



## 1. Introduction

Arrowroot (*Curcuma angustifolia*) is a herb belongs to Zingiberaceae family (Elias et al., 2015; Srivastava et al., 2006; Shukla et al., 2007; Rai, 2004; Saikia and Borthakur, 2010; Sharma, 2012) and widely cultivated in Tropics (Pandey and Saini, 2007; Odeku, 2013; Devi et al., 2014; Rani and Chawhaan, 2012; Rao and Rao, 2006; John, 2013), native to Central India (Srivastava et al., 2006; Saikia and Borthakur, 2010; Sharma, 2012). Besides India, it is cultivated and common in other countries such as Sri Lanka, Cambodia, North Australia and China (Edison et al., 2006; Misra et al., 2013). About 70 species of rhizomatous herbs are found all over the world (Edison et al., 2006).

In India, it is widely distributed in Kerala, Karnataka, Tamilnadu and Andhra Pradesh (Rajeevkumar et al., 2010). In Malayalam East Indian arrowroot is called "koova", in ancient language it is called Tavakshira, Tavaksheera, Payaksheera, Tavakshiri, and Vamsalocana (Elias et al., 2015; Rajeevkumar et al., 2010). Around 30 species are found in India and 2 species are useful for starch (Edison et al., 2006).

Roots and tuber crops are the second popular cultivated species in Tropical countries after cereals (Lebot, 2009). Tuber crops play a major role in fulfilling human nutritional requirements and provide a good source of variety of vitamins, fibre, potassium (K), copper (Cu), manganese (Mn) and iron (Fe) (John, 2013; Moorthy, 2002; Gallant et al., 1982; Hoover, 2001). Starch from these tuber crops were used in a variety of applications especially bakery and confectioneries, pharmaceutical and industrial fields (Gallant et al., 1982; Peroni et al., 2006; Jobling, 2004; Moorthy, 2002; Slattery et al., 2000; Zeeman et al., 2010).

Morphological variations exist in Arrowroot plants and their nutritional properties also differ (Jayakumari and Stephen, 2009; Angel et al., 2008; Kumar et al., 2012). The plant has about 90-180 cm in height; rhizome or grain is the main parts of the plant which consist of mainly starch (Elias et al., 2015; Rajeevkumar et al., 2010; Shukla et al., 2007). The rhizome is a good source of carbohydrate, minerals (Pérez and Lares, 2005; Hoover, 2001; Moorthy, 2002).



## 1.1 Taxonomical classification

- Kingdom: Plantae
- Class: Liliopsida
- Subclass: Commelinidae
- Order: Zingiberales
- Suborder: Zingiberanae
- Family: Zingiberaceae
- Genus: Curcuma
- Species: angustifolia

Vernacular names (Nadkarni, 1976; Bapalal, 1985)

- **Sanskrit** -Tavakshira, tavaksheera, payaksheera, tavakshiri, vamsalocana.
- **Hindi** - Tekhur, tikhur, theksura, thavsasheera, thikora, thavakheera.
- **English** - East Indian arrow root, curcuma starch
- **Kannada** - Kaadu arrow root, kovegida, kove hitting gida, thavakeela.
- **Telugu** - Gaddalu.
- **Tamil** - Kisangu, araukizhangu, kooa, artimavu, kookai, kua.
- **Malayalam**- Koova, kuva-kizhanna.
- **Tulu** - Koove.
- **Konkani** - Koovyajhaad.
- **Marathi** - Tavakira, thavakheera, thavakil.
- **Gujarat** - Tavkhir, tikhur
- **Bengali** - Tikkur, keturihalodhi

The *Curcuma angustifolia* is a minor tuber crop with medicinal properties (Ved and Goraya, 2007; Shukla et al., 2007; Pande et al., 2007; Pattanaik et al., 2008; Singh, 2010; Rani and Chawhaan, 2012; Paikra et al., 2014). Arrowroot is native to Himalayan ranges and India; also found in Cambodia, Malaya archipelago, and North Australia (Edison et al., 2006; Srivastava et al., 2006; Elias et al., 2015; Basak, et al., 2010; Behar et al., 2014).



Arrowroot is a slender branched herb with flesh cylindrical rhizome; rhizomatous herb with small rootstock (Basak, et al., 2010; Behar et al., 2014). Stems are usually short replaced by pseudostems along with the leaf sheaths (Elias et al., 2015; Shukla et al., 2007; Pande et al., 2007; Pattanaik et al., 2008; Singh, 2010; Rani and Chawhaan, 2012). Leaves characteristics include simple, smooth, bladeless, and reduced to sheaths, leaf sheath is open, numerous lateral veins, pinnate, parallel and margin entire (Elias et al., 2015; Paliwal et al., 2011). Flowers are bisexual, epigenous, and zygomorphic while fruits are like capsule, fleshy or dry, dehiscent or indehiscent and sometimes berry like (Ojha, 2004; Paliwal et al., 2011; Roh et al., 2006).

