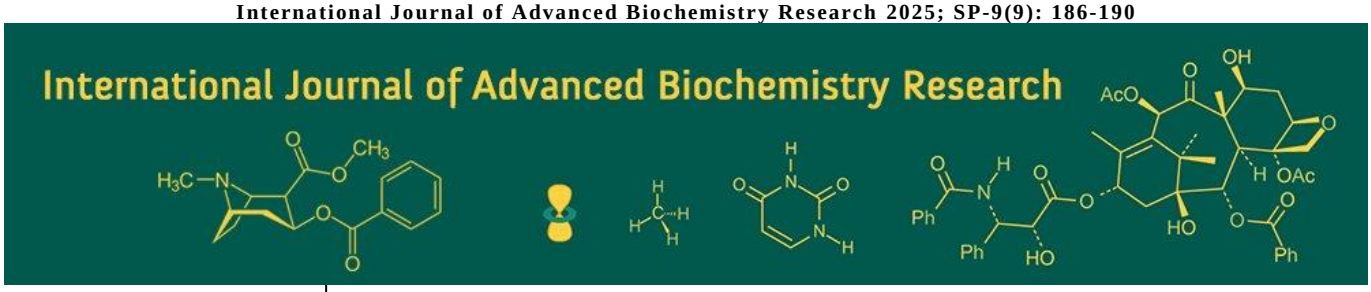

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Standardization of method for development of popped, flaked and puffed rice from newly released paddy varieties of JNKVV, Jabalpur

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Abstract
The study focuses on the standardization of methods for producing flaked, popped, and puffed rice from newly released paddy varieties developed by the Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur. The primary objective was to optimize the processing conditions to enhance the quality and yield of these value-added rice products. Various processing parameters, such as soaking duration, roasting temperature, and pressure application, were systematically evaluated for different paddy varieties. The results demonstrated significant variations in the physical properties and sensory characteristics of the rice products based on the paddy variety and processing conditions. The study concludes with recommended protocols for each paddy variety, providing a foundation for commercial production and further research into the nutritional and economic benefits of these rice products.

Keywords: Flaked, popped, puffed, roasting, optimization

Introduction
Rice is one of the most important staple foods worldwide, particularly in Asia, where it serves as a primary source of calories for a large segment of the population. Beyond its conventional use as cooked rice, various value-added rice products, such as flaked, popped, and puffed rice, have gained popularity due to their unique textures, flavours, and versatile applications in both traditional and modern cuisines (Juliano, 1985) [5]. The production of these rice products involves specific processing techniques, such as flaking, popping, and puffing, each of which significantly impacts the final product's quality, nutritional content, and consumer acceptability (Bhattacharya & Kundu, 1987) [4].

The development of new paddy varieties by agricultural research institutions, such as Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), presents an opportunity to enhance the production of these value-added products. However, the processing conditions for these newly developed varieties must be standardized to ensure the desired product quality and yield. This standardization is essential not only for optimizing the use of these new paddy varieties but also for improving the economic viability of rice-based food products (Singh *et al.*, 2005) [8].

This study aims to standardize the methods for developing flaked, popped, and puffed rice from newly released paddy varieties by JNKVV. By optimizing the processing parameters such as soaking, roasting, and pressure application, this research seeks to establish protocols that maximize product quality and yield, thereby supporting the commercialization of these rice varieties and contributing to the diversification of rice-based food products in the market.

Materials and Methods
Materials
Paddy Varieties
Newly released paddy varieties developed by Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur, were selected for this study. These varieties were specifically chosen based on their unique physicochemical properties, which were anticipated to influence the quality of the flaked, popped, and puffed rice. The selected varieties included Kranti, JR-206, IR-36, JRH-19, JRH-10, JRH-5 and JRH-8.

Chemicals and Reagents
All chemicals and reagents used in the study, including sodium chloride, calcium hydroxide, and other food-grade processing aids, were of analytical grade and procured from.

Equipment
The equipment used in the study included a laboratory-scale flaking machine, hot air oven, pressure cooker, puffing gun, and moisture analyzer (Juliano, 1985; Bhattacharya & Kundu, 1987) [4, 5]. These tools were calibrated prior to the experiments to ensure accuracy and consistency in the results.

Methods
Pre-processing of Paddy
Cleaning and Drying: The harvested paddy was cleaned to remove impurities and foreign materials. It was then sun-dried to reduce the moisture content to approximately 12-14%, a level suitable for processing (Singh *et al*., 2005) [8].

Soaking: The dried paddy was soaked in water at room temperature for 4-6 hours. This step aimed to soften the grains, making them pliable for subsequent processing (Bhattacharya, 2011) [3].

