.

Out of the 10 plants selected for studying their use as cut flower, none were found suitable. Five plants were selected for their suitability for dry flower production. Among them, *Cassia fistula* got the highest cumulative score followed by*Antigonon leptopus*,*Calicopteris floribunda* and *Barleria obtusa.* Least cumulative score was obtained for *Clerodendrum paniculatum.* In *Antigonon leptopus* and *Clerodendrum paniculatum* best method of drying was microwave oven drying. Press drying was selected as the best method for *Barleria obtusa* and *Calicopteris floribunda.* Embedded drying was found the most suitable method of drying in *Cassia fistula.*

The fragrant flowers selected for extraction of essential oils were *Gardenia jasminoides, Plumeria spp* and *Quisqualis indica.*Maximum essential oil yield was observed in *Gardenia jasminoides* (0.61%).

The components in the essential oils were identified by gas chromatography and mass spectrometry. In *Gardenia jasminoides* the components identified were Ascalbin (0.7%), Nonadecane (0.80%), Dendaralasine (0.96%), Alpha famesene

(1.12%), Linalool (1.38%), Beta famesene (2.75%), Famesene (3.04%), Henecosane (5.26 %), n-Tricosane (6.91%), n-octacosane (10.43%), Pentacosane (13.19%), Monoethylhexyl phthalate (44.74 %). The volatile components identified in *Plumeria* were α-Farnesene (1.08%), Benzoic acid, [(E,E)-3,7,11-trimethyl-2,6,10-dodecatrien-1-yl] ester (1.08%), 1,6,10-Dodecatriene, 7, 11-dimethyl- 3-methylene-E(1.17%), Cyclohexasiloxane, dodeca methyl (1.92%). Phenyl ethyl alcohol (2.20%), 1,3,6,10-Dodecatetraene, 3,7,11-trimethyl-(Z,E)(2.93%), Oxalic acid, decyl 2-phenyl ethyl ester (4.3%), Triphenyl phosphare (4.3%), Heptacosane (6.32%), Nonacosane(6.40%) and Z-14-Nonacosane (6.40%) and Z-14-Nonacosane(11.65%). The components responsible for fragrance in *Quisqualis indica* were 2 H- Pyran-3-ol, 6-ethenyl tetra hydro-2,2,6-trimethyl(1.24%), Heptacosane (1.44%), Cyclotetra siloxane, octamethyl (1.95), Triphenyl phosphate (2.30%), Nonacosane(2.89%) and 5-Isoquinoline carbonitr (12.5%).

The flowers selected for extraction of pigments were *Caesalpinia pulcherrima, Cassia fistula, Clerodendrum paniculatum and Delonix regia.* Two methods of extraction selected were solvent extraction after fermentation and solvent extraction after pretreatment with NaOH. In the entire species pigment yield was higher for solvent extraction after pretreatment. Highest oleoresin yield was observed in *Clerodendrum paniculatum* (0.60g), which was followed by *Delonix regia* (0.5g) and *Cassia fistula*(0.39). The lowest yield was observed in *Caesalpinia pulcherrima (*0.38g). After fermentation, *Clerodendrum paniculatum* gave highest oleoresin yield (0.43g). This was followed by *Delonix regia*(0.4g), *Cassia fistula*(0.3g) and *Caesalpinia pulcherrima*(0.28g). Highest carotenoid yield was observed in *Cassia fistula* (70.04mg/ 100 g) and highest anthocyanin yield was in *Clerodendrum paniculatum* (574.76mg/100g)). In *Caesalpinia pulcherima* carotenoid content was recorded as 15.35mg/100g and anthocyanin 488.75mg/100g. Anthocyanin yield of *Cassia fistula* was 0.35mg. *Clerodendrum paniculatum* recorded 2.98mg of carotenoid. *Delonix regia* recorded carotenoid and anthocyanin yield of 60.2 mg and 510 mg respectively.

In the present study none of flowers were found suitable for use as cut flower. Out of the 5 plants selected for studying for use as dry flower, *Cassia fistula*was the most suitable one. All the species selected for essential oil extraction were suitable for the purpose .In pigment extraction, highest oleoresin yield was observed in *Clerodendrum paniculatum* (0.60g), which is followed by *Delonix regia* (0.5g) and *Cassia fistula*(0.39).

Future line of work suggested in this aspect based on the light of results are evaluation of more underutilized ornamental flowers available in our locality with a view of their commercialisation for specific traits and further evaluation of extracted pigments for their use in food industry.