

# Red Rices – Past, Present, and Future

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## Abstract

*Rices with a red bran layer are called red rices. This paper briefly reviews the history, definition, and types of red rices; the uses of red rices as food and medicine, and their role in cultural and religious ceremonies; the varieties of red rices, areas of cultivation, and their use in breeding programs for the improvement of cultivated varieties; and finally the revival of interest in red rices in recent times. Susruta (c. 400 BC), Charaka (c. 700 BC), and Vagbhata (c. 700 AD), the well-known vriddha trayi (Trio of Elders) of Ayurveda, considered red rice (rakta shali) the best among the shali varieties of rice. Red rices were highly valued as they had the power to redress the imbalance in the tridosha (the cornerstone of Ayurvedic medicine is the concept of doshas or the biological humors. The doshas are the basic operating principles that govern the psychobiological aspect of the body. The three doshas – the vata, the pitta, and the kapha – are collectively called the tridosha). In recent times, interest in red rices has been revived because of the presence of antioxidants. The paper also discusses their revival in India and Japan due to the high mineral, iron, and antioxidant contents, which make these rices an ideal health food. These rices have been used as food in India, China, Korea, and Japan since more than 3,000 years.*

In Asian countries, where rice (*Oryza sativa*) is the staple food of more than two-thirds of the population, it has become a synonym of food itself. So much so that the United Nations declared the year 2004, the International Year of Rice (IYR). Such dedication of an International Year to a single agricultural commodity was unprecedented in the history of the United Nations. The theme of IYR was *Rice for Life*, which reflected the importance of rice as a primary food source, and set the tone for a major World Rice Research Conference in Japan during November 2004. Similarly, rice has become synonymous with the color white. In the traditional growing areas of Asia, rices of various colors – red, purple, black, brown, yellow, and green – have been known and grown, but for the present-day generation, rice connotes pearly white grain. Colored rices have been preferred in the past for their special features such as medicinal value and exclusive taste. Flavored, black rices were the favorites of the royals of China, while red rices were preferred by people in many parts of India, Sri Lanka, and Bhutan.

In the areas of relatively recent introduction of the crop, red rices are considered as weeds and as major contaminants that reduce the market value of the end product. American scientists and farmers identify it as a menace that warrants much effort and money to control in the field. Costly color sorting machines are installed to separate this ‘red menace’ (Rood, 2000).

## Origin

The origin of colored rices is as old as rice itself. According to a Japanese myth, the rice plant originally did not bear any grains. Then the Goddess Kuan Yin sprinkled her milk over the plant

and white grains appeared, but excessive squeezing caused blood to come out and some grains became red (Sharma, 1991).

Whereas in the Balinese mythology of *Catur Bumi*, the God Ciwa sent down a bird that carried seeds of four different colored rices – yellow, black, red, and white. On the way, the bird ate the yellow seed and only three were left. So, three types of rices (red, white, and black) are the main foodstuff of Balinese people (Ismani, 1985).

## History

The earliest record of colored rice is found in the Taittiriya Samhita of the Yajurveda [1200 BC (c. 7000 BC – editors)]. During this period, rice formed an important part of the ritual offering to God. Different types of rices were offered to different and specific divinities. A cake of black rice (*Krishnavrihi*) was offered to Agni (the God of Fire), a cake of fast-growing rice (*Asunamvrihi*) to Savitr (Sun God), a cake of wild *nivara* (red-grained) to *Brihaspati* (the God of Speech), and a cake of large-seeded *Mahavrihi* to Indra (the God of Rain).

The *Satapatha Brahmana* [1000 BC (6000–4000 BC – editors)] refers to another variety of red rice, *hayana*, that was considered sacred and its pap was offered to Indra.

In India, red rices have occupied a special position since time immemorial. In their respective treatises, the founding fathers of ancient Ayurveda – Susruta (c. 400 BC), Charaka (c. 700 BC), and Vagbhata (c. 700 AD) – refer to the medicinal value of *shali*, *vrihi*, and *shastika* rices, and list the rices according to their relative medicinal value, with the most useful type at the top of the list. Charaka, the author of Charaka Samhita, and other, later authorities classify the *rakta shali* or *lohit shali* rice (with red husk and grain) as the best; this variety is considered the most efficacious, and subdues the three deranged *doshas* (Kumar, 1988; Krishnamurthy, 1991).