Development of Flaked Rice
Steaming: The soaked paddy was steamed at 100 °C for 20 minutes to gelatinize the starch. This step was crucial for achieving the desired flake texture (Bhattacharya & Kundu, 1987) [4].

Flaking: The steamed paddy was then passed through a flaking machine to produce rice flakes. The thickness of the flakes was controlled by adjusting the roller gap in the flaking machine to achieve a thickness of 1-2 mm.

Drying: The rice flakes were dried in a hot air oven at 60 °C for 2 hours to reduce the moisture content to less than 10%, ensuring shelf stability (Juliano, 1985) [5].

Development of Popped Rice:
Roasting: The soaked and partially dried paddy was roasted at 250 °C for 10-15 seconds in a sand medium. The roasting temperature and time were optimized to ensure even popping without burning the grains (Singh *et al*., 2005) [8].

Separation of Popped Rice: After roasting, the popped rice was separated from the sand using a sieve. The yield and expansion ratio of the popped rice were recorded.

Development of Puffed Rice
Pressure Cooking: The soaked paddy was pressure cooked at 15 psi for 10 minutes to further gelatinize the starch and make the grains more amenable to puffing (Bhattacharya, 2011) [3].

Puffing: The pressure-cooked rice was subjected to sudden pressure release using a puffing gun at 200 °C. The rapid expansion of the grains was observed, and the puffed rice was collected for further analysis.

Drying: The puffed rice was dried at 50 °C for 1 hour to remove excess moisture and improve texture and crispiness.

Quality Analysis
Recovery of prepared rice products
After processing the popped, flaked and puffed rice were thoroughly cleaned for husk and bran. The cleaned rice products were separated into whole and broken as suggested by Kumar *et al*., (2018) [6].

Results and discussion
The findings of the investigation conducted to ascertain the different quality features (physical, chemical, and functional) of each of the seven paddy varieties-Kranti, JR-206, JR-10, JRH-8, JRH-5, JRH-19, and IR-36-are covered in this chapter. Using all kinds, several products, including popped rice, flaked rice, and puffed rice, were created, and the qualities of the finished goods were assessed as well. The investigation's findings are categorised under several categories and subheads, and tables 4.1 to 4.50 give the statistical analysis of the data collected for the various quality attributes.

Standardization of process parameters for development of popped rice
The optimization of process parameters for popped rice production was assessed by testing two levels of moisture content (16% and 18%) and two roasting temperatures (220 °C and 240 °C). Four treatment combinations (T_1, T_2, T_3, and T_4) were evaluated, with T_2 emerging as the optimal combination, producing the best quality popped rice based on physical, chemical, functional, and other relevant quality attributes.

Table 1: Treatment combination of different paddy varieties for development of popped rice

S. No.	Treatments	Combination	Treatment Description
1.	T_1	M_1T_1	16% moisture and temperature 220 °C
2.	T_2	M_1T_2	16% moisture and temperature 240 °C
3.	T_3	M_2T_1	18% moisture and temperature 220 °C
4.	T_4	M_2T_2	18% moisture and temperature 240 °C

Recovery percentage of popped rice
The recovery percentage of popped rice is presented in Table 2 and Fig. 1. The results indicated that the popping quality was significantly influenced by the variety of rice used. The JRH-19 variety recorded the highest husk and bran percentage at 24.21%, while the lowest was observed in the Kranti variety at 22.13%, which was statistically comparable to JRH-5, followed by JRH-8 and JR-206. Kranti also exhibited the highest total popping percentage at 77.87%, whereas the JRH-10 variety had the lowest at 75.95%, statistically similar to JR-10. The percentage of unpopped rice was highest in the JRH-8 variety at 3.21% and lowest in the JR-206 variety at 2.05%, with the latter being statistically comparable to IR-36, followed by JRH-5, JRH-19, and JR-10. The expansion ratio is a measure to determine the popping quality whereas the amount of popping is primarily determined by the temperature and moisture. The findings of present investigation are in conformity with the reported results of Swarnakara *et al*., (2014) [9].

