Physical Properties of Rice for Puffing

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Abstract: Puffed rice is a popular snack food product in India and has been widely produced for centuries. It has been estimated that about 10% of rice is converted into snack foods. In order to understand the rice puffing technology and to know how the different parameters influencing the puffed rice making process, the present investigation "Physical Properties of Rice for Puffing" has been under taken in the Dept. Processing and Food Engineering, College of Agricultural Engineering, UAS, Raichur during the year 2012-13.The different physical properties viz., moisture content, angle of repose, coefficient of friction, bulk density were determined. The raw parboiled rice obtained from the market is moistened to 13-14 % and kept the mass for overnight. The mass of the material after initial roasting come down to 10.5 %. In the final roasting with sand the moisture content of puffed rice was 1-2 %. The angle of repose was recorded 20.5o for IR-64 variety. The co-efficient of internal friction were recorded for IR-64 variety was 0.55. . Higher the density results in higher expansion ratio. The bulk density obtained for IR-64 variety of rice was recorded as 0.607 g/cm3.

Key words: Puffed rice, Moisture content, angle of repose, roasting, IR-64 variety and Expansion ratio.

I. INTRODUCTION

Paddy is the most important and extensively grown food crop in the World. It is one among the three leading food crops of the world, i.e., rice, wheat, and maize. Although grown practically in all continents, climates and altitudes, about 90% of the world's rice crop is grown as well as consumed in East, South-East and South Asia (1). In India, paddy has been cultivated since ancient period. South India was the first place where paddy is cultivated,whereas India and Burma are regarded as the center of origin of paddy cultivation.

Paddy is the staple food for 65% of the population in India. It is the largest consumed calorie source among the food grains. With a per capita availability of 73.8 kg it meets 31% of the total calorie requirement of the population. India is the second largest producer of rice in the world next to China. India produces annually around 93 Million Tons of paddy (2012-13). It is estimated that about 10 per cent of food grains produced in India, are lost in processing and storage. It has been reported that about 9 per cent of paddy is lost due to use of old and outdated methods of drying and milling, improper and unscientific methods of storage, transport and handling. It has been estimated that total post harvest losses of paddy at producers' level was about 2.71 per cent of total production.

Rice is belongs to *Oryza sativa L*. of Gramineae family. It is a self-pollinated crop. A complete seed of rice is called paddy and contains one rice kernel. Outer layer of rice shell is called husk. The next layer is called rice bran and the innermost part is called rice kernel.

Rice is a major source of energy and an important source of protein. The availability of nutrients per 100 g of raw white rice provides 361 kcal and 6 g of protein. It also contains substantial amounts of zinc and niacin. On the other hand, it is low in calcium, iron, thiamine and riboflavin and has virtually no beta-carotene (Vitamin A). It is noteworthy that the highest the degree of polishing, the lowest the level of proteins, vitamins and minerals in the final product (2).

Rice is primarily a high energy calorie food. The major part of rice consists of carbohydrate in the form of starch, which is about 72-75 per cent of the total grain composition. The protein content of rice is around 7 per cent. The protein of rice contains glutelin, which is also known as oryzenin. The nutritive value of rice protein (biological value = 80) is much higher than that of wheat (biological value = 60) and maize (biological value = 50) or other cereals. Rice contains most of the minerals mainly located in the pericarp and germ and about 4 per cent phosphorus. Rice also contains some of the beneficial enzymes.

Changing of lifestyles, food habits, organized food retail and urbanization are the key factors for processed foods in India. These are the post-liberalization trends and they give boost to the processing sector. There has been a notable change in consumption pattern in India. Unlike earlier, now the share and growth rates for fruits, vegetables, meats and dairy have gone higher compared to cereals and pulses. Such a shift implies a need to diversify the food production base to match the changing consumption preferences. Going by this pattern, in future, there will be demand for prepared meals, snack foods and convenience foods and further on the demand would shift towards functional, organic and diet foods.

Once milled, rice can be stored without refrigeration for over one year and consumed directly by the household with no further major transformation except simple cooking. For these reasons, rice is generally considered an “easy” food. Nonetheless, in response to new consumer needs, processing of raw rice into new products has been undertaken, with the development of instant rice, specialty a ready to serve rice value added products viz., rice flour, starch and puffed food; cakes and puddings, baked bread and crackers; breakfast cereals; rice snacks and noodles, baby/weaning foods, canned rice, instant rice, expanded rice, flaked rice, rice milk, fermented foods and beverages; pet foods and bran products etc. There are many ways of domestic use like khichadi, pulav, kheer, zeerarice, iddli, dosa etc.