Red rice finds mention in the Buddhist scripture *Milinda Panha*, which dates back to the reign of the Greek king Manadros (*Milinda* in Sanskrit) who ruled the region of present-day Northwest India in the 1<sup>st</sup> century BC. This text mentions two kinds of red rices – one that was considered healthy, and the other (*Parumbhaska*) that was not (Kumar, 1988). During the Puranic period, religious uses of rice were many. Reference to the use of red, black, and wild *nivara* rice appear in the Agni Purana (900 AD) and the Vishnu Purana (200 AD). The Garuda Purana gives details of the medicinal uses of red *shali* as a destroyer of the three *doshas*; it delays thirst, and arrests perspiration. *Mahashali* is referred to as highly restorative (Kumar, 1988; Sensarma, 1989).

In Kashyapiyakrishisukti, one of the first Indian treatises on agriculture, the compiler Kashyapa (c. 800 AD) describes various *shali* rices and the importance of procuring and preserving seeds, and specifically mentions red rices of *shali*, *kalama*, and *sambaka* types (Raychaudhury, 1964; Ayachit, 2002).

Red rices of *japonica* type were grown in Japan since the pre-Nara era (710 AD). Later, long-grained red *indica* type rices were introduced from China during 11<sup>th</sup> to 14<sup>th</sup> century, which made a significant contribution to the expansion of the rice area. Taitoumai, being an early-ripening, drought- and insect-resistant, and high-yielding variety, spread to large areas (Itani and Ogawa, 2004). White rice varieties were in great demand during the 18<sup>th</sup> century (1890), and red rices were subjected to eradication programs for insurance against contamination of white rices. Red rices almost disappeared from cultivation in 1930. However, they remained confined to a few pockets and they were considered sacred in Shinto shrines (Matsuo and Hoshikawa, 1993).

In neighboring Korea, red rices were grown since long, as seeds of wild and cultivated red rice (*indica* and *japonica* types) were found embedded in a Buddha statue in a 1,300-year-old shrine (Suh *et al.*, 1994).

## What is red rice?

Rices with a red bran layer are called red rices. Though the color is confined to the bran layer, a tinge of red remains even after a high degree of milling. The color of the bran ranges from light to dark red. The bran layer contains polyphenols and anthocyanin, and possesses antioxidant properties. The inner portion of red and white rices is alike and white. The zinc and iron content of red rices is 2–3 times higher than that of white rices (Ramaiah and Rao, 1953). American scientists have reported a similar high iron content in the Chinese red varieties ‘Bloody Sticky’ and ‘Dragon Eyeball’ (Rood, 2000).

## Types of red rices

Red rices occur as wild, weedy, or cultivated types, and the red kernels are covered with dark or light-colored husk.

**Wild red rices.** Of the various species of wild rices, *Oryza granulata*, *O. officinalis*, *O. rufipogon*, and *O. nivara* occur in India. *Oryza rufipogon* and *O. nivara* have red grains, and both are used as food and medicine. The term *nivara* is derived from the Sanskrit root *niv*, which means fattening or nourishing.

According to the ancient Indian texts on Ayurveda, *nivara* rice has the unique medicinal property of redressing any imbalances in the *tridosha*. This rice is widely used in Ayurvedic treatment, and has the rare capability to enrich the body elements, to exclude toxic metabolites, to strengthen, regenerate, and energize the body, to regulate blood pressure, and to prevent skin diseases and premature aging. It is also eaten on the traditional days of fasting in many parts of India.

In China, people have been consuming wild rices for the past 3,000 years. Clinical tests have revealed that these rices do not have any harmful effects. Rather, antioxidant properties have been reported from wild rices (Asmarai *et al.*, 1996).

Wild rices have been utilized in rice varietal improvement programs to impart resistance against many diseases and pests. The male sterility in rice first found in *O. rufipogon*, the feature that triggered the hybrid rice program in China, was transferred in cultivated rices. Other, agronomically beneficial traits of wild rice such as tungro and bacterial leaf blight resistance (*Xa 21* gene) and acid sulfate tolerance have played an important role in rice breeding (Song *et al.*, 2005). *Oryza nivara* has also been used as a donor for a number of diseases, but it is the only available source for resistance against grassy stunt virus (Khush, 1977).