Table 2: Recovery percentage of popped rice

Parameters	Kranti	JR-206	JR-10	JRH-8	JRH-5	JRH-19	IR-36	CD @ 5%	Sem±
Husk & Bran%	22.13	23.45	22.52	23.59	24.05	24.21	23.12	1.06	0.35
Total popping%	77.87	76.55	77.48	76.41	75.95	75.79	76.88	1.08	0.36
Un-popped rice%	2.11	2.05	2.85	3.21	3.12	3.04	3.15	0.45	0.15
Recovery%	75.76	74.63	74.50	73.20	72.83	72.75	73.73	1.75	0.58

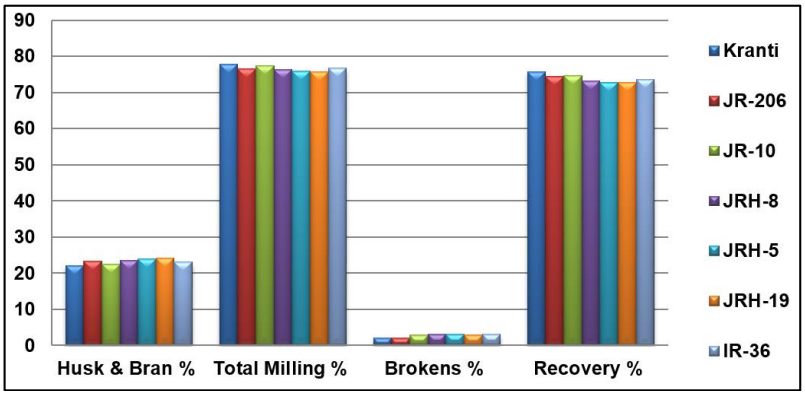

Fig 1: Recovery percentage of popped rice

Standardization of process parameters for development of flaked rice

The optimization conditions for flaked rice production were evaluated by testing two levels of soaking time and roasting temperatures (180 °C and 200 °C), along with four treatment combinations (T_1, T_2, T_3, and T_4). Among these, the T_2 treatment produced the highest quality flaked rice, as determined by various physical, chemical, functional, and other quality attributes in the preparation process.

Table 3: Treatment combination of different paddy varieties for development of flaked rice

S. No.	Treatments	Combination	Treatment Description
1.	T_1	S_1T_1	12 hr Soaking time and 140 °C
2.	T_2	S_1T_2	12 hr Soaking time and 160 °C
3.	T_3	S_2T_1	15 hr Soaking time and 140 °C
4.	T_4	S_2T_2	15 hr Soaking time and 160 °C

Recovery percentage of flaked rice

The recovery percentages for flaked rice are detailed in Table 4 and Fig. 2. The data indicate that the variety of rice used had a significant impact on flaking quality. The JR-10 variety exhibited the highest husk and bran percentage at 26.34%, while the Kranti variety showed the lowest percentage at 25.20%, which was significantly lower than that of the JRH-19 variety. The Kranti variety also had the highest total flaking percentage at 74.8%, whereas the JR-10 variety recorded the lowest at 73.66%, a value statistically comparable to JR-206 for total flaking percentage. The JRH-19 variety had the highest percentage of broken flakes at 12.49%, while the Kranti variety had the lowest at 7.53%, with significantly higher broken percentages observed across all other varieties. Flaking is an efficient processing parameter for converting paddy into a value-added product due to the recovery percentage, which would be significant compared with that of rice milling, and relative lower losses when compared to milling. The results of the current investigation agree with those published by Bandara *et al*., (2007) [2] and Shankara *et al*., (1984) [7].

Table 4: Recovery percentage of flaked rice

Parameters	Kranti	JR-206	JR-10	JRH-8	JRH-5	JRH-19	IR-36	CD @ 5%	Sem±
Husk & Bran%	25.20	25.45	26.34	25.74	25.65	26.09	26.12	0.44	0.14
Total flaking%	74.80	74.55	73.66	74.26	74.35	73.91	73.88	0.44	0.14
Brokens %	7.53	8.75	10.31	11.60	11.34	12.49	11.30	0.73	0.24
Recovery %	67.27	65.80	63.35	62.66	63.01	61.42	62.58	0.67	0.22

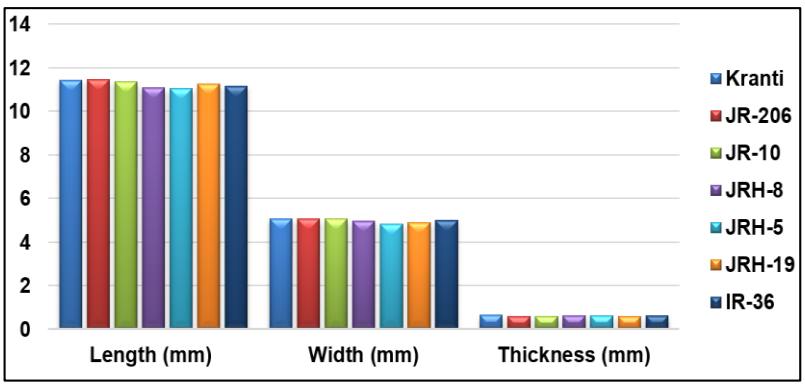

Fig 2: Physical properties of flaked rice

Standardization of process parameters for development of puffed rice

The optimization of conditions for puffed rice production was analyzed by testing two levels of moisture content (13% and 15%) and two levels of roasting temperature (180 °C and 200 °C). Four treatment combinations (T_1, T_2, T_3, and T_4) were evaluated, with the T_3 combination producing the best quality puffed rice based on various physical, chemical, functional, and other quality attributes.

