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Ethnobotanical, Nutritional, Phytochemical and Antimicrobial Studies of *Garcinia xanthochymus* Fruit Extracts

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SKR and JKP designed the study and wrote the first draft of manuscript. Authors PM and SK did the ethno-botanical survey and carried out the lab work. Author NRS performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Aim: An attempt has been made to document the ethnobotanical values of the fruits of *G. xanthochymus* in and around the Similipal Biosphere Reserve (SBR) forest and evaluate the nutritional, phytochemical and antimicrobial potential of fruit extracts of *G. xanthochymus*.
Study Design: Ethnomedicinal collection were made, followed by nutritional evaluation of the fruits. Phytochemical analysis was carried out by qualitative method and antimicrobial activity was evaluated.
Place and Duration of Study: Samples were collected from Similipal Biosphere Reserve and its adjoining areas during 2013 to 2014. Laboratory work was done at Ravenshaw University, Cuttack.
Methodology: Ethnobotanical data collections were made mainly through semi-structured questionnaires focusing on local name(s), present knowledge on uses as food, degree of uses,

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medicinal and economic values. Nutritional and qualitative phytochemical analysis was done by standard methods. Antimicrobial activity was evaluated against two Gram-positive bacterial strains, three Gram-negative bacterial strains and one fungal strain by disc diffusion method.

Results: Ethnobotanical survey suggested that the plant is widely used as a food or food supplement by the tribal people as well as in treatment of various ailments like fever, stomach problems, skin diseases and sexual disorders. Nutritional evaluation showed that the fruit was rich in carbohydrate and starch. The qualitative phytochemical analysis revealed that the fruits are rich in different types of bioactive compounds like saponin, tannins, alkaloid, terpenoid and phenolic compounds. The pathogenic strains showed concentration dependent susceptibility to crude extracts.

Conclusion: The results support the traditional use of the plant parts for the treatment of bacterial and fungal infections. However, further work on this fruit will open avenues for discovery of new lead molecules which might be used in pharmaceutical industries.

Keywords: Anti-microbial activity; bioactive compounds; ethnobotany; food values; Garcinia xanthochymus.

1. INTRODUCTION

The plant from the genus *Garcinia* belonging to family Clusiaceae, consists of over 200 species distributed in the tropical area of the world. About 35 species exist in India, many of which are endemic and economically important with huge medicinal properties [1]. In India, *Garcinia* species grow extensively in the Konkan region of Maharshtra, Goa, coastal areas of Karnatak, Kerala and evergreen forests of Assam, Khasi, Jantia hills, Nagaland, West Bengal and Gujarat and Odisha [2]. *Garcinia xanthochymus* (Hook). f. is a plant having good agronomic characteristics (Plate 1). It is commonly known as false Mangosteen. Botanically, it is a medium sized, branched evergreen tree or shrub with greenish gum resins perennial up to 17cm high. Trunk rough, brown bark with white latex. Branches numerous, slender, decussate, horizontal and twigs distinctly angled. Leaves are mostly opposite, elliptic to lanceolate and oblong. The leaf is pale green when young and becomes dark green and shiny on the upper surface and glabrous and petiole is thick. Flowers are white, small, solitary, fascicled, umbelled or panicled, polygamous or dioecious. Sepals are leathery persistent. Fruits are thin skin, berry with fleshy rind enclosing 2-8 large pulpy seeds. Fruits are green in colour and turn to a deep yellow to orangey yellow colour when ripen. *Garcinia xanthochymus* grows very dynamically and can adapt to a variety of soil types. This is a heavy bearer and sometimes even bears two crops a year. It is cultivated and has grown to be semi-naturalised in condition [3]. It is distributed in Asia-temperate and tropical regions, western Africa, Australia, South America, and Polynesia, regions of world. In India it is distributed in Andhra Pradesh, Assam, Goa, Karnataka, Kerala, Maharashtra, Meghalaya, Odisha, Bihar, Sikkim, Tamil Nadu, Tripura [4]. The plant is widely distributed throughout Odisha.