Arrowroot plant prefers a moist cool climate is cultivated from its tubers containing mostly preferable at an altitude of 450 m. Harvesting done in November- January month when the stem is completely dried. The rhizome is processed to washing, pulping, and straining procedures. White powdered starch is collected is known as the arrowroot powder (Paikra et al., 2014; Sharma, 2012; Tiwari and Patel, 2013). Root contains D - cymarose, B -D- glucosy 1- L-thebatose, cinnamic acid and acetic acid (Qin et al., 2007; Khurana and Ho, 1988; Yang et al., 2007). Stem contains Glycosides tenacissoids A-E, Feronic acid-plyoxytregnanes, Marstenacigenins A&B dresgenin (Ojha, 2004; Rani et al., 2010; Sasikumar, 2005). Rhizome contains Sesquiterpenoids, curcumol, Zederon, Fyrocurzerenone, procurcumenol, Curcumanolide A&B (Ojha, 2004; Sasikumar, 2005; Devi et al., 2012; Policegoudra et al., 2007a; Policegoudra et al., 2007b). Arrow root has health benefit uses like therapeutic, external and internal (Pandey and Shukla, 2008; Misra et al., 2013; Pattanayak et al., 2015). Rhizome is nutritious starch containing can be used for the easy digestion of children (Pandey and Shukla, 2008; Misra et al., 2013; Pattanayak et al., 2015; Basak, et al., 2010; Behar et al., 2014). It can be used as a promoter for the healing of stomach ulcers, diarrhea, dysentery, and colitis (Ojha, 2004; Pandey and Shukla, 2008; Misra et al., 2013; Pattanayak et al., 2015).

Morphological difference may exist in different types of Arrowroot in Kerala. According to the different conditions changes may occur. Soil, climatic parameters and other factors make variation. The nutritional quality, leaf structure, color, rhizome characters, flower characters and stem characters varied. This can be easily identified. Given



lacking qualitative and quantitative data on *Curcuma angustifolia* in Kerala, the objectives of this research work were: (1) to identify and characterize morphological variations and (2) to determine antimicrobial properties against *Staphylococcus aureus* and *E.coli*.

## **1.2 Hypothesis**

The current research work is based on the following hypothesis: (1) morphological differences exist among *Curcuma angustifolia* in Kerala; (2) morphological variations include leaf structure, arrangement, colour, rhizome, stem and flower characteristics; (3) antimicrobial properties vary among the varieties; (4) antimicrobial activity also vary with the type of solvent used for extraction.

## **2. Materials and Methods**

### **2.1 Study area**

Kerala state covers an area of 38,863 km<sup>2</sup> with a population density of 859 per km<sup>2</sup> and spread across 14 districts. The climate is characterized by tropical wet and dry with average annual rainfall amounts to 2,817 ± 406 mm and mean annual temperature is 26.8°C (averages from 1871-2005; Krishnakumar et al., 2009).

### **2.2 Sample collection**

Samples of *Curcuma angustifolia* were collected based on an elaborative literature survey as well as information's collected from farmers. A total of 4 varieties were collected from different regions of the Kerala from January 2016 to February 2016. Locations of the sample collection areas were recorded using a Trimble Geoexplorer II (Trimble Navigation Ltd, Sunnyvale, California) and data were transferred using GPS Pathfinder Office software (Trimble Navigation Ltd, Sunnyvale, California).

