MINISTRY OF FOOD PROCESSING INDUSTRIES
GOVERNMENT OF INDIA

PMFME
सूक्ष्म उद्यमों का संबल

NIFTEM
THANJAVUR

PM Formalisation of
Micro Food Processing Enterprises Scheme

Processing of Puffed and Flaked Rice

AATMANIRBHAR BHARAT

National Institute of Food Technology, Entrepreneurship and Management (NIFTEM) - Thanjavur

(an Institute of National Importance under Ministry of Food Processing Industries, Government of India)
Pudukkottai Road, Thanajvur – 613005
https://niftem-t.ac.in/
Ph : 04362-228155, Fax:04632-227971

TABLE OF CONTENTS

		Page No.
Chapter 1: Introduction		
1.1 Status and Market size		1
	1.1.1. Socioeconomic significance	1
	1.1.2. Cultivation Scenario	2
	1.1.3. Production and yield of Rice in major states in India	3
	1.1.4. Composition & Nutritive Value of Rice	6
	1.1.5. Health benefits of Rice	10
	1.1.6. Medicinal properties of Rice	11
1.2 Indian Market Outlook		12
1.3 Puffed & Flaked Rice		13
	1.3.1 Puffed Rice	13
	1.3.2 Flaked Rice	15
Chapter 2: Processing of Puffed & Flaked Rice		
2.1 Processing flow for production of Puffed Rice		17
2.2 Processing flow for production of Flaked Rice		19
Chapter 3: Packaging of Puffed & Flaked Rice		
3.1 Deteriorating factors		24
3.2 Packaging requirements for Puffed & Flaked Rice		25
3.3 Packaging materials for Puffed & Flaked Rice		25
Chapter 4: Food Safety Regulations and Standards		27
Machineries Manufacturers & Suppliers		29

CHAPTER 1

INTRODUCTION

1.1. Status and Market Size

Rice (Oryza sativa) belonging to the family Gramineae and subfamily Oryzoides is the second most important cereal crop and staple food for more than half of the world's population. Rice is a grain belonging to the grass family. It is related to other grass plants such as wheat, oats and barley which produce grain for food and are known as cereals. Rice refers to two species (Oryza sativa and Oryza glaberrima) of grass, native to tropical and subtropical south-eastern Asia and to Africa, which together provide more than one-fifth of the calories consumed by humans. It occupies about 23 per cent of gross cropped area, 35 per cent of the area under food grains and 44 per cent of area under cereals. It is grown under diverse cultural conditions and over wide geographical range. The slogan 'Rice is Life' is more appropriate for India as this crop plays a vital role in our National food security and is a means of livelihood for millions of rural households.

In the world scenario, the highest productivity is seen as 6710 kg per ha of China followed by Vietnam (5573 kg /ha), Indonesia (5152 kg/ha), Bangladesh (4375 kg/ha) etc.

1.1.1. Socioeconomic importance

Rice has shaped the culture, diets and economic of thousands of millions of peoples. For more than half of the humanity "rice is life". Considering its importance position, the United Nation designated year 2004 as the "International Year of rice. Importance of rice is given below.

a. Rice is an important staple food crop for more than 60 per cent of the world people. In 2008, more than 430 million metric tons of rice was consumed worldwide, according to the USDA.
b. Ready to eat products eg. popped and puffed rice, instant or rice flakes, canned rice and fermented products are produced.
c. Rice straw is used as cattle feed, used for thatching roof and in cottage industry for preparation of hats, mats, ropes, sound absorbing, straw board and used as litter material.

d. Rice husk is used as animal feed, for paper making and as fuel source.
e. Rice bran is used in cattle and poultry feed, defatted bran, which is rich in protein, can be used in the preparation of biscuits and as cattle feed.
f. Rice bran oil is used in soap industry. Refined oil can be used as a cooling medium like cotton seed oil / corn oil. Rice bran wax, a by-product of rice bran oil is used in industries.

1.1.2. Cultivation Scenario

Rice is one of the most important food crops and feeds more than 60 percent population of India. The area under rice crop was 30.81 million /ha in 1950-51 which has increased to 43.86 million hectares during 2014-15 which is nearly 142 per cent higher.

The rice growing areas in the country can be broadly grouped into five regions as given below:

North-Eastern Region

This region comprises of Assam and North eastern states. In Assam rice is grown in the Basin of Brahmaputra River. This region receives very heavy rainfall and rice is grown under rain fed condition.

Eastern Region

It region comprises of Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, Eastern Uttar Pradesh and West Bengal. In this region rice is grown in the basins of Ganga and Mahanadi rivers and has the highest intensity of rice cultivation in the country. This region receives heavy rainfall and rice is grown mainly under rain-fed conditions.

Northern Region

This region comprises of Haryana, Punjab, Western Uttar Pradesh, Uttarakhand, Himachal Pradesh and Jammu & Kashmir. The region experiences low winter temperature and single crop of rice from May-July to September-December is grown.

Western Region

This region comprises of Gujarat, Maharashtra and Rajasthan. Rice is largely grown under rainfed condition during June-August to October – December.

Southern Region

This region comprises of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. Rice is mainly grown in deltaic tracts of Godavari, Krishna and Cauvery rivers and the non-deltaic rain-fed areas of Tamil Nadu and Andhra Pradesh. Rice is grown under irrigated condition in deltaic tracts.

1.1.3. Production and yield of Rice in major states in India

Rice is grown in almost all the states in the country however the major 5 states in rice production are West Bengal, UP, Andhra Pradesh, Punjab and Tamil Nadu. West Bengal produces 15 percent of total quantity of rice produced in the country.

The rice production has registered an appreciable increase from 20.58 million tonnes in 1950-51 to 104.86 million tonnes during 2014-15, which is nearly 5 times. The yield was 668 kg/ha in 1950-51 which has increased to 2390 kg/ha during 2014-15. Major share of rice production is in Kharif season. Yet, there are improved technologies and various interventions which could be adapted to increase the productivity in the country. Cultivation of hybrid rice has potential to increase the productivity and needs to be promoted.