The fruits have fleshy endocarp which is very delicious [5]. In north eastern region of India these *Garcinia* fruits are used for culinary purposes and as folk medicine. It is rich source of oxygenated and prenylated xanthones [6,7]. The fruits of *Garcinia xanthochymus* are highly acidic, bitter taste and used as food for preparing pickle, chutney and flavour curries [8,9]. The fruits are usually consumed by the aboriginals and tribes throughout India. In odisha, the tribes like Kandho, Gond, Santal, Soasa, Shabar, Munda, Bhatudi and Bhunya use these *Garcinia xanthochymus* fruits as their source of food and livelihood. The fruit also contain several phytochemicals such as xanthones, flavonoides, saponins, tannins, alkaloids, lipids, benzophenones and biflavonoids [10-13]. Methanol extract of *Garcinia xanthochymus* fruit produced two new benzophenones, guttiferone H and gambogenone. These compounds play major role for prevention of colon cancer and breast cancer [13,14]. The petroleum ether and methanol extract of *Garcinia xanthochymus* fruits showed good activity against *Staphylococcus arueus, Escherichia coli, Streptococcus faecalis, and Pseudomonas aeruginosa* [15]. Fungi play a vital role either directly or indirectly in our daily life. Some of them are beneficial as well as harmful to us. The petroleum ether and methanol extracts of *Garcinia xanthochymus* fruits showed prominent activity against *Trichophyton mentagrophytes, Sporotrichum aureus, Aspergillus fumigatus* and *Candida albicans* [13,15].

Plate 1. Photograph showing the whole plant (A) of *Garcinia xanthochymus* (Hook).; leaves with the fruit (B); stem of the plant with unripe fruits in a bunch (C); and collection of fruits from the forest of Similipal Biosphere Reserve by the tribal people for eating purpose (D)

Keeping the importance of this plant, an investigation was made to document the ethnobotanical data from peripheral areas of Similipal Biosphere Reserve and to evaluate the nutritional, phytochemical and antimicrobial properties of *Garcinia xanthochymus* fruits.

2. METHODOLOGY

2.1 Collection of Ethnobotanical Data

The field work was conducted with the rural and tribal communities of Similipal Biosphere Reserve and its adjoining areas during 2013 to 2014. The methodological frameworks for the ethno botanical study, were as per the standard techniques of exploration and germplasm collection [16], qualitative and quantitative ethno-biological approaches in the field, interviews, elicitation methods, data collection and further authentication [17,18]. Intensive and extensive field surveys were done in different landscapes and micro-ecological niches across forest types, adjoining valleys, homesteads, kitchen gardens, farm lands, fallow lands etc. in the core, buffer and peripheral regions of SBR covering randomly selected villages of the locality. The field surveys were carried out in the weekly markets (Haat) of peripheral regions of SBR. Opinions of tribal people were taken regarding the uses of experimental plant species through questionnaires. Primary data collection were made mainly through semi-structured questionnaires (Passport Data Form) focusing on local name(s), collecting season(s), present knowledge on use(s), mode of use(s), part(s) of the plant used, degree of wildness, economic values, change in collecting pattern over time, possible threats and potential of the experimental plants. A clear expression of consent was obtained from the informants before the interview to provide information on elaborating the aim of the study as per the guidelines and code of ethics of International Society of Ethnobiology (ISE 2006). To elicit food values and ethnobotanical information from the informants, two methods were adopted, such as (1) open-ended and semi-structured interviews for qualitative data collection and (2) Structured interview using the predetermined questionnaire.

2.2 Collection of Plant Materials

Fruit of *Garcinia xanthocymus* were collected from Similipal Biosphere Reserve and was identified by second author (Reference herbarium specimen Voucher no. 2764-rprc, RPRC, India).

2.3 Preparation of Fruit Extracts

Successive solvent extraction procedure was used to prepare different solvent extracts of the fruit by taking 50 ml each of the solvent (Hexane, acetone, ether, methanol, butanol and aqueous) on the basis of their polarity using Soxhlet apparatus. 50 g of powdered fruit was fed into the apparatus for each extraction. Extracts were collected with acetone, hexane, petroleum ether and water after 5-6 siphons. The extracts were then dried over a period of 24 hours at room temperature. The dried samples were then weighed and stored.

2.4 Estimation of Biochemical and Phytochemical Analysis

Biochemical analysis and qualitative analysis was done using the standard methods [19-22].

2.5 Microbial Strains

The microbial strains employed in the study included *Vibrio cholera* (MTCC 3909), *Salmonella typhimurium* (MTCC 1252), *Shiegella flexneri* (MTCC 1457), *Streptococcus pyogenes* (MTCC 1926), *Streptococcus mutans* (MTCC 497) and *Candida parapsilosis* (MTCC 2513) procured from IMTECH, Chandigarh. All strains were maintained on nutrient agar slants. The first three are Gram negative strains, the second two are Gram positive and the last one is a fungus.

