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Research Article

# Valorization of Ridge Gourd Peel in the Development of Nutrient-Rich Pearl Millet Rusk

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## ABSTRACT

**Background:** Pearl millet is a nutrient-rich cereal with good functional properties, while ridge gourd peel is an underutilized by-product rich in dietary fiber and bioactive compounds. The present study was undertaken to develop pearl millet rusk incorporated with ridge gourd peel powder and evaluate its sensory acceptability, nutritional composition and storage stability as a functional bakery product. **Materials and Methods:** Pearl millet flour and ridge gourd peel powder were used to prepare four rusk formulations: T0 (control), T1 (5% ridge gourd peel powder), T2 (10%) and T2 (15%). Sensory evaluation was conducted by 20 semi-trained panelists using a 9-point hedonic scale. Nutritional analysis, including carbohydrate, protein, fat, crude fiber, moisture, ash and energy, was carried out using standard AOAC methods. Storage stability was evaluated by assessing sensory quality on the 0$^{th}$, 15$^{th}$ and 30$^{th}$ day. **Results:** Among the formulations, T1 (5% ridge gourd peel powder) recorded the highest overall acceptability score of 7.9±1.02. Incorporation of ridge gourd peel powder significantly improved the nutritional profile of the rusks. Protein content increased from 9.62±0.11% (T0) to 11.60±0.15% (T3), while crude fiber increased from 1.36±0.10% to 3.24±0.08%. In contrast, carbohydrate, fat and energy values decreased with increasing levels of ridge gourd peel powder. The developed rusks maintained acceptable sensory quality throughout 30 days of storage. **Conclusion:** Pearl millet rusks incorporated with ridge gourd peel powder, particularly at the 5% inclusion level, demonstrated superior sensory acceptability and enhanced nutritional quality. The incorporation of ridge gourd peel powder effectively increased protein and dietary fiber while maintaining acceptable storage stability for 30 days, indicating its potential for developing fiber-rich functional bakery products.

**Keywords:** Nutritional analysis, Pearl millet rusk, Ridge gourd peel powder, Sensory evaluation.

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## INTRODUCTION

Cake rusks, originally believed to have originated in the Mediterranean region, have evolved over time and are now enjoyed by people across the world. They are prepared by baking cake batter in an oven, slicing the baked cake into thin pieces and then toasting or dehydrating the slices until they become crisp (Brown and Taylor, 2019). It is characterized by its proper texture, flavor and aroma. It is a hard, dry, brittle and crunchy baked product that is prepared through a double-baking process (Mozaffarian and Willett, 2009).

Ridge gourd (*Luffa acutangular* L. Roxby.), commonly known as "Kalantari," belongs to the genus Luffa of the Cucurbitaceae family. It is a widely consumed vegetable in India and other Asian countries, primarily used for culinary purposes. When cooked, ridge gourd has a mildly sweet taste, a cooling effect on the body and is easy to digest. Both the tender pulp and peel are used in the preparation of various dishes, especially in South Indian cuisine, where chutneys made from the pulp and peel are valued for their health benefits (Devi and Geethanjali, 2017). It acts as a natural blood purifier, possessing mild laxative properties and aiding in the management of conditions such as jaundice and diabetes (Barik *et al*., 2018). Ridge gourd peel is one such edible bio-waste; however, it is often underutilized due to its high dietary fiber content and coarse texture (Shyamala and Prakash, 2014).

Pearl millet is a nutrient-dense cereal that contains higher levels of protein and is particularly rich in essential minerals such as iron and zinc when compared to commonly consumed cereals like rice, wheat and maize (Kumar, 2021). It has the ability to withstand drought and high-temperature conditions, making it well suited for cultivation in regions where crops like wheat, maize and other cereals are unable to thrive (Rathore and Kumar, 2016). It is an excellent source of energy, carbohydrates and proteins and contains significant amounts of crude fiber, including both soluble and insoluble dietary fibers. It also provides soluble and insoluble fats, ash, antioxidants and minerals such as iron and zinc.