**Weedy rices.** Off-type plants having a red pericarp or seeds are considered weedy. These generally have awns of varying degree, a high rate of out-crossing, high seed shedding rate, and dormancy. Weedy rices generally shed seeds earlier than cultivars; they are hardy, more prolific in nature, and carry genes for tolerance to various adverse conditions. Scientists believe that these rices have evolved through hybridization between wild and cultivated rices. In Korea, short-grained red rices of *japonica* type are sometimes crossed with long-grained *indica* types to produce hybrids, which survive the freezing winter of Korea (Oka, 1988).

In USA, red rice is often referred as the ‘Red Menace’. American growers spend much energy and money in fighting red rices and term them “fat beggars”, as they accept what is offered and

thrive on it. These rices cross with the cultivated varieties and produce herbicide-tolerant progeny (Rood, 2000). On the other hand, the peoples of the Orient have always shown tolerance towards red weedy rices, since they eat these rices and often have special names for them (e.g., *sharei* in Korea, and *lutao* in China). The *sharei* weedy rices of Korea were kept preserved in Buddhist shrines along with cultivated rices.

In India, it is the poor who consume weedy rices. At present, red weedy rices are not preferred in quality rices and are separated and mixed with the low-grade rice by the traders. In some areas, specific weedy rices are left at the time of harvesting, and are later collected for eating or for special purposes. In the Sonipat district of Haryana, the small red weedy rice, *dania/rana* is collected for cooking of *kheer*, a rice-based sweet confection. Now, scientists are looking at weedy rices from another angle, as some useful hybrids have been reported between wild and cultivated rices.

**Cultivated red rices.** Before the advent of high-yielding varieties, which are mostly white, red rices formed an important group in almost all the rice-growing Asian countries such as Sri Lanka, Philippines, Korea, China, Japan, and India. A scan in the literature reveals that about 20% of the germplasm collected in China comprises red rices. The annual acreage of different colored rices in China is 1.26% of the total rice cropping area (Chaudhary and Tran, 2001). In Bhutan, about 30% of the area is under red rices. In an evaluation program for biotic stresses conducted on around 12,750 entries under the auspices of the Directorate of Rice Research (Hyderabad, India), 28.31% of the entries were colored rices. Of these, 10.48%, 9.41%, and 8.40% had red, brown, and purple pericarps (Anonymous, 1998). The collection of the Central Rice Research Institute (CRRRI), Cuttack, Orissa) of 2,960 entries, mainly from the eastern states of India, had a relatively higher number of red rices. Of 20% colored rices, 17.40%, 3.44%, and 2.50% were red, purple, and brown rices, respectively. A survey conducted by the National Bureau of Plant Genetic Resources (NBPGR) from 1991 to 1998, recorded about 35% and 21% red rice varieties in Orissa and Manipur (Krishnamurthy and Sharma, 1970; Dikshit *et al.*, 2004).

In India, red rices were prevalent in the South, East, and the hilly tracts of the Northeast and West (Table 1). Red rice cultivars showed high tolerance to such unfavorable environments as infertile soils, deep water, and mountain lands. Few red varieties were reported from the plains of Haryana, Punjab, Rajasthan, western Uttar Pradesh, and Gujarat (Table 1).

A number of red-grained varieties were cultivated in Kerala, Tamil Nadu, Karnataka, Bihar, Orissa, Bengal, Madhya Pradesh, and the northeastern states with areas having unfavorable conditions such as deep water, drought, sandy soils, salinity, and cold conditions.

As in white rices, great diversity exists among red rices. They are glutinous and non-glutinous; scented and non-scented; late and early maturing, and short- and long-grained. However, most red rices are coarse-grained. Among the long-grained red rices, Himalayan red has made its presence felt in the export market also.

Some of the famous red varieties include Matta of Kerala, Patni of Maharashtra, and Jatu and Matali of the Kulu valley in Himachal Pradesh. It is said that the Commissioner of Kulu, during the British period, was so fond of Jatu rice for its sweet taste that he used to send it to his family in England.

## Uses of red rices

In some areas of India, red rices are considered highly nutritive and medicinal. The rice is eaten as whole grain; Red gunja is preferred for making bread and *chapati* (Rani and Krishnaiah, 2001).