2.6 Antimicrobial Activity Assay Using Disc Diffusion Methods

Disc diffusion method [23] was followed to test the antimicrobial activity of various extracts against the five bacterial strains and one fungal strain. Nutrient agar plates were prepared as per manufacturer's instructions. 100 µL of nutrient broth cultures of the test microbes prepared a day before were poured over the plates uniformly and a lawn culture was prepared using a sterile spreader in a laminar hood. After drying (not more than 15mins), Watman (No.1) paper disc of 6cm diameter, containing 10 µL of crude fruit extracts dissolved in 100% DMSO (dimethyl sulphoxide) were applied in the plate. The activity is determined by the measurement of diameter of inhibitory zone in mm after incubation at 37 ºC for 24 h. Only the solvent (DMSO) was poured into the disc in another set of plates as part of negative control. The positive control set consisted of standard antibiotics like Kanamycin, Neomycin, Gentamycin and Gatifloxacin. Zones of inhibition, free of microbial growth appeared around each disc in the form of clear rings, which confirmed the antimicrobial activity of the respective extracts. Those extracts which did not have any inhibitory effect on the microbe did not form any clear ring. The cleared zone around each disc was measured and average diameter was taken. Results were presented as triplicates of mean with SEM.

3. RESULTS AND DISCUSSION

Ethnobotanical survey about the plant along with the documentation of medicinal uses (Table 1, Plate 1) clearly indicates that *Garcinia xanthochymus* fruit is widely used as a food or food supplement by the tribal people of Similipal and its adjoining areas. The fruit as a whole or its extracts are used in treatment of various ailments like fever, stomach problems, skin diseases and sexual disorders. The plant is also used in treatment of various ailments of livestock. In addition to the above uses, the fruits are also used in batter system i.e. tribal exchange the fruits of this plant for other commodities in the market. Hence, results of ethnobotanical survey indicate that *Garcinia xanthochymus* fruit exhibits potential to be treated as a source of medicines along with high nutritive value.

The forest of Similipal is among the most luxuriant and valuable forest of the state. It harbours a rich flora of 1076 species of vascular plants which includes 93 species of Orchids, 52 species of rare and endangered plants and more than 300 species of medicinal plants [24]. There are 61 villages within the biosphere reserve and 1200 villages all around within a distance of 10 km from the periphery. The tribal population of SBR mainly includes Santal, Kolha, Bathudi, Kharias, Mankadias, Gond and Ho. They depend solely on the surrounding forest for most of their requirement from food to medicines. The indigenous traditional knowledge of medicinal plants has been transmitted orally for centuries. This practice is slowly becoming extinct, due to changes in traditional culture and introduction of modern technologies. Hence, these traditional practices need proper documentation. Limited studies on ethnomedicinal uses of medicinal

plants from Similipal have been reported [25,26]. However, the present study gives information about the ethnomedicinal uses of *Garcinia xanthochymus* from Similipal. Ethnobotanical uses of this plant have not been documented earlier from Similipal. Nutritional analysis of raw fruit of *G. xanthochymus* was carried out to evaluate the quantity of carbohydrate, starch, total oil and saponin present. Raw fruits were macerated and evaluated for the presence of nutrients. Raw fruit was found to contain 11.44% carbohydrate, 9.06% starch, 1.64% total oil and 28.04% saponin (Fig. 1). High carbohydrate and starch content attribute to the high nutritional value of the fruit. Manohar *et al.,* (2014) [27] have reported that 2.35% ash, 45.22 % carbohydrate and 6.93% protein are present in *Garcinia xanthochymus*. *Garcinia xanthochymus* seeds contain about 29.4% saponin [28]. Both primary and secondary metabolites are necessary for normal metabolism and defense of the plant respectively.

Different extracts (aqueous, acetone, methanol, hexane, butanol and ether) of fruits of *G. xanthochymus* were screened for presence of various phytochemicals like saponin, tannin, flavonoid, alkaloid, phenol, steroid and terpenoid and the result are presented in Table 2. Except hexane extract all the solvents showed the presence of almost all phytochemicals. Hexane extract did not show the presence of any phytochemicals. Steroid and terpenoid were absent in aqueous, acetone and petroleum ether extract. Similarly, phenolic compounds and steroids were absent in butanol extract.

Phytochemicals are major components responsible for bioactivity potential and hence it has become all the more important to determine the phytochemical constituents in plants. Production of a variety of phytochemicals through development of various physiological mechanism, are the most successful adaptation of plants by which they protect themselves from biotic and abiotic stresses [29]. The metabolites belonging to a variety of chemical classes like aliphatic alcohols, starch, amino acids, carbohydrates, carotenoids, hydrocarbons, free fatty acids, lipids, phorbol esters, phenolics and related compound, steroids, tannins, terpenes and related compounds have been characterized from medicinal plants [30]. The curative properties of medicinal plants are perhaps due to the presence of various secondary metabolites like alkaloids, flavonoids, glycosides, phenols, saponins, sterols etc. [31]. Sodipo et al. [32] reported that saponins are special class of glycosides that have been shown to be antifungal agent. Flavonoids are currently of growing interest owing to their supposed properties in promoting health [33]. Steroidal compounds are of importance and interest in pharmacy due to their relationship with such compounds as sex hormones [34]. Tanins are responsible for many physiological activities like stimulation of phagocytic cells, host mediated tumor activity and anti-infective actions in humans [35]. Alkaloids are associated with cytotoxicity in physiological systems [36]. Isolated plant alkaloids and their synthetic derivatives are used for their analgesic, anti-spasmodiac and bactericidal effects [37].

