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Research Article

COMPARATIVE STUDY ON PUFFING CHARACTERISTICS OF SOME POPULAR RICE VARIETIES OF CHHATTISGARH

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Abstract: The puffed rice is a whole grain puffed product prepared from pregelatinized (parboiled) rice. The parboiled rice was first cleaned and conditioned with salt solution to get moisture content of 11% (wb) and salt concentration of 1% (w/w). The pre-treated parboiled rice then puffed in hot sand (185-190°C) for sort time (14-17 s). The puffing characteristics of three popular rice varieties namely Swarna, Mahamaya and IR-1010 were studied and compared. The average values of moisture content of puffed rice were found 1.23, 1.22 and 1.27% (wb) for Swarna, Mahamaya and IR-1010 rice varieties, respectively. The different puffing characteristic for Swarna, Mahamaya and IR-1010 rice varieties were found as; Volume Expansion Ratio (VER) 7.30, 7.47 and 7.25; Bulk Density 0.125, 0.121 and 0.124 g/cm^3; Hardness 10.98, 10.83 and 10.95 N; Crispness 84.37, 86.33 and 81.19 number of fractures; Whiteness Index (WI) 39.29, 39.75 and 37.68; and Puffing Efficiency (PE) 92.62, 93.01 and 92.02%, respectively. On comparing the various puffing properties of all the three rice varieties only crispness and whiteness index were varying significantly, at the level of 5%. The sensory attributes do not show any significance difference among the puffed rice produces from these three varieties.

Keywords: *Number of fractures, Whiteness Index, Puffing Efficiency, Volume Expansion Ratio*

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Introduction

Puffed rice is one of the simple and low-cost cereal snack food prepared from parboiled rice widely consumed in different parts of the world due to its ready-to-eat (RTE) lighter and crispy characteristics. In general, puffed rice is prepared from parboiled rice by puffing it over hot sand or salt bed for short time. It is consumed as such as puffed rice and used in the preparation of varieties of recipes like Bhelpuri, Jhalmuri, coated with jaggery or other sweeteners, flavored with spices etc. Puffed rice has also gained popularity among the health-conscious consumers due to its lower calorie as compare to other fried snack foods [1]. In some of the countries it finds uses in the preparation of RTE value added products like puffed rice balls, bars, confectioneries, and sweets with jaggery or other sweeteners. Further, due to changing life style and food habits due to dynamic work culture, the use of RTE is increasing day-by-day and the popularity of products like puffed and popped from cereals are increasing.

Though a large number of rice cultivars are available, people prefer only certain varieties for puffing. Only a limited amount of work has been done to study the puffing characteristics of different rice varieties; hence, this study was undertaken to provide useful information to machine manufacturers, puffed rice processors and end users about the puffing characteristics of three popular rice varieties commonly used for production of puffed rice in the Chhattisgarh state.

Materials and Methods

Raw Materials

Three popular varieties of parboiled rice commonly used for the preparation of puffed rice namely Swarna, Mahamaya and IR1010 were procured from the local market of Raipur (Chhattisgarh) for preparation of puffed rice.

Rice Puffing

The procured parboiled rice was cleaned and conditioned by adding salt solution to get 11% (wb) moisture content and 1% (w/w) salt concentration. The conditioned rice was puffed by rice puffing machine at 185-190°C for 14-17 seconds. The puffing characteristics of developed puffed rice from three different varieties were analyzed and compared. The complete process flow chart for the preparation of puffed rice is shown in [Fig-1].

Puffing Characteristics

Product moisture

Moisture content of puffed rice samples was determined following the standard oven drying method (AOAC, 2010). Moisture content was calculated using the following expression.

Moisture content (% wb) = (Initial weight of sample (g)- Final weight of sample (g))/(Initial weight of sample (g)) × 100

Volume expansion ratio

The volume expansion ratio is the ratio of volume of puffed rice to volume of parboiled rice. It was determined by measuring the volumes of puffed rice and parboiled rice of known equal quantities and calculated using following formula [3].

Volume expansion ratio = Volume of 50 g puffed rice (ml)/Volume of 50 g parboiled un-puffed rice (ml) "

Bulk density

The bulk density estimates how light the products are after being puffed. It is the ratio of mass of the puffed rice sample to its total volume. Bulk density was determined by measuring the weight of a known volume of the puffed rice sample. The weight of the sample was divided by volume and is expressed in g/cm^3 [10].