Glutinous rice is used in making *puttu* in South India. In Himachal Pradesh, Jatu red rice is prized for its aroma and taste. Matali and Lal dhan of Himachal Pradesh are used for curing blood pressure and fever. Kafalya, from the hills of Himachal Pradesh and Uttar Pradesh, is used for treating leucorrhoea and abortion complications. Kari kagga and Atikaya of Karnataka are used for coolness and as tonic, while Neelam samba is used for lactating mothers in Tamil Nadu (Arumugasamy *et al.*, 2001).

The Chinese use red rice for preparing vinegar, tart, cosmetics, red kojic, and red rice yeast, which is used for medicinal purposes. Red rice yeast is prepared by fermenting yeast *Monascus purpurea* over red rice. It is said to promote blood circulation, and is used in treating upset stomach, indigestion, bruised muscles, and hangovers; and it is a cholesterol-lowering product that is commercially marketed the world over (Chaudhary and Tran, 2001). Red rice in Japan is used for preparation of red *sake*, colored noodles, and cakes for ceremonial occasions. In Sri Lanka, red rices are a favorite as food and some are used as medicines.

## Use in religion and culture

In parts of Japan, red and white colors are considered auspicious, and on its first birthday, a child is given to eat red and white rice cake. In Maharashtra, India, during the months of August and September, three festivals/rituals called *Hal shashti*, *Rishi panchami*, and *Shirawundevasdasee* are celebrated in which people are required to abstain from food grown with the help of animals; they are advised to take wild rice (*O. nivara*) and other self-grown plants (Watt, 1896; Ahuja *et al.*, 2001; Ghate and Sane, 2004).

In Himachal Pradesh, the entire process of cultivation of Jatu rice is a ceremonial affair. Seed soaking and preparation of land for transplanting is accompanied with the worship of the family deity *Ishtadeo*. Before transplanting, the seedlings are placed at the entrances of temples. Before harvest, the ripe grains are first cooked and offered to the deity *Kuladeo*. On this occasion, there is a tradition of distributing such cooked rice among family members, neighbors, and relatives. After the harvested grain is brought home, some rice is separately preserved for religious ceremonies associated with the Gods. The cultivation of Jatu is done on fixed dates. The fields are prepared and seeds are soaked on the *Sankranta* (the beginning of a month or year) of *Vaishaka* (April–May). The grains are covered with the leaves of *bhojpatra* (*Betula alnoides*) for one month. On the next *Sankranta*, the sprouted seeds are put into the nursery area. Again on the *Sankranta* of *Ashadha* (June–July), transplanting is undertaken. From the *Sankranta* of *Sawan* (July–August) to that of *Bhadon* (August–September), weeding is carried out. The harvest of Jatu is started on the *Sankranta* of *Kartik* (October–November). The new harvest is eaten after the month of *Magha* (January–February).

## Special features

In addition of being nutritive and having medicinal value, red rices possess many other special features. It is common experience that red- and black-husked rices are comparatively more resistant to storage insect pests than brown-husked rices. Red rices too possess this feature. In Japan, it has been reported that red rice grains stored since 1905 (Kitano *et al.*, 1993) have remained intact and preserved their original status, as against white-colored rices that were seriously damaged. The Patni rice of Maharashtra and the Jatu of Himachal Pradesh are well known for such hardiness and resistance.

In addition to storage capability, red rice varieties suitable for various agroclimatic conditions and adverse situations are also commonly cultivated in certain regions. Agronomically, or from the

cultivation point of view, such rices possess resistance to drought, flood, submergence, alkalinity, salinity, and resistance to pests and diseases (Table 2) (Chaudhary and Tran, 2001).

## Varietal improvement

The introduction of high-yielding varieties in the 1970s and the market demand of white rices have resulted in a drastic reduction of the area under red rices in India. However, scientists in the states of Kerala and Tamil Nadu tried to improve the yield of red rices, and a number of red rice varieties have been developed and released (Table 1). The variety Annapurna, released by Kerala, is quite popular in Goa, Tamil Nadu, Orissa, and West Bengal. Though Bihar, Orissa, and Tamil Nadu had innumerable red rices in the past, only a few high-yielding reds have been released. Tamil Nadu released a few varieties for Kanyakumari district only. In Japan, red rices were known for pest and drought resistance. After the emergence of white rices as favorites, red rices disappeared completely, except for some red *japonica* types that were considered sacred and protected in shrines.

