INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print); 2222-5234 (Online)
Website: https://www.innspub.net
Email contact: info@innspub.net
Vol. 27, Issue: 6, p. 1-6, 2025

RESEARCH PAPER OPEN ACCESS

Phytochemical screening, proximate, quantitative screening and nutritional properties of 'Karuppu Kavuni' variety rice of Tamil Nadu

S. Annapoorani*, R. Anuradha

PG and Research Department of Biochemistry, Sengamala Thayaar Educational Trust Women's College (Autonomous) (Affiliated to Bharathidasan University), Sundarakkottai, Mannargudi, Thiruvarur (Dt.), Tamil Nadu, India

Key words: Alkaloids, Black rice, Phenols, *Oryza sativa*

DOI: https://dx.doi.org/10.12692/ijb/27.6.1-6 Published: December 03, 2025

ABSTRACT

Plants are increasingly explored as alternative sources for the development of safe, effective, and affordable drugs against various infections. Recent studies highlight that black rice (*Oryza sativa* L.), a nutrient-rich staple consumed by much of the global population, possesses infection-suppressing properties. Ancient palm-leaf manuscripts also document the use of black rice powder in Ayurvedic preparations. Inspired by this traditional knowledge, the present study investigates the medicinal potential of black rice seed powder. Accordingly, the proximate composition, nutritional properties, and preliminary phytochemical profile of the aqueous seed extract of black rice were analyzed to identify the types and diversity of phytochemicals present. Using water as the extraction solvent, the analysis revealed the presence of biologically active compounds such as alkaloids, flavonoids, phenols and tannins.

***Corresponding author:** S. Annapoorani ✉ v.ramamoorthy07@gmail.com

INTRODUCTION

Rice is cultivated globally across tropical, subtropical, and temperate regions. According to FAOSTAT (2019), worldwide paddy production is estimated at 755 million tons, with cultivation extending over approximately 162 million hectares. Traditional rice varieties, commonly referred to as speciality, coloured, or pigmented rice, are characterized by pigments in the bran layer that impart distinctive red, black, purple, or brown hues (Pengkumsri *et al.*, 2015).

These colours are largely attributed to the accumulation of anthocyanins or pro-anthocyanidins in the outer grain layers (Chaudhary, 2003).

Among these, black rice is notable for its dark black to purple pigment concentrated in the pericarp (Rahman *et al.*, 2015). When cooked, its colour changes to a deep purple or violet, resembling that of blueberries (Kumar and Murali, 2020). Nutritionally, black rice is an excellent source of anthocyanins, dietary fibre, antioxidants, and essential vitamins such as B1, B2, and E (tocopherols), in addition to minerals like iron, zinc, folic acid, magnesium, niacin, selenium, and phosphorus (Mau *et al.*, 2017). It is naturally free from gluten, cholesterol, sugar, salt, and fat (Kushwaha, 2016). Notably, many pigmented traditional rice cultivars have long been used in ayurvedic medicine for managing conditions such as diabetes and certain cancers, highlighting their therapeutic and nutritional significance.

Black rice is recognized for its potential health benefits, largely attributed to its high dietary fibre content and strong antioxidant properties, which may contribute to lowering the glycemic index (GI) and thereby reducing the risk of type II diabetes. Dietary fibre plays a key role by delaying gastric emptying, slowing carbohydrate absorption, and enhancing satiety, all of which contribute to lowering the GI. In recent years, pigmented rice varieties have gained considerable global attention due to their health-promoting effects, including low glycemic response, antioxidant activity, and anti-carcinogenic and anti-atherosclerotic properties (Deng *et al.*, 2013).

Globally, more than 200 varieties of black rice are cultivated. Their demand is steadily increasing, particularly in the USA and European countries, not only because of their nutritional and therapeutic value but also for their use as a natural organic food colorant (Kong *et al.*, 2008). However, in India, relatively little scientific research has been carried out on black rice. Our interest in this grain was sparked during the process of digitizing an ancient palm-leaf manuscript (*talapatra*) belonging to our ancestors from the Rayalaseema region of Andhra Pradesh, which documented its use in Ayurvedic practices. Among the many medicinal plants recorded, black rice stood out due to its frequent mention and the vast body of literature supporting its importance.

In this context, the present study focuses on evaluating the physicochemical and phytochemical properties of black rice to further substantiate its medicinal and nutritional significance.

MATERIALS AND METHODS

Chemicals

All chemicals were used for analytical grade.

Sample collection

Black Rice was purchased from agriculture farm of Sundarakottai, Tamil Nadu, India. The black rice was powdered finely in a blender. It was packed in air tight pouches and stored in ambient condition for further analysis.

