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A comprehensive investigation of proximate composition and energy content of deoiled seed cake derived from *Garcinia indica*

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Abstract
This study investigated the composition, energy content, and nutrient profile of *Garcinia indica* deoiled seed cake. Physical parameters, such as color, odor, appearance, and calorific value, were determined. Proximate composition analysis measured moisture, ash, crude fiber, and crude fat content. Macro-nutrients like nitrogen, phosphorus, potassium, calcium, and magnesium were also analyzed. Results showed that the deoiled seed cake had a dark brown color, pleasant odor, crystalline appearance, and calorific value of 19.957 J/g. Proximate composition revealed moisture content of 1.23%, ash content of 3.49%, crude fiber content of 18.19%, and crude fat content of 16.12%. Macro-nutrient analysis indicated nitrogen content of 1.23%, phosphorus content of 0.10%, potassium content of 0.64%, calcium content of 1.60%, and magnesium content of 0.60%. These findings highlight the potential of *Garcinia indica* deoiled seed cake as a nutrient source and energy-rich feedstock. Further research is needed to explore the value-added applications and promote commercial utilization of this underutilized seed resource.

Keywords: *Garcinia indica*, deoiled seed cake, proximate composition, energy content, nutrient profile, physical parameters

1. Introduction
Garcinia indica a genus belonging to the family Clusiaceae, comprises over 200 species distributed in tropical regions worldwide. These evergreen polygamous trees are ecologically and economically important, known for their medicinal properties. Among the Garcinia species, *G. indica* "Choisy" is particularly significant as an indigenous tree spice crop, originating from the Western Ghats of India. It can be found in evergreen and semi-evergreen forests, as well as home gardens. *G. indica* thrives in various regions such as the Konkan region of Maharashtra, Goa, coastal areas of Karnataka, Kerala along the evergreen forests of Assam, Khasi, Jantia hills, West Bsengal, and Gujarat. It is known by various names across India, including Tallow tree in English, Murugalu in Kannada and Punarpuli in Malayalam. Other regional names for *G. indica* include Bindin, Biran, Bhirand, Bhinda, Kokum, Katambi, Panarpuli, Ratamba or Amsolare. *G. indica* is a slender tropical evergreen tree with sloping branches, reaching heights of up to 15 meters. It has thin lined bark and glossy, elliptic to oblong-lanceolate deep-green leaves measuring 5.5-8 cm in length and 2.5-3 cm in width. From November to February the tree produces fleshy, dark pink flowers, either solitary or in spreading clusters. The fruit of *G. indica* is brownish-gray or dark purple, marbled with yellow and crowned by a 4-parted structure. It is approximately 4 cm (1.5 in) in diameter and contains 5-8 seeds. The seed of *G. indica* yields oil that remains solid at room temperature. This oil has numerous applications in the food, pharmaceutical and cosmetic industries. The butter derived from *G. indica* is considered nutritive, demulcent, astringent and emollient, making it suitable for ointments, suppositories, candles, soap, and confectionery. Various parts of the tree, including the root, bark, fruit and seed oil are used in the treatment of piles and abdominal disorders. The deoiled cake left after extracting oil from the seeds of *G. indica* is a rich source of macro and micronutrients. It is widely used for healing purposes and as a local application for ulcerations, fissures of the lips and hands. The leftover cake is also used as manure. *G. indica* butter is specifically employed as a remedy for diarrhea and dysentery and it is now being utilized in cosmetics and medicines, known as Vrikshamala in Ayurveda (Subash Chandran, 2005) [9].
Garcinia indica has diverse applications, ranging from culinary (production of high-quality beverages), pharmaceutical uses, and industrial sectors.

It possesses a pleasant flavour and a sweet acidic (sour) taste, making it a popular food additive. Traditionally, it is used as an acidulant in many Indian dishes. Additionally, it has been reported to be effective in treating dysentery, tumors, heart complaints, stomach acidity, and liver disorders (Krishnamurthy *et al*., 1982) [1].

The by-product of the seed, known as the oilseed cake is obtained after extracting oil from the seeds. Oilseed cakes can be classified into edible and non-edible types. Edible oilseed cakes, such as sunflower oilseed cakes, are rich in protein, antioxidants, fibers, and vitamins, making them suitable as supplement feed for animals and sometimes beneficial for humans. On the other hand, non-edible oilseed cakes contain a high amount of toxic compounds after the oil is extracted from the seeds (Jangir *et al*., 2020; Dias *et al.*, 2017). Oilseed cakes, whether edible or non-edible, have potential applications in the production of bioenergy, biopolymers, pesticides and bioelectricity (Naik *et al.*, 2018; Nicholson *et al.*, 2012) [6, 7].

