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Wild relative of turmeric, *Curcuma zanthorrhiza* Roxb.- A source of edible starch

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Curcuma zanthorrhiza Roxb., a wild relative of turmeric belongs to the family Zingiberaceae, is an important under exploited rhizomatous herb. Inspite of its medicinal uses, the traditional benefits extends to the isolation of starch powder from its rhizomes, and could be used as nutritional supplement like arrowroot powder. In the present study, the crude starch powder was isolated from the rhizomes of *C. zanthorrhiza,* was subjected to various characterization and acute oral toxicity study. The results showed that the starch recovery percentage of *C. zanthorrhiza* as 10.40±3.65 and the presence of the coumarin and natural colourant curcumin content on the isolated crude starch powder. Relatively very small amount of moisture, crude protein, fat, fibre, and ash content was noticed. Acute oral toxicity studies of the starch powder in Swiss Albino Mice showed non-toxic and there were no significant change in body weights, food and water consumption by the animals from all dose groups (50-6400 mg/kg bw). Observations against various physico-chemical parameters and granular morphology were also noticed. The present work substantiates the usefulness of the starch powder isolated from this wild turmeric and supports its nutritional significance and non-toxic effect. This underutilized minor tuber crop is potential in many food and non-food applications based on their physico-chemical characteristics.

Key words: *Curcuma zanthorrhiza*, Granular morphology, Nutritional attributes, Phytochemicals, Starch, Toxicity

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Many of the rhizomatous species under Zingiberales are sources of edible starch and are under exploited and under investigated. *Curcuma zanthorrhiza* Roxb. commonly termed as *manja-koova/kudamanjal*/ false turmeric is one among them. It is a native to Indonesia, grown in India, Thailand, Philippines, Sri Lanka and Malaysia; cultivated and naturalized throughout South East Asia. In India, *C. zanthorrhiza* was used as a dye earlier, but now it is often used as a substitute for *C. aromatica* in cosmetics[1-2]. The plant bears a cluster of erect pseudostem up to 2 m tall from an underground rhizome and each pseudostem is made up of about eight leaves with blades that can be 40-90cm long and 15-21 cm wide[3]. The rhizome is fleshy with an aromatic, pungent odor, bitter taste and bright orange colour. In traditional medicine *C. zanthorrhiza* is reported to be useful for the treatment of hepatitis, liver complaints, diabetics, rheumatism, anticancer, hypertension and heart disorders. It also showed diuretic, anti-inflammatory, anti-oxidant, anti-hypertensive, anti-rheumatic, anti-hepatotoxic, anti-dysmenorrheal, anti-spasmodic, anti-leucorrhoea, anti-bacterial and anti-fungal effects[4]. Traditional benefits of *C. zanthorrhiza* were further supported by the isolation of crude starch powder from the rhizomes which is used as a functional food for children and patients suffering from fever and other ailments aiming easy digestion and instant energy, as nutritional food supplement and substitute for true arrowroot powder[5]. It is also employed as dye, spice, and food flavorings mainly due to their exotic aroma[6]. Toxicity studies on this plant are meagre and studied only methanolic and aqueous extracts[7]. No work has been carried out on crude starch powder isolated from the rhizomes with respect to the toxicity screening in animals. In the present study, data on phytochemical composition, nutritional attributes, toxic effect and physico-chemical characters of the isolated crude starch powder were determined. The study also determined the granular morphology of the starch powder of this underutilized *Curcuma* species.

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Methodology

Sample collection:

Mature fresh rhizomes were collected during its mature and dormant season (November to January) from the Medicinal Plant Germplasm of JNTBGRI. Voucher specimens were submitted at TBGT (83452).

Method of starch isolation:

An improved version of the method for starch extraction from the rhizomes of *Curcuma* species (Kokate, 1994)[8], was adopted here. The collected fresh rhizomes were washed thoroughly with water and chopped into fine pieces, followed by grinding to get a smooth paste. The paste was stirred well in water, decanted and the residue was washed repeatedly until the colour of the residue becomes pure white. The residual water was filtered off completely using a fine cotton cloth. The residue kept in a wide mouthed earthen pot was allowed to sediment overnight and later the residual water was decanted. The sedimented starch was well dried in sunlight. The starch powder was stored in airtight containers for further studies.

