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Research Article

PREPARATION AND MEDICINAL USE OF THE RHIZOME POWDER OF *CURCUMA ANGUSTIFOLIA* ROXB. (ZINGIBERACEAE) IN RURAL ODISHA, INDIA

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ABSTRACT: Odisha has a history of using underground parts of plants in various ways. These parts have immense medicinal value that can be evident from old Indian Scriptures. *Curcuma angustifolia* Roxb. (locally known as *Paluo*), a monocotyledonous plant, grows abundantly throughout India. It is a plant that has long been used medicinally and whose rhizome contains starch. The present study focused on the investigation and documentation of the tribal people and forest dwellers' long-standing habit of extracting starch from *C. angustifolia* rhizomes. The extraction of starch from the rhizomes of the plant requires several unit processes, which are discussed and demonstrated in this study. Efforts have been made to properly document the practical consequences of ethnic peoples' traditional knowledge about the manufacture of *Paluo* starch. Additionally, the traditional knowledge of *Paluo* based on usage, mode of preparation, health benefits, and dosage was recorded from different districts of Odisha through informal personal open or semi structured interviews. The present study recorded the parts used, collection pattern, methods of propagation, cultivation practices, step-wise starch extraction methodology with justification, practical implications, market values, and various modes of consumption of *Paluo* starch. This study also described the detailed methodology of cultivation of *Paluo*, which can be followed by the farmers for better production. We have also tried to record and preserve forest inhabitants' indigenous knowledge before it vanishes from the world. This information will further help researchers in bioprospecting and adding value for sustainable production and utilization of *C. angustifolia* in Odisha.

Key words: Traditional Knowledge, Cultivation, Starch extraction, Zingiberaceae, Odisha.

INTRODUCTION

People residing in rural India traditionally have some knowledge to use medicinal plants in healthcare. Many such uses are found effective by analyzing through modern scientific studies (Pattanayak 2021, Pradhan *et al.* 2021, Paul and Sujatha 2022). *Curcuma angustifolia* Roxb., a rhizomatous herb of Zingiberaceae, is native to the Indian subcontinent. It is more commonly known as wild or East Indian Arrowroot or white turmeric (Paikra *et al.* 2013). It is known under various names in local languages, including *Paluo* in Odia; Palu, Palo in Ho; Palao, Palu in Santali, and *Tikhur*, *Tekhur*, and *Thikora* in Hindi. It is a perennial herb having spiked inflorescences, three to four yellow flowers enclosed in tufts of lower green fertile bracts and pink terminal bracts called coma, blooms in moderate climate. Flowering starts at the beginning of the rainy season from July to August and it continues until the leaves are fully developed or the plant is almost matured. The leaves smell and taste similar to turmeric, and grow about 36-37 cm high and 8-10 cm wide.

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The considerable significance of the arrowroot plant is its strong rhizome. The nutritional and therapeutic qualities of this plant are primarily derived from its rhizomes. The plant is naturally propagated by vegetative reproduction and grows wild in its habitat. In nature, propagation of arrowroot (*Paluo*) occurs through the rhizome, which is a slow process. In India, the wild populations of the plant are distributed in the north-eastern and western coastal plains and hills including the states of Maharashtra, Madhya Pradesh, Andhra Pradesh, Himachal Pradesh, Chhattisgarh, Bihar, Jharkhand, West Bengal, Odisha, Tamil Nadu and Kerala (Nahak *et al.* 2011, Ravindran *et al.* 2007, Sharma *et al.* 2019). It is most prevalently found in moist deciduous Sal and mixed forests (Tiwari and Patel 2013). The starch or powder is highly nutritious and easily absorbed. So, infants, and frail children are advised to take this as a diet. It is used for the preparation of many Indian sweets like *halwa, burfi, jalebi* and *khir* (Acharya *et al.* 2012). The rhizomes of *Paluo* are used to make powdered flour that has therapeutic potential and is useful for treating a variety of illnesses. It is often used to treat cough and bronchitis (Patel *et al.* 2015).

Phyto-chemical analysis and pharmaceutical properties have been investigated for the plant (Rajeevkumar *et al.* 2010, Sanatombi 2017). *Paulo* can replace maize starch because of its binding and disintegration capabilities (Rajeevkumar *et al.* 2010). It is an important resource under non-timber forest products (NTFPs) and plays a vital role in the livelihood of tribal families as they contribute significantly to sustaining their lives in different ways.