State wise Production (Million Tonnes) of Rice during 2010-11 to 2014-15

S.No	State	2010-11	2011-12	2012-13	2013-14	2014-15
1	Andhra Pradesh	7.88	7.75	6.86	6.97	7.23
2	Arunachal Pradesh	0.23	0.26	0.26	0.28	0.29
3	Assam	4.74	4.52	5.13	4.93	5.22
4	Bihar	3.10	7.16	7.53	5.51	6.36

5	Chattisgarh	6.16	6.03	6.61	6.72	6.32
6	Gujarat	1.50	1.79	1.54	1.64	1.83
7	Himachal Pradesh	0.13	0.13	0.13	0.12	0.13
8	Jammu & Kashmir	0.51	0.54	0.82	0.61	0.52
9	Jharkhand	1.11	3.13	3.16	2.81	3.36
10	Karnataka	8.19	3.96	3.36	3.57	3.54
11	Kerala	0.52	0.57	0.51	0.51	0.56
12	Madhya Pradesh	1.77	2.23	2.77	2.84	3.63
13	Maharashtra	2.70	2.84	3.06	3.12	2.95
14	Manipur	0.52	0.59	0.26	0.40	0.33
15	Meghalaya	0.21	0.22	0.23	0.27	0.30
16	Mizoram	0.05	0.05	0.03	0.06	0.06
17	Nagaland	0.38	0.38	0.41	0.43	0.45
18	Odisha	6.83	5.81	7.30	7.61	8.30
19	Sikkim	0.02	0.02	0.02	0.02	0.02
20	Tamil Nadu	5.79	7.46	4.05	5.35	5.73
21	Telangana	6.54	5.15	4.65	5.75	4.44
22	Tripura	0.70	0.72	0.71	0.71	0.75
23	Uttar Pradesh	11.99	0.55	14.42	14.64	12.17
24	UttaraKhand	0.55	0.59	0.58	0.58	0.60
25	West Bengal	13.05	14.61	15.02	15.37	14.68
26	**All India**	95.97	**105.30**	**105.24**	**106.65**	**105.48**

State wise Yield (kg/ ha) of Rice during 2010-11 to 2014-15

S.No	State	2010-11	2011-12	2012-13	2013-14	2014-15
1	Andhra Pradesh	2843	3302	3106	2852	3022
2	Arunachal Pradesh	1925	2065	2086	2092	2241
3	Assam	1843	1843	2061	2012	2093
4	Bihar	1095	1095	2282	1759	1948
5	Chattisgarh	1663	1597	1746	1766	1660
6	Gujarat	1852	2141	1843	2076	1223
7	Himachal Pradesh	1673	1705	1629	1625	971
8	Jammu & Kashmir	1942	2079	3126	2250	1019
9	Jharkhand	1541	2131	2237	2238	3028
10	Karnataka	5317	2793	2632	2666	2670
11	Kerala	2452	2733	2577	2551	2836
12	Madhya Pradesh	1106	1340	1474	1474	1684
13	Maharashtra	1776	1841	1963	1934	1899
14	Manipur	2453	2453	2099	1788	1488
15	Meghalaya	1911	1988	2125	2493	2703
16	Mizoram	1160	1411	2088	1522	1643
17	Nagaland	2103	2106	2210	2267	2326
18	Odisha	1616	1450	1814	1821	1992

19	Sikkim	1727	1730	1768	1815	1818
20	Tamil Nadu	3040	3918	2127	3100	3191
21	Telangana	3303	2942	2656	3009	3138
22	Tripura	2655	2700	2681	2800	2903
23	Uttar Pradesh	2120	2358	2424	2447	2072
24	UttaraKhand	1901	2121	2071	2289	2307
25	West Bengal	2639	2688	2765	2788	2730
26	**All India**	**2239**	**2393**	**2462**	**2416**	**2391**

1.1.4. Composition & Nutritive Value of Rice

Rice is a nutritional staple food which provides instant energy as its most important component is carbohydrate (starch). On the other hand, rice is poor in nitrogenous substances with average composition of these substances being only 8 percent and fat content or lipids only negligible, i.e., 1per cent and due to this reason it is considered as a complete food for eating. Rice flour is rich in starch and is used for making various food materials. It is also used in some instances by brewers to make alcoholic malt. Likewise, rice straw mixed with other materials is used to produce porcelain, glass and pottery. Rice is also used in manufacturing of paper pulp and livestock bedding.

The variability of composition and characteristics of rice is really broad and depends on variety and environmental conditions under which the crop is grown. In husked rice, protein content ranges in between 7per cent to 12per cent. The use of nitrogen fertilizers increases the percentage content of some aminoacids.

The comparative nutritional value of cereals in the table 1 showed difference in nutritional content of rice bran and raw rice. The brown rice is rich in some vitamins, especially B1 or thiamine (0.34mg), B2 or riboflavin (0.05 mg), niacin or nicotinic acid (4.7 mg). In contrast, the white rice is poor in vitamins (0.09 mg of vitamin B1, vitamin B2 0.03 mg and 1.4 mg of niacin) and minerals as they are found mostly in the outer layers of the grain, which are removed by polishing

process, or "bleaching" whereas parboiled rice is rich in these vitamins as a result of their particular process.

Cooking procedures can reduce the richness of vitamins and minerals in rice, and in fact, cooking is usually done with water which is then neglected and much of these nutrients dissolve in water and get wasted. Rice is strongly recommended in preparing specific diets against stomach and intestinal disease processes as well as feeding the infants and old people due to its good digestibility.

