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Anti-diabetic property of purple rice

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Purple rice is a colored variety of rice (*Oryza sativa* L.) that is cultivated widely in South-East Asia. It contains purple black pigments (anthocyanins) and is use as a food colorant in bread, ice cream and liquor. It is entirely non-allergenic and gluten free. Its purple colour is from antioxidant anthocyanins. Several health benefits are attributed to purple rice. Some of which are explained. The antioxidant activity in purple rice may also have anti-inflammatory and anti-carcinogenic properties. A powerful antioxidant, anthocyanins has been link to reduce cases of diabetes, obesity, and heart disease. The present article will collect health benefit of purple rice, beneficial effect against diabetes mellitus, dietary anthocyanins and insulin sensitivity/resistance, antidiabetic activity. *In vivo* and *in vitro* and few clinical studies data to suggest that dietary anthocyanins could ameliorate insulin resistance and offer health benefits in diabetic conditions. One of the key features of their pharmacological effects appear to be linked to multiple mechanisms ranging from inhibiting carbohydrate digestion in the gut, pancreatic β-cell protection and insulin secretion to enhancing sensitivity in vital organ.

Key Words : Anti-diabetic, Anthocyanins, Insulin resistance/sensitivity

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INTRODUCTION

Purple rice is a colour variety of rice (*Oryza sativa* L.) that is cultivated widely in South-East Asia. It contains purple black pigments (anthocyanins) and is use as a food colorant in bread, ice cream and liquor. The composition of purple rice anthocyanins consists of cyaniding 3-O-glucoside, peon dine 3-O-glucoside and cyaniding 3-O-gentiobioside (Tamura *et al.*, 2010). Purple rice consumption may be an effective alternative dietary approach to prevent diabetes, instead of white rice (Shimoda *et al*., 2015). Purple rice has a high content of anthocyanins, which are water- soluble pigments. They are widely available in human diet, in cereals, beans, fruits, vegetables and red wine. Anthocyanin has been proved to have antioxidant, anti-hyperglycaemic and anti-hyperlipidemia effect (Hlaing *et al.*, 2017). The effects of anthocyanins as including reducing of blood glucose, increasing of insulin secretion, protection from free radical induced damage and improving of insulin resistance (Guo *et al*., 2007).

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What is purple rice?

Black rice also known as purple rice is a range of rice types of the species *Oryza sativa* L. Purple rice is one of more than 40,000 varieties of rice. Black rice has deep black colour and usually turns deep purple when cooked. Its dark deep colour is primarily due to its anthocyanins content, which is higher by weight than that of other colour grains. While the nutritional values vary, all varieties of rice are good source of carbohydrate, have

no fat or no cholesterol and are a source of protein too. It is slightly chewy and has a nutty flavour. It is entirely non-allergenic and gluten free. Its purple colour is from antioxidant anthocyanins.

White rice and purple rice:

White rice is milled rice from which husk, bran germ are remove. The complete milling process and polishing that converts brown rice to white rice destroys 67 per cent of vitamin B3, 80 per cent of B1, 90 per cent of B6, 60 per cent of iron and overall dietary fibre and essential fatty acid and black rice could be either medium or long grain. It can extremely reduce true digestibility of its protein (72.4%) and high digestibility of starch due to its levels of anthocyanin. It also rich in phytonutrients, rich in iron and high in fibre (*www.Shodganga.com*).

Nutritional composition of purple rice:

Purple rice has a similar amount of calories as white or brown rice, yet it has more protein and fibre. Nutritional values per 50 g of raw purple rice (Amanda Barrell, 2017).

Energy (kcal)	186
Protein (g)	5.82
Carbohydrate (g)	39.53
Fibre (g)	2.4
Sugars (g)	1.17
Iron (mg)	0.88

Source: *www.medicalnewstoday.com*

Antioxidants:

Purple rice's colour is creating by flavonoids called anthocyanins.

Protein:

Protein is essential for growth and body repair, as well as the maintenance of health. All cells and tissues in the body contain protein, which is involved in a wide range of metabolic interactions. Purple rice is good source of protein. It helps reduce muscle loss by helping the body build and repair muscle tissue.