The plant contains secondary metabolites, such as flavonoids, tannins, and glycosides, which contribute to its antibacterial capabilities. The most significant chemical components of the plant are camphor, cineol, and methyl eugenol (Nath *et al.* 2022). The therapeutic, morphological, and ethnobotanical importance of the arrowroot plant can't be estimated without proper study. This exploratory study provides primary data, which will spur researchers to do further research on the extraction of *Paluo* starch. It may be possible to create suitable new machine-aided procedures to make the process scientific and enhance it so that it may be scaled up sustainably to a greater scale. The main objectives of the study are: (i) to document the ethnobotanical knowledge of *C. angustifolia* from tribal people of Odisha, (ii) to enumerate the traditional methods of starch extraction of *C. angustifolia*, and (iii) to study the cultivation techniques of *C. angustifolia* in Odisha.

MATERIALS AND METHODS

Study Area

The state Odisha is situated on the eastern coast of India *i.e.*, located between 17°49' and 22°34' North latitude and between 81°27' and 87°29' East longitude (Fig. 1). The state is spread over an area of 1, 55,707 km^2 occupying 4.74 percent of India's total land area. It comprises a coastline of nearly 482 Kilometers long, forest-clad hills, and mountain ranges of the Eastern Ghats. The forest cover of 52,155.95 sq km is 33.50 percent of the state's total geographical area, which includes Moist Peninsular low-level Sal forest, Northern Dry Mixed deciduous forest, Dry Peninsular Sal forest, Dry deciduous Scrub forest, Northern secondary mixed moist deciduous forest, and Mangroves forest. The state possesses a varied topography, physiography, and climate. The state receives about 1,200 - 1,600 mm of rainfall annually, with a variability of 25-30 percent (ISFR 2021). Most of Odisha has no access to irrigation and depends on rain for cropping based on ecology and soil texture. The state experiences a temp of about 35-45ºC in summer and in winter the temperature falls to 12-14ºC.

Several field surveys were made to document the ethnobotanical knowledge along with starch extraction processes from informants of remote tribal villages present in different district zones. The informants mostly belong to Kondh, Saura, Shabar, Santhal, Bathudi, Ho, Munda, Gond, Kolha, Kol, Kharia, Bhumij, Bhuyan, and Lodha tribes. The starch extraction process is done majorly in Malkanagiri (Kudumulguma), Koraput (Mathapada), Kandhamala (Daringbadi, Greenbadi, Dandimaha, Alimaha, Biraguda, Sikarmaha), Bolangir, Keonjhar, Rayagada, Khordha, Nayagarh (Nakhamundali, Khilamunda), Balasore, Mayurbhanj districts (Fig. 1). The major surveys were done in Myurbhanj district which covered 14 villages of 4 different divisions, namely Karanjia Division (Kalakada, Gurguria, Beldihi, and Rangmattia); Rairangpur Division (BadamPahar, Dudhijaran, and Chaunradihi); Baripada Division (BhudiKhambari, Suliapada, and Khunta); Udala Division (Udala, Kapatipada, Nuagaon, and Budamara).

Survey and data collection

The surveys were carried out during 2021-22 to document the traditional uses of different parts of *C. angustifolia* in Odisha. The plants were photographed and collected in air-tight poly bags during the field study. The collected specimens were carefully pressed in the blotting paper with special care to the floral parts. After pressing, the specimens were dried by artificial heat methods and they were mounted in herbarium sheets and deposited in the Herbarium of the Department of Botany, Maharaja Sriram Chandra Bhanja Deo University, Baripada. The specimens collected from different localities were identified with the help of available literature and floras (Saxena and Brahmam 1994-96, Gamble and Fischer 1915-36, Haines 1921-25). The nomenclature of the taxa follows the Plants of The World Online (POWO). The flowchart of the entire survey and data collection is presented in Fig. 2.

RESULTS AND DISCUSSION

Demographic details of informants

The ethnobotanical information was gathered at the time of the field survey from tribals, local people, and medicine men (Vaidya, Guniyas, Ojhas) through informal personal interviews. There were 126 informants (52 males and 74 females) between the ages of 35 to 83, who were interviewed for documentation of ethnobotanical information. Among them 35 were workers, 23 were housewives, 50 were farmers, 8 were vaidyas, and 10 were retired persons (Table 1). The majority of females were well-practiced in starch extraction procedures. People within the age group of 55-60 years were more aware of traditional knowledge and its practices as compared to the younger generation.