### **2.3 Morphological characterization**

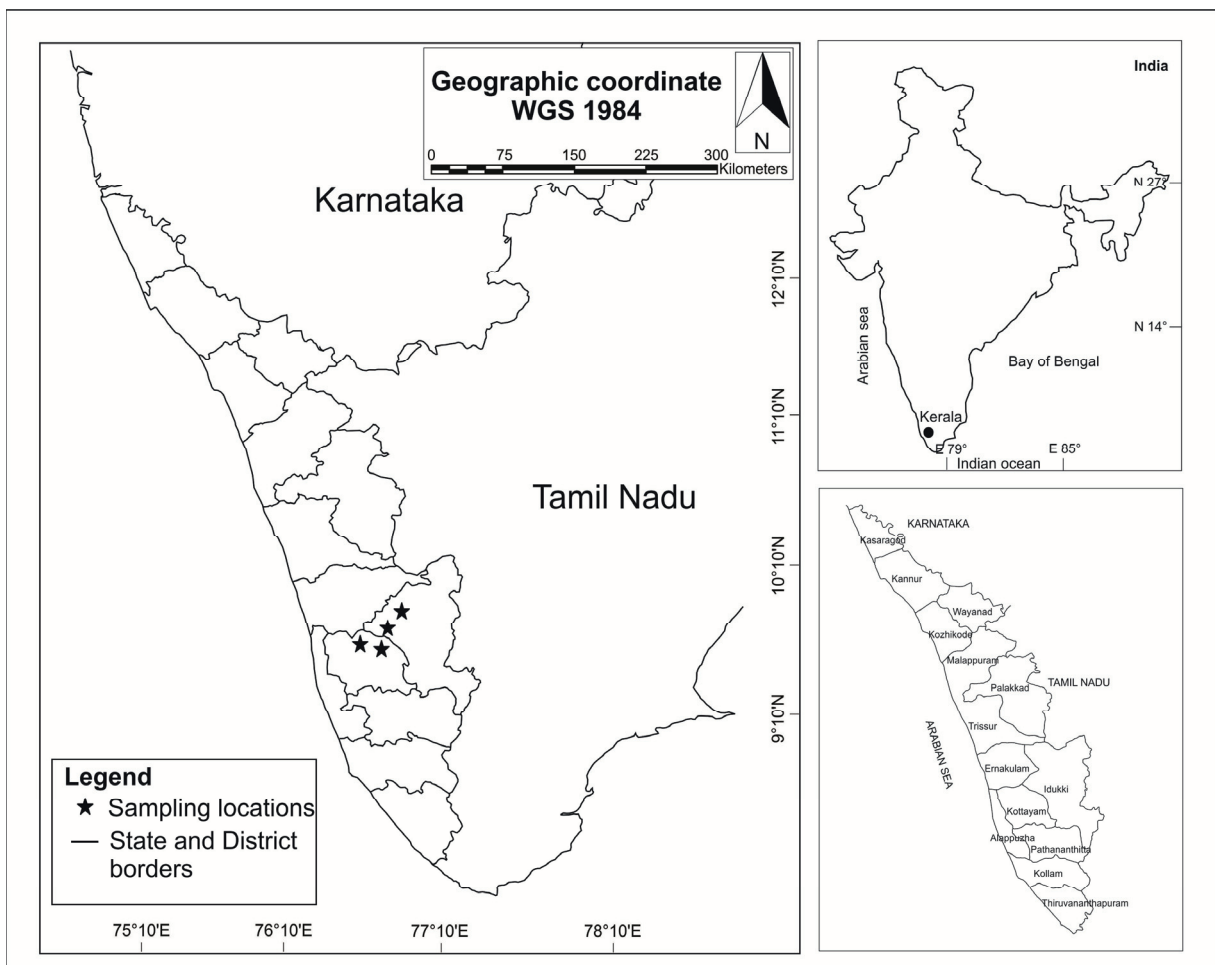
Morphological characterization of *Curcuma angustifolia* and specific characteristics of different varieties were studied. The instruments used to collect data are, Measuring scale (30 cm), tape (160 cm) weighing machine, camera, field book, twine etc.,. The samples were collected based on primary and secondary data. Parameters taken were leaf structure, color, rhizome characters, flower characters and stem characters (Sasikumar, 2005).



**Table 1.** Important discriminating qualitative features of *Curcuma* spp. (Modified after Sasikumar, 2005).

Parameters	Variation
<b>Character 1 (above ground vegetative)</b>	
Plant type	Erect, semi-erect
Leaf habit	Erect, semi-erect, prostrate
Sheath colour	Purple green, light or dark purple, purple brown, purple green
Leaf margin	Highly wavy, medium wavy, low wavy
Leaf vein	Close, distant
Hair on dorsal surface of leaf	Hairy, glabrous
Hair on ventral surface of leaf	Hairy, glabrous
Leaf mid rib colour	Green, light purple green, light purple brown
Leaf mid rib fading	Absent, present
Inflorescence position	Central, lateral and both
Coma	Absent, present
Calyx colour	White, yellow, purple
Corolla	White, orange, red, purple, pale yellow, purple spot, blue
Staminode colour	White, red, pale yellow, orange, yellow
Anther spur	Absent, present
Nature of stigma	Exserted or appressed
<b>Character 2 (below ground rhizome)</b>	
Shape of root stock	Oblong, cylindrical
Colour of root stock	Reddish yellow, yellow, blue-black
Nature of rhizome	Sessile tubers present, no sessile tubers, stoloniferous
Presence of stipulate tubers	Absent, present
Presence of stolon	Absent, present
Shape of stipulate tubers	Fusiform, long fusiform
Aroma of rhizome	Mango aroma, camphoraceous aroma, turmeric aroma, no aroma
Taste	Bitter, sweet, inert, turmeric taste

Branch leaf and stem were also collected and analyzed for various parameters including stem length (SL), stem texture (ST), leaf color (LC), leaf shape (LS), leaf texture (LT), leaf length (LL), leaf breadth (LB), margins or lines, flower color (FC), flower shape (FS), rhizome shape (RS), rhizome color (RC), rhizome texture (RT), rhizome length (RL), rhizome breadth (RB), rhizome diameter (RD), and rhizome weight (RW).



**Figure 1.** Map of Kerala showing the various sample collection points of *Curcuma angustifolia* during January to February 2016.