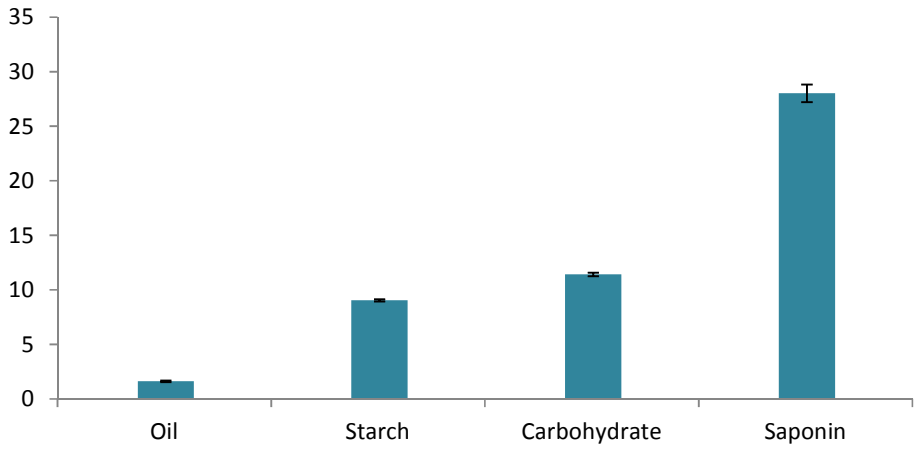

Fig. 1. Approximate nutritional composition (in %) of *Garcinia xanthochymus* fruit

Table 1. Ethnomedicinal values of *Garcinia xanthochymus* (fruits) collected from selected villages of Mayurbhanj

Village	Block	Races	Age (Sex) of person enquired	Local name(s)	Food values	Ethnomedicinal values	Commercial value
Sialinai	Jashipur	Santal	Male (48)	Pita ambo	Fruits are eaten mostly by monkeys and birds	Used in diarrhoea	This fruit rarely available and so it has less demand in the local market.
Tulsibani	Jashipur	Santal	Male (65)	Gaaliyam	Fruits and seeds are edible	Fruits are used against stomach problems	Selling the fruit in tribal markets.
Durdura	Jashipur	Santal	Male (75)	Mithuul	Fruits are used in making pickle	The latex of fruit used as medicine for curing wound and other skin diseases	Fruits are exchanged for other commodities.
Podagoda	Jashipur	Kolho	Male (75)	Gansargi	Fruits are edible. Oil of seeds are edible	Fruits are used as medicine in sexual disorders	Fruits are exchanged for other commodities.
Mohanpur	Jashipur	Santal	Male (65)	Gurchi	Fruits are edible	Grinding fruit and mix with rice water (pejo). It is then given to goats for curing fever.	Fruits are exchanged for other commodities.
Burndeiposi	Jashipur	Bathudi	Male (71)	Pinar	Fruits are edible	Use as medicine for curing pakulia disease of cattle.	Fruits are exchanged for other commodities.
Jamuani	Jashipur	Gond	Female (35)	Kaadu	Tribal people use the seeds and fruits for preparation of jaau (Khechudi)	Wound healing	Fruits are exchanged for other commodities.
Kundagoda	Jashipur	Santal	Male (78)	Makolul	Fruits are edible	Tribal people use bark of the plant for homeopathic medicine.	Fruits are exchanged for other commodities.

Antimicrobial activity is an important aspect of bioactivity studies of medicinal plant extracts. Antimicrobial activity has been performed by disc diffusion method. Gram positive bacteria, gram negative bacteria and a fungus were employed in determining the antimicrobial activity. The antimicrobial activity of fruit extract of *G. xanthochymus* showed prominent zones of inhibition against *Vibrio cholera* (MTCC 3906), *Salmonella typhimurium* (MTCC 1252), *Shigella flexnerii* (MTCC 1457), *Streptococcus pyrogens* (MTCC 1926), *Streptococcus mutans* (MTCC 1497) and *Candida parapsilosis* (MTCC 2513) at different concentrations. The antimicrobial activity in terms of zones of inhibition showed that the extracts were active against a wide range of microorganisms and also their activity varies with response to dose. The activities of the extracts were compared with standard antibiotics (Tables 3-6, Figs. 2-3). Goel et al. [15] have reported that the petroleum ether and methanol extracts of *Garcinia xanthochymus* fruits showed prominent activity against *Staphylococcus arueus, Escherichia coli, Streptococcus faecalis,* and *Pseudomonas aeruginosa*. Similarly *Streptococcus faecalis* showed the highest degree of inhibition and *Candida albicans* showed less inhibition in petroleum ether and methanol extracts of *Garcinia xanthochymus* fruits [38]. Our study suggests that other solvent extracts are also active against not only bacteria but also fungus. Also the antimicrobial activity is dose dependent.