Ethnobotanical uses

According to the local healers, *Paluo* can help to treat various diseases. Most of the uses it is performed at its raw stage, without boiling or any other chemical processing. The rhizome of the plant is generally grounded into flour/ powders. These powders are mixed with milk/water to form a nutritious meal and consumed. It is also used to make a variety of Indian sweets, including halwa, burfi, and jalebi. It is a key component of cakes, fruit preserves, cookies, and puddings. It is used as food by major tribes, *viz.*, Santhal, Bathudi, Kamar, Gond, Kharia, and Kolha. Due to its high energy content, during fasting (*Upwas*) people consume it frequently. *Paluo* herbal drink (*sarbat*) is a popular preparation using starch and is consumed especially during the summer season as it works as a cooling agent for the stomach and human body. Arrowroot powder is also used to remove toxins from the kidney, ensure optimal function of the kidney, balancing of blood pressure, and increase immunity power. The rhizomes of the plant can be used to treat peptic ulcers, dysentery, diarrhea, and colitis and they are frequently used as a herbal tonic for those with tuberculosis.

The substances isolated from the plant showed antimicrobial activity against various bacterial and fungal strains, making it suitable for use as an antibiotic. Arrowroot powder mixed with turmeric is also used for face or skin treatment. Young rhizomes can be eaten as vegetables. Cattle are fed both the plant's top and its tubers. The ethnobotanical information, mode of preparation, health benefits, and no of respondents cited for a particular use gathered from different localities are represented in a tabular form (Table. 2).

Cultivation of *C. angustifolia*

Generally, *C. angustifolia* grows wild in the forests of hilly regions (Fig. 3C, 3D). Some tribal people living in forest sides are cultivating it in the backyards of their homes.

Land preparation

The land is plowed 1 to 2 times for loosening the soil. After ploughing finger rhizomes are planted by following the ideal method for its cultivation. The land is divided into small pits and beds are made in rows (Fig. 3A).

Climate and soil

It requires a temperature at or above 1°C (34ºF) (Sharma *et al.* 2019). It prefers shady areas and grows best in moist soil that is sandy, loam with rich humus, or clay loamy. The highest yield of *C. angustifolia* will be in a moist climate. It is also seen growing at the edges or in the clearings of forests. Planted in late autumn and watered occasionally during the dry period.

Time of plantation

The best time is the middle of April when there is sufficient moisture in the soil. Due to the storage of

high content of water in the rhizome, it increases its viability and can withstand a limited temp change in the environment. The planting of rhizomes varies from area to area depending on the availability of sufficient moisture in the soil. In northern Odisha, the plantation is done during the middle of April-May. While in central Odisha the plantation is done during the month of May-June, when the monsoon starts. But in southern Odisha, the plantation is done during Sept-Oct, where there is moderate climate condition.

Method of plantation

C. angustifolia is propagated from small rhizomes known as bits or fingers. The bits/ daughter/ finger rhizomes are separated from the mother rhizomes by hand or by using knives. These small rhizome pieces are used for planting. Bits are 4-5 cm long. A spacing of 30cm × 25cm is considered ideal for its cultivation. Rhizomes are planted at a depth of 9-10 cm in furrows and covered with soil or sometimes covered with dried leaves to maintain the temperature and prevent it from drowning during heavy rain (Fig. 3B). There is no need for fertilization as it is a wild species; it gives a better yield without using fertilizers. As the pattern of planting this plant separates it from other plants so there is no urgent need for weeding. It is always grown in semi-dry or moist climates but giving excess water will damage the rhizomes and plant. So there is no need for irrigation. During normal climate and temperature, it will grow. In case of drought conditions, it may be irrigated.

Harvesting

After planting the initiation of root starts within 6 days and several root hairs starts arising from the main root. Shoot initiation takes place at the same time as root elongation i.e. about 10-12 days of planting. Leaf initiation starts from day 16. Then the plant grows up to its height. Approximately, it takes about 6 months for the complete growth and maturation. The harvesting stage or the maturity of the rhizomes is well indicated by the yellow-colored partially dried leaves. The dried leaves are gradually dropped from the plants in case of excessively matured rhizomes. Excessive matured rhizomes are not preferred for the extraction of starch as it results in comparatively less yield compared to young ones. Rhizomes are traditionally dug out from the soil with the help of a spade, khurpi, kudali, or any other user-friendly hand metal tools. Harvesting is generally done in Dec- January in northern Odisha and October-November in central Odisha, while the harvesting is done in January in southern Odisha.

