Nutritional Composition and Medicinal Potential of Chakhao (Black Rice) for Health Improvement

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Abstract

Chakhao, the renowned black scented rice of Manipur, carries significant cultural, nutritional, and economic value. Among the various rice varieties cultivated in the region-such as high-yielding types (HYVs), white grain aromatic rice, and local red rice- Chakhao is distinguished by its deep pigmentation (anthocyanin-rich black pericarp), distinct fragrance, elevated antioxidant levels, and high market demand. Despite these advantages, its production faces challenges due to lower yields, limited mechanized processing, and market constraints. Beyond its sensory appeal, Chakhao is recognized for its therapeutic properties, particularly in diabetes management. Studies highlight its low glycemic index, abundant antioxidants, and rich phytochemical composition, making it a valuable dietary option for diabetic individuals. The following discussion explores the biological mechanisms and research supporting its antidiabetic potential.

1. Introduction

Chakhao Amubi and Chakhao Angangba are two prominent varieties of black scented rice known for their unique aroma and pigmentation. Although they yield less than high-yielding varieties (HYVs), they command 3to 4 times higher prices in the market, making them economically appealing. This premium is largely attributed to their distinctive color, fragrance, and health benefits. Chakhao requires a longer maturation period of approximately 150 days, compared to about 120 days for HYVs. This extended growing season increases vulnerability to unpredictable weather, pest infestations, droughts, and excessive rainfall. Despite producing fewer grains per unit area, Chakhao remains highly profitable due to strong demand in niche markets, driven by its medicinal properties, antioxidant richness, and aromatic appeal. Farmers earn significantly more per kilogram than with conventional rice, offsetting the lower yields. In summary, while Chakhao presents cultivation challenges and lower productivity, its high market value and niche demand make it an economically sustainable crop.

2. Nutritional Composition and Health Benefits

The traditional black rice of Manipur-*Chakhao*-is not only valued for its aroma and deep pigmentation but also for its therapeutic role, especially in managing diabetes. Research underscores its low glycemic index, high antioxidant content, and rich phytochemical profile, making it highly beneficial for diabetic patients. The following highlights the biological mechanisms and supportive findings behind its antidiabetic potential.

2.1. Low Glycemic Index (GI)

- Chakhao is digested and absorbed slowly, resulting in reduced postprandial glucose spikes, crucial for diabetic control.
- Unlike polished white rice, which has a high GI (about73), Chakhao has a significantly lower GI (about 42–50) *(Shijagurumayum et al., 2021).*

2.2. High Anthocyanin Content

- The black pigment in Chakhao pericarp is due to anthocyanins, particularly cyanidin-3-glucoside, which has:
  - Insulin-mimetic activity.
  - Ability to regulate GLUT4 transporters.
  - Suppressive effects on α-glucosidase, thereby delaying carbohydrate absorption *(Chanu, 2015).*

2.3. Rich in Dietary Fiber

- Chakhao contains 2-3 x more fiber than white rice. Fiber helps:
  - Reduce glucose absorption in intestines
  - Improve satiety, thereby managing obesity-linked insulin resistance *(W Elison et al., 2023).*

2.4. Natural Inhibitors of Hyperglycemia

- Compounds found in Chakhao (phenolics, flavonoids, and γ-oryzanol) inhibit key enzymes like:
  - α-amylase and α-glucosidase, preventing rapid starch breakdown.
  - Animal model trials on diabetic rats have shown reduced blood glucose and improved lipid profiles when fed black rice extracts *(R. Chakraborty et al., 2023).*

2.5. Antioxidant Defense and Pancreatic β-Cell Protection

- The high antioxidant capacity of Chakhao neutralizes reactive oxygen species (ROS) which otherwise damage β-cells in diabetes.

Oxidative stress reduction leads to improved insulin secretion *(HS Devi et al., 2014)*.

2.6. Traditional Usage for Diabetes

- Indigenous medical practitioners in Manipur have historically prescribed Chakhao for regulating blood sugar and improving digestion.

Regular consumption in small quantities has shown benefits in community-based ethnomedical surveys *(Singh et al., 2024)*.