The bacterial and fungal strains selected in the study are responsible for causing many diseases in humans. *Vibrio cholerae* causes cholera, a severe diarrheal disease [39]. *Shigella flexnerii* causes diarrhea, dysentery, fever, nausea, vomiting and stomach cramps [40]. Antimicrobial activity might be due to the active components present in the extracts. However the antimicrobial activity varies with plant species. Such activity might be due to distribution of antimicrobial substances, which varied from species to species [41]. The antimicrobial activity of plant extracts may be attributed to the presence of phytochemicals like alkaloids, tannins, flavonoids etc present in the extracts [42]. These findings have great practical applications in the recent times as infectious diseases are leading cause of death worldwide. Use of antibiotics is the only solution to this problem. Further, indiscriminate use of antibiotics has led to the development of antimicrobial resistance to drugs which has forced the search for new antimicrobial substances from various sources [43]. Thus the present study revealed the great potential of the studied plant and its part (fruit) for the discovery of antimicrobial substances which may find its application for microbial infections. However, further studies are required in this direction to identify the active principles (lead molecules) responsible for significant bioactivity and isolation and characterization of compounds of this plant.

Table 2. Phytochemical screening of *Garcinia xanthochymus* fruit

Solvents	Phytochemicals						
	Saponin	Tannin	Flavonoid	Alkaloid	Phenolic compound	Steriod	Terpenoid
Aqueous	+	+	+	+	+	-	-
Acetone	+	+	+	+	+	-	-
Methanol	+	+	+	+	-	-	+
Hexane	-	-	-	-	-	-	-
n-butanol	+	+	+	+	-	-	+
Petroleum ether	+	+	+	+	+	-	-

'+'- detected. '- not detected

Table 3. Zone of inhibition of antibiotics using antibiotic discs

Strains	Inhibition zones in diameter (mm)*			
	Kanamycin	Neomycin	Gentamycin	Gatifloxacin
Vibrio cholera (MTCC 3906)	16.33±1.53	21.33±0.58	26.67±0.58	43.00±0.00
Salmonella typhimurium (MTCC 1252)	15.67±0.58	21.33±0.58	26.33±0.58	41.33±0.58
Shigella flexnerii (MTCC 1457)	17.33±0.58	21.67±0.58	27.00±0.00	42.33±0.58
Streptococcus pyrogens (MTCC 1926)	17.67±0.58	21.67±0.58	28.33±0.58	42.33±0.58
Streptococcus mutans (MTCC 1497)	17.33±0.58	22.67±0.58	26.00±1.00	42.33±1.15

**Data expressed as mean value ± standard deviation*

Table 4. Antimicrobial activity of fruit extracts of *G. xanthochymus* using disc diffusion method (1000 µg/ml)

Extracts	*Salmonella typhimurium* (MTCC 1252)	*Shigella flexnerii* (MTCC 1457)	*Vibrio cholera* (MTCC 3906)	*Streptococcus pyrogens* (MTCC 1926)	*Streptococcus mutans* (MTCC 1497)	*Candida parapsilosis* (MTCC 2513)
Petroleum ether	1.5±0.057*	0.8±0.1	1.4±0.115	0.8±0.1	1.4± 0.057	1.5±0.057
Acetone	0.8±0.1	0.9±0.1	0.7±0.1	0.9±0.1	0.7 ±0.1	0.8±0.1
n-Hexane	0.8±0.1	0.9±0.1	0.8±0.1	0.7 ±0	0.9±0.1	0.8±0.1
Aqueous	0.7 ±0.1	0.8±0.1	0.7 ±0	1.5±0.057	0.9±0.1	0.9±0.1

**Data expressed as mean value ± standard deviation*

Table 5. Antimicrobial activity of fruit extracts of *G. xanthochymus* using disc diffusion method (500 µg/ml)

Extracts	*Salmonella typhimurium* (MTCC 1252)	*Shigella flexnerii* (MTCC 1457)	*Vibrio cholera* (MTCC 3906)	*Streptococcus pyrogens* (MTCC 1926)	*Streptococcus mutans* (MTCC 1497)	*Candida parapsilosis* (MTCC 2513)
Petroleum ether	1.2±0.1*	0.8±0.1	1.4±0.051	0.8±0.057	1.4±0.1	0.8±0.1
Acetone	0.8±0.152	0.7±0.1	0.7±0.057	0.8±0.1	0.7±0.057	0.7±0.1
n-Hexane	0.7±0.152	0.7±0.152	0.7±0.1	0.7±0.057	0.7±0.115	0.7±0.057
Aqueous	0.7±0.115	0.8±0.057	0.7±0.152	0.7±0.115	0.9±0.057	0.8±0.115