Marketing

The extracted starch from its rhizome is marketed in different forms, either in fine powder form or cut into rectangular or rhomboidal pieces and pocketed. These packets are exported to different areas of the state. Some also sell either raw materials (Prices range from 40-50 Indian Rupees per kg) or extracted starch powder in nearby local village markets. Despite its value and significant usage, powdered starch is sold in the market at a price range from Indian Rupees 300 to 600 per kg.

Methods of starch extraction

The slightly dried golden leaves are a good indicator of the rhizomes' maturity or harvesting stage. The rhizomes are generally collected by the local people or tribals for their consumption and livelihood. The starch extraction is done by the traditional processing method by the families residing in and around the forest areas of these regions. It is important to note that the traditional processing of the rhizomes into starch is laborious, time-consuming, and difficult. On the other hand, the amount of final processed product produced per person per day is relatively small. Tribal people have developed their traditional processing methods for the extraction of starch from *C. angustifolia* rhizomes (Fig. 4). The different steps of the processes are described below.

Preparation of raw materials

When the rhizomes are fully mature, the dried leaves eventually fall off the plants. Rhizomes that are too mature provide a somewhat lower yield when starch is extracted from them than those that are young. Traditionally, rhizomes are removed from the soil when the leaves appear slightly golden yellow with a spade, *khurpi, kudali*, or any other user-friendly hand metal tools. Using a knife, the rhizomes are then separated from the plant's stem; in certain cases, if the stem has sufficiently dried, this can be done by hand. Rootlets (hairy roots), tuber leaves, and adherent soil particles are all cleaned to the best of their ability before being detached from the rhizome bulbs. The newly acquired fresh rhizome bulbs are then properly cleaned under water. The mother rhizomes bulbs joined

by the finger rhizome bulbs are separated from the finger rhizomes using a knife.

Soaking of rhizomes

Cleaned and washed rhizomes are soaked in water at room temperature in vats or buckets for 10 to 12 hours. Rhizomes are often bathed for a whole night to increase their softness which may be easily ground or rubbed in the subsequent steps. Rhizomes are then peeled after being soaked. The outer skin of the rhizomes may be easily peeled off with the aid of soaking; sometimes peeling is not required as the skin of rhizomes is automatically removed when soaked in water. Some people believe that removing the skin before processing enhances the quality of the finished product, while others think that doing so, losses the starch contents of the rhizomes.

Rubbing of rhizomes

The rubbing of rhizomes refers to the grinding of rhizomes to form a paste-like mass. Traditional processors primarily employ rough stone or metal surfaces for rubbing rhizomes (Fig. 5A, 5B). It is also observed that most people use steel/tin screens/sieves instead of rough stones to rub or grate the rhizomes, which will minimize the loss of large amounts of starch from grated rhizome paste. Rubbing of rhizome by both methods *i.e.*, through rough stone and tin sieve is self-demonstrated and the differences are well marked. This is a crucial unit process carried out to transform the rhizomes into paste-like *Paluo* pulp. Rhizome rubbing must be done by hand, which makes the procedure time-consuming and difficult. The goal is to grate the rhizomes during the process so that the final quantity of grated material is as fine as feasible. Rhizomes are thought to produce more starch when they are finely rubbed or grated, and this is especially true of the color (whiteness) and fineness of the starch.

Filtration

Rhizome pulp that has been produced by rubbing or grating is turned into a solution by adding water to it measuring a ratio of about 1:2 (Pulp: water) and stirring with a spoon to create a homogenous mass. The rubbed rhizome pulp is added with water of about ratio 1:2 to make a homogenous solution. Then the homogeneous mass is passed into a pot covered with a cotton cloth (Fig. 5C). By this process, it releases the majority of starch into the pot. The remaining grated pulp after the first filtration is again mixed with water, stirred, and filtered until it releases all the starch contents into the pot. The remaining debris or substrate (skin fragments, fibers, flakes) left on the fabric (cotton cloth) is discarded (Fig. 5D).