Rice quality comprises its size, shape, color, aroma and milling, marketing, nutritional, cooking, eating and product making qualities. Many of these are related to the physical features and only need measurement and classification. Cooking, eating and product making qualities of rice, however, related to its different engineering parameters, the cause of effect on relations of which have remained a mystery till date (3). It is mainly consumed after cooking in water to a soft fluffy product. During cooking, it absorbs about 2.5 to 3 times its weight of water. Cooked rice cannot be preserved for more than a few hours. Hence, the cooked rice, have been developed to improve storage, and increase consumer acceptability.

The processing of puffed rice from paddy is traditionally takes about 6 days. Some of the tasks, particularly manual roasting of paddy and immersing in water, mixing the ingredients with milled rice and stirring the rice in roaster pan for uniform heating are highly labour intensive operations. Complete mechanization of the process has not yet been undertaken. Many of the rice puffing units are of the traditional type and are inefficient. Modern rice puffing machines are having high capacity and are capital intensive, although efficient.

Since marketing of products is more remunerative than raw commodities, farmer processor linkages are needed to add value as per demands of the consumers. There is a great scope of developing some of our traditional food items from cereals. Appropriate and cost-effective processing and packaging technology for these items is needed to ensure safety and prolonged shelf life. In order to understand the rice puffing technology and to know how the different parameters influencing the puffed rice making process, the present investigation on “Physical Properties of Rice for Puffing”.

Chandrasekhar and Chattopadhyay(1989) developed the pneumatic rice puffing machine for increasing the production capacity of puffed rice. The physical properties of the rice grains and other fluidization parameters, necessary for this study was experimentally determined. The surface heat transfer coefficient in case of hot air fluidized bed puffing was found to be 155.39 W/m^2K. The calculated grain surface temperature for puffing was about 170°C and this did not vary significantly for experimental puffing air temperatures ranging from 200°C to 270°C. the air temperature ranging from 240°C to 270°C with corresponding exposure time of 9.7 s to 7s was found to be optimum for higher expansion ratio (8.5 to 10) and better color of the product.The temperature differential between surface and center temperatures and between surface and average temperatures of the grains at the time of puffing were found to vary linearly with various puffing air temperatures and their ratios remained almost constant at 2.056(4).

Pordesimo*et al.*(1990) evaluated kernel dimensions/sphericity, kernel size and specific gravity of popcorn as indicators of popping characteristics of microwave popcorn. Expansion volume correlated positively with sphericity whereas there was poor correlation between sphericity and unpopped kernel ratio. Smaller, shorter and broader kernels had a higher sphericity and such kernels had higher expansion volume. Unpopped kernel ratio decreased with increasing kernel size when popped in a microwave oven. Specific gravity of kernels had a significant effect on expansion volume and flake size, but not on unpopped kernel ratio. Expansion volume increased with increasing specific gravity. Flake size increased up to specific gravity of 1.350 to 1.370 and then leveled off(5).

Srivastava and Batra(1998) studied relationship between physical properties and popping qualities of various genotypes of foxtail millet, finger millet, barnyard millet and pros millet. Significant differences in puffing yield of various genotypes of above mentioned millets were observed. Of all the millets, the highest popping yield (92.77%) and expansion volume (6.51) were observed for proso millet followed by finger millet, foxtail millet and barnyard millet. Foxtail millet revealed significant positive correlations between 1000-kernel weight and popping per cent; 1000 kernel weight and expansion volume; 1000-kernel volume and expansion volume. Finger millet showed significant positive correlations between hydration capacity and popping per cent and between per cent floaters and expansion volume (6).

Madhuri(2002) studied physical and chemical characteristics of fifteen rice varieties and were evaluated for popping and puffing qualities. The rice varieties showed a wide significant variation for Physico-chemical and processing qualities. Grain dimensions, L: B ratio, thousand kernel weight, volume and bulk density were strongly related to processing quality of rice varieties. The optimum total amylose content 27.60 per cent and 13.40 percent hot water insoluble amylose of rice variety were found to be the best combination for better expansion of puffed and popped rice. Intan, a commercial cultivar showed superior puffing and popping qualities over the newly developed rice varieties (Prasanna, MTU-1001, Mugadbasumati, and Pusa-basumati) as well as earlier varieties (Dodiga, Udarsali, Navali etc.)(7).

II. MATERIALS AND METHODS

This chapter deals with the approach followed to accomplish the objectives of the present study. The materials used and methodology adopted for the "Comparative study of manual and mechanical rice puffing methods" are discussed in this chapter under the following major headings *viz*., physical parameters of rice, process of rice puffing methods and performance evaluation of rice puffing methods.

Raw materials

The raw materials of parboiled rice of variety IR-64 were procured from different puffing units of M/S. Govinda Reddy and M/S. Brahmananda, Raichur for conducting physical properties.

Physical properties of rice

The collected raw materials were stored in the suitable conditions till the further evaluation. The different physical properties viz., moisture content, angle of repose, coefficient of friction, bulk density were determined. The details of the procedure to measure the above parameters were explained in the following sub sections.