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With a fat content ranging from 3-8% and better fat digestibility compared to many major cereals, bajra offers superior nutritional benefits (Scott *et al.*, 2018).

Psyllium husk is considered one of the richest sources of arabinoxylan, a non-starch polysaccharide responsible for its distinctive physicochemical characteristics. When mixed with water, psyllium husk forms a highly viscous gel due to its remarkable water-holding capacity, making it a useful ingredient in food formulations designed to enhance dietary fiber intake and support physiological functions (Geremew *et al.*, 2024).

## MATERIALS AND METHODS

### Materials

Pearl millet grains, Fresh ridge gourds, milk powder, sugar, butter or refined oil, ordinary salt and instant dry yeast was bought from the local store, Hyderabad, Telangana, India.

### Preparation of pearl millet flour

The millet grains were thoroughly cleaned to remove dust and other debris. The cleaned grains are lightly roasted at 80 to 90°C to enhance aroma and reduce anti-nutritional components. That were be cooled before being finely ground in a lab grinder and sieved through an 80-mesh sieve to create uniform flour. The flour will be stored in sealed containers at room temperature until it is needed again.

### Preparation of ridge gourd peels

Fresh ridge gourds were be peeled and cleaned and their peels were then cut into small pieces. These pieces will be dried in a tray dryer set at 50°C to reduce the moisture content to roughly 10%. The dried peels will be ground into a fine powder, sieved through a 60-mesh sieve and stored in food-grade, sealed pouches to prevent moisture absorption.

### Preparation of rusk

Rusk was be prepared by the method of (Neha *et al.*, 2023) with slight modification. The required RGPP and pearl millet flour were be mixed with sugar, milk powder, salt, yeast and fat until the dough is soft and workable, water is gradually added Table 1. The dough was be fermented for 45 to 60 min at 28 to 30°C after being kneaded until it was uniform. After fermentation, the dough is shaped into loaves, proofed for 30 to 40 min and baked at 180 to 200°C for 20 to 25 min. After cooling to room temperature, the cooked loaves will be cut into pieces that are 8 to 10 mm thick and baked once more for until golden brown and crisp, about 20 to 30 min at 150°C to 160°C. The rusks will be promptly placed in sealed pouches after cooling.

### Nutrition Analysis

The Kjeldahl technique was be used to assess the rusk samples crude protein content (AOAC, 2000, 979.09). The AOAC (2000, 4.501) procedure will be used using the Automated Soxhlet equipment to determine the fat content of the rusk samples. The AOAC (2000, 920, 169) technique was be used to assess the rusk sample crude fiber content. The AOAC method (1990) was be used to assess the rusk ash content. The difference approach was be used to determine the total carbohydrate content (Southgate, 1991). Rusk energy content was be determined using the factorial approach of AOAC (1995).

### Sensory Evaluation

Twenty semi-trained panelists were assessing the rusk's color, texture, flavor, taste, and overall appeal using a nine-point hedonic scale.

### Storage study

Pearl millet rusk incorporated with ridge gourd peel were be stored in air tight container. The effect of storage duration on rusk sensory attributes was be assessed during the 0 day, 15$^{th}$ day and 30$^{th}$ day.

### Statistical analysis

The samples were undergoing three analyses. Microsoft Excel 2023 was used to compute the mean score and standard deviation of the three replicates for each test (for all samples). The Statistical Program for Social Science (SPSS) was used to perform a One-Way Analysis of Variance (ANOVA) on all of the collected data. A *p*-value of less than 0.05 was employed, and means were compared using LSD.