Sedimentation and decantation

The starch particles are settled using sedimentation (Fig. 5E, 5F), and the starch bulk is separated from the supernatant through decantation. In the tribal culture, this procedure is known as washing and purifying of the starch bulk. This is important for two reasons: first, to lessen the starch's sourness or bitterness; second, to enhance the product's whiteness, which would otherwise produce starch with an unpleasant flavor and a dull appearance. Both flavor and color have a big impact on marketing and customer acceptability. To prevent fermentation, the filtrate collected in the pots holding the starch particles is allowed to sediment for about 12 hours before the supernatant is securely drained away at a somewhat low temperature. Since it is the last step before drying the starch, there is a chance of fermentation of the collected starch with low water content (just like dough).

So, to prevent fermentation, the collected filtrates are allowed to sediment completely before draining the water content from it. When draining, enough care is required to ensure that there are no starch particles in the water. Enough water is added to the leftover white wet mass of starch to dilute it (about 2.5 to 3 times its volume) and thoroughly stirring is done to mix it properly. Once more, this was left undisturbed for 6 to 8 hours to settle before being similarly decanted.

Depending on the color of the paste or starch mass, the processes of sedimentation and decantation are repeated four to six times. Finally, the surplus water is removed to the greatest extent possible, leaving behind a white, thick, semi-solid, moist lump of starch. The quantity of decantation enhances the starch's color and lessens its sourness or bitterness, but there is also a danger of starch loss, the degree of which relies on the worker's expertise.

Drying and crushing

After final decantation, a thick or semi-solid, white mass of starch is collected and is then spread out on plates in thin layers exposed to solar radiation. These plates are left in an open area for sun drying (Fig. 5G, 5H). Starch is constantly dried until the moisture

content of the starch mass is suitably decreased and further drying is prevented by the ambient air. The starch bulk becomes brittle and dry.

The dry starch is crushed or ground into a fine powder using a wooden pastel or a wooden kitchen belan. After that, the starch powder is inserted into high-quality polyethylene bags (Fig. 5I), sealed, and stored in a dry environment.

The plant *Curcuma angustifolia* is an advanced monocot plant having tremendous medicinal values (Tabassum and Hamdani 2014, Paikra *et al.* 2018, Nath *et al.* 2022) as well as ethnobiological values (Mishra *et al.* 2011). There are many reports available on the nutritional value of *Paluo* rhizome (Tiwari 2013, Paikra *et al.* 2018, Yograj *et al.* 2018). The physically extracted powder is used unaltered most of the time, and the plant parts contain the highest number and quantity of their phytoconstituents at their raw or succulent stage to exert the highest possible beneficial health impacts (Pattanayak 2020).

The starch obtained is easily digestible and highly nutritious (Yograj *et al.* 2018). It is found that tribal people consume it frequently during fasting as it works as an energy booster. The powder is having reported use in enteritis and dysentery (Pattanayak *et al.* 2015a) and as a digestive stimulator and tonic (Pattanayak *et al.* 2015b). Beyond that it is reported that the plant has anti-microbial (Dubey *et al.* 2018); antioxidant (Assumi *et al.* 2017, Nahak and Sahu 2011); anti-proliferative, antidiabetic (Sheikh *et al.* 2015); anticancer, Hepato-protective (Jena *et al.* 2019); anti- ulcerogenic (Rajashekhara *et al.* 2014). Various other physico-chemical properties are studied by Kumari *et al.* (2017), Sharma *et al.* (2019), and Krishnan and Satish (2022). It was also found that the plant bears many important ethnobotanical uses and traditional values.

The various methods of extraction of starch from rhizomes have already been mentioned by a few researchers in India (Sharma 2012, Paikra *et al.* 2013, Maneesha *et al.* 2018). But the traditional methods of extraction of *Paluo* starch have not been documented in Odisha. The traditional way of extraction/processing leads to a very high loss of powder along with huge time and labor requirements. Detailed information on the unit processes involved in starch extraction is discussed in this study. Additional efforts have been made to properly document and consider the practical consequences of ethnic peoples' traditional knowledge regarding the manufacture of *Paluo* starch. The sedimentation and decantation process decreases the bitterness and increases the whiteness of the product (Patel *et al.* 2015). Our study showed the same results *i.e.*, loss of the starch contents due to the series of decantation. The filtration is done with muslin cloth as described by Patel *et al.* (2015), but in Odisha, only pure cotton cloth is used for filtration as it works best for maximum removal of starch from the substrate. Yograj *et al.* (2018) described the physicochemical variation of *Paluo* powder extracted by laboratory grinder and extraction machine. The machinery starch extraction process is also described through a processing flow chart (Patel *et al.* 2015). In the developed partial mechanical method of processing, all the process is similar to that of the traditional method except for the size reduction of rhizomes and drying (Tiwari and Patel 2013).

