Introduction

Rice is the monocot seed plant commonly known as *Oryza sativa* in Asia and *Oryza glaberrima* in Africa. Rice is an important staple food of Asians and globally half of the human population consumes whole grain of rice in the cooked form (Ahuja *et al*., 2008). Rice occupies world’s second largest position next to corn in production. Though maize crops have been extensively cultivated and used for purposes other than human consumption, rice forms an important position contributing to human nutrition. Globally, one-fifth of the calories consumed by the humans are provided by rice.

According to Umadevi *et al*., (2012), genetic evidence of rice revealed that it was originated from a single cultivation in the Pearl River valley area of China around 8,200–13,500 years ago. Earlier, archaeological data also reported that rice was cultivated in the Yangtze River valley area in China. The cultivation of rice was extended from East Asia to Southeast and South Asia. It was from Western Asia, rice was introduced to Europe and through European colonization to the Americans. The record in China reveals that the rice cultivation prevailed remained for over 4000 years. In India, a vast majority considers the origin of rice as that dates back to 3000 BC, the people found the plant in the wild and carried out experiments with it.

Rice is a perennial plant grown in tropical regions and for a period of upto 30 years, it can produce a ratoon crop. It grows approximately upto a height of 1–1.8 m depending upon the environmental conditions, varietal differences and fertility of the soil. The leaves of rice plant are 50–100 cm long and 2–2.5 cm broad. The pollinated flowers are seen in a branch arching to pendulous inflorescence of 30–50 cm long. The edible part of the plant is seed which is the functional grains approximately 5–12 mm long and 2–3 mm thick (http://www.knowledgebank.irri.org).

China alone contributes to nearly forty thousand rice varieties, which are half of the varieties of rice produced all over the world. All rice varieties are not common;
half of the people are unaware of about half of the rice varieties. The morphological properties of rice looks similar in colour however vary in size and shape. According to Ahuja et al. (2001), in Asian regions, the cultivation of rice genotypes with either red or purple/black bran layer has been there from ancient period. Only after removing the hull, the kernel colour of the rice is directly visible, since it is harvested as an enclosed caryopsis (paddy rice). The pigments are concentrated as a unique layer of cells above the nucellar cuticule in the seed coat of the unripe caryopsis. This interior seed coat exists beneath the pericarp in the caryopsis of pigmented rice when the seed gets matured and other integument layers are compressed and reabsorbed.

Though rice gained popularity as an important cereal crop in the world for consumption, the cultivation of pigmented varieties of rice is observed in limited areas, where the grain is appreciated for its nutrition and considered as a treasure. Recently, the pigmented varieties of rice have gained increased attention due to their phytochemical constituents and bioactive components (Oki et al., 2002; Hu et al., 2003; Zhang et al., 2005; Nam et al., 2005; Abdel et al., 2006; Finocchiaro et al., 2007; Ahuja et al., 2007; Jang and Xu, 2009; Shen et al., 2009).

Experimental studies conducted, in vivo with supplementation of coloured rice have reported reduction in oxidative stress and concurrently increased antioxidant capacity in vivo and in vitro (Ling et al., 2001; Toyokuni et al., 2002; Xia et al., 2003). The presence of bioactive compounds like phenolic compounds, tocopherols and oryzanols in rice relates to the prevention of non communicable diseases (Ling et al., 2001; Xu et al., 2001; Finocchiaro et al., 2007).

Black rice is also known as Fortune or Emperor’s Rice. The nomenclature denotes that it is a tribute food and stayed popular during the Tang Dynasty which began in 618 AD and lead to the Sung Dynasty which originated in 960 AD. The other name of black rice is forbidden rice, since it was restricted to consumption by ordinary people during the past. When the black rice became available to the masses, its beneficial properties were identified and this rice acquired significance. Although no such ban is being practiced now-a-days, the production of black rice is in low amounts, when compared to brown and white rice.
All varieties of rice fall under the grasses family – Gramineae, and the well consumed members of the family are Oryza sativa followed by indica, japonica and javanicca varieties. Worldwide, long grain rice varieties are polished and consumed. Black rice grows in many parts of India, especially in Manipur. Locally it is known as "Chak Hao / Chakhao Poreiton" (Tasty Rice). In South India, it is also grown in the state of Tamilnadu in Keelapoongudi village in Karaikudi district and known as “kavuni rice”.