Bulk density (g /cm³) = Mass of puffed rice (g) /(Volume of puffed rice (cm³))

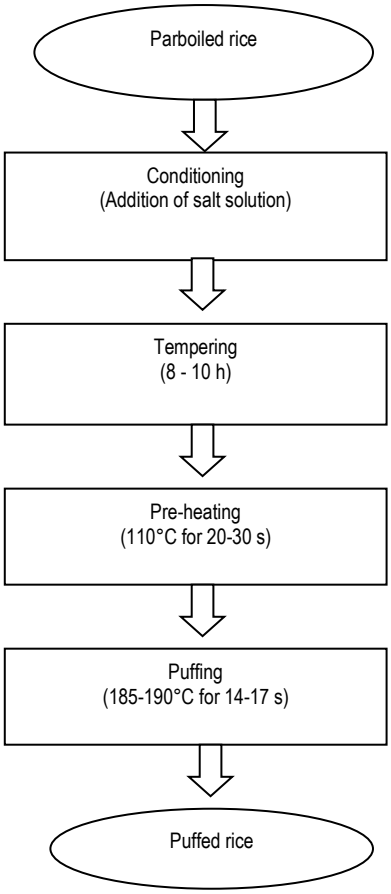

Fig-1 Preparation of puffed rice using rice puffing machine

Texture analysis

The textural properties (hardness and crispness) of puffed rice samples were evaluated by texture analyser (TA-HD Plus, Stable Micro System, UK). A single compression force time graph was used to compress single rice grain along the thickness and the parameters setup for texture analyser were; pre-test speed 0.10 mm/s, test speed 0.5 mm/s, post-test speed 10.0 mm/s, strain 70%, testing force 0.05 N with a setup of return to its original position. A single grain was compressed using a stainless steel (P/5) probe with a diameter of 5 mm. The sample's hardness was determined by the peak force of the force-time curve. The probe for the determination of textural properties was selected as [11] for analysis of hardness of popped brown rice.

Fig-2 Stable Micro System TA-HD plus Texture Analyzer

Fig-3 Cylindrical probe P/5 in position

Hardness

Hardness is the prime textural property of the puffed product which determines its acceptability. Hardness of the sample was determined by crushing method using Texture Analyzer [Fig-2] with P/5 probe [Fig-3]. The peak force indicated by the force time curve [Fig-4] was taken as the hardness of the sample.

Crispness

Crispness is the number of positive peaks obtained from the force versus time curve [2]. It was determined in similar method as used for determination of hardness. To measure the crispness, a macro-region was specified which helped in making the count of the number of positive peaks during the compression test through the force-time deformation curve [14], [16].

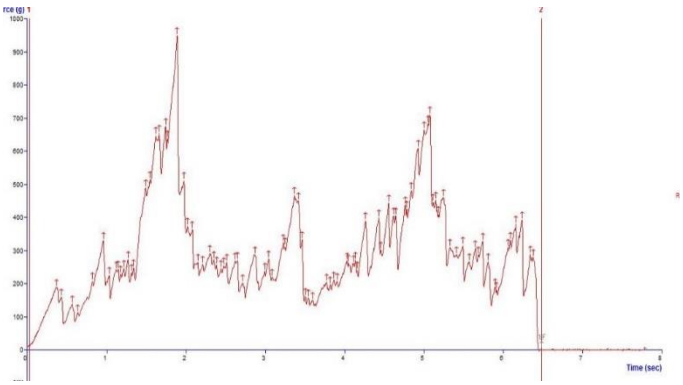

Fig-4 Force time curve

Whiteness index

The whiteness index of the puffed rice was measured using a Hunter colour lab colour -flex calorimeter [Fig-5]. The colour readings were recorded in terms of L, a and b values. The samples of puffed rice were directly filled into the transparent sample cup previously wiped with a clean tissue paper. Whiteness index was calculated by putting the values of L, a and b in the following equation [7], [8].

$WI = 100 - \sqrt{((100-L)^2 + a^2 + b^2)}$

Where,

WI-Whiteness index

L-Represent the light-dark spectrums

a-Represents green-red spectrums

b-Represents blue-yellow spectrum

Fig-5 Measurement of colour by Hunter colour Lab colour-flex calorimeter

Puffing efficiency

Puffing efficiency is important parameter to evaluate the performance of puffing process. Puffing efficiency measures the quantity of grain fully puffed out of raw grains used for puffing. Puffing efficiency is calculated as weight percentage of puffed grains to the sum of total weight of puffed, semi-puffed and un-puffed grains and expressed in percentage [12], [15], [17]. The analysis is performed in three replications and average was recorded.