Large-scale cultivation of East Indian arrowroot is done in the Keonjhar and Mayurbhanj districts of Odisha. Kandhamal district of Odisha is one of the hubs of all Zingiberaceous plants. Kandhamal is also famous for the production of different varieties of *Curcuma* spp. (Haldi) and cultivation of *C. angustifolia*. Further, because of its potential value for sustainable production and development, the detailed methods of cultivation and starch extraction are discussed here. A proper cultivation methodology provided here gives a better yield as per our survey. So, it is necessary to preserve indigenous knowledge and practice the provided cultivation method for the benefit of future generations.

Table 1. Demographic features of the informants in different study sites of Odisha.

Features		No. of informants	Percentage (%)
Gender	Male	52	41.26
	Female	74	58.73
Age Group	35-54	57	45
	55-64	42	30
	64-83	27	25
Occupation	Farmer	50	39.68
	Worker	35	27.77
	Vaidya	8	6.34
	Homemaker	23	18.25
	Retired Person	10	7.93

Table 2. Ethnobotanical information shared by informants in different parts of Odisha.

Usage		Mode of preparation, Health benefits, Dosage	No. of respondents
Food	i) Breakfast	Raw rhizome is burnt or boiled and consumed which provides nutrition.	111
	ii) Meal	Dried rhizome powder mixed with milk/water to form a nutritious meal and consumed during fasting.	121
	iii) Herbal Drink	*Paluo* herbal drink (*sarbat*) is a popular preparation using the starch and consumed especially during summer season as it works as a cooling agent for the stomach and human body.	126
	iv) Baby's food	After weaning, a beverage containing *Paluo* starch is also used to complement or replace breast milk for babies' nutritional needs.	101
Fodder		Leaves are used for cattle feeding	76
Cosmetics	i) Face pack	It is also used as face mask mixed with turmeric powder to maintain the smoothness of skin.	124
	ii) Body Scrub	Rhizome powder is mixed with rice flour and used for scrubbing to remove dirts, tan from body.	114
Medicinal	i) Dysentery	1-2 spoon of rhizome powder mixed in one glass of water and sugar twice a day for four to five days.	123
	ii) Fever	A half bowl of starch powder cooked in the form of 'Khiri' and Consumed.	125
	iii) Skin infection	Powdered starch along with haldi and neem oil mixed together to prepare a paste and directly applied on skin.	108
	iv) Stomach disorder	2-3 spoon of rhizome powder mixed in one glass of water and taken everyday early morning in empty stomach.	124
	v) Immunity Booster	10 gm rhizome powder is added with glass of milk and sugar candy consumed to improve physical strength and body potency.	120
	vi) Worm disease	1-2 table spoon of starch powder added in glass of milk, taken to kill the worm and gives instant relief.	99
	vii) Burning of fat	Daily use of arrowroot encourages the synthesis of bile from liver which decreases blood cholesterol levels.	72
	viii) Fungal infection	The usage of arrowroot powder as a foot treatment quickly absorbs all moisture and lowers the possibility of infection.	122