## RESULTS

### Sensory analysis of control and experimental rusks

Sensory analysis of control and experimental rusks was described in Table 2. The appearance scores of the control and experimental rusk samples were 7.65±0.87, 7.95±0.88, 7.15±1.18, and 6.8±1.3, independently, Table 2 and Figure 1 shows that the T3 sample had the smallest appearance score (6.8±1.3), while the T1 sample had the loftiest score (7.95±0.88). The color of the control and experimental rusk samples were 7.7±0.97, 7.85±1.03, 7.2±1.36, and 6.7±1.30, respectively. T3 sample had the lowest color score (6.7±1.30), while the T1 sample had the highest score (7.85±1.03) Figure 2.

The flavor of the control and experimental rusk samples were 7.45±1.23, 7.8±0.76, 7.25±1.55, and 7±1.71, respectively. T1 sample received the highest flavor score (7.8±0.76), whereas the control sample T0 had a lower score (7.45±1.23) Figure 3. The taste of the control and experimental rusk samples were 7.75±1.11, 8±0.64, 7.35±1.18, and 7.15±1.42, respectively. T1 sample had the highest taste score (8±0.64), while the control sample T0 showed a lower score (7.75±1.11) Figure 4.

The texture scores of the control and experimental rusk samples were 7.5±1.27, 7.8±0.61, 6.95±1.39, and 6.75±1.68, T1 sample achieved the highest texture score (7.8±0.61), whereas the T3 sample recorded the lowest score (6.75±1.68) Figure 5. The overall acceptability of the control and experimental rusk samples were 7.75±1.09, 7.9±1.02, 7.15±1.49, and 6.75±1.58, respectively. T1 sample received the highest overall acceptability score (7.9±1.02), whereas the control sample T0 recorded a lower score (7.75±1.09) Figure 6.

## Nutritional properties of control and experimental rusks

Nutritional properties of control and experimental rusks was reported in Table 3. The carbohydrate content of the control and experimental rusk samples was 80.22±0.36, 77.54±0.55, 73.05±0.71, and 72.33±0.34, respectively. As shown in Table , the lowest carbohydrate content was observed in the T3 sample (72.33±0.34), whereas the highest value was recorded in the control sample T0 (80.22±0.36).

The energy content of the control and experimental rusk samples was 397.74±0.33, 384.80±2.74, 367.73±0.57, and 364.79±2.22, respectively, the lowest energy content was observed in the T3 sample (364.79±2.22), while the highest was recorded in the control sample (397.74±0.33). The protein content of the control and experimental rusk samples ranged from 9.62±0.11 to 11.6±0.15. The significant highest protein content was observed in sample T3 (11.6±0.15), while the significant lowest was recorded in the control sample T0 (9.62±0.11). The experimental samples (T1, T2, and T3) exhibited higher protein values (10.48±0.10, 11.0±0.07, and 11.6±0.15, respectively) compared to the control.

The fat content of the control and experimental rusk samples ranged from 3.13±0.10 to 4.26±0.08. The lowest fat content was observed in sample T3 (3.13±0.10), while the highest was recorded in the control sample T0 (4.26±0.08). The experimental samples (T1, T2, and T3) showed lower fat values (3.63±0.08, 3.35±0.09, and 3.13±0.10, respectively) compared to the control. The fibre content of the control and experimental rusk samples varied from 1.36±0.10 to 3.24±0.08. The highest fibre content was recorded in sample T3 (3.24±0.08), whereas the lowest was observed in the control sample T0 (1.36±0.10). The experimental samples (T1, T2, and T3) showed a gradual increase in fibre

**Table 1: Formulation of control and experimental rusks.**

| Ingredients (g) | $T_0$ | $T_1$ | $T_2$ | $T_3$ |
|---|---|---|---|---|
| Pearl millet flour | 100 | 95 | 90 | 85 |
| Ridge gourd peel powder | 00 | 05 | 10 | 15 |
| Sugar | 12 | 12 | 12 | 12 |
| Butter | 10 | 10 | 10 | 10 |
| Milk powder | 04 | 04 | 04 | 04 |
| Salt | 0.5 | 0.5 | 0.5 | 0.5 |
| Instant yeast | 1.5 | 1.5 | 1.5 | 1.5 |
| Psyllium husk | 05 | 05 | 05 | 0.5 |

T0: 100:00 (Pearl millet flour, Ridge gourd peel), T1: 95:5 (Pearl millet flour, Ridge guard peel), T2: 90:10 (Pearl millet flour, Ridge guard peel), T3:85:15 (Pearl millet flour, Ridge guard peel).