Table 4: Composition of Rice (100 g edible portion)

Nutrient proximates	Brown rice	White rice
Energy	82 calories	68 calories
Protein	1.83 g	1.42 g
Total Lipid (Fat)	0.65 g	0.15 g
Carbohydrates	17.05 g	14.84 g
Fiber, Total Dietary	1.1 g	0.2 g
Sugars, Total	0.16 g	0.03 g
Calcium	2 milligrams (mg)	5 mg
Iron	0.37 mg	0.63 mg
Sodium	3 mg	1 mg
Fatty Acids, Total Saturated	0.17 g	0.04 g
Fatty Acids, Total Trans	0 g	0 g
Cholesterol	0 mg	0 mg

Table 5: Nutritive value of Rice

Vitamins	DM basis	Unit
Vitamin D	0	1000 IU/kg
Vitamin E	9.8	mg/kg
Vitamin K	0.02	mg/kg
Vitamin B1 thiamin	6.1	mg/kg
Vitamin B2 riboflavin	2.8	mg/kg
Vitamin B6 pyridoxine	4.5	mg/kg
Vitamin B12	0	µg/kg
Niacin	57	mg/kg
Pantothenic acid	18.2	mg/kg
Folic acid	0.3	mg/kg
Biotin	0.1	mg/kg
Vitamin C	0	mg/kg
Minerals		
Calcium	0.7	g/kg
Phosphorus	2.8	g/kg
Phytate phosphorus	2.3	g/kg
Magnesium	1.7	g/kg
Potassium	3.1	g/kg
Sodium	0.28	g/kg
Chlorine	0.3	g/kg
Sulfur	0.5	g/kg

Manganese	78	mg/kg
Zinc	20	mg/kg
Copper	6	mg/kg
Iron	18	mg/kg
Selenium	0.2	mg/kg
Cobalt	2	mg/kg
Molybdenum	0.9	mg/kg
Iodine	0.03	mg/kg
Lysine	3.2	g/kg
Threonine	3.1	g/kg
Methionine	2.1	g/kg
Cystine	1.6	g/kg
Methionine + cystine	3.6	g/kg
Tryptophan	1.5	g/kg
Isoleucine	3.8	g/kg
Valine	5	g/kg
Leucine	6.7	g/kg
Phenylalanine	4.3	g/kg
Tyrosine	3.6	g/kg
Phenylalanine + tyrosine	7.9	g/kg
Histidine	1.9	g/kg
Arginine	6.7	g/kg
Alanine	4.7	g/kg
Aspartic acid	7.6	g/kg

Glutamic acid	15.1	g/kg
Glycine	3.8	g/kg
Serine	4.1	g/kg
Proline	3.9	g/kg

Source: USDA National Nutrient Database

1.1.5. Health benefits of Rice

India has a wealth of medicinal plants, most of which have been traditionally used in Ayurveda, Unani systems of medicines and by tribal healers for generations. In ancient Indian literature it is clearly mentioned that every plant on this earth is useful for human beings, animals and for other plants. In Ayurveda the medicinal values of rice have been described: rice is considered to be acrid, oleaginous, tonic, aphrodisiac, fattening, diuretic and useful in biliousness. In Chhattisgarh, rice is widely cultivated and the region is known as "the rice bowl of India". Rice is believed by some to have medicinal properties. Although, this is not scientifically proven effective, it has been used in many countries for medicinal purpose.

Rice water is prescribed by the Pharmacopoeia of India as an ointment to counteract inflamed surface. In Indian state Chhattisgarh, Rice is considered as medicinal plant. Insects attacking on rice are also used in Traditional Healing. The Traditional Healers use different parts of medicinal rice in treatment of both common as well as complicated diseases. Medicinal rice variety "Laicha" was so named because of its unique property to prevent "Laicha" disease (skin infection). During the survey it was observed that the younger generation is less aware about these medicinal rice varieties than the older generations, so there is a strong need for documentation of this valuable information about the medicinal values of traditional rice varieties in the region. The poplar medicinal rice Alcha, Laicha, Baissour, Maharaji, Jhilli, KanthiBanko, Udan Pakheru, Ramkeli, ShyamLal, Tenduphool etc. are still under cultivation and in use in Traditional Healing.

1.1.6. Medicinal properties of Rice

Health benefits of rice can be found in more than forty thousand varieties of this cereal available in the world. The two main categories include whole grain rice and white rice. Whole grain rice is not processed much, therefore it is high in nutritional value, whereas white rice is processed so that the bran or outer covering is removed and it has less nutritional value. Rice can also be defined by the length of each grain. Indian or Chinese cuisines specialize in long grained rice, whereas western countries prefer short or medium sized grains. According to Rice-Trade, rice is extremely nutritious.

- Great Energy Source: As rice is rich in carbohydrates, it acts as fuel for the body and aids in normal functioning of the brain.
- Cholesterol Free: Eating rice is extremely beneficial for health, just for the fact that it does not contain harmful fats, cholesterol or sodium. It forms an integral part of balanced diet.
- Rich in Vitamins: Rice is an excellent source of vitamins and minerals like niacin, vitamin D, calcium, fiber, iron, thiamine and riboflavin.
- Resistant Starch: Rice abounds in resistant starch, which reaches the bowel
- High Blood Pressure: As rice is low in sodium, it is considered best food for those suffering from high blood pressure and hypertension.
- Cancer Prevention: Whole grain rice like brown rice is rich in insoluble fiber that can possibly protect against many types of cancers. Many scientists believe that such insoluble fibers are vital for protecting the body against cancerous cells.
- Dysentery: The husk part of rice is considered as an effective medicine to treat dysentery. A three month old rice plant's husks is said to contain diuretic properties. Chinese people believe that rice considerably increases appetite, cures stomach ailments and indigestion problems.
- Skin Care: Medical experts say that powdered rice can be applied to cure some forms of skin ailments. In Indian subcontinent, rice water is duly prescribed by ayurvedic practitioners as in undigested form. It aids the growth

of useful bacteria for normal bowel movements. an effective ointment to cool off inflamed skin surfaces.

- Alzheimer's disease: Brown rice is said to contain high levels of neurotransmitter nutrients that can prevent Alzheimer's disease to a considerable extent.
- Heart Disease: Rice bran oil is said to have antioxidant properties that promotes cardiovascular strength by reducing cholesterol levels in the body.