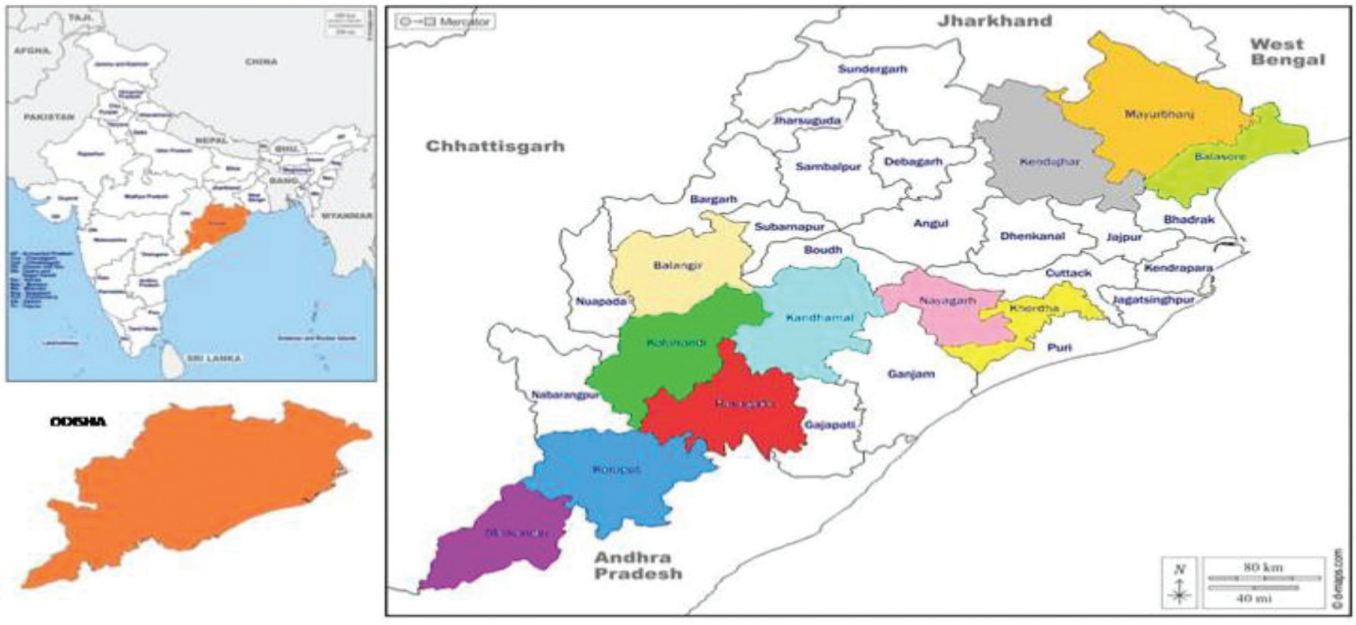

Fig. 1. Map of study area (colours highlighting the study sites).

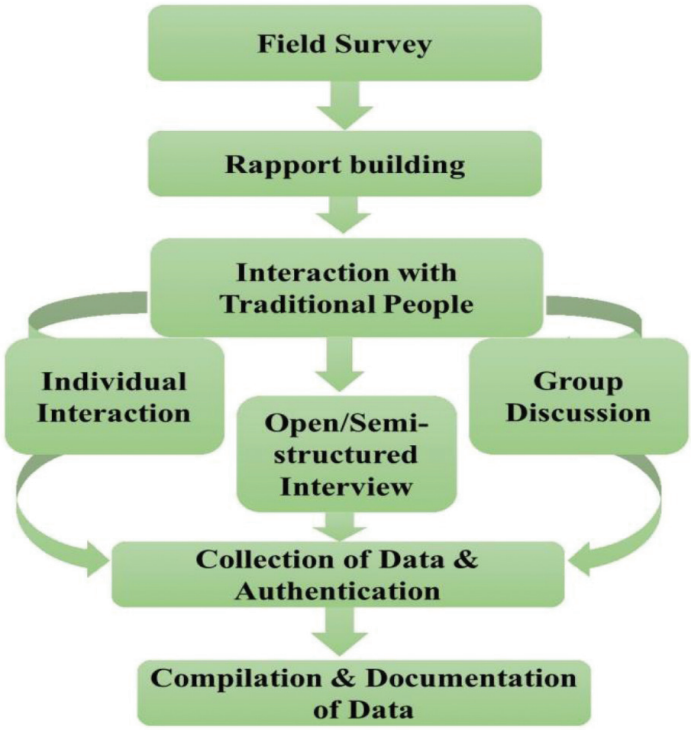

Fig. 2. Methodology for documentation of Traditional knowledge.

Fig. 3. (A) land preparation: land is ploughed 1-2 times for loosening the soil (B) Land covered with dried leaves for temperature maintenance (C) *C. angustifolia* plant with inflorescence (D) Rhizomes of *Curcuma angustifolia*.