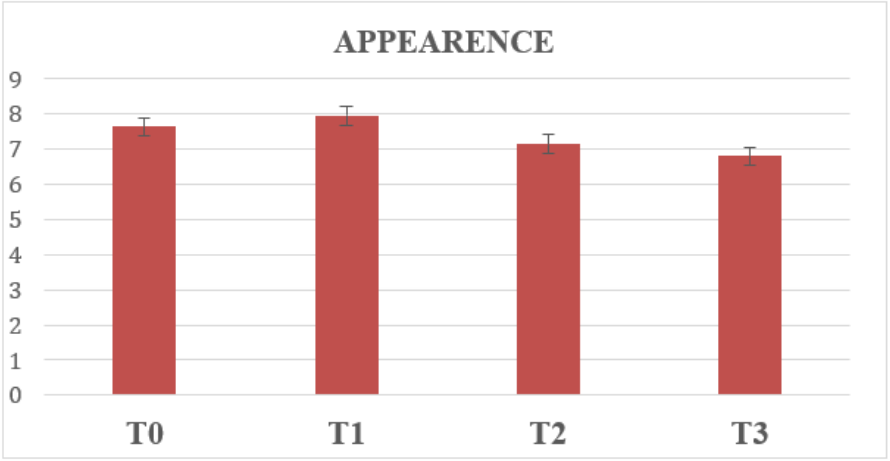


**Figure 1:** Appearance of control and experimental rusk.

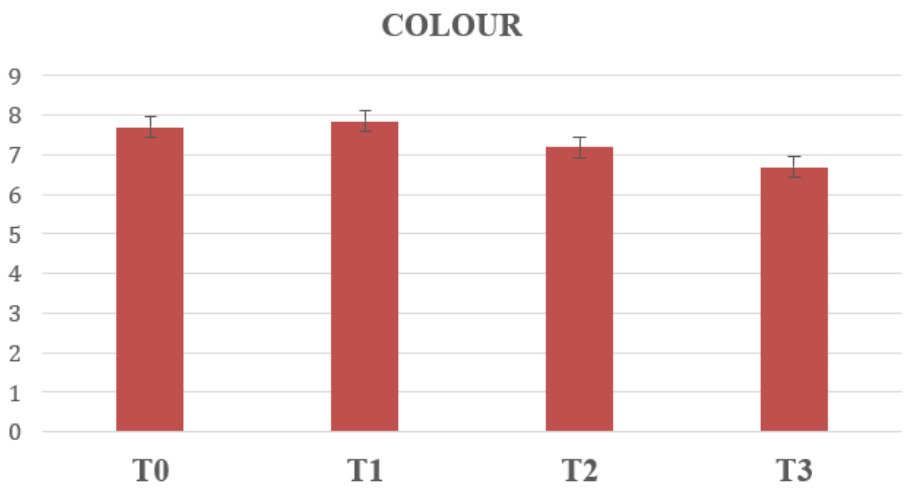


**Figure 2:** Colour of control and experimental rusk.

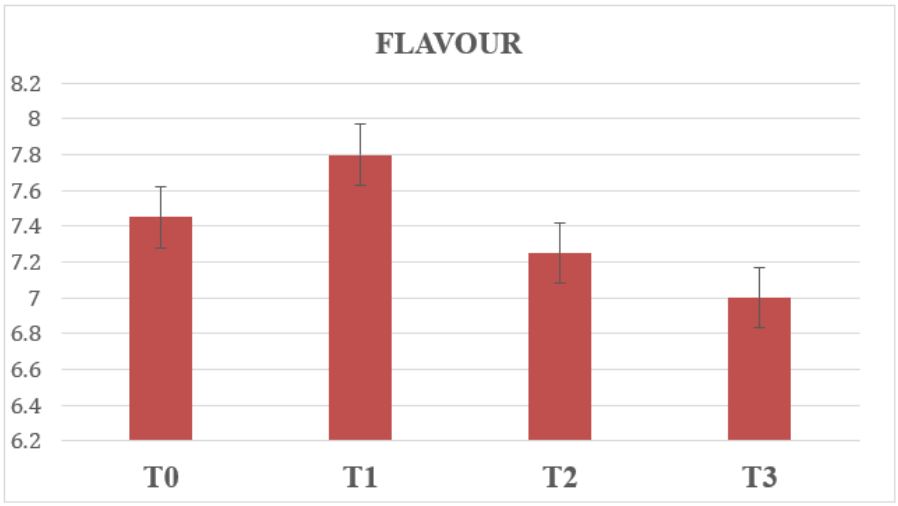


**Figure 3:** Flavour of control and experimental rusk.

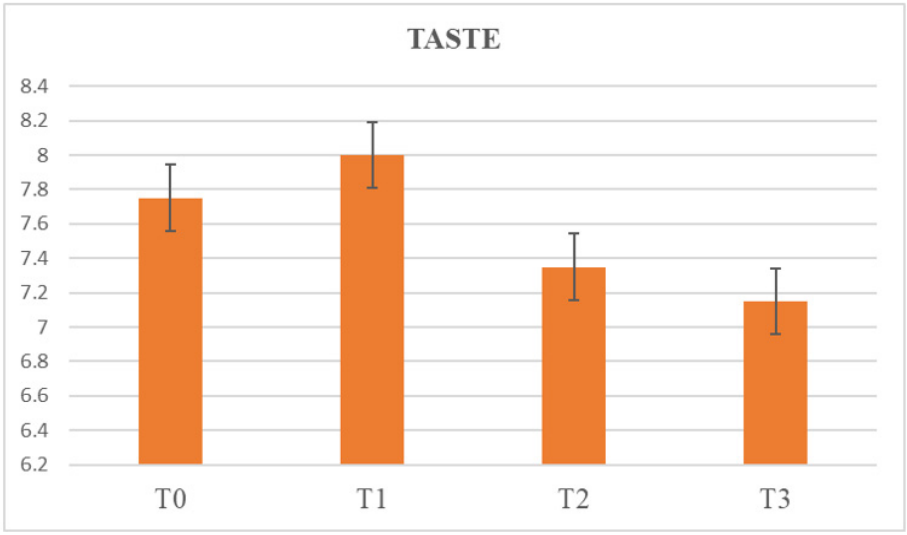


**Figure 4:** Taste of control and experimental rusk.

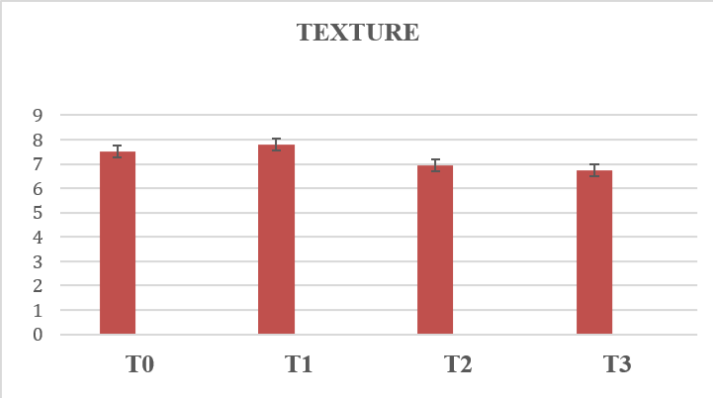


**Figure 5:** Texture of control and experimental rusk rusk.

**Table 2: Sensory analyses of control and experimental rusks.**

| Sensory attributes | T0 | T1 | T2 | T3 |
|---|---|---|---|---|
| Appearance | 7.65±0.87$^{a}$ | 7.95±0.88$^{ac}$ | 7.15±1.18$^{ade}$ | 6.8±1.3$^{be}$ |
| Colour | 7.7±0.97$^{a}$ | 7.85±1.03$^{a}$ | 7.2±1.36$^{ac}$ | 6.7±1.30$^{bc}$ |
| Flavour | 7.45±1.23$^{a}$ | 7.8±0.76$^{a}$ | 7.25±1.55$^{a}$ | 7±1.71$^{a}$ |
| Taste | 7.75±1.11$^{a}$ | 8±0.64$^{ab}$ | 7.35±1.18$^{a}$ | 7.15±1.42$^{ac}$ |
| Texture | 7.5±1.27$^{a}$ | 7.8±0.61$^{ab}$ | 6.95±1.39$^{ace}$ | 6.75±1.68$^{ade}$ |
| Overall Acceptability | 7.55±1.09$^{a}$ | 7.9±1.02$^{a}$ | 7.15±1.49$^{a}$ | 6.75±1.58$^{a}$ |

Mean values followed by the different letters with subscript within the row are significantly different ($p$<0.05).