Black rice is a heirloom variety mainly cultivated in Asia and consumed as unmilled rice, as it is rich in fiber due to black husk. Milling is a process where the outer layers of the grains are removed, exposing the white kernels inside. For parboling, rice is first soaked and during steaming process, the nutrient from the husk imbibes before hulling. The unusual colour makes black rice very popular for its high nutritional value as an added benefit. Black rice contains anthocyanin pigments hence is black in colour and when cooked the colour changes to deep purple. Along with pigments it is a source of minerals and several vital amino acids.

Nutraceutical potentials of black rice exhibits mainly in the prevention of lifestyle disorders namely diabetes, cardiovasular diseases and cancer. But milling and polishing of black rice destroys the vitamins, minerals and other nutrient contents and all of the dietary fiber and essential fatty acids. Due to its rich mineral, vitamin and fiber content, consumption of black rice is found to be beneficial due to its hypocholesterolaemic effect, normalization of blood pressure and other signs of cardio - vascular disease. Consumption of unmilled black rice produced organically is highly beneficial.

Black rice is black in colour even without husk. However there may be variations in few varieties such as, black japonica which is occasionally brown on the exterior and almost white beneath the hull. Thai rice, grown in the bank of river Yangzi River, looks purple when cooked than raw and is thinner and longer when compared with Chinese black rice. In Asian culture, this purple rice variety is used for making sweet preparations and is mostly known as Thai rice or purple rice rather than black rice.
Black rice disintegrates on prolonged cooking due to exceptionally high amylopectin content. Hence, Chinese black rice is cooked along with the seed coat. It is a traditional practice to steam the black rice in a bamboo tube for two hours. Now, it is consumed by many people in the world in the term of cooked or steamed grains for around one hour or 40 minutes. Further, twenty minutes is allowed to absorb any remaining water for the grains to separate.

Among the Chinese population particularly in the Yunnan Province, Black rice forms the staple food crop, because black rice production in that region is high. The consumption of black rice is highly influenced by sweet taste, chewiness, starchy consistency and retention of nutrients. Apart from it, black rice is also used vinegar making which is not aged in oak barrels but it is stored in ceramic jars. Wine making industries also make use of black rice for delicately scented variety.

In Traditional Chinese Medicine (TCM), Chinese black rice is suggested for elderly patients since it enhances their appetite and serves as a better healing for digestive disorders among them. It can also be used by diabetics and anorexia subjects. One of the common beliefs of consuming black rice is that it makes hair black and shiny.

The main nutritional advantages of black rice over white rice are high protein, fiber, vitamin as well as minerals (including iron) and supplying several important amino acids. However, it varies depending on the cultivation site. The unique phytochemical properties of black rice have contributed to reduced risk of developing chronic diseases. Medical research also reveals that black pigmented rice husk is rich in antioxidant and anti-inflammatory properties. It suppresses low-density lipoprotein molecules by scavenging free radicals. Recent research focuses on the nutraceutical properties of black rice and functional food formulation (Newmann, 2004). Several authors have documented the presence of proanthocyanidins (PA) as a characteristic of Black rice (Oki et al., 2005; Finocchiaro et al., 2007). The accumulation of anthocyanins, mainly cyanidin-3-glucoside and peonidin 3-glucoside has also been reported by Ryu et al. (2008); Hu et al. (2003); Abdel et al. (2006); Zhang et al. (2010) and Jang and Xu, (2009).
These compounds protect the plant against infections and also prove to be powerful antioxidants.

Anthocyanins are mostly glycosylated but belong to monomers whereas proanthocyanidins are either oligomeric/polymeric. Anthocyanins are coloured whereas proanthocyanidins gain red colour on oxidization to form complex compounds (Finocchiaro et al., 2007). In black rice, the phytochemicals present such as phenolics and flavonoids are antioxidants linked with lowered risk of onset of degenerative diseases.