1.2. Indian Market Outlook

The snack food is one of the most important areas of the food industry. Designing snack foods today can be a complex process to meet changing consumers taste and expectations and elusive search for something unique that also appeals to a wide variety of people. Most snack manufacturers use some form of existing technology as the basis for creating snack products and incorporate variations that increase the resulting snacks' health image. Therefore, puffing and popping using advance technologies are processes, which can accomplish all these targets. As the simplest, inexpensive and quickest traditional method of dry heat application for preparation of weaning food formulations and ready-to-eat snacks products, popping and puffing have been practiced since hundreds of years. Explosion puffing by sudden release and expansion of water vapour is a relatively well known and widely used process.

Puffed grain being a pre-cooked ready-to-eat material can be used in snack foods, specialty foods and as a base for development of supplementary foods. Examples of the use of the puffing process are the manufacture of expanded rice. Convenient snack foods like popcorn, popped and puffed rice, popped sorghum, popped wheat roasted and puffed soybean and other legumes are very popular not only in Indian sub- continent, but also worldwide.

The production level of this rice product is not known exactly, but it has been indicated that about 10% of total rice production is utilized for flaked rice, expanded rice and popped rice. In states where it is consumed as breakfast, there is more production and larger industries exist. In Karnataka, the flaked rice production centers are situated at Hubli, Bhadravathi, Davengare, Udipi, and Belgam. Gujrat, Navasari, Ahmedabad, Umreth, and Bavala are the locations of other major

production centers, and Madhya Pradesh and Orissa are major producers as well. In other states, production is only at a cottage level.

Rice products being gluten free can be a suitable breakfast food item especially for the patients' undergoing the hardship of celiac disease. Puffed rice possesses adequate amounts of nutrient, dietary fiber and phyto-chemicals, which have been linked to minimize disease risk. The bran, which is rich source of oil (19-23%) also contains natural antioxidant. The γ-oryzanol as natural antioxidant lowers the total cholesterol and low-density lipoprotein cholesterol level on consumption and thus reduces the risk of coronary heart diseases. The incidences of life style disorders in present days are accelerating mainly due to sedentary lifestyle with the dependence on unhealthy food combinations with or without the junk foods. So, there is a need to move towards the traditional whole grain based foods. As pre cooked product with unique flavor the puffed rice is becoming an important ready-to-eat food item. Thus, the present investigation is planned to characterize the changes in the properties at different stages of puffed rice manufacturing.

1.3. Puffed & Flaked Rice

1.3.1. Puffed Rice

Puffed rice is very popular in India as a low cost ready-to-eat breakfast cereal as well as snack because of its crispness and lightness. It is also a favourite food product made in different forms like puffed rice balls, bars and fatty pastes, chocolate (or) boiled sugar confectioneries in many countries.

Puffing of rice grains results from the sudden expansion of water vapour (steam) in the interstices of starch granules during high-temperature-short-time (HTST) heating of the grains. The particle is fixed in its expanded state by the dehydration resulting from the rapid diffusion of the water vapour out of it. Puffed product should be maintained around 3 percent moisture in order to achieve the desired crispness. Puffing processes may be broadly classified into two groups:

1) atmospheric pressure processes which rely upon the sudden application of heat to obtain the necessary rapid vaporization of water, and

2) pressure drop processes which consists of suddenly transferring superheated particles into a space at lower pressure.

The pressure drop may be achieved by releasing the seal on a yes el containing a product, which has been equilibrated with high temperature steam or it may be secured by transferring the hot material from the atmosphere into an evacuated chamber.

Sand puffing, air puffing, oil puffing, roller puffing and oven puffing are examples of atmospheric pressure processes while gun puffing, extrusion puffing are examples of pressure-drop processes.

a. Sand Puffing

This method is traditionally followed in India where parboiled rice grains having initial moisture content of 11-12 percent are mixed with 2 percent salt and limited water so that moisture content of rice increases upto 16-29 percent (wb), Moistened rice grains are heated (tempering) for 30 minutes to 8 h for moisture equilibration within the grains. The treated rice grains are dried in the bright sun or by conduction heating in a hemispherical metallic container with continuous stirring until grains get dried upto 10 to 11 percent (w.b). Small quantity of the rice is roasted at an optimum sand temperature between 230 to 275°C for 6 to 20 seconds to give puffed rice with expansion ratio of 8 to 10. The process is tedious and the production capacity is very low (2-2.5kg/hr).

b. **Roller Puffing**

In roller puffing, dough with moisture content of 8 to 18 percent is fed into the rolls with temperature of 190 to 440°C. Puffed products are obtained at 6 to 7 % moisture content. The rolls are heated by radiant heat or by circulation of high temperature fluid media inside the cylinder.

c. **Oil Puffing**

Pre heated rice (parboiled) is puffed in vegetable oil at 200 to 220°C to give expansion ratio of 5 to 7.

d. **Gun Puffing**

In this process raw milled rice and other grains can be puffed and do not need pre-treatment (parboiled) before puffing which is an essential step for puffing with other

technique. Pro-moistened pearled or unpearled grains are fed into a pressure vessel, which is continuously rotated and externally heated. As the optimum pressure, varies from grain to grain, the sudden release of chamber pressure causes the superheated water to flash into steam resulting in porous structure of the puffed products. In some cases preheated grains at 272-337°C are fed to the pressure vessel in which pressure is built by superheated steam upto 15.1 kg/sq cm at a temperature of 241.6°C at the gun. After a short cooking time, the gun is suddenly opened to produce puffed rice. Initial moisture content of the grains and attaining optimum pressure within minimum time are critically important for gun puffing.