Fibre:

Sticky purple rice is a whole grain, meaning the outer bran layer is intact. This make in high in fibre as well as slightly nutty in flavour. Dietary fibre has many health benefits, including potential to reduce heart disease and diabetes risk and help with weight loss. Fibre is important for regular bowel movements and overall bowel heath.

Iron:

Purple rice is a significant source of iron. Iron is needed to make red blood cells, which carry oxygen around the body. It also supports the transmission of nerve impulses, which control body movement. A diet lacking in the mineral can lead to iron deficiency anaemia.

Health benefit if purple rice:

Several health benefits are attributing to purple rice. Some of which are explained. The antioxidant activity in purple rice may also have anti-inflammatory and anti-carcinogenic properties. A powerful antioxidant, anthocyanins has been link to reduce cases of diabetes, obesity, and heart disease (*www.healthline.com*).

Hearth heath and cholesterol:

According to a study published in the Journal of Agriculture and Food Chemistry, purple rice contains more antioxidant compounds than white rice. Antioxidants have shown to promote heart health and may help lower the risk of some cancer. They help to protect the body's cells from harmful free radicals. Regarding heart health, studies have been found purple rice, when part of healthy lifestyle, helps to increase the levels of the good high-density lipoprotein (HDL) cholesterol in the body.HDL cholesterol is vital for healthy cardiovascular system. It has also been shown to decrease the atherosclerotic plague formation in the arteries that can lead to heart failure (*www.medicalnewstoday.com*).

Anti-cancer effects:

Anthocyanins, like other antioxidants, help protect the body from free-radical damage, which can lead to cancer. A study showed that anthocyanins extracted from black rice drastically inhibit the spread of specific cancers by restricting the damage of DNA. A more recent study, has also indicated that black rice anthocyanins have the potential to stop tumour metastasis in breast cancer cells (Kushwaha, 2016 and Luo *et al.*, 2014).

Anti-diabetic effects:

Black rice contains low quantities of sugar and high amounts of fibre which are known to protect the body from diabetes mellitus. It does not trigger fluctuations in blood glucose levels that white rice tends to cause. Black rice also contains essential minerals which help to regulate blood pressure. Therefore, diabetics stand to benefit

considerably by including black rice in their diet (Kushwaha, 2016).

Prevention of constipation:

Black rice is rich source of fibres. So this is useful for patients suffering from chronic constipation as it helps in improving the bowel movements (Kushwaha, 2016).

Diabetes mellitus:

Diabetes mellitus (DM) or simply diabetes is a group of metabolic diseases in which a person has high blood sugar, either because the body does not produce enough insulin, or because cells do not respond to the insulin that is produce. The high blood sugar produces the classical symptoms of polyuria (frequent urination), polydipsia (increased thirst) and polyphagia (increased hunger) (Deshmukh *et al.*,2015). Diabetes mellitus (DM) is commonest endocrine disorder that affects more than 100 million people worldwide (6% population). It is cause by deficiency or ineffective production of insulin by pancreases which results in increase or decrease in concentration of glucose in the blood (Ismail *et al.*,2009). DM has been classifying into two type's *i.e*. insulin dependent diabetes mellitus (IDDM, Type I) and non-insulin dependent diabetes mellitus (NIDDM, Type II). Type I diabetes is an auto-immune disease characterized by a local inflammatory reaction in and around islets that is followed by selective destruction of insulin secreting cells whereas Type II diabetes is characterized by peripheral insulin resistance and impaired insulin secretion (Arora *et al.*,2009). Type 2 diabetes mellitus is a common chronic metabolic disease, which is characterized by hyperglycaemia. Diabetes results from impaired pancreatic beta cell functioning which leads to failure to secrete adequate insulin or insulin resistance or both (Imamura *et al.*,2013). The mechanism that explains pathogenesis of diabetes are endoplasmic reticulum stress, oxidation stress, and ectopic lipid deposition in the muscle, liver and pancreas (Nolan *et al.*,2011). The liver is a major organ for the regulation of glucose homeostasis fatty acid metabolism and lipoprotein metabolism. Hepatic insulin resistance is a major contributing feature of type-2 diabetes (Paquot *et al.*,2002). Anthocyanins has been proved to have antioxidant, anti-inflammatory, anti-hyperglycaemic and anti-hyperlipidemia effect (Guo *et al.*, 2007).