**Data expressed as mean value ± standard deviation*

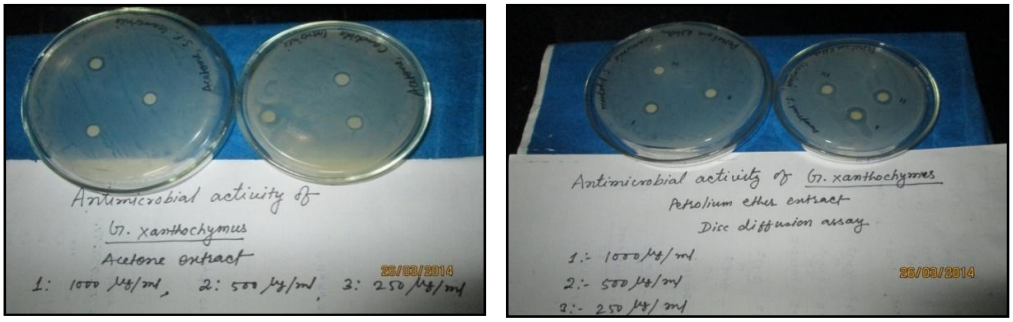

Fig. 2. Antimicrobial activity of fruit extracts of *G. xanthochymus* using disc diffusion method

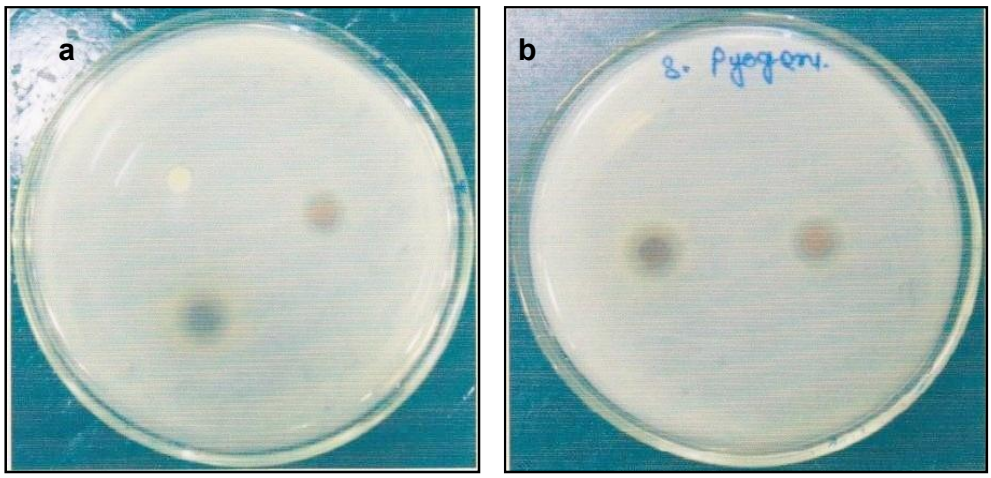

Fig. 3. Antimicrobial activity of Petroleum ether and Acetone extract of *Garcinia xanthochymus* fruit in three different concentration. 1) 1000 µg/ml. 2) 500 µg/ml. 3) 250 µg/ml. against a. *Streptococcus pyogenes* b. *Streptococcus mutans*

Table 6. Antimicrobial activity of fruit extracts of *G. xanthochymus* using disc diffusion method (250 µg/ml)

Extracts	*Salmonella typhimurium* (MTCC 1252)	*Shigella flexnerii* (MTCC 1457)	*Vibrio cholera* (MTCC 3906)	*Streptococcus pyrogens* (MTCC 1926)	*Streptococcus mutans* (MTCC 1497)	*Candida parapsilosis* (MTCC 2513)
Petroleum ether	1.0±0.1*	0.8±0.057	1.3±0.1	0.8±0.057	1.2±0.057	0.8±0.1
Acetone	NI	NI	NI	NI	0.7±0.1	NI
n-Hexane	0.7±0.057	0.7± 0.057	0.7±0.152	0.9±0.1	0.7±0.152	0.8±0.152
Aqueous	0.7±0.057	0.8±0.1	0.7±0.1	0.7±0.152	0.9±0.152	0.7±0.1