e. **Extrusion Puffing**

Rice Based Products Puffed breakfast cereals and snacks are made by extruding superheated and pressured dough through an orifice into the atmosphere. Either single screw (or) twin screw extruders is used. The sudden expansion of water vapour in the extrudate as the excess pressure is released results in a volume increase of several times. Apparent specific volume can reach or exceed those attained by gun puffing and the process seems to have several advantages over gun puffing, such as high and continuous production rates, greater versatility in product shape, and easier control of product density. However extrusion puffing is possible for dough only and not for whole grain kernels, which is possible for gun puffing. The rice flour mix containing a 60-75% expand able starch base is moistened with water (or) steam and equilibrated to ensure a uniform supply of extrusion material. The resultant mass is compacted by a screw revolving inside a barrel, which may be heated by steam or electrical band heaters. The thread of the screw has a progressively closer pitch as it approaches discharge. In some extruder designs, the rice premix is fed directly into the extruder. The water and/or steam are injected into the barrel and mixed with the premix. The pressurizing, shearing, and steam heating brings the dough to a temperature of around 150-175 °C and a pressure of 2.46 to 35.2 kg/cm at the die head. Under these conditions the dough is quite flexible and easily adapts to complex orifice configurations.

1.3.2. Flaked Rice

Flaked rice is a major product in India. It is known by a number of names, including aval (Tamil), avalakki (Kannada), atukulu (Telugu), and poha (Hindi). It has played

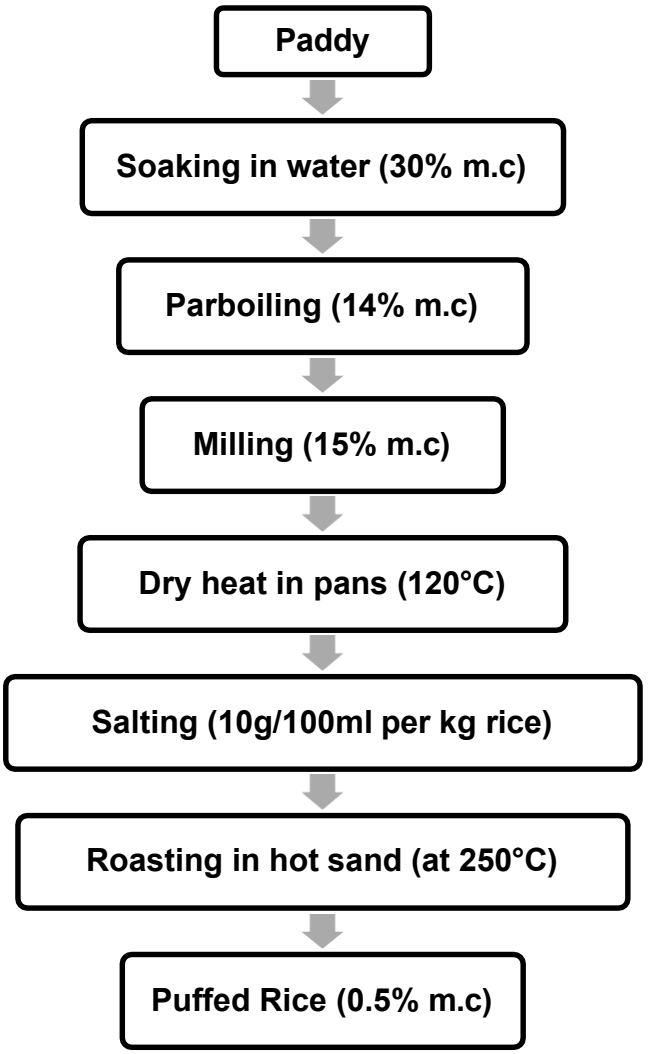
an important role in religious ceremonies for a very long time, and it is also one of the main breakfast items in the states of Maharashtra, Madhya Pradesh, Karnataka, Gujarat, and Rajasthan. Flaked rice is consumed raw or with milk. The common dishes made with it are onion poha and potato poha. The roasted, thick-flaked rice called chiwda or chura is used in namkins, which are a fried, crispy snack made with a mixture of cereals and pulses.

The processes involved in creating flaked rice are cold or hot soaking, roasting, flaking, sieving, and packing. There are a number upgrades for the flaked rice industry, including developing a method to achieve uniform moisture content of the soaked paddy and advancement of the temperature control systems of the roasters. Increased interaction with government departments and R&D institutions will further enhance the future of this rice product.

CHAPTER 2

Processing of Puffed & Flaked Rice

2.1. Processing Flow for Production of Puffed Rice



2.1.1. Soaking

At cottage level, soaking is done in metal drums or cement tanks for about 10–12 h, after which the water is drained. For larger processors, soaking times range from 2–24 h. Many large- scale processors have replaced the cement tanks with vertical metallic tanks where the paddy is fed through surge bins from the top.

After soaking, the water is drained and the paddy is conditioned for 2–3 h within the soaking tank or after heaping or spreading on a cement floor. Hot water soaking is not practiced in the field, since it imparts color to the end product. The moisture

content of soaked paddy reaches 25-33%, depending on climatic condition and the methods of soaking and preconditioning.

2.1.2. Parboiling

It involves steeping the soaked paddy in hot water and steaming at steam pressure of 1.5 kg/ cm^2 for 10 minutes. Degree of parboiling depends on the water content of the steeped grain. Then drying is done to reduce the moisture content to around 14%.

This process allows the vitamins and minerals present in the hulls and bran coat to be carried into the endosperm.

2.1.3. Milling

The parboiled paddy is passed through de-husker and polisher for the removal of husk and bran layers, respectively. The obtained parboiled rice having the moisture level of 14-15% was tempered to achieve the moisture content in the range of 17±1%.

2.1.4. Dry heating

The rice is now preheated under slow heat for 35 minutes in order to attain approximate grain temperature of 110°C.

2.1.5. Salting

Salt conditioning of parboiled rice is usually done to increase the smoothness and uniformity of puffing. A salt solution of 10 percent concentration was sprayed at the rate of 100 millilitres per kilogram of milled rice and kept for 15 hours.