Starch recovery:

Starch recovery was calculated on the basis of following formula (Yograj, 2017)[9]

Starch recovery (%) = Ws /Wr×100

Where,

Ws= Weight of extracted starch and

Wr= Weight of rhizome taken

Characterization:

Preliminary phytochemical screening of the isolated crude starch powder was carried out in methanol extract[10]. Nutritional/Proximate composition[11], Acute toxicity study in Swiss Albino Mice[12], Physico-chemical characters – Swelling Power and Solubility[13], Water and Oil Binding Capacity[14], Bulk Density, True Density, Porosity[15] and Curcumin content[16] were determined using standard procedures. 0.5 mg of isolated starch was studied for the CHNS analysis using a CHNS analyser (Elementar Vario EL III) at SAIF, Cochin. It is a powerful and relatively reliable method for determining the purity of a compound by providing a precise and accurate analysis of percentage of carbon, hydrogen, nitrogen and sulfur.

Acute oral toxicity study:

Acute oral toxicity study of the starch powder isolated from *C. zanthorrhiza* was studied in Swizz Albino Mice. Females grouped in to VI groups with 4 animals each, with a body weight ranging 20-25 g. The dose values were selected based on data from FDA Draft Guidelines[17]. The ethanolic extract of the powder was suspended in distilled water before administration. Group I-V animals were administered 1 mg/kg bw respectively. Group VI received the vehicle (distilled water) only was served as control. The animals were observed 30 min after dosing, followed by hourly observation for 8 h and once a day for the next 14 days. All observations were systematically recorded with individual records being maintained for each animal. Surviving animals were weighed and visual observations for mortality, behavioral pattern, changes in physical appearance, injury, pain and signs of illness were conducted daily during the period.

Granular morphology:

The microstructure level characterization of isolated starch was examined under light microscopy using a stereomicroscope (Leica DM 2500, Switzerland) equipped with a Leica DFC 290 camera. Starch sample mounted on a slide with glycerin was observed with 40 X objective in the randomly selected fields under normal light. Suitable views were photographed and the grain size was determined using the image analyser. The microstructure of starch granules was also viewed and documented using SEM (JEOL Model JSM-6390 LV) at SAIF, Cochin and nature and shape of the isolated starch granules were studied, the size of the starch granules was measured (1000 X).

Results

The starch recovery percentage of *Curcuma zanthorrhiza* was found as 10.40±3.65% and the colour of the starch powder was pale yellow (Fig. 1). Preliminary phytochemical screening revealed the absence of common phytochemical constituents such as alkaloids, steroids, terpenoids etc. except coumarin (Table 1). Nutritional/proximate composition of the starch powder was with low amount of moisture, crude protein, fat, fibre and ash content whereas with a high calorific value/ energy content (Fig. 2). In the isolated crude starch powder, starch is the major component (79.16%) which comprises amylose (26.56%) and amylopectin (73.44%) with some amount of curcumin

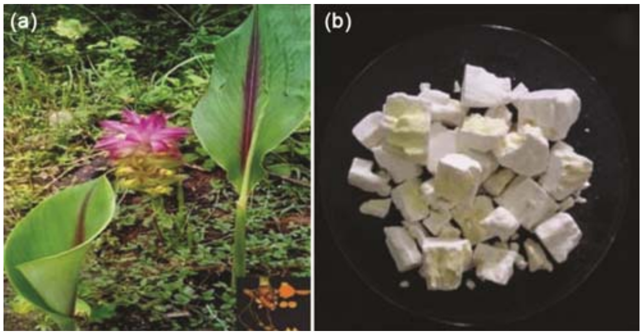

Fig. 1A — *Curcuma zanthorrhiza* Roxb. – Habit; B. Lumps of Crude Starch Powder

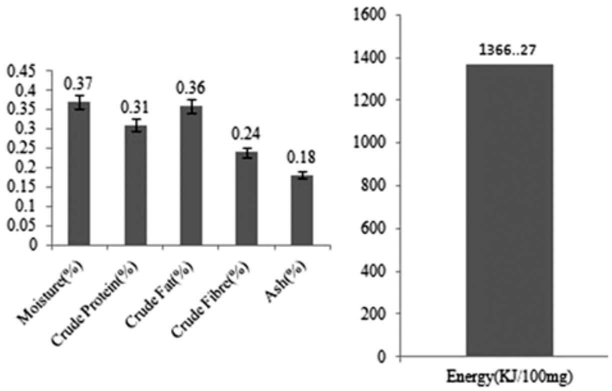

Fig. 2 — Graphical representation of nutritional / proximate analysis of the crude starch powder from *C. zanthorrhiza*