Puffing efficiency = Weight of puffed grains in sample (g) / Total weight of the sample (g) × 100

Results and Discussion

The puffing characteristics of three popular rice varieties were studied. The puffed rice was manufactured by three runs of puffing for all the three rice varieties and two representative samples were collected from each run and mean values of six samples results were used for the analysis and comparison. The details of the results on puffing characteristics of different rice varieties are given in [Table-1] and briefly discussed. The puffed rice produced from the three popular rice varieties is shown in [Fig-2].

Fig-6 Puffed rice prepared from different varieties

Product moisture

Puffed rice was found to have a moisture content that varied between 1.11 to 1.30% (wb). The variation in puffed rice moisture content (%, wb) for Swarna (1.11 to 1.29), Mahamaya (1.18 to 1.25) and IR-1010 (1.25 to 1.30) as given in [Table-1]. The mean moisture content was found maximum for IR-1010 (1.27%, wb) followed by Swarna (1.23%, wb) and minimum for Mahamaya (1.22%, wb) as shown in graph [Fig-3]. Statistical analysis shows that there is no significant variation in the moisture content of puffed rice produce from different varieties.

Volume expansion ratio

The volume expansion ratio, an important indicator for puffed products, has been found to vary from 7.04 to 7.57; however, the mean value of volume expansion ratio for different varieties of puffed rice was shown in [Fig-8]. The maximum value of volume expansion ratio was obtained for Mahamaya (7.47) followed by Swarna (7.30) and minimum for IR-1010 (7.25). The volume expansion ratio for puffed rice varieties varied as Swarna (7.19 to 7.71), Mahamaya (7.41 to 7.57) and IR-1010 (7.04 to 7.37) The statistical analysis shows that there is no significant difference in volume expansion ratio of puffed rice produce from different varieties.

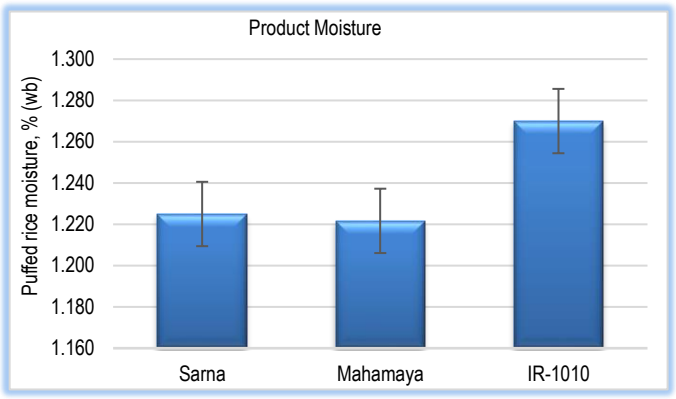

Fig-7 Variation in puffed rice moisture content of different varieties

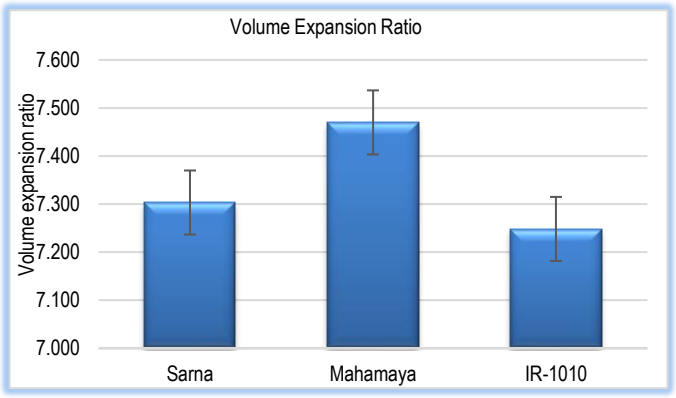

Fig-8 Variation in puffed rice volume expansion ratio of different varieties

Bulk density

The bulk density of puffed rice was observed to vary between 0.112 to 0.136 g/cm³, while the mean values were 0.125, 0.121, and 0.127 g/cm³ for Swarna, Mahamaya, and IR-1010 puffed rice, respectively as shown in graph [Fig-9] *i.e.*, maximum for IR-1010, minimum for Mahamaya and moderate for Swarna. The variation in bulk density for Swarna (0.116 to 0.131), Mahamaya (0.112 to 0.126) and IR-1010 (0.118 to 0.136) as given in [Table-1]. The statistical analysis shows that there is no significant difference in bulk density of the puffed rice of the three rice varieties.