Pathophysiological aspects:

Type 2 DM is characterize by insulin insensitivity as result of insulin resistance, declining insulin production, and eventual pancreatic beta-cell failure. This leads to decrease in glucose transport into the liver, muscle cells and fat cells. There is an increase in the breakdown of fat with hyperglycaemia (Kahn, 1994 and Robertson *et al.*, 2015). Type I diabetic patients are usually young (children or adolescents) and not obese when they first develop symptoms. Studies of identical twins have shown that genetically predisposed individuals must additionally to expose to an environmental factor such as viral infection. Viral infection may damage pancreatic B- cells and exposed antigens that initiate a self-perpetuating autoimmune process. In this type, insulin deficiency attenuates long term potentiating and might lead to deficits in learning and memory. Type-2 diabetes is accompanied both by insulin resistance and by impaired insulin secretion, each of which are important in its pathogenesis (Rang and Dale, 2008 and Sims- Robinson *et al.*, 2010).

Glycemic index, glycemic load, carbohydrates, type 2 diabetes:

Type 2 -diabetes is leading cause of cardio-vascular disease with global prevalence 10 per cent (World Health Organisation, 2012).

An individual's diet is considered to contribute to the development, in particular the capacity that foods containing carbohydrates have to increase blood glucose (Sheard *et al.*, 2004).

It's has been suggested that diets with high glycemic index (GL) may predispose to higher postprandial blood glucose and insulin concentrations, which, in turn, increase glucose intolerance and risk of eventual type 2 diabetes (Jenkins *et al.*, 1981).

Accordingly to American Diabetes Association's dietary guidelines for diabetes prevention currently state that there is insufficient consistent evidence to say that diets low in GL reduce diabetes risk (Bantle *et al.*, 2006).

Glycemic index of purple rice:

The glycemic index is a ranking of food based on the postprandial blood glucose response compared with a reference food (Jenkins *et al.*, 1981). Consumption of a diet low in glycemic index influences multiple parameters of glucose lipid metabolism. The reduced rate of glucose absorption after consumption of low glycemic index

carbohydrate foods will reduce the postprandial rise in gut hormones (incretin) and insulin. The prolonged absorption of carbohydrate seen over a will maintain suppression of free fatty acids and the country regulatory response while at the same time achieving lower blood glucose concentration. High glycemic index forms of carbohydrate are foods that produce high concentrations of blood glucose and increase insulin demand and that therefore, could plausibly contribute to higher risk of type 2 diabetes (Srilakshmi, 2014). The glycemic index of purple of 42 and glycemic load is 14.

Benificial effects of anthocyanins against diabetes mellitus:

Anthocyanins are present in almost all plants are varying concentration and are widely present in fruits and vegetables (Chaiyasut *et al.*,2016). ACN have a heterocyclic and two benzyl rings and are connecting by a carbon bridge (3n of C) (Li *et al.*, 2017; Sivamaruthi, *et al.,* 2018). ACN are easily susceptible to deprivation and biological (enzymes) and physical (PH, temperature and light) factors, which can trigger the degradation of anthocyanins. The PH is responsible for colours of the anthocyanins are more stable in acidic PH compared to alkaline condition. The temperature and oxygen play a crucial role in anthocyanins stability and the anaerobic condition comparatively protects the ACN degradation. (Sivamaruthi *et al.,* 2018).The biological benefits (anti-diabetic, anti-neurodisorder, anti-cardiovascular diseases, anti-gastrointestinal diseases, and disorders) of flavonoids and anthocyanin have been reported. Several *in vitro* and *in vivo* reports demonstrated that anthocyanins rich plant extracts ameliorate the diabetes-associated consequences by reducing the glucose absorportion (Sivamaruthi *et al*., 2018).