3. Comparative Agricultural Trials

Studies comparing high-yielding varieties (HYVs) with Chakhao show that while HYVs produce more rice per hectare, Chakhao has several advantages that make it more appealing in certain contexts.

Specifically, Chakhao is more profitable despite lower yields because it sells at much higher prices due to its aroma, color, and health benefits. It also shows better environmental resilience, meaning it can withstand tough conditions like poor soil or erratic weather better than some HYVs.

Additionally, consumers increasingly prefer Chakhao for its nutritional value, especially its high antioxidant content and potential health benefits. So, even though HYVs are better in terms of raw production, Chakhao often provides greater overall value for both farmers and consumers.

3.1 Varietal Diversity and Landraces

In Manipur, there are more than 20 traditional varieties, or landraces, of Chakhao rice. Each of these landraces has its own unique traits-for example, they vary in how long they take to flower (flowering time), how strong their aroma is, and the shape of the rice grain.

Among these, Chakhao Poireiton is the most popular variety. It is especially valued for its rich fragrance and deep pigmentation, which makes it stand out in both local and niche markets. This diversity is important because it reflects the rich agricultural heritage of the region and offers different options for farmers and consumers based on preferences and growing conditions.

3.2 Phenotypic and Cooking Quality

Chakhao rice has unique physical and cooking characteristics. It requires special cooking conditions compared to regular white rice. Once cooked, it has a chewier texture and releases a distinct nutty aroma, which adds to its appeal.

One notable difference is that Chakhao takes longer to cook than white rice. However, this longer cooking time is offset by a major benefit: it retains more nutrients after cooking. This means the health benefits-like antioxidants and vitamins-remain largely intact, making it a more nutritious option overall.

3.3 Genetic and Morphological Traits

Chakhao rice varieties are genetically and physically different from high-yielding varieties (HYVs) and red rice. When analyzed using their appearance (morphological traits) and protein markers, Chakhao varieties form a separate group. This means they have unique characteristics that set them apart from other types of rice.

One of the most distinctive features of Chakhao is its deep purple pericarp (the outer layer of the grain). This coloration is due to the presence of specific genetic markers, such as the Rc and Pb genes. These genes are responsible for the pigmentation and are not typically found in common white or red rice varieties. These unique genetic traits contribute to Chakhao's nutritional and medicinal value, as well as its visual and market appeal.

Constraints in Cultivation and Marketing

Farmers growing black rice, such as Chakhao, encounter several difficulties that limit its widespread cultivation. One major issue is the low availability of quality seeds, which makes it hard to expand production. Additionally, poor irrigation facilities in many farming areas make it difficult to manage the crop properly, especially since Chakhao has a longer growing season and is more sensitive to weather conditions.

Another key challenge is the lack of strong market linkages-meaning farmers often don't have direct access to reliable buyers or markets that value black rice. This can lead to inconsistent pricing and reduced profits.

Moreover, many farmers of Manipur still use traditional farming methods, which limits the scale of production compared to modern, high-yielding varieties (HYVs) that benefit from advanced techniques and better infrastructure. As a result, black rice remains a niche crop with limited scalability.

Policy and Promotion Needs

Although Chakhao has received a Geographical Indication (GI) tag, which recognizes its uniqueness and ties to Manipur, there is still limited institutional support to actively promote it. This means that government and organizational efforts to market and scale up Chakhao production and branding are currently insufficient.

To improve its visibility and market access, experts recommend several strategies:

- Agro-tourism: Encouraging tourism that highlights traditional Chakhao farming can create awareness and additional income for local farmers.
- **Organic certification**: Getting certified as organic can help Chakhao attract health-conscious consumers and sell at higher prices.

- **Farmer cooperatives**: Organizing farmers into cooperatives can improve bargaining power, streamline marketing, and reduce costs by sharing resources.

Together, these steps can help Chakhao reach wider markets and bring better returns to farmers.

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Summary

Chakhao's medicinal effectiveness in diabetes management stems from its bioactive compounds, fiber content, and traditional use. Modern research confirms its ability to regulate blood sugar levels, improve insulin sensitivity, reduce oxidative stress, and prevent related complications like dyslipidemia. It represents a promising nutraceutical alternative for dietary therapy in diabetic care.

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