In India, where intensive cropping with chemical fertilizers has led to challenges such as soil degradation, decreased productivity and increased pollution hazards, the utilization of organic and integrated nutrient management practices has gained significance in improving soil productivity and sustainability (Ramesh *et al*., 2009) [8].

2. Material and Methods

Deoiled seed cake of *Garcinia indica* obtained after mechanical extraction of decorticated Garcinia seeds through mechanical expeller was collected from Ganesh oil mills of Siddapura, Uttar Kannada district, Karnataka state (Fig 1). The following observations and analysis were done as followed.

2.1 Estimation of calorific value of seed deoiled cake

Determination of the energetic values of *Garcinia indica* deoiled seed cake contains the following steps: Determination of the moisture content, heat of combustion, calorific value and ash content.

The moisture content is determined in the heating oven Memmert model 100-800 according to the standard: ČSN P CEN/TS 14774-1 (-2, -3). The calorific value was determined according to the standard EN 14918 as follows:

2.1.1 Gross calorific value

Gross calorific value is the amount of heat per unit of weight released by complete combustion of the fuel in the pressure vessel built in the calorimeter under compressed oxygen at 25ºC. (EN 14918 method).

2.1.2 Net calorific value: Net calorific value is gross calorific value minus the heat of vaporization of water, resulting from the fuel during combustion.

2.1.3 Volatile matter

Will be determined according to the standard EN 15148. The sample is combusted 7 minutes in anaerobic conditions in air temperature (900 ± 10 ºC). The content of volatile matter was expressed as percentage of weight loss from the sample.

2.2 Estimation of Macro and micronutrients

2.2.1 Digestion of sample

1g of powdered sample was pre-digested with Conc. HNO_3 overnight. Further digestion was carried out with 5 ml of di-acid mixture (HNO_3 + $HClO_4$) until clear solution was obtained. The residue was dissolved in 6 N HCl and the volume was made up to 50 ml using distilled water. Five ml of di-acid mixture served as blank (AOAC, 1990) [3].

2.2.2 Nitrogen content

Nitrogen content was determined by micro Kjeldhal method (AOAC, 1990) [3].

2.2.3 Phosphorus content

The phosphorus content in the sample was determined by vanadomolybdophosphoric acid method using spectrophotometer at 660 nm (AOAC, 1990) [3].

2.2.4 Calcium and Magnesium

Calcium and magnesium content was determined by Versenate titration method (Cheng *et al.*, 1951)

2.3 Proximate Composition

2.3.1 Moisture content

The wet sample obtained immediately after collection is oven dried at 60 °C for 24 h with the weight of the wet sample and the weight after drying noted. The drying is repeated until a constant weight was obtained. The moisture content is expressed in terms of loss in weight of the wet sample (AOAC, 1990) [3].

2.3.2 Ash Content

1 g of the oven-dried sample in powder form is placed in crucible of known weight. This is ignited in a muffle furnace for 5 hours at 550 ºC. The crucible is cooled and weighed and the ash content was expressed in terms of the oven-dried weight of the sample (AOAC, 1990) [3].

2.3.3 Crude fiber

2 g of the ground sample is digested in 50 ml of H_2SO_4 (1.25%). The solution is boiled for 30 min. after which it is filtered and washed with hot water. The filtrate is also digested in 50 ml of NaOH (1.25%). The solution was heated for 30 min., filtered and washed with hot water and oven dried. Finally, the oven-dried residue is ignited in a furnace at 550 ℃. The fiber content is measured by the weight of the left after ignition and was expressed in term of the weight of the sample before ignition (AOAC, 1990) [3].

2.3.4 Crude lipid content

The lipid content was determined by extracting the fat from 5 g of the sample using petroleum ether in a soxhlet apparatus. The weight of the lipid obtained after evaporating off the petroleum ether from the extract gives the weight of the crude fat in the sample (AOAC, 1990) [3].

3. Result and Discussion

The results of Physical, chemical and energy characteristics of deoiled seed cake of *Garcinia indica* are depicted below.

Table 1: Physical parameter in deoiled seed cake of *Garcinia indica*

Physical parameter	Observation
Colour	Dark Brown
Odor	Slightly Pungent
Physical Appearance	Amorphous Solid
Calorific value	19,957 J/g

Table 2: Proximate composition in deoiled seed cake of *Garcinia indica*

Parameter	Share (%)
Moisture content	8.096%
Ash content	3.49%
Crude fiber	18.19%
Crude fat	16.12%

Table 3: Macro-nutrient content in deoiled seed cake of *Garcinia indica*

Nutrient	Quantity (%)
Nitrogen (N)	1.23
Phosphorus (P)	0.10
Potassium (K)	0.64
Calcium (Ca)	1.60
Magnesium (Mg)	0.60

3.1 Physical parameter of deoiled seed cake

Physical properties of seed cake of *Garcinia indica* the colour observed was dark brown, odour observed was pleasant where physical appearance of cake was crystalline and calorific value was obtained by Bomb calorimeter was 19,957 J/g depicted in table 1.