Physicochemical properties

The physico-chemical characteristics of raw rice grains of black rice were studied using standard techniques. Grain length and breadth were measured by slide caliper. Classification of rice based on length indicates three major classes *viz* long (>6 mm in length), medium (5-6 mm in length) and short (<5 mm in length). The sub-classification pertaining to size and shape includes length/breadth ratio; slender (ratio more than 3); bold (ratio 2-3); round (ratio less

than 2) (Dipti *et al.*, 2002). Thousand kernel weight and porosity were measured (Bhattacharya and Sowbhagya, 1972; Juliano, 1998; Oghbaei and prakash, 2010).

Bulk density, water absorption capacity, fat absorption capacity, foam capacity and foam stability, emulsification capacity

Weigh 1g of sample. Add 25ml of water. Blend in a mixer for 30 secs at low speed. Add5ml of refined oil and blend again for 1min. observe for formation of emulsion. Continue addition of 5ml oil and blending for 1min till separation of oil is observed. Record the milliliters (mL) of oil that can be emulsified per gram of the sample. Repeat the procedure twice more, using the second-to-last measured volume of oil with an increment of 1 mL for confirmation (Beuchat *et al.*, 1975).

Proximate composition (dry basis)

Moisture content was determined by using Moisture analyzer. Fat, protein, ash, total fiber (soluble and insoluble fiber) was estimated as per the AOAC standard methods.

Qualitative phytochemical analysis

The extract was subjected to qualitative test for the identification of various phytochemical constituents as per standard procedures (Sofowora, 1993).

Quantitative analysis

The extract was subjected to quantitative analysis for the determination of secondary phytochemical constituents, determination of total alkaloids *(*Obadoni and Ochuko, 2001*),* total phenolic content (Kaur and Kapoor, 2002).), total flavonoids content *(*Chang *et al.,* 2002), estimation of total tannins (Siddhuraju and Manian, 2007), estimation of total anthocyanin (Abdel-Aal andHucl, 2003).

RESULTS AND DISCUSSION

Traditional Black Kavuni rice is a potential source of bioactive substance and fibre which act as functional food ingredient. The dominant nutritional and functional properties of Black Kavuni rice attract the farmers towards cultivation of this variety. However, low yield limits the large scale cultivation of Black Kavuni.

Table 1. Morphological properties of black kavuni rice

Characteristic	Black rice
Length (mm)	5.74±0.02
Breadth (mm)	2.72±0.05
Length/Width ratio	2.12±0.12
1000 kernel weight(g)	19.12±0.22
Porosity (%)	26.2±0.42

The size of rice samples was classified based on kernel length. Grain length plays a significant role in the global market from both industrial and consumer perspectives, with long-grain rice being highly preferred worldwide. A recent survey indicated that traditional rice varieties cultivated in the Cauvery Delta region of Tamil Nadu command higher market value in international markets.

The size of a rice variety is determined by its length, while its shape is defined by the length-to-breadth (L:B) ratio. According to the classification scale proposed by Singh (2000), the size of the KK variety is categorized as medium and short, respectively, whereas its shape falls under the medium class. The thousand-kernel weight (TKW) of the rice samples is presented in Table 1. From the results studied, Black Kavuni recorded the highest thousand-kernel weight (19.12 g). The porosity of Black Kavuni rice was found to be 26.2%, as shown in Table 1.

Table 2. Physicochemical properties of black kavuni rice

Characteristic	Black rice
Bulk density(gm/100ml)	72 .1±0.35
Water absorption capacity (ml/100)	125.5±0.14
Fat absorption(gm/100ml)	119.4±0.23
Foam formation (%)	3.5±0.72
Emulsification capacity(ml/g)	2.3±0.12

The bulk density, water and fat absorption capacity, foaming capacity, and emulsifying capacity of the samples were analyzed in Black rice (Table 2). The physicochemical properties of Black rice revealed distinct differences when compared with other rice varieties.

The bulk density of Black rice was lower than that of other varieties, which is advantageous in the formulation of weaning foods. Water absorption capacity was found to be lower in brown rice than in black and white rice. The fat absorption, foam formation, and emulsification capacities of Black rice were comparatively lower than those of other rice varieties.

The bulk density and water uptake ratio varied depending on the rice variety. The water absorption capacity of Black rice was moderate compared with white and brown rice. High water absorption is generally associated with longer cooking times, which may not be favorable for fuel efficiency.

Foam capacity and foam stability were found to be low in Black rice, which could be attributed to its lower protein content. The reduced fat absorption capacity was due to decreased availability of amino acids, as non-polar residues become masked within the interior of protein molecules. Emulsification capacity, however, depends strongly on the protein quality, which influences the interfacial properties of rice proteins.