**Data expressed as mean value ± standard deviation; NI- No Inhibition*

4. CONCLUSION

The present study provides the scientific rational for medicinal use of *G. xanthochymus*. Nutritional, phytochemical and antmicrobial evaluation of the fruit extracts of *G. xanthochymus* were carried out. Ethnomedicinal survey of the plant was carried out in tribal dominated areas of Similipal Biosphere Reserve. Results revealed that the fruit was rich in nutrients like carbohydrates and starch. Almost all the solvent extracts showed the presence of secondary metabolites like tannins, alkaloids, saponins, flvanoids etc. The result of the study showed good antibacterial and antifungal activity of *Garcinia xanthochymus* fruit. The antimicrobial activity of the plant may be attributed to the various phytochemical constituents present in the crude extract. The work carried out was a basic approach to find out an antimicrobial activity residing in medicinal plant. This work has clearly demonstrated that the medicinal knowledge held by the tribal people is relatively measurable in the laboratory based assay. Further works on the types of phytoconstituents and purification of individual groups of bioactive compounds can reveal the exact potential of the plant. Therefore, if a systematic investigation is initiated into the traditional medicinal systems practiced by tribals, it can open new avenues for the discovery of potent bioactive compounds with great scope for their pharmaceutical application.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Roberts E, Sing B, Sing MP. Vegetable Materia Medica of India and Ceylon, Dehra Dun, Ind; 1984.
2. Parthasarathy U, Babu KN, Kumar RS, Ashis GR, Mohan S, Parthasarathy VA. Diversity of Indian Garcinia – a medicinally important spice crop in India. Indian Inst. of Spices Res. Calicut, Kerala, India. 2013; 467-476.
3. Lim TK. Edible medicinal and non-medicinal plants: Fruits. 2012;2:21-128.
4. Rema J, Krishnamoorthy B. *Garcinia species,* economic importance, distribution and uses. Ind. Spices. 2000;37:20–23.
5. Asinelli MEC, Souza MCOD, Mourao KTSM. Fruit ontogeny of *Garcinia gardneriana* (Planch and Triana) zappi (Clusiaceae). Act. Bot. Brassill. 2011;25: 43-52.
6. Mbwambo ZH, Kapingu MC, Moshi M, Machumi J, Apers F, Cos SP, Ferreira D, Marais JP, Berghe DV, Maes L, Vietinck L, Pieters L. Antiparasitic activity of some xanthones and biflavonoids from the root bark of *Garcinia livingstonei*. J. Nat. Prod. 2006;69:369-372.
7. Chen Y, Fan H, Yang G, Jiang Y, Zhong F, He H. Prenylated *xanthones* from the bark of *Garcinia xanthochymus* and their 1, 1-Diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activities. Molecules. 2010;15: 7438-7449.
8. Krishnamoorthy B, Mathew PA, Rema J, Diwakaran M, Jayarajan. Soft Wood Grafting of *Garcinia xanthochymus* (Hook. f.) [Syn. *Garcinia tinctoria* (Wight)]. Ind. J. of Spices Arom. Crops. 2006;15(1):63–64.
9. Facciola S. Cornucopia II: A source book of edible plants, Kampong Publications, California. 1998;79.
10. Baggett S, Protiva P, Mazzola EP, Yang H, Ressler ET, Basile MJ, Bernard W,

Edward JK. Bioactive benzophenones from *Garcinia xanthochymus* fruits. J. Nat. Prod. 2005;68:354-360.