Table 1 — Preliminary phytochemical screening of the crude starch powder from *C. zanthorrhiza*

SI. No.	Phytochemicals	Method	Result
1.	Steroids and Terpenoids	Liebermann-Burchard Test	Absent
2.	Alkaloids	Dragendroff's Test & Mayer's Test	Absent
3.	Flavonoids	Shinoda Test	Absent
4.	Coumarins	Alkaline Test	Present
6.	Saponins	Chloroform Test	Absent

content. The sulfur content was not recorded. Various other physico-chemical parameters of the starch powder was also detected (Table 2). Granular morphology of the starch powder showed the form and shape of the starch grains as simple, oval to elliptical, rounded with faint eccentric striations (Fig. 3) with a wide range of the length (7-72 µm) and width (4- 33 µm). Average granule size as per SEM is 23.95×15.23 µm. Acute oral toxicity study proves that, the isolated starch powder was devoid of any significant toxic effect up to 6400 mg/kg body weight of Albino mice, in oral administration.

Table 2 — Physico-chemical analysis of the crude starch powder from *C. zanthorrhiza*

SI. No.	Physico-chemical parameters	Observations
1.	Swelling Power (mL/g)	26.16
2.	Solubility (mL/g)	16.23
3.	Water Binding Capacity (g/g)	1.12
4.	Oil Binding Capacity (g/g)	0.47
5.	True Density (g/mL)S	1.26
6.	Bulk Density (g/mL)	0.50
7.	Porosity (%)	60
8.	Starch (%)	79.16
9.	Amylose (%)	26.56
10.	Amylopectin (%)	73.44
11.	Curcumin(g/mg)	0.12
12.	Carbon (%)	34.33
13.	Hydrogen (%)	7.36
14.	Nitrogen (%)	0.05%
15.	Sulfur (%)	Not Detected

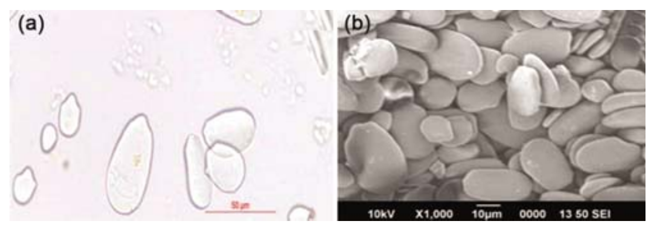

Fig. 3 — Microstructure of starch granules from *C. zanthorrhiza* (A). Lightmicrograph (40 X); (B). Scanning electron micrograph (1000 X).

Discussion

Starch recovery (10.40%) of *C. zanthorrhiza* is very much comparable to the yield of 'arrowroot' (*Marantaarundinacea* L.) (13.87%) one of the most popular source of today's edible starch. The finding was supported by the report of Vimala and Nambisan (2010)[18]. The isolated starch powder was pale yellow in colour due to the presence of colourant viz., curcumin. Neutraceuticals can be incorporated into food systems for the development of functional foods, whereas curcumin is one of the well-studied neutraceutical with bioactivities and many health promising benefits[19]. Therefore curcumin content retained in the starch powder of *C. zanthorrhiza* is an added advantage. Presence of the phytochemical, coumarin derivatives which exhibit a wide range of biological properties promising antioxidant activities[20] is also another significance of its edible value.