Few studies are conducted on calorific value of deoiled seed cake of *Garcinia indica*. But studies on *Madhuca longifolia* by Mulimani and Navindgi (2018) [5] reports that calorific value of *Madhuca longifolia* was 19.97 MJ/kg.

3.2 Proximate composition of *Garcinia indica* deoiled cake

The moisture content of seed cake recorded was 8.096%, ash content was 3.49%, crude fiber content recorded was 18.19% and crude fat or lipid content observed was 16.12% shown in table 2.

Mulimani and Navindgi (2018) [5] studied on deoiled seed cake of Neem records moisture content was 4.7%, ash content 4.8%. Kamat, (2006), crude fat content of deoiled seed cake of Neem was 25% and the crude fibre content of *Carthamus tinctorius* deoiled seed cake was 34.41% reported by Montrimaite and Moscenkova (2018) which was highest crude fibre of seed cake. Mostafa *et al.*, (2011) studied on deoiled seed cake of *Swietenia mahagoni* reports that crude fibre content 19.60%, crude fat content 19.42% and moisture content 14.37%.

3.3 Macro nutrient of deoiled seed cake of *Garcinia indica*

In present study varied macro nutrient N, P, K, Ca and Mg were found. Nitrogen (N) obtained 1.23%, Phosphorus (P) 0.10%, Potassium (K) observed which was 0.64%, the Calcium (Ca) was 1.60% and Magnesium (Mg) was 0.60% mentioned in table 3.

Annongu and Joseph (2008) [2] studied on deoiled seed cake of *Ricinus communis* and reports that Calcium was 27.22% and 61.47% Magnesium.

Kiran *et al.*, (2019) [4] studied on deoiled seed cake of *Azadirachta indica* and reports that 4.51% of Nitrogen, 0.79% of Phosphorus and 1.40% of Potassium content.

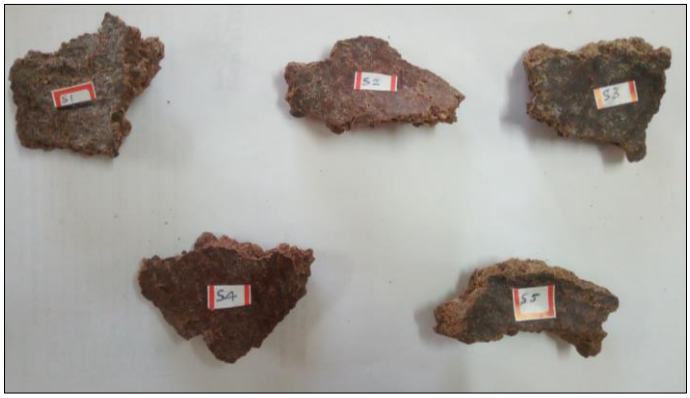

Fig 1: *Garcinia indica* deoiled seed cake

4. Conclusions

Seed butter derived from *G. indica* has been traditionally utilized for various purposes such as frying edibles, moisturizing, and treating conditions like cracks, rashes, burn wounds, sunstroke, and dehydration. However, despite the familiarity with seed butter extraction, a significant portion of the population does not engage in it, resulting in the seed being discarded as waste without any value addition. Pyrolysis emerges as a promising method for producing high-calorific-value fuel from the deoiled seed cake of *G. indica*, thanks to its high volatile matter, low moisture and ash content, and reduced fiber content, making the end product an excellent quality fuel. The *G. indica* seed cake, left after oil extraction, contains 18.19% fiber, making it suitable for cattle feed, while the lipid content of the cake is 16.12%, indicating room for improvement in oil extraction. The deoiled seed cake displays a dark brown color, Slightly Pungent and a calorific value of 19,957 J/g. Furthermore, the macro-nutrient content of the cake includes nitrogen (1.23%), phosphorus (0.10%), potassium (0.64%), calcium (1.60%) and magnesium (0.60%). The cake left after extraction of oil is having potential to be used as nutrient for crop, good source of energy and high fibre content. To promote the utilization of this underutilized seed resource, it is crucial to develop and promote suitable seed decorticators within the local community, thereby facilitating commercial-scale butter extraction and value addition.

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