2.1.6. Roasting

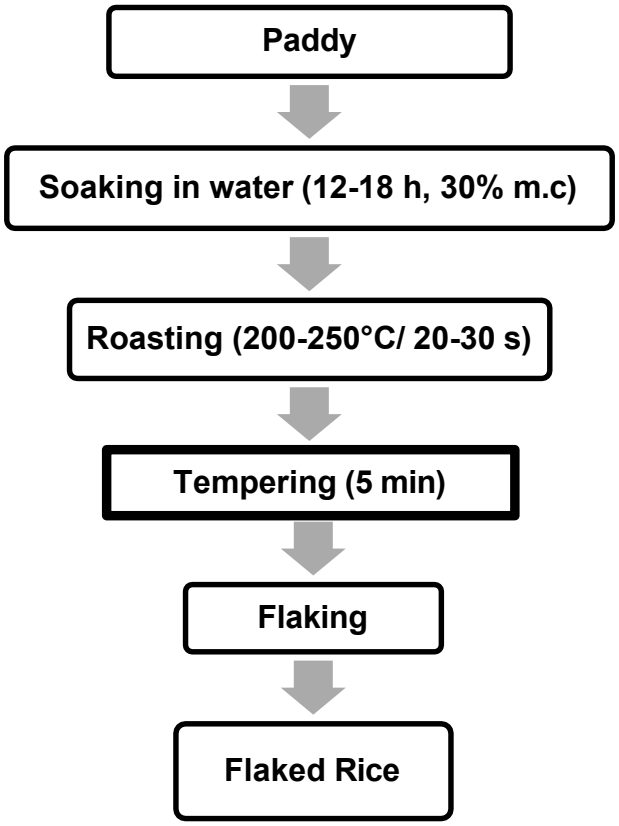
The conditioned paddy is roasted in a paddy roaster maintained at the temperature of 270-280 °C for an exposure of parboiled paddy to a short duration of time

(29±1 s) having heat transfer medium as fine sand. The sand is of 600 micron grade. The sand is preheated in ordinary pot (either earthen or metallic pot) so as to raise the temperature to 250-280°C. The ratio of sand to rice is 4 to 1 by weight in order to get the best performance. It takes about 12 to 20 seconds to puff up the rice.

The obtained puffed rice is then cooled to room temperature.

2.2. Processing Flow for Production of Flaked Rice

In flaked rice production, generally freshly harvested paddy is preferred, as it gives more whiteness.



The moisture content and temperature at various processing steps of flaked rice are given in the following table.

Process step	Sample	Duration	Moisture content(%)	Temperature
Soaking/conditioning	Paddy	2–24 h	25–33 Cold soaking	Room temperature
Roasting	Paddy	40–60 sec.	14–18	110-180°C (Roaster temp) (105–120°C paddy temp
Conditioning by water addition	Roasted paddy		16–19	90–105°C
Flaking	Roasted paddy	20–60 sec.	14–16	80–95°C
Packing	Flaked rice		10–11	--

2.2.1. Soaking

At the cottage level, soaking is done in metal drums or cement tanks for about 10-12 h, after which the water is drained. Instead of cement tanks, vertical metallic tanks (where the paddy is fed through surge bins from the top) can also be used.

After the given soaking time, the water is drained and the paddy is conditioned for 2-3 h within the soaking tank or after heaping or spreading on a cement floor. Hot water soaking is not practiced in the field, since it imparts color to the end product. The moisture content of soaked paddy reaches 25–33%, depending on climatic condition and the methods of soaking and preconditioning.

2.2.2. Roasting

Roasting, which can be performed with or without sand, is a strenuous, labor intensive, and costly manual operation that requires skill and fine judgment to determine the appropriate termination point. Even a slight shift from the optimal roasting conditions may entail loss of yield caused by puffing of grains during roasting or breakage during flaking due to under-roasting. In Tamil Nadu, paddy is roasted in sand, whereas in Karnataka it is roasted in a fine silt medium.

For smaller cottage-level operations, roasting can be done in shallow iron pans placed on the hearth. Pans made of thick iron material measuring 620 mm in diameter, 200 mm in height, and weighing about 17 kg can be used. One to two kg of paddy is roasted at a time for about 1–2 min at 200–250°C.

In medium and large scale industries, roasting is usually performed by continuous roasters using a sand medium. The partial gelatinization of soaked paddy is achieved from roasting at 110–180°C for 10–60 sec. The soaked paddy is fed to the roaster by means of belt conveyors or by manually feeding the hopper. A medium-scale processor may have one such roaster and five edge runners. Larger processors would simply have more roasters and flaking units. Some of these larger processors have a pre-cleaning facility, whereas in other places the raw paddy is soaked and the floating chaff and immature paddy are collected manually.

Mechanical roasters are available as batch types or continuous types. The roasters are operated either by electricity, diesel, or firewood. The electrical roaster consists of a circular heating coil over which a circular iron pan is mounted inside the metallic cover. Roasting is performed in batches with 8–10 kg of soaked paddy at about 200°C. The completion of roasting is indicated by the initiation of a popping sound of the roasted grains, after which the roasted paddy is discharged with a lever.

2.2.3. Tempering

The roasted paddy is moistened and conditioned to obtain different types of flakes, such as thick (~1 mm), medium (~0.6 mm), thin (0.55–0.3 mm), and very thin (<0.3 mm).

In case of continuous type of roasters, the sand roasted paddy is sieved in order to remove the adhering sand and impurities. After sieving, the roasted paddy is fed directly onto a screw conveyor, where the addition of water takes place at the beginning of the conveyor and uniform mixing occurs as it travels through the conveyor. The amount of water added varies widely, mostly depending on the type of flaked rice processed, i.e., thin or thick. The approximate flow rate is 60–70ml per minute. Due to the water addition, an increase of moisture content by 2–3% occurs. At the end of the screw conveyor, it is collected in bamboo or plastic baskets holding 1–2 kg roasted paddy and arranged as sets containing 4–12 baskets.