Moisture content

Moisture content of rice is an important parameter which has direct impact on puffing process. The moisture content of rice was measured by gravimetric method. 50 g of sample were weighed and put in the empty weighed moisture box, the weight of rice with box were recorded. The moisture box is kept in hot air oven at 105°C ± 2 °C for 24 hours. After 24 hours the weight of the moisture box with rice is measured. The moisture content of rice can be measured by using the following formula (8).

$$M_w = (M_2-M_3) / (M_2-M_1)$$

Where, M_w= Moisture content, % (w.b) ; M_1= weight of moisture box, g; M_2= weight of moisture box + paddy before drying, g; M_3= weight of moisture box + paddy after drying, g.

Angle of repose

Angle of repose of rice is required to design hopper for mechanical rice puffing unit for proper feeding. The angle of repose of rice can be measured by using cylinder having circular opening mounted on stand at certain height. The rice is filled in the cylinder and the valve is opened. The rice falls freely on the horizontal surface forming a shape of inverted cone. The natural angle of repose is formed between the horizontal surface and inclination of heap. This angle is measured. The angle of repose depends upon moisture content and variety of the rice (9).

$$\text{Angle of repose} = \tan^{-1} \frac{2\,(\text{height of the cone} - \text{height of the platform})}{\text{diameter of the platform}}$$

Coefficient of friction

Coefficient of friction of rice is required to design of hopper for mechanical rice puffing unit and uniform feeding of the rice. Coefficient of friction is equal to tangent of angle of internal friction. Consider a sliding mass of grains kept in a container and the container has no bottom. This container is placed over a horizontal plane and is pulled by using some weight. The weight at which the box starts sliding is noted. If 'F' is the horizontal force or pull required to move the box and 'N' is the vertical force caused by the weight of grain. Then the coefficient of friction μ is calculated by using the following formula (9).

$$\mu = F/N$$

Where, μ = Co-efficient of friction; F = Horizontal force, kg/m^2; N = Vertical force, kg/m^2

Bulk density

Bulk density of rice is required to design of hopper capacity for holding the rice for uniform feeding. Density is defined as mass per unit volume. The rice is filled in a pan of unit volume without any compaction. After completely filling the pan with rice, the wooden striker is placed on the edge of pan and with gentle stroke the extra rice is removed. The rice present in the pan is weighed and noted. The density of the rice can be calculated by using the following formula (9).

$$\rho = m/v$$

Where, ρ = density of paddy, g/cc; m = mass of paddy in pan, g; v = volume of pan, cc

III. RESULTS AND DISCUSIONS

Physical properties of rice

Results pertaining to the physical properties of rice which affect the puffing operations such as production and quality of puffed rice are considered. Some of the properties considered are moisture content, angle of repose, coefficient of friction, and bulk density. The details of the physical properties are given below table.

Moisture content

Moisture content of rice is one of the important parameter which affect the quality of puffed rice. In puffing technology moisture content is a critical factor that has to be monitored in 3 stages i.e. Initial moisture content of raw rice, conditioning of rice and roasting. The raw parboiled rice obtained from the market is moistened to 13-14 % and kept the mass for overnight. The mass of the material after initial roasting come down to 10.5 %. In the final roasting with sand the moisture content of puffed rice was 1-2 %.

Angle of repose

The angle of repose of rice is an important physical property which helps in the design of different hopper capacity. The angle of repose was recorded 20.5^o for IR-64 variety. The angle of repose is depends on the moisture content of grains.

Co-efficient of friction

This property is also an important one in the design of hopper especially the selection of construction material. The co-efficient of internal friction were recorded for IR-64 variety was 0.55.

Bulk density

Bulk density of the agricultural produce plays an important role in many engineering applications such as design of post-harvest as well as processing equipments. In puffing operation, the volume of puffing is depends on the bulk density of rice. Higher the density results in higher expansion ratio. The bulk density obtained for IR-64 variety of rice was recorded as 0.607 g/cm^3.

Table.1Physical properties of rice

SL.No.	Description	Manual	Mechanical
1	Moisture content of raw rice, %	14	14
2	Moisture content of rice in conditioning, %	25	25
3	Moisture content of rice in roasting, %	10.5	10.5
4	Moisture content of puffed in puffing, %	1-2	1-2
5	Angle of repose, ^{o}	20.5	20.5
6	Co-efficient of friction	0.55	0.55
7	Bulk density, g/cm^3	0.607	0.607

Fig.1 IR-64 variety of paddy

IV. SUMMARY AND CONCLUSION

The details of the experiment are pertaining to physical properties of the rice, comparison of manual and mechanical methods and evaluation of manual and mechanical machines are listed as follows. The physical properties of moisture content, angle of repose, coefficient of friction, and bulk density of IR-64 variety is 13-14%, 20.5^o, 0.55 and 0.607 g/cm^3, respectively. The physical properties is depends upon the moisture content of the grains and it is directly proportional to the puffing quality.

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