**Table 2. Special features of red rices.**

Special feature	Varieties/states
<b>Abiotic stresses</b>	
Deep water	Hbj-Aman 3 (Assam), Br 14, Br 15 (Bihar), Taotabi (Manipur), Varappu kudainchan (Tamil Nadu), Ptb 16 (Kerala), Jalnidhi (Uttar Pradesh)
Cold tolerance	Jatu, Matali (Himachal Pradesh), Majehra, Jhaildu (Uttar Pradesh), Lal nakanda 41 (Punjab)
Sandy soils	Ptb 22, Ptb 23, Ptb 25 (Kerala)
Flood resistance	M 142 (Assam), Br 6 (Bihar), Bhetiasia, Dhal pattia (Orissa), Bhutmuri, Dhairal (West Bengal), Vaigunda (Tamil Nadu), Ptb 4, Ptb 10 (Kerala), Halga Red (Maharashtra)
Low-lying areas	Kudaivazhai, Neelam samba (Tamil Nadu), Ptb 31 (Kerala), Apk 5 (Andhra Pradesh)
Submergence tolerance	Ptb 1 (Kerala)
Upland	C 203-3 (Assam), Br 16, Br 30, Gora (Bihar), Valia champan, Ptb 29, Ptb 30 (Kerala), Puzhuthi samba (Tamil Nadu), Sudha (Uttar Pradesh), Lal nakanda (Punjab)
Drought resistance	Mtu 17, Mtu 18 (Andhra Pradesh), Kalla modan, Chennellu, Ptb 35, Ptb 28, Ptb 12, Ptb 7, Ptb 2 (Kerala), Kuzhiyadichan, Kullakar, Pismi, Puzhuthi samba, Puzhuthikkar, Vaigunda, Tkm 1 (Tamil Nadu), Boro ponko (Orissa)
Earliness	Ptb 49, Ptb 35 (Kerala), Konakkuruvai, Asd 8 (Tamil Nadu), C 203-3 (Assam), Hr 33 (Andhra Pradesh), Tipakhia (Uttar Pradesh)
Non-lodging	As Sel. 35, As Sel. 86, M 36-30 (Assam), Putta bhatha (Karnataka), Halga red, Jaddu 1061 (Maharashtra), Boro ponko (Orissa), Ptb 1, Ptb 10, Ptb 12, Ptb 20, Mo 2 (Kerala)
Non-shattering	Sanna bhatha (Karnataka), Jaddu 1061, Halga red (Maharashtra), Mo 1, Mo 5 (Kerala), Kele (West Bengal)