2.2.4. Flaking

Roasted paddy is collected in bamboo baskets and fed into an edge runner in1-2kg batches. It is then flaked for 15-60 sec, depending on the quality of flaked rice. Thin flaked rice is obtained from longer running times, i.e., for 60 sec.

Edge runners are batch type flaking machines with the capacity to flake 50, 100, and 140 kg/hr of paddy. In edge runners, the paddy is pressed in between the body of the edge runner and the flaking roller. The husk and bran come out through the perforated mesh at the base of the edge runner. The remaining husk parts and bran that continue along with the flaked rice are cleaned by manual winnowing or by using a sieve shaker. After completion of flaking, the flaked rice is scooped out by hand and collected in wide-mouthed, shallow bamboo baskets.

The flaked rice obtained from the edge runner may again be pressed and flattened in roller flakers to further reduce the thickness. The reduction in thickness is accomplished by passing the paddy through the set of rollers in sequence and pressing the flakes for further flattening. The gap between the two rollers is maintained by pressure. Different types of flakes can be produced and the end products can be categorized according to the thickness of the flakes.

2.2.5. Sieving and Packing

The flaked rice is sieved in a sieve shaker in order to separate small, broken, powdered material and lumps. The graded flaked rice is collected in heaps and turned from time to time until cool. The thick flaked rice requires drying in order to reduce the moisture content before packing. After this, the flaked rice is packed directly into gunnies or in polyethylene bags inserted in gunnies. Different packing systems are in practice, such as 5, 45, and 50 kg bags depending on the requirements of the local market and the quality and type of flaked rice. The shelf life of the thick type of flaked rice is less than the medium and thin types as it contains more moisture and undergoes less polish than the other grades.

Different types of flakes based on thickness

S.No	**Type of flakes**	**Thickness (mm)**
1	Thick	~1
2	Medium	~0.6
3	Thin	0.55-0.3
4	Very thin	<0.3

Yield of Flaked Rice

Generally 55-70% of yield is obtained in the field depending on the variety, quality of paddy, processing conditions, and the type of flaked rice processed. Different states are using different paddy varieties, such as ADT-38, CO43, IR64 and TRY1 in Tamil Nadu and IR 8, Jaya, and IR 64 in Karnataka and IR8 and Gurjari in Gujrat.

CHAPTER 3

Packaging of Puffed & Flaked Rice

3.1. Deteriorating factors

The factors influencing the quality of cereals and pulses are:

a. Physical

Physical losses are caused by spillages, which occur due to use of faulty packaging materials.

- **Loss of Crispness**

The crispness is lost due to moisture absorbed by the product. Hence, the packing material should have good barrier properties to keep away the moisture from penetrating inside. Packages for Breakfast Cereals Plastic Pouches for Breakfast Cereals

- **Mechanical Damage**

The rigidity of the packing material could save the packed product from handling damages including transport.

b. Physiological

Examples of physiological losses include respiration and heating in grains, temperature, humidity and oxygen.

- **Lipid Oxidation**

In dry breakfast cereals, lipid oxidation is one of the primary means of chemical deterioration. The grains used in breakfast cereals have high ratio of unsaturated and saturated fat, which gives rise to lipid oxidation. To minimize oxidative rancidity, it is necessary that the package excludes light. Excluding oxygen may be of limited assistance in extending the shelf-life. When a case study for storage stability of flaked oat cereal was conducted, it was found that PVC/PVDC copolymer coated with PP-LDPE performed to offer good oxygen barrier. Use of antioxidants in packing materials can increase the shelf-life of a product, but is not permitted in most countries.

- **Loss of Vitamins**

This can be a problem when certain cereals are flavoured with fruit. In such cases, loss of flavours would indicate the end of shelf-life of the cereal. Micronutrients present in cereals are not the major factor in determining the shelf-life of cereal.

c. Biological

Losses due to micro-organisms, insects, rodents, etc. The grains and pulses are low moisture commodities due to which they are less susceptible to spoilage and have greater shelf-life. The spoilage mainly occurs due to moisture absorption during storage leading to fungal growth at high temperature and humidity. Before bulk packaging and storage, the whole grains are fumigated to reduce microbial load and increase storage period.

3.2. Packaging requirements for Puffed & Flaked Rice

The following factors are to be taken into consideration while developing packaging materials for cereal and cereal products:

- Protection against environmental conditions like humidity, temperature, etc
- The packaging material should be able to withstand mechanical hazards during transportation and facilitate stacking several tiers high so as to optimize the use of available space
- To protect the contents from spillage
- To protect the contents from insect infestation
- To protect from external odour
- Easy to handle
- Economical and easily available

3.3. Packaging materials for Puffed & Flaked Rice

Owing to the changing food habits of people, cereal products like breakfast cereals, weaning food have acquired lot of importance in the diet of Indian consumers. The packaging of these products are discussed here.

Breakfast Cereals

Breakfast cereals made from both “whole” grains and milled grains, are served hot and cold and may be previously cooked or uncooked.

Ready to eat breakfast cereals are classified as flaked products, puffed products, shredded products and granulated products. They are low moisture products, crispy in nature and fortified with essential nutrients. Hence, the packaging material requirement includes the high moisture barrier properties and retention of nutrients throughout the storage period. Hot breakfast cereals are made from whole grains and must be cooked before eating.

By extruding and expanding through different dies and with varying toasting and healing temperatures a variety of different products like puffed rice, shredded and flaked wheat, puffed and toasted oats are obtained. Flavours are also added using synthetic sweetener.

The shelf-life of the breakfast cereal depends on the quality of oil contained in them. Rice cereal having low oil content of 1.5 – 2% have comparatively long shelf-life to cereals made from oats where the oil content in the product is about 4 – 11%.

Packaging Materials

Other packaging material that is used include

- 15µ BOPP/200 gauge LDPE laminate
- 12µ metallised polyester/200 gauge LDPE laminate The above laminates are less expensive as compared to the carton pack.

