

# Red Yeast Rice: A Fusion of Tradition and Modernity in Food Processing and Preservation

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Red rice is a variety of whole grain rice in which the rice kernel is covered in red-colored bran. Red yeast rice is a nutraceutical created by using the yeast *Monascus* sp. to ferment cooked white rice. Red yeast rice is also known as red mould rice in the United States, Hong Qu, Ang-Khak (China), Beni-Koji, and Red Koji (Japan) (Nguyen *et al.*, 2017).

East Asian nations including China, Japan, and Korea have employed RYR in their cuisine as well as a herbal supplement. For a long time, it has also been utilised in traditional Chinese medicine and for food flavouring, colouring, and preservation. Many species of the mold *Monascus* have also been widely used in making different products like red wine and red soybean cheese. China is the primary producer and exporter of RYR, which is used as a food ingredient and dietary supplement in the US, Italy, Central Asia, Southeast Asia, and Europe. (Hu *et al.*, 2020).

## History

RYR was first utilised in China during the Tang Dynasty (800 AD), mostly as a flavouring, colourant, and preservative for fish and meat. The seventeenth-century T'ien Kung K'ai Wu provided the earliest account of the red yeast rice solid-state fermentation process. Since World War II, the Asian American population in the US has also used red yeast rice. Red yeast rice is also listed in the Ben Cao Gangmu, an old Chinese pharmacopoeia of herbs and foods that was penned by Li Shi-zhen in 1590. Speaking positively about RYR, Li Shi Zhen declared, "It is the genius of nature and the miracle medicine." (Wang *et al.*, 2019).

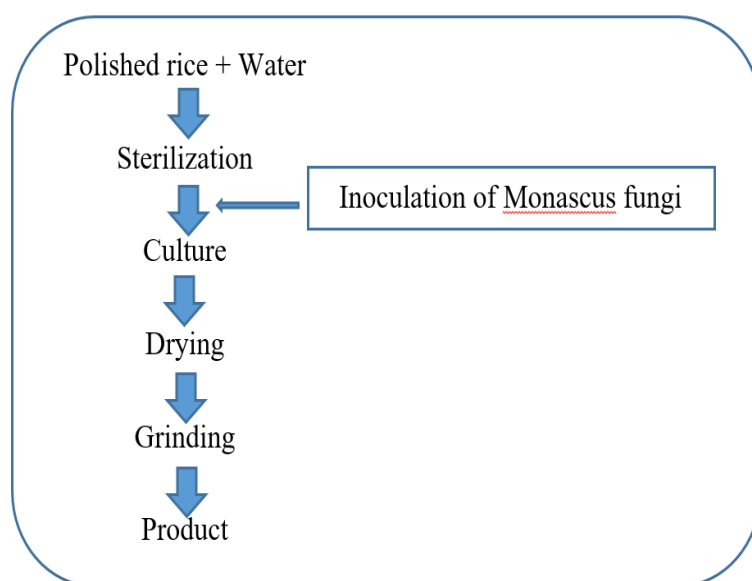
## Production of Red Yeast Rice

1. Rice Preparation Water Saturation: Soak rice in water until fully saturated. Steaming: Steam the water-saturated rice for 20 minutes.
2. Sterilization Sterilization: Sterilize the steamed rice at 15 psi and 121°C for 15 minutes.
3. Inoculation and *M. purpureus* Pre-culture: Grow *Monascus purpureus* mold for 7 days. And inoculate the sterilized rice with the 7-day pre-culture of *M. purpureus*.

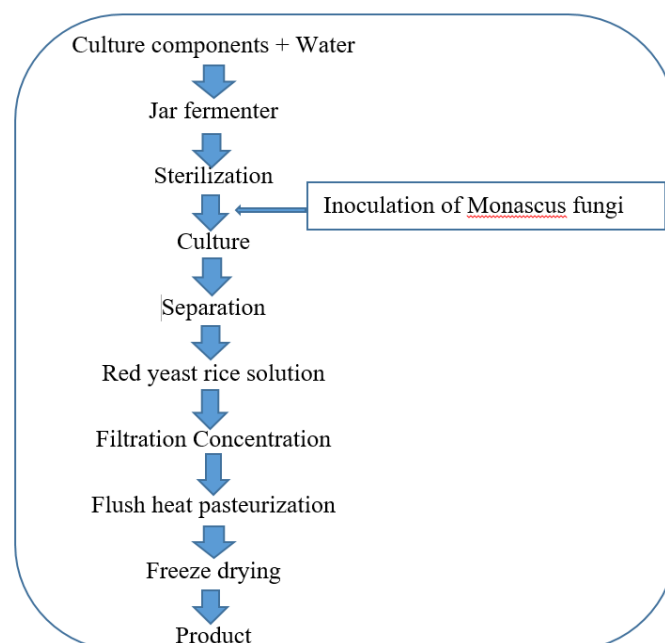
4. Fermentation Cultivation: Ferment the inoculated rice at 30°C for 2 to 3 weeks.