Table 5: Treatment combination of different paddy varieties for development of puffed rice.

S. No.	Treatments	Combination	Treatment Description
1.	T_1	M_1T_1	13% moisture and temperature 180 °C
2.	T_2	M_1T_2	13% moisture and temperature 200 °C
3.	T_3	M_2T_1	15% moisture and temperature 180 °C
4.	T_4	M_2T_2	15% moisture and temperature 200 °C

Recovery percentage of puffed rice

The recovery percentage of puffed rice was assessed and is presented in Table 6 and visually represented in Fig. 3. Recovery percentage of seven rice varieties was found out to be 61.91% to 66.65% while, recovery percentage of puffed rice was 10.02 to 72.91%. This increasing rate depends on the porosity value is due to the increase in pore space due to puffing. The Kranti variety had the lowest husk and bran percentage, with a value of 23.77%, followed by JR-206 at 24.21%. In contrast, the JRH-19 variety recorded the highest percentage at 25.11%. The Kranti variety also yielded the highest percentage of parboiled rice at 76.25%, followed closely by JR-206 at 75.79%, while the JRH-5 variety had the lowest percentage at 74.77%. The total recovery percentage was highest for the Kranti variety at 72.90%, followed by JR-206 at 65.49%. The lowest recovery was observed in the JR-10 variety at 10.02%, followed by IR-36 at 11.47%.

In puffed rice, some un-puffed grains were also found. Thus, it can be said that the ideal grain ratio for puffing purposes appears to be 1:15. The findings of present investigation are in conformity with the reported results of Bandara *et al*., (2007) [2] and Shankara *et al*., (1984) [7].

Table 6: Recovery percentage of puffed rice

Parameters	Kranti	JR-206	JR-10	JRH-8	JRH-5	JRH-19	IR-36	CD @ 5 %	Sem±
Husk & Bran %	23.77	24.21	24.59	24.55	25.11	25.23	24.91	0.08	0.02
Parboil rice %	76.25	75.79	75.41	74.85	74.77	74.74	75.05	0.08	0.02
Un-puffed %	3.34	10.30	85.43	87.32	87.34	88.14	86.52	0.05	0.01
Recovery %	72.91	65.49	10.02	12.47	12.57	13.40	11.47	0.13	0.04

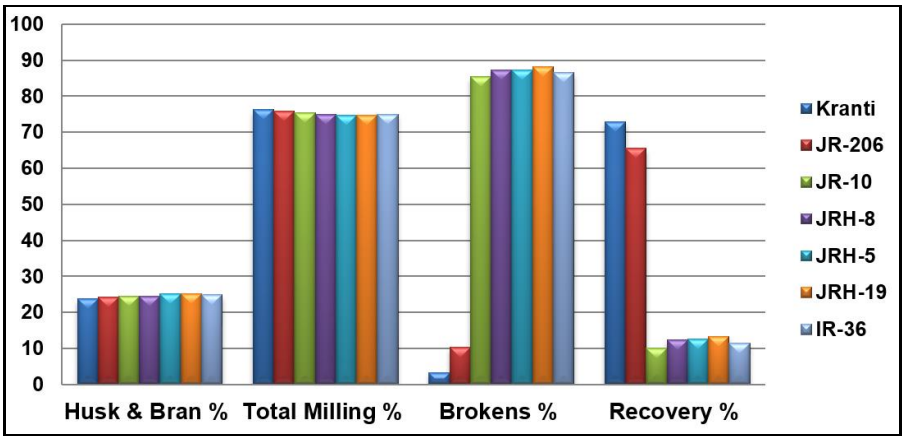

Fig 3: Recovery percentage of puffed rice

Conclusion

The study comprehensively evaluated the physical, chemical, and functional properties of seven paddy varieties (Kranti, JR-206, JR-10, JRH-8, JRH-5, JRH-19, and IR-36) and standardized process parameters for developing popped, flaked, and puffed rice. Results highlighted significant varietal differences in recovery percentages, husk and bran content, expansion ratio, and product quality. Among the treatments, T_2 (16% moisture, 240 °C) was optimal for popped rice, T_2 (12 hr soaking, 160 °C) for flaked rice, and T_3 (15% moisture, 180 °C) for puffed rice. The Kranti variety consistently recorded superior recovery and product quality across processing methods. Overall, findings confirm that varietal characteristics and optimized processing conditions are crucial for producing high-quality value-added rice products.

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