11. Singh MP, Parveen N, Khan N, Achari B, Dutta P constituents of *Garcinia xanthochymus*. Fitoterapia. 1991;62:286-289.
12. Chanmahasathien W, Li YS, Satake M, Oshima Y, Ishibashi M, Ruangrungsi N, Ohizumi Y. Prenylated xanthones from *Garcinia xanthochymus*. Chem. Pharm. Bull. 2003;51:1332-1334.
13. Han QB, Qiao CF, Song JZ, Yang NY, Cao XW, Peng Y, Yang DJ, Chen SL, Xu HX. Cytotoxic prenylated phenolic compounds from the twig bark of *Garcinia xanthochymus.* Chem. Biodivers. 2007; 4(5):940–946.
14. Protiva P, Hopkins ME, Baggett S, Yang H, Lipkin M, Holt PR, Kennelly EJ, Weinstein IB. Growth inhibition of colon cancer cells by polyisoprenylated benzophenones is associated with induction of the endoplasmic reticulum response. Int. J. Cancer. 2008;123(3):687–694.
15. Goel HC, Prasad J, Singh S, Sagar RK, Kumar IP, Sinha AK. Radioprotection by a herbal preparation of *Hippophae rhamnoides*, RH-3, against whole body lethal irradiation in mice. Phytomed. 2002; 9(1):15-25.
16. Hawkes JG. Crop genetic resources: field collection manual. International Board of Plant Genetic Resources, Rome, Italy and EUCARPIA, University of Birmingham, England; 1980.
17. Martin JM. Ethnobotany: A method manual. Champaman and Hall, London; 1995.
18. Cotton CM. Ethnobotany: Principles and applications. Wiley, Chichester; 1996.
19. Sadasivam S, Manikam A. Biochemical Methods. Third print, New Age International, New Delhi; 2010.
20. Trease GE, Evans WC. Pharmacognasy, 14th Ed. W.B. Scanders Company, Ltd-London. 1989;89-300.
21. Sofowora. Medicinal plants and traditional medicines in Africa. Chichester John Wiley and Sons New York; 1993.
22. Harborne JB. Phytochemistry. Academic Press, London. 1993;89-131.
23. CLSI Clinical and laboratory standards institute. Method M27-A2, 2nd Ed. Wayne Ed. 2002;22:1-29.
24. Saxena HO, Brahmam M. The Flora of Similipahar (Similipal), Orissa with particular reference to potential economic plants. Regional Research Laboratory, Bhubaneswar; 1989.
25. Behera KK. Ethnomedicinal plants used by the tribals of *Similipal bioreserve*, Orissa, India: A pilot study. Ethnobot Leaflet. 2006;10:149-173.
26. Rout SD. Medicinal plants of Similipal Biosphere Reserve. Ph.D. Thesis. T. M. Bhagalpur University, Bhagalpur; 2004.
27. Manohar SH, Naik PM, Patil LM, Karikatti SI, Murthy HN. Chemical composition of *Garcinia xanthochymus* seeds, seed oil, and evaluation of its antimicrobial and antioxidant activity. J. Herbs. Spices. Med. Plants. 2014;20:148-155.
28. Naveen GPAN, Krishnakumar G. Biochemical analysis and seed oil characterizations of *Garcinia indica, G. xanthochymus* and *G. gummi-gutta* for nutritional qualities. Indian. J. of Sci. 2012; 1:1.
29. Pushpangadan P, George V. Biotechnological approaches in herbal drug production - secondary metabolites through metabolic engineering, In: A textbook of molecular biotechnology (Ed.) Chauhan AK, Varma A. I. K International Publishing House Pvt. Ltd. Delhi; 2009; 763-773.
30. Krishnaiah D, Sarbatly R, Bono A. Phytochemical antioxidants for health and medicine – A move towards nature. Biotechnol. Mol. Biol. Rev. 2007;1(4):097-104.
31. Odebiyi A, Sofowora AE. Phytochemical screening of nigerian medicinal plants. Part III. lloydia. 1978;41(3):234-246.
32. Sodipo OA, Awanji MA, Kolawole FB, Oduntuga AA. Saponin is the active fungal principle in *Garcinia kola*, Hekle seed. Bio Sci. Res. Commun. 1991;3:171.
33. Rauha JB, Remes S, Herinonen W, Hopia A, Kgjala T, Pitinlaja K, Vaorela H, Vaorela P. Antimicrobial effects of finished plant extract containing flavonoids and other phenolic compounds. Int. J. Food Microbiol. 2000;56:3-12.
34. Okwu DE. Phytochemicals and vitamin content of indigenous spices of southern Nigeria. J. Sustain. Agric. Environ. 2004; 6(1):30-37.
35. Bandaranayake WM. Bioactivities, bioactive compounds and chemical constituents of mangrove plants. Wetlands Eco. Manag. 2002;10:421-452.

36. Nobori T, Miurak K, Wu DJ, Takabayashik LA, Carson DA. Deletion of the cyclin-dependent kinase-4 inhibitor gene in multiple human cancers. Nature. 1994; 368:753-756.
37. Okwu DE, Okwu ME. Chemical composition of *Spondias mombin* Linn plant parts. J. Sustain Agric. Environ. 2004;6:140-147.
38. Tandon RN, Srivastava OP, Baslas RK. Preliminary investigation on the antimicrobial activity of a phytochemical, xanthochymol from the fruits of *Garcinia xanthochymus.* J. Curr. Sci. 1980;49:472-473.
39. Ryan KJ, Ray CG. Sherris Medical Biology (4th Ed.), McGraw Hill; 2004.
40. Alam M, Zurek L. Association of *Escherichia coli* O157:H7 with houseflies on a cattle farm. Appl. Environ. Microbiol. 2004;70(12):7578-7580.
41. Lustigman B, Brown C. Antibiotic production by marine algae isolated from the New York/New Jersey Coast. Bull. Env. Contamin. Toxicol. 1991;46:329-335.
42. Ravikumar S, Gnanadesigan M, Suganthi P, Ramalakshmi A. Antibacterial potential of choosen mangrove plants against isolated urinary tract infectious bacterial pathogens. Int. J. of Med. Medical Sci. 2010;2:94-99.
43. Bhattacharjee I, Chatterjee SK, Chandra G. Isolation and identification of antibacterial components in seed extracts of *Argemone mexicana* L. (Papaveraceae). Asian Pac. J. Trop. Med. 2010;3:547-551.

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