5. Drying Heat Drying: Dry the fermented rice at 65°C for 6 hours.

Final Product Red Yeast Rice: The result is red yeast rice, ready for use. Traditional solid-state fermentation method since ancient is shown in Fig 1 and Liquid-state fermentation method is shown in Fig 2.



**Fig. 1 Traditional solid-state fermentation method**



**Fig. 2 Liquid-state fermentation method**

## Active components of RYR

### Monacolins

The substance thought to be most effective at reducing serum cholesterol is monacolin K. It was also discovered that structural analogues, such as monacolin J, L, and X, inhibit the production of cholesterol.

### Gamma-Aminobutyric Acid (GABA)

Within the brain system and tissue, GABA is an inhibitory neural signal transmitter. It is said that GABA regulates blood pressure. It is helpful in managing hypertension, Parkinson's disease, and Alzheimer's disease.

### Citrinin

Citrinin is a teratogenic, hepatotoxic, and nephrotoxic substance. The overall quantity of citrinin should be restricted due to safety concerns.

### Pigments

Red, orange, and yellow chemicals known as Monascus pigments (MPs) are produced by the well-known red mould species *Monascus purpureus*. These pigments are useful secondary metabolites. (Gong *et al.*, 2023).

Composition of red yeast rice is shown in table 1.

| Constituent                                     | Content (% by wt.) |
|---|--------------------|
| Protein   | 5.8                |
| Starch  | 73.4               |
| Fiber   | 0.8                |
| Moisture  | 3-6                |
| Total natural pigments                          | <0.3               |
| Saturated fatty acids                           | <0.5               |
| Mono and poly unsaturated fatty acids           | <1.5               |
| Total HMG-CoA reductase inhibitors (monacolins) | 0.4                |
| Phosphorus                                      | 0.4                |
| Trace elements                                  | Trace              |

Source: (Kalaivani *et al.*, 2010)

## Therapeutic roles of RYR

### Cardioprotective effect

Supplementing with RYR extract greatly reduces the peptide hormone angiotensin II that causes vasoconstriction.

**Osteogenic effect:** RYR helps cure osteoporosis and encourages the growth of new bone.

**Anti-diabetic effect:** By increasing insulin production, RYR lowers blood glucose levels.

**Hypotensive effect:** Systolic blood pressure can be lowered with RYR without causing any appreciable negative side effects.

**Anti-cancer effect:** The pigment monascorubrin, which is found in RYR, has antibacterial properties and prevents cancer cells from proliferating.

**Cholesterol lowering effect:** The HMG-CoA reductase enzyme, which is essential for the production of cholesterol, is inhibited by RYR. (Patel *et al.*, 2016).

### Role of Red yeast rice supplementation in replacing lipid lowering drugs (Statins)

Red yeast rice (RYR) contains a bioactive component called monacolin K, which inhibits the enzyme 3-hydroxy-3-methyl-glutaryl-CoA (HMG-CoA) reductase, potentially lowering cholesterol. The rate of cholesterol production is regulated by this enzyme. The pharmaceutical medication lovastatin (Mevacor), which likewise reduces cholesterol, and monacolin K have the same structural makeup. In addition to gastrointestinal issues, statin-associated myalgia (which includes muscular soreness and weakness), cognitive decline (memory loss), liver function impairment, and more recently, an elevated risk of diabetes are the statin side effects. Red yeast rice supplementation is therefore an option.

### Dosage

Red yeast rice is commonly accessible as tablets and capsules. 1200 mg per day is the usual dosage for red yeast rice supplements. The quality and amount of ingredients in RYR dietary supplements might vary, and the recommended daily dose of monacolin is between 2.5 and 10 mg. The daily dosage of 10 mg of monacolin K has been determined by the European Food Safety Authority (EFSA) to be the most effective means of maintaining blood cholesterol levels. (Wang *et al.*, 2019).