Comparatively large amount of amylose content of the starch is important because amylose largely determines the gelling ability of the starches[21]. The high amylose content is beneficial for the manufacture of extruded and fried snack foods particularly where low expansion, high crispiness, and reduced fat uptake are desirable[22]. The relatively low moisture content of the starches made them easy to store at room temperature and less prone to colonization by micro-organisms, making them suitable for industries like phrarmaceuticals[23]. The isolated starch powder has very low amount of crude protein, fat, fibre and ash content. The results matched with the study of Yogaraj (2017)[9] on the starch powder isolated from *Curcuma angustifolia*, which is commonly known as 'East Indian Arrowroot'. The ash content is an estimate of the mineral content and the presence of inorganic component in the starch. The low ash content is an indication of good quality edible starch. Ash level may also be regarded as a measure of the quality or grade of the flour and often a useful criterion in the authenticity of the food[24]. The starch powder has high calorific value/ energy content and this attribute can be utilized in the gluten free and infant food products to aid people with celiac disease[21].

Physico-chemical parameters such as swelling power and solubility properties represent an evidence of interaction between the amorphous and crystalline areas[25-26]. Factors that may influence solubility of starches are source, swelling power, inter-associative forces within the amorphous and crystalline domains, and presence of other components like phosphorus etc.[27]. Furthermore it is influenced by amylose and amylopectin characteristics[28]. The results showed relatively good amount of swelling power and solubility that is 26.16 mL/g and 16.23% respectively. Swelling power and solubility properties of the starch used as an ingredient may influence the characteristics of bakery products[29]. Water binding capacity of the starch from *C. zanthorrhiza* indicated that, it will be a good ingredient for bakery products since such quality was reported to be helpful to maintain the freshness of bread, cakes and sausages. Oil binding capacity reflects the emulsifying capacity and the amount of oil picked up by the sample during frying[21]. Bulk density is the measure of heaviness of solid samples, which is important for determining packaging, material handling and thus its application in the food industry[31]. Bulk density of starch powder from *C. zanthorrhiza* (0.50 g/mL) was quite lesser than that of the bulk density reported in wheat flour (0.73 g/cc)[32]. Thus it is not suitable as a thickener in food products as it is recommended that the flour with high bulk densities (>0.7 g/mL) are used as food thickeners[30]. CHNS analysis revealed the absence of sulfur, which positively indicates the edible value whereas very low percentage of the nitrogen is an evident to the purity of the extracted starch and matched with the study conducted by Pascoal *et al*., (2013)[33] in starch from *Solanum lycocarpum.*

Resistant starch is any starch or starch digestion products are not absorbed by small intestine in healthy individuals[34]. *C. zanthorrhiza* starch with comparatively good amount of amylose (25.56%), that predominates in resistant starch and are digested slowly, which functions like soluble fibre and it improves insulin sensitivity which could lower the blood sugar level. Thaha (2013)[20] reported that, *Curcuma rakthakanda* is a source of resistant starch. These starch act as dietary fibre and thus good for diabetic patients, when it is consumed as uncooked. When cooked, it become easily digestible and could give instant energy and thus good for children and patients.

The behavior of experimented Swiss Albino Mice was recorded regularly through daily observations of each animal from the stage of dosing to the end of the study. The cage slide parameters observed were normal condition of the fur, skin, pupil diameter, colour and consistency of the faeces, condition of teeth, and gait. There were no subcutaneous swellings, abdominal distension, eye dullness and opacities, ptosis, wetness or soiling of the perineum and breathing abnormalities. There were no significant changes in body weights, food and water consumption by the animals from all dose groups (50-6400 mg/kg bw). There was no mortality recorded even at the highest dose level, which proves that the crude starch powder from *C. zanthorrhiza* was devoid of any significant toxic effect up to 6400 mg/kg body weight in oral administration.

The application of light microscope and scanning electron microscope helps in understanding of physical characters and morphology of the isolated starch powder. *C. zanthorrhiza* showed the shape and size variation (7-72 µm×4-33 µm) in its starch granules. Granule structure, size and their distribution are important as they can affect the functional properties of starch.

The present study substantiates the usefulness of the crude starch powder isolated from *Curcuma zanthorrhiza* by traditional method, as nutritionally significant and non-toxic. The promising flour from this under exploited source of starch could be recommended as a direct food and also as major ingredient for various food products. Suitable modifications of the starch, based on their properties, can be utilized for diverse food and non-food industrial applications in order to satisfy the consumer needs.

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