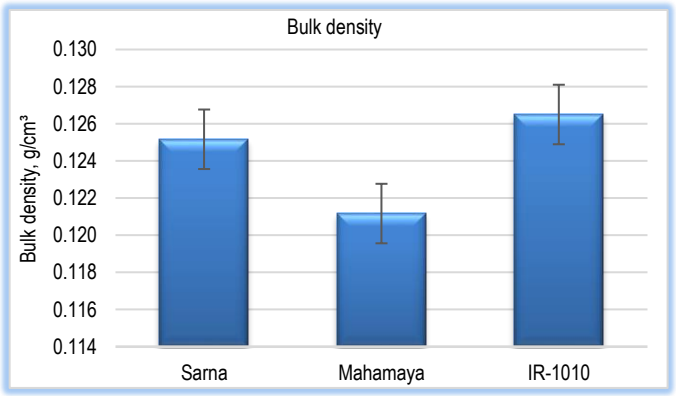

Fig-9 Variation in bulk density of puffed rice with respect to different varieties

Hardness

The hardness of puffed rice varied between 10.54 to 11.46 N. The variation in hardness for different varieties of puffed rice; for Swarna (10.64 to 11.42), Mahamaya (10.54 to 11.21) and IR-1010 (10.58 to 11.46) as given in [Table-1]. The mean hardness values were found maximum for Swarna (10.98) followed by IR-1010 (10.95) and minimum for Mahamaya (10.83) as shown in graph [Fig-10]. Statistical analysis shows that the hardness of the puffed rice are same across all the three varieties, *i.e.*, no significant difference at the level of 5%.

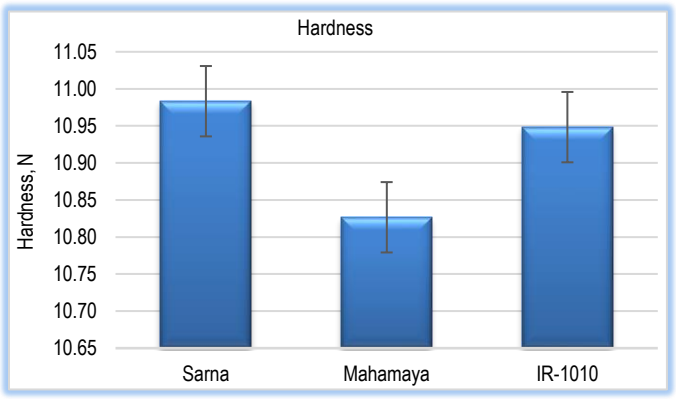

Fig-10 Variation in puffed rice hardness of different varieties

Crispness

The range of puffed rice crispness was found to be between 78.66 and 87.37. The variations in crispness for different varieties of rice for Swarna (82.27 to 85.42), Mahamaya (85.05 to 87.37), and IR-1010 (78.66 to 84.36) as given in [Table-1]. The mean crispness for Swarna, Mahamaya, and IR-1010 were recorded 84.37, 86.33, and 81.19, respectively [Fig-11]. Statistically, there were significant differences in crispness of puffed rice produced from three varieties at the level of 5%. This could be a result of the rice's varietal characteristics. However, manual perceptiveness on crispness is not clearly noticeable.

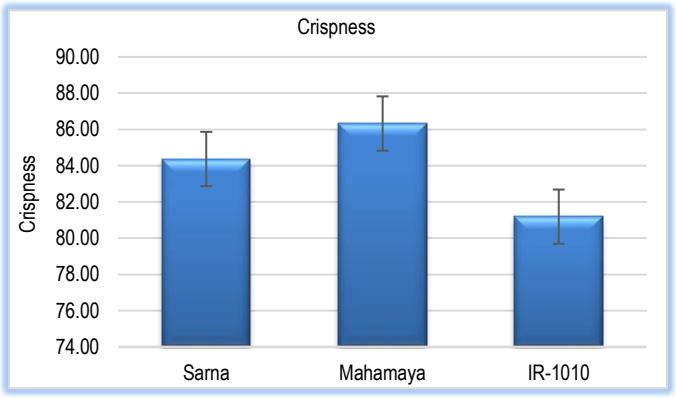

Fig-11 Variation in puffed rice crispness of different varieties

Whiteness index

The whiteness index of puffed rice was observed to vary between 36.25 to 40.88. The variation in puffed rice whiteness index for Swarna (38.62 to 40.88), Mahamaya (38.72 to 40.69), and IR-1010 (36.25 to 38.85) as given in [Table-1]. The mean whiteness index was found maximum for Mahamaya (39.75) followed by Swarna (39.29) and minimum for IR-1010 (37.68) as shown in graph [Fig-12]. According to statistical analysis, there are appreciable differences in whiteness index among the varieties at the level of 5%. This may be due to the varietal characteristics of the rice.