According to reports of Zhang et al. (2006), in black rice bran, the total antioxidant activity was proportional to the content of total phenolics, total flavonoids, and total anthocyanins influenced by cyanidin-3-glucoside, cyanidin-3-rutinoside, and peonidin-3-gluicoside content. The presence of phenolics, flavonoids, and anthocyanins makes black rice bran is superior to white rice bran and also these constituents are present in free form. In black rice bran, the detailed phytochemical profile as well as antioxidant activity gives insights to its possible function to enhance health and well being.

Anthocyanins, found in black rice, are found to possess health-promoting properties. Oxidative stress is an important factor to be considered in pathogenesis of many degenerative diseases induced by free radicals (Kim et al., 2008). Lee et al. (2007) identified that anthocyanin pigments can help in lowering cholesterol levels in human subjects. The antioxidative as well as antihyperlipidemic effects on HepG2 cells by the anthocyanins rich extract from black rice and hence it can be beneficial for health promotion by reducing oxidative stress and enhancing low density lipoprotein clearance, regulating low density lipoprotein receptor production on the cell surface membrane, thereby maintaining lipid homeostasis (Sangkitikomol et al., 2010).

Hui et al. (2010) reported that the anthocyanin rich extracts of black rice induces apoptosis, suppress angiogenesis and shows antioxidant activities against the malignant cells. Several studies were done on rice by Ichiyangi et al. (2001) and Yawadio et al. (2007) to assess the anthocyanin content. The antioxidant activity
was proved by Choi et al. (2007) and Shen et al. (2009) and when compared with various fractions, rice bran was preferred due to its higher antioxidant content.

The bioactive compound in black rice is cyanidin-3-O-beta-D-glucoside (C3G), which has a strong anti-allergic effect and when given orally on rats gets metabolized into protocatechuic acid. These observations prove that C3G-rich black rice grain is beneficial in skin disorders namely psoriasis, acute dermatitis and rhinitis (Han et al., 2009). Research carried out by Sriramulu et al. (2009) and Yao et al. (2009) among black rice and other coloured grains showed that the highest antioxidant activity and alpha-glucosidase inhibitory activity were found to be high in black rice and it was explored as a functional food. Black rice extracts showed the significant results on the immunomodulating activities on the cell proliferation and cytokine production of mouse immunocompetent cells by cell culture experiments (Okai et al., 2009). Research conducted by Kim et al. (2008) on exchange of white rice with black rice substituted mixed rice in weight control showed significant improvement in antioxidant enzyme activity, and thereby recommended for diet therapy in obesity.

Studies conducted by Salgado et al. (2010) and Moemin, (2011) on the impact of supplementation of diet containing black rice versus white rice diet in rats proved that black rice significantly lowered lipid profile, low-density lipoprotein (LDL) and hydroperoxides. Choi et al. (2007) proved that black rice bran extract was beneficial to allergic reactions in in-vivo models. Chen et al. (2005) reported that the active components of anthocyanins namely peonidin 3-glucoside and cyanidin 3-glucoside also proved to exhibit the inhibitory effect of cell invasion on various tumour cells. Numerous studies have reported the beneficial effect of black rice or the anthocyanins fractions in reducing oxidative stress especially in degenerative disorders (Adom and Liu, 2002; Kim et al., 2006; Abdel et al., 2006; Honghui et al., 2007).

Black rice is consumed by people in many regions of the world. However, systematic studies on the nutrient content, nutraceutical potentials and hypoglycaemic activity of black rice are not available in India. Hence there is a need for the present study.
The Specific Objectives of the present study are: To

- Assess the physico-chemical characteristics and nutrient content of black rice and white rice in raw and cooked forms.
- Study the acceptability trial of black rice in traditional recipes.
- Evaluate the nutraceutical potentials of black rice and white rice in raw and cooked forms.
- Assess the hypoglycaemic potentials of Black rice in streptozotocin induced diabetic rats.