In situ sprouting	Maranel, Adt 1 (Tamil Nadu), Ptb 2, Ptb 7, Ptb 12, Ptb 20, Mo 1 (Kerala), Kele (West Bengal)
Weed competition	Vaigunda (Kerala)
Salinity	Bhura ratta, Kala ratta, Halga red (Maharashtra), Kagga (Karnataka), Adt 1 (Tamil Nadu), Ptb 7 (Kerala)
Competitive with weeds	Vaigunda (Kerala)
Sandy soils suitability	Ptb 22, Ptb 23, Ptb 25 (Kerala)
<b>Other features</b>	
Scent	Jatu, Matali (Himachal Pradesh.), Majehra, Jhaildu (Uttar Pradesh), Lal nakanda 41 (Punjab), Kunsum kesari (Karnataka), Lal dhan (Himachal Pradesh), Lala dhodhi (Maharashtra), Tedasi (Bd 1319), Kasigilas (Bd 295) (Madhya Pradesh)
Medicinal value	Matali, Neelam samba, Kuzhiyadichan (Tamil Nadu), Atikaya, Kari kagga (Karnataka), Nivaru (Kerala)
Storage pest resistance	Jatu, Patni (Maharashtra), Kagga (Kerala)
Disease and insect resistance <sup>1</sup>	
Disease and insect resistance in general	Br 7 (Bihar), Kagga (Karnataka), Bhetriasia (Orissa), Halga red (Maharashtra), Kullakar, Kappa samba, Kala samba, Neelam samba, Perungar, Adt 1 (Tamil Nadu), Ptb 9, Ptb 7, Ptb 10, Ptb 20, Asha (Kerala), Bhutmuri, Bhogjira, Marichabeti (West Bengal)
Resistance to brown plant hopper (BPH)	INRC 7058, 7503, 9263, 9364, 9365, 9876, 11811, 11872, 12532, 12577, 12579, 12594, 12605, 12653, 12676, 12775, 12785, 12809, 12811, 12614, 12931, 12986, 12987, 13070, 13087, 13088, 13106, 13123, 13141, 13185, 13222, 13238, 13251, 13252, 13282, 13312, 13315, 13318, 13320, 13323, 13332, 13340, 13342, 13377, 13431, 13512, 13540, 13541, 13542, 13535, 13544, 13555, 13580, 13582, 13583
Resistance to BPH, GM 4 (gall midge biotype 4)	INRC 9266, 12775, 12980, 13088, 13123, 13185, 13320, 13238, 13251, 13252, 13261, 13315, 13323, 13540, 13551, 13583
Resistance to BPH, GM 4, stem borer, white ear	INRC 13251
Resistance to BPH, GM 1, leaf blast	INRC 9263
Resistance to BPH, GM 1	INRC 9365, 9366
Resistance to GM 1, GM 4	INRC 1997
Resistance to stem borer, white ear	INRC 1615
Resistance to sheath blight	INRC 557
Resistance to leaf blast	INRC 4371, 5403, 8980

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**1. INRC = Indian Rice Collection.**

## Red rice donors for white rice improvement

The main emphasis of rice varietal improvement in all countries and in international research institutions has been on increasing the production per unit area, followed by imparting resistance against biotic stresses, and finally on cooking and grain quality. Most varieties released have been white, due to market demand that has resulted in the reduction and depletion of red varieties from Asia and Africa. All countries outside Asia and Africa identify and recognize rice only as white rice. Moreover, even historical listings of rices (e.g., “Races of Rices in India”, compiled during the British period) reveal very low numbers of red rices compared with white rices, though current records put the figure at about 25%.

In white rice varietal improvement programs, red rice varieties have proved to be useful donors for sources of resistance/tolerance to many stress environments and for imparting resistance to important pests and diseases. Red landraces such as Ptb 18, Ptb 19, Ptb 21, and Ptb 33, with broad-spectrum resistance to the dreaded brown plant hopper, have been used in resistance breeding programs all over the world. In addition, *nivara* rices have been used as sources of resistance to insect pests and viral diseases; Lal nakanda has been used as a drought resistance donor. Ptb 10 has been used for high photosynthetic activity.

## Revival

With the sharp increase in lifestyle-related health issues and diseases – such as diabetes, cancer, and heart problems – scientists are looking at quality traits other than carbohydrates, protein, and fat in foodstuffs. Evaluation of foodstuffs now places greater focus on their antioxidant properties, glycemic index, and mineral content.

Scientists are looking at rice as more than just starchy food, and are analyzing the antioxidant properties of colored rices. Also, the mineral content of rice varieties is gaining importance. Red rices have been found to have greater antioxidant property than black and white rices. With this rediscovery of their nutritive and medicinal value, red rices have begun to regain their old position and prestige. There is a revival of red rices in Japan, and new cultivars are being released that are suitable for preparations such as red *sake*, noodles, and rice cakes (Itani and Ogawa, 2004).

## Outlook

It is now known that flavonoid and anthocyanin compounds are closely related to the antioxidation properties of black rice (Zhang *et al.*, 2005). Oki *et al.* (2005) found that the DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging activity is higher in red rices than in black and white rices, and that this activity is correlated with polyphenols and proanthocyanidin content.

Considering that the highest scavenging activity due to the presence of polyphenols is in red rices than in black and white rices (Oki *et al.*, 2005), red rices could once again find favor with health-conscious consumers. It is high time that people in India took a fresh look at similar properties in the vast pool of indigenous red rices. There is also a dire need for clinical validation of the medicinal value of red rices reported in ancient literature, and for research on food preparations such as *poha* (flake rice), noodles, and *sewai* (vermicelli) from red rices.

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