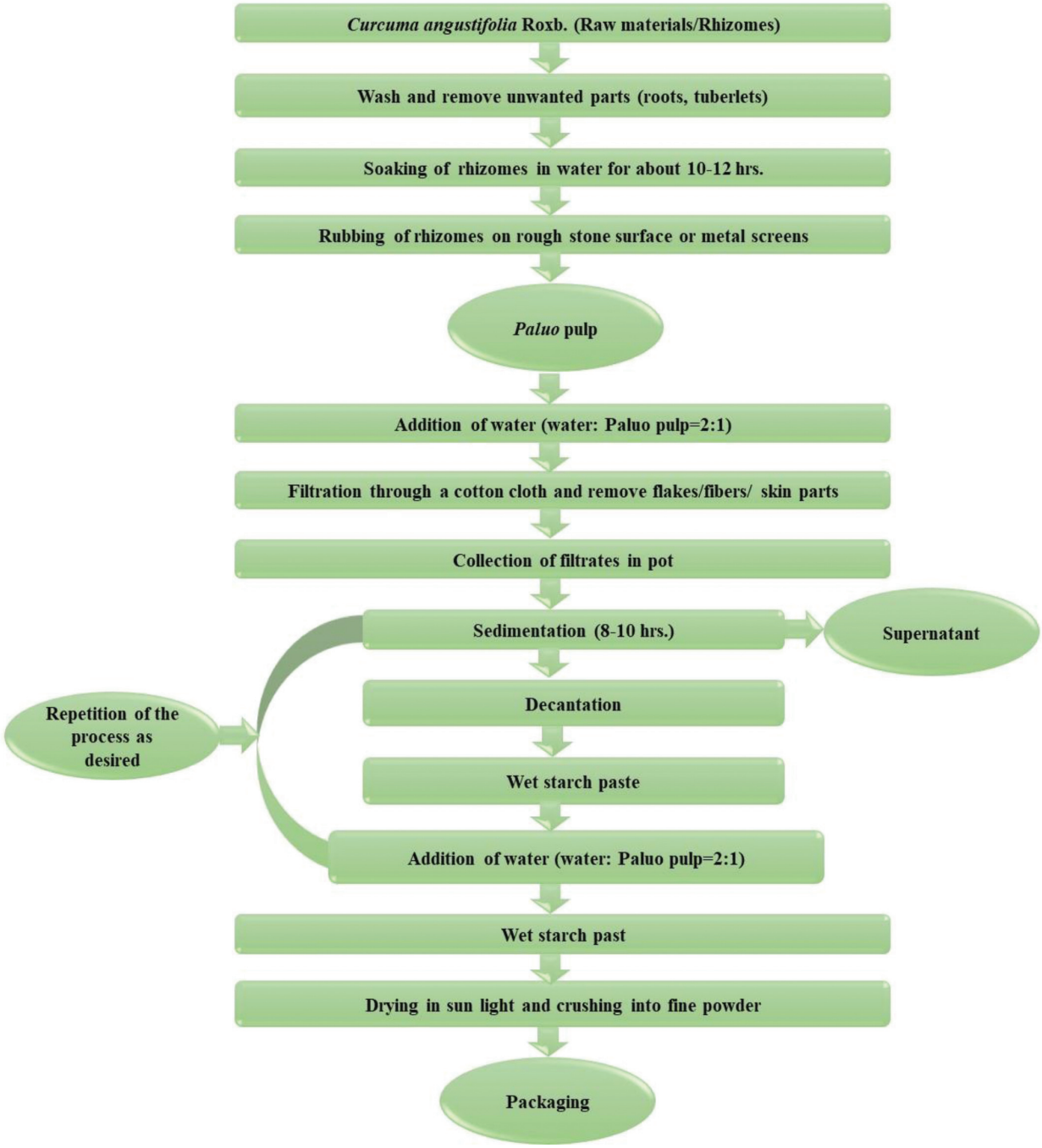

Fig. 4. Flow chart showing step wise methods of starch extraction from *C. angustifolia*

CONCLUSION

It has been noted that the traditional knowledge of wild edible plants, such as *Curcuma angustifolia*, and the ethnic dishes made from them is rapidly vanishing. The processing and value-addition techniques of *C. angustifolia* rhizome by the tribal community are indicative of their rich culture and art. The extraction of the starch is a necessary component of their daily lives although the procedure used by the processors at the hamlet level is extremely time-consuming and labor-intensive. Therefore, the purpose of this ethnobotanical study is to alert scientists and engineers to the need for comprehensive research on the extraction of *Paluo* starch. Soon, the knowledge about starch extraction may disappear if efforts aren't taken to teach the younger generations of their significance. Every effort should be made to increase food security in rural regions and to better the status of wild foods, whose

Fig. 5. Step wise methodology of starch extraction from *C. angustifolia* rhizome.

potential as a source of nutrition is currently undervalued. This work provided the record of the indigenous knowledge of the ethnic people of Odisha in the preparation or extraction of *Paluo* starch, which will guide the researchers to explore the possibilities of its refinement and mechanization to boost the activity. In-depth educative awareness is required among the tribal people of remote places on the values of *Paluo* as a nutrient-balanced diet and as a direct or indirect source of income, especially for resource-poor families.

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