CHAPTER 4

Food Safety Regulations and Standards

According to the FSSAI standards,

2.4.6 Food grains:

1. Food grains meant for human consumption shall be whole or broken kernels of cereals, millets and pulses. In addition to the under-mentioned standards to which foodgrains shall conform, they shall be free from Argemone, Maxicana and Kesari in any form. They shall be free from added colouring matter.

	Parameter	Limitations
1.	Moisture	Not more than 14 per cent by weight (obtained by heating the pulverised grains at 130oC133oC for two hours).
2.	Foreign matter (Extraneous matter)	Not more than 1 per cent. by weight of which not more than 0.25 per centBy weight shall be mineral matter and not more than 0.10 per cent. by weight shall be impurities of animal origin.
3.	Other edible grains	Not more than 6 per cent by weight
4.	Damaged grain	Not more than 6.0 per cent by weight including kernel bunt afected grains and got affected grains The limit of kernel bunt affected grains and ergot affected grains shall not exceed 3.0 per cent and 0.05 percent by weight, respectively
5.	Weevilled grains	Not more than 10 per cent by count
6.	Uric acid	Not more than 100 mg. per kg
7.	Deoxynivalenol	Not more than 1000 micrograms per kilogram

2.4.6 (2-14):–

(a) "foreign matter" means any extraneous matter other than foodgrains comprising of-

(i) inorganic matter consisting or metallic pieces, sand, gravel, dirt, pebbles, stones, lumps of earth, clay and mud, animal filth and in the case of rice,

kernels or pieces of kernels, if any, having mud sticking on the surface of the rice, and

(ii) organic matter consisting of husk, straws, weed seeds and other inedible grains and also paddy in the case of rice;

(b) poisonous, toxic and/or harmful seeds - means any seeds which is present in quantities above permissible limit may have damaging or dangerous effect on health, organoleptic properties or technological performance such as dhatura (D. fasturlinn and D. stramoniumlinn), corn cokle (Agrostem magithago L, Machai Lalliumr emulenumlinn), Akra (Vicia species).

(c)"Damaged grains" means kernels or pieces of kernels that are sprouted or internally damaged as a result of heat, microbe, moisture or whether, viz., ergot affected grain and kernel bunt grains;

(d)"Weevilled grains" means kernels that are partially or wholly bored by insects injurious to grains but does not include germ eaten grains and egg spotted grains;

(e)"Other edible grains" means any edible grains (including oil seeds) other than the one which is under consideration.

6.1 Whole, broken, or flaked grain, including rice - No additives permitted

6.3 Breakfast cereals, including rolled oats Includes all ready-to-eat, instant, and regular hot breakfast cereal products. Examples include granola-type breakfast cereals, instant oatmeal, corn flakes, puffed wheat or rice or other cereals (puffed, pounded, popped) like poha, kheel, popcorn, multi-grain (e.g. rice, wheat and corn) breakfast cereals, breakfast cereals made from soy or bran, and extruded-type breakfast cereals made from grain flour or powder etc.

Food Categories or Individual Food Items where GMP Table shall not apply

29. 6.1 Whole, broken or flaked grain, including rice

Manufacturers List of Food Processing Machineries

S.no	Name of the company	Machineries
1.	Kantam International 13, B.B. Ganguly Street, "Punarnava", 1st Floor, Room 104, Kolkata, West Bengal, 700012, India	Puffed Rice Roaster
2.	Bharat Machine Tools Industries 61, Ganesh Chandra Avenue, Kolkata, West Bengal, 700013, India	Puffed Rice Roaster
3.	Growmax Machinery Mr Manish Sharma B- 42, SECTOR 58, Noida, Uttar Pradesh, 201301, India	Puffed Rice Roaster
4.	MMM buxabhoy& Co 140 Sarang Street 1st Floor, Near Crawford Market, Mumbai India Tel: +91 22 2344 2902 Fax: +91 22 2345 2532	Packaging and labelling machines
5.	Acufil Machines S. F. No. 120/2, Kalapatty Post Office Coimbatore - 641 035 Tamil Nadu India Tel: +91 422 2666108/2669909 Fax: +91 422 2666255 Email : acufilmachines@yahoo.co.in	Packaging and labelling machines
6.	Hindustan Vibro tech Pvt. Ltd. Office No. 2, Ground Floor, Vrindavan Building, Vile Parle East, Mumbai – 400057, Maharashtra, India	Sieve, shifter, screen
7.	Fry-Tech Food Equipments Private Limited S. No. 4, Raviraj Industrial Estate, Bhikhubhai Mukhi Ka Kuwa Bharwadvash, Ramol, Ahmedabad - 380024, Gujarat, India	Fryer, roaster

8.	Flour Tech Engineers Private Limited Plot No. 182, Sector 24, Faridabad - 121005, Haryana, India	Rice product machineries
9.	P Square Technologies 3, Swami Mahal, Gurunanak Nagar, Off. Shankarsheth Road Bhavani Peth, Pune - 411002, Maharashtra, India	Conveyers, mixers
10.	Ricon Engineers 10 To 13, Bhagwati Estate, Near Amraiwadi Torrent Power, Behind Uttam Dairy, Rakhial, Ahmedabad - 380023	Shifter , conveyers
11.	Gurdeep Packaging Machines Harichand Mill compound LBS Marg, Vikhroli, Mumbai 400 079 India Tel: +91 22 2578 3521/ 577 5846/ 579 5982 Fax: +91 22 2577 2846	Packaging and labelling machines
12.	Kamdhenu Agro Machinery Plot No. 6, Near Power House, Wathoda Road Wathoda, Nagpur - 440035, Maharashtra, India	Paddy processing machinery

Contact Us

National Institute of Food Technology, Entrepreneurship and Management (NIFTEM) - Thanjavur

(an Institute of National Importance under Ministry of Food Processing Industries, Government of India)

Pudukkottai Road, Thanjavur – 613005, Tamil Nadu,India

Ph: 04362-228155, Fax:04362-227971

Email: director@iifpt.edu.in Web: https://niftem-t.ac.in/