Proximate composition

The proximate composition determined in the rice variety is summarized in Table 3 and it shows the data about the moisture content of KK rice variety. The moisture content of Black Kavuni parent was found to be 15.4.

Table 3. Proximate composition of black kavuni rice

Parameters	Value (%)
Moisture content	15.4±0.04
Total ash	9.8±0.02
Crude fibre	10.4±0.14
Crude lipid	3.5±0.06
Protein	6.4±0.18
Carbohydrates	20.4±0.26

Moisture content plays a crucial role in determining the shelf life of food products. In the present study, the ash content of Black rice was found to be high (15.4%), which reflects the presence of a greater concentration of minerals in the sample.The protein content of black rice reported in earlier studies was higher than the present result (Kang *et al.*, 2011). According to Lee *et al.* (2006), the major fatty acids in Black rice are oleic, linoleic, and palmitic acids, which together account for nearly 90% of the total fatty acid content.In a study conducted by Thomas *et al.* (2013), the fat content of Black rice was reported as 0.7%, whereas in the present study it was observed to be 3.5%. Such variations in fat content may be attributed to differences in cultivation practices, regional growing conditions, or possible laboratory errors (Kang *et al.*, 2011).

Table 4. Qualitative analysis of phytochemicals in aqueous extract of rice variety

Constituents	Aqueous
Alkaloids	+
Flavonoids	+
Phenols	+
Steroids	+
Tannins	+
Saponins	-
Terpenoids	+
Cardiac glycosides	+
Carbohydrates	+
Protein	+

Qualitative screening of phytochemicals identified the presence of alkaloids, flavonoids, phenols, steroids, steroid, phenol, tannins, terpenoid, cardiac glycoside protein and carbohydrate in black rice varieties, whereas saponin was absent in black rice. These phytochemicals are the essential constituents of herbal medicine and also commonly detected in various parts in most of the angiosperms (Table 4).

Table 5. Quantitative analysis of phytochemicals in aqueous extract of rice variety

Parameters	Value (mg/100g)
Alkaloids	4.7±0.03
Flavonoids	62.4±0.1
Phenols	3.23 ±0.02
Tannin	8.64 ±0.12
Anthocyanin	12.94 ±0.6

Alkaloids are naturally occurring nitrogenous compounds, many of which are widely used for medicinal purposes, such as atropine (an anticholinergic) and morphine (an analgesic). In the present study, a small amount of alkaloids was

detected in black rice (Table 5). Phenolic compounds are considered promising alternatives to conventional anti-inflammatory therapeutics in the management of chronic inflammatory diseases. Flavonoids, another group of bioactive compounds, play a crucial role in regulating cellular mechanisms related to carcinogenesis, cell cycle progression, and apoptosis (Xing Kang and Sun, 2016). In particular, quercetin, a dietary flavonoid, has been reported to reduce the risk of lung cancer (Khan *et al.*, 2016).

The present study revealed a significant flavonoid content in black rice. The mechanism of action of flavonoids is primarily attributed to their antioxidant activity, either through free radical scavenging or metal chelation (Ivey *et al.*, 2015). Phenolic compounds are also important plant constituents, as their hydroxyl groups impart strong radical-scavenging ability (Diplock, 1997). Tannins, another class of phenolics, serve as protective agents against predation and exhibit notable antibacterial activity. The results indicated the presence of a considerable amount of tannins in Black rice, suggesting a potential role in protection against pathogenic toxicity.

Anthocyanins of black rice act as antioxidant agents because they help to prevent the occurrence of tumour and reduce the genome of normal cells by oxidative stress (Shih *et al.*, 2007; Yi *et al.*, 2010). Black rice has high antioxidant activity due to its functional groups. Black rice has high antioxidant activity due to its functional groupssuch as sugars. So the anthocyanin content is higher, that's why antioxidant activity level is higher (Zhang Shao *et al.*, 2015).

CONCLUSION

The present study confirmed the presence of several medicinally important phytochemicals in Black rice, including alkaloids, glycosides, flavonoids, phenolic compounds, tannins, and other secondary metabolites. These findings suggest that, apart from its nutritional value, Black rice may offer therapeutic potential in the management of various diseases. This preliminary phytochemical analysis provides valuable baseline information that could guide future research aimed at isolating and identifying bioactive principles from this rice variety, thereby advancing current knowledge on its role in promoting human health.

ACKNOWLEDGEMENTS

The authors are thankful to Our College Correspondent sir, Dr. V. Dhivaharan, S.T.E.T.Women's College, Sundarakkottai-614 016 for the kind support for the successful completionof the project work.

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