Deitary anthocyanins and insulin sensitivity/ resistance:

Anthocyanins are a group of polyphenolic natural products that belong to a broad class of secondary metabolites collectively called flavanoids (Tarun *et al.* , 2017). Being a bright coloration, ranging red pink, purple and blue, anthocyanins are the principal components of pigmented plant parts such as flower and fruits. Their functions to the plant that produce them include aiding pollination (Harborne and Smith,1978 ; Saito *et al*.,1992) and seed dispersal by attracting and other insects and animals, while their antioxidant effects have been implicated to the plants survival, especially in UV prevalent high attitude environment (Costa *et al.,* 2015). Insulin resistance is an abnormal physiological state that occurs when insulin from pancreatic beta cells is unable to trigger a signal transduction pathway in target organs such as the liver muscle and adipose tissues. The loss of insulin sensitivity is generally associated with persistent hyperglycaemia (diabetes), hyperinsulinemia, fatty acids and/ lipid dysregulation which are often prevalent under obesity conditions. Hence, insulin sensitizers are one class of drug currently employed to treat diabetes and other metabolic disorders. Some of the research findings so far appear to suggest that anthocyanins such of the common cyanindin, plegonidin, delphinidin and petunidin glycosides are the effective carbohydrate digestive enzyme inhibitors. *In vitro* studies on cell culture including in insulin resistance hepatocytes, human adipocytes have been conducting to evaluate the potential of anthocyanins in insulin resistance. It can be summarize from these reports that anthocyanins may increase insulin sensitivity and glucose uptake in vital organs such as muscle and adipose tissues. A vast number of *in vivo* protective activities of anthocyanins against insulin resistance diabetic and obesity condition have been perform on insulin resistant diabetic obese animal model using either anthocyanins rich extract or isolated compound. The Isolated anthocyanins compound such as cyanadin, delphinidin and pelorgonidin glucosides were tested. These compounds along with anthocyanins rich extract purple rice were found to be effective in ameliorating the insulin resistance condition and also increase insulin sensitivity, decrease body weight gain and accumulation of lipids (Cheng *et al*.,2014; Barbalho *et al.,*2011 and Seymour *et al.,* 2008). A few studies on the structure activity relationship (SAR) of anthocyanins with respect to their anti-diabetic potential have been conducted. For instance, the intestinal α-amylase inhibition activity was found higher in cyanadin 3-O position substituted with glucose or Galactose (Akkarachiyasit *et al.,*2010). Among all the anthocyanins, the higher activity was recorded for cyaniding-3-glucoside and delphinidin 3-O-3-O-glucoside as compared to their galactoside thus, with increasing number of hydroxyl groups in anthocyanins B-ring, insulin secretion also increases (Jayaprakasam *et al.,* 2005).

Anti-diabetic activity:

Type 2 diabetes mellitus is a common chronic metabolic disease, which is characterized by

hyperglycaemia. Diabetes results from impaired pancreatic beta cell functioning which leads to failure to secrete adequate insulin or insulin resistance, or both (Imamura *et al.,* 2013). The proposed mechanisms that explain pathogenesis of diabetes are endoplasmic reticulum stress; oxidative stress; and ectopic lipid deposition in the muscle, liver and pancreas (Nolan *et al.,* 2011). The liver is a major organ for the regulation of glucose homeostasis, fatty acid metabolism and lipoprotein metabolism. Hepatic insulin resistance is a major contributing feature of type 2 diabetes (Defronzo *et al.,* 1982). Purple rice has a high content of anthocyanins, which are water-soluble pigments. They are widely available in human diet. Anthocyanins have been proved to have antioxidant, anti-inflammatory, anti-hyperglycaemic and anti-hyperlipidemia effect. A study in purple rice extract treated male Sprague-Dawley rats reported the effects of anthocyanins as including reducing of blood glucose, increasing of insulin secretion, protection from free radical induced damage, and improving of insulin resistance (Guo *et al.,* 2007). Purple rice extract inhibits alpha glucosidase, alpha amylase and aldose reductase activities in diabetic model. In a small-scale human study, low dose of purple rice extract was found to effectively suppress postprandial increase in the blood glucose levels (Shimoda *et al.,* 2015).

Conclusion:

Purple rice is a colored rice containing anthocyanins and has mainly consumed in Southeast Asia countries. Purple rice consumption may be an effective alternative dietary approach to prevent diabetes, instead of white rice. Purple rice has a high content of anthocyanins, which are water- soluble pigments. *In vivo* and *in vitro* and few clinical studies data to suggest those dietary anthocyanins could ameliorate insulin resistance and offer health benefits in diabetic conditions. One of the key features of their pharmacological effects appear to be linked to multiple mechanisms ranging from inhibiting carbohydrate digestion in the gut , pancreatic β-cell protection and insulin secretion to enhancing sensitivity in vital organ.

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