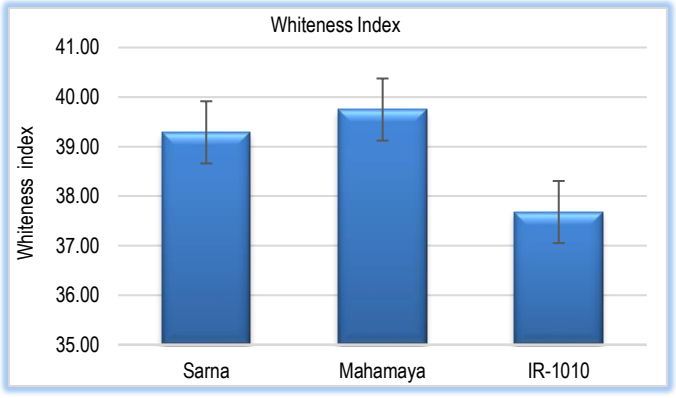

Fig-12 Variation in puffed rice whiteness index of different varieties

Puffing efficiency

The puffing efficiency of puffed rice was observed to vary between 91.35 to 93.78%; for Swarna (91.75 to 93.54%), Mahamaya (9190 to 93.78), and IR-1010 (91.35 to 92.59) as given in [Table-1]. The maximum average value of puffing efficiency was observed for Mahamaya (93.01%), followed by Swarna (92.62%), and the minimum value for IR-1010 (92.02%). The statistical analysis shows that there is no significant difference in the puffing efficiency between the different varieties of puffed rice produced.

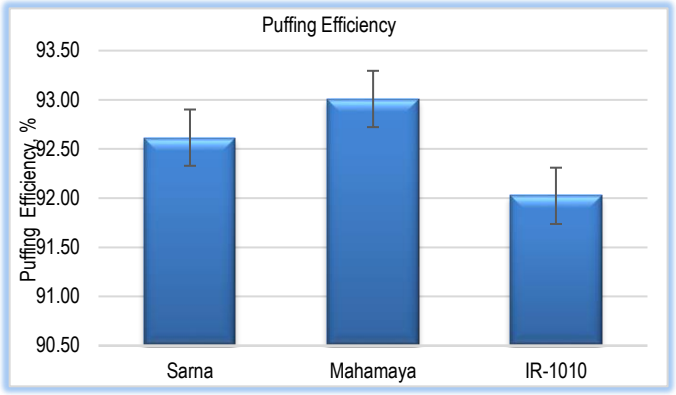

Fig-13 Variation in puffed rice puffing efficiency of different varieties

It is evident that the puffing characteristics like moisture content, volume expansion ratio, bulk density, hardness and puffing efficiency are found similar to each other of puffed rice prepared from the three rice varieties. However, it was found that the crispness and whiteness index found to be distinct from one another, which are directly related to rice varietal characteristics.

Conclusion

Parboiled rice of popular rice varieties namely Swarna, Mahamaya and IR-1010 prepared by the rice millers for production of puffed rice and commonly used by the processors for the production of puffed rice. In the study the puffed rice manufactured by rice puffing machine at 185-190°C by three rice varieties and puffing characterizes were studied. The mean puffing characteristics were found as: product moisture 1.23, 1.22 and 1.27% (wb), volume expansion ratio 7.30, 7.47 and 7.25, bulk density 0.125, 0.121 and 0.127 g/cm^3, hardness 10.98, 10.83 and 10.95 N, crispness 84.37, 86.33 and 81.19, whiteness index 39.29, 39.75 and 37.68, and puffing efficiency 92.62, 93.01 and 92.02% for Swarna, Mahamaya and IR-1010 rice varieties, respectively. On comparing the puffing characteristics of puffed rice prepared from three varieties, it was found that puffing characteristics like moisture content, volume expansion ratio, bulk density, hardness and puffing efficiency are found to be similar. While the crispness and whiteness indices were found different from one another, statistically at the significant level of 5%. The sensory qualities of puffed rice produced did not vary significantly.

Application of research: The study provides useful information to machine manufacturers, puffed rice processors and end users about the puffed rice characteristics of some popular rice varieties used for puffing.

Research Category: Agricultural Processing and Food Engineering

Abbreviations: wb-Wet basis , RTE-Ready-to-Eat
L-Represent the light-dark spectrums, a -Represents green-red spectrums
b-Represents blue-yellow spectrum, w/w-Weight by weight

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Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Chhattisgarh, India

Cultivar / Variety / Breed name: Swarna, Mahamaya, IR-1010

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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