### FSSAI - RYR (NUTRACEUTICAL)

**Ingredients:** The FBO will keep the documentation proving the data and adopt the usage level based on pertinent scientific facts. The element for which the marker compound standardization has not been established must adhere to the quality standards, purity requirements, and manufacturer specifications as outlined in the regulation. When requested, FBO will provide the Food Authority with the relevant data.

**Nutrients:** The amount of nutrients used cannot exceed the threshold set by the Food Authority. If a claim of higher nutrient content is made, the nutrient content must not be less than thirty percent of the recommended daily allowance and must never exceed one RDA. If the levels are not specified by the food authority, the usage level must be at least fifteen percent of the RDA as specified by the ICMR.

Source: FSSAI, 2022.

### Red Yeast Rice in food processing and preservation

Red yeast rice pigments have found use in stewed octopus, salmon roe, jam, tomato ketchup, sweetened bean jam, and processed meat goods like sausage and ham. They have also been employed in processed fish paste products, including crab-flavored fish paste cakes. Furthermore, red yeast rice pigments are widely used as food colouring in Asia and Europe, as well as for colouring bread, confections, especially rice confectionaries, and drinks. (Fukami *et al.*, 2021).

Red yeast rice powder, or RYR, is a food colouring agent that may be used to make a variety of culinary items, such as coloured buttermilk, coloured lemon juice, coloured ice cream, and coloured sweetened milk that enhances appearance, while red yeast rice's health advantages are supported by monacolins and HmG co-A reductase, which have demonstrated a lower risk of cardiovascular illnesses. It follows that RYR has the potential to successfully provide value addition. (Toshniwal *et al.*, 2020). It has been used by the Chinese for many centuries as a food preservative, food colorant (it is responsible for the red color of Peking duck), spice, and an ingredient in rice wine.

### Brewed Foods Produced Using Red Yeast Rice

In China and Taiwan, red yeast rice is commonly used as a colouring ingredient for food or a preservative for meat. It is also used to make anchū (Chinese red wine) and tofunyu (fermented bean curd). Tofunyu is a flavoured dish made from fermented bean cakes that have been salted and allowed to develop by soaking in raw sake. Red funyu, a fermented bean curd made with red yeast rice, is frequently used. (Fukami *et al.*, 2021).

### Safety of Red Yeast Rice

In addition to its long history in Asian cuisine, red yeast rice produced correctly by traditional solid-state fermentation using *Monascus* fungi is thought to be safe for consumption because its producers have taken great care to assure its safety through a battery of tests, including mutagenicity, acute toxicity, and chronic toxicity tests.

The three most commonly utilised *Monascus* fungi are *M. pilosus*, *M. ruber*, and *M. purpureus*. It has been noted that certain strains of *Mycobacterium purpureus* and *Mycobacterium ruber* have functional copies of the gene producing citrinin, a mycotoxin that causes kidney damage. Using a next-generation sequencer, a whole-genome investigation of these three strains of *Monascus* fungus revealed that *M. pilosus* was unable to produce citrinin. According to this research, only *M. pilosus*—one of the three commercially available species of *monascus* fungi—does not produce the mycotoxin known as citrinin.

### Limitations

Citrinin and aflatoxin B1 are the harmful secondary metabolites produced during fermentation. Citrinin is an extremely harmful, mutagenic, and carcinogenic metabolite that can lead to brain damage, liver and kidney disorders, and cancer. Strong carcinogen, aflatoxin damages all organs, but particularly the liver and kidneys, and can lead to birth abnormalities in children.

### Standards for safety inspections of RYR

Citrinin content cannot exceed 50 µg/kg according to "The Specification of Sichuan Province's Traditional Chinese Medicine" and "Functional Red Yeast Rice QB/T 2847-2007." Aflatoxin B1 content cannot exceed 5 µg/kg according to "The Food Additive Red Yeast Rice GB1886.19-2015" and "The Specification of Sichuan Province's Traditional Chinese Medicine." (Hu *et al.*, 2020)

### Conclusion

Red yeast rice demonstrates promising efficacy in reducing cholesterol levels. Continued research is needed to optimize dosing, establish long-term safety, and explore potential interactions with other medications or supplements.

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