content (2.56±0.18, 2.80±0.17, and 3.24±0.08, respectively) when compared to the control.

The moisture content of the control and experimental rusk samples was recorded as 2.83±0.09, 3.77±0.38, 7.30±0.26 and 7.52±0.41 respectively. The highest moisture content was observed in the T3 sample (7.52±0.41), while the lowest was found in the T0 sample (2.83±0.09). The ash content of the control and experimental rusk samples ranged from 1.69 ±0.04 to 2.16±0.32. The highest ash content was observed in sample T3 (2.16±0.32), while the lowest was recorded in the control sample T0 (1.69±0.04). The experimental samples (T1, T2, and T3) exhibited higher ash values (2.00±0.06, 2.14±0.01, and 2.16±0.32, respectively) compared to the control.

## Effect of storage period on sensory analysis of selected rusk

Effect of storage period on sensory analysis of control and experimental pearl millet with ridge gourd peel rusk was presented in Table 4. Hedonic scores for all sensory attributes showed a significant decrease as the storage period increased. The hedonic scores for all sensory attributes showed a gradual decline throughout the storage period. As presented in Tables 3 and 4, the appearance scores of the selected rusk samples on the 0$^{th}$ 15$^{th}$ and 30$^{th}$ day of storage were 7.95±0.88, 7.35±1.03 and 7.20±1.00 respectively Figure 7. The highest appearance score was recorded on the 0$^{th}$ day whereas the lowest score was observed on the 30$^{th}$ day of storage.

The hedonic scores for all sensory attributes decreased significantly during the storage period. The color scores of the selected rusk samples on the 0$^{th}$ 15$^{th}$ and 30$^{th}$ day of storage were 7.85±1.03, 7.45±0.82 and 7.00±0.79 respectively Figure 8, the highest color score was noted on the 0$^{th}$ day whereas the lowest score was observed on the 30$^{th}$ day of storage. The hedonic scores for all sensory attributes showed a gradual decrease during the storage period. The flavor scores of the selected rusk samples on the 0$^{th}$ 15$^{th}$ and 30$^{th}$ day of storage were 7.8±0.76, 7.25±0.85 and 7.1±0.85 respectively Figure 9, the highest flavor score was recorded on the 0$^{th}$ day whereas the lowest score was observed on the 30$^{th}$ day of storage.

The hedonic scores for all sensory attributes showed a gradual decline during the storage period. The taste scores of the selected rusk samples on the 0$^{th}$, 15$^{th}$ and 30$^{th}$ day of storage were 8.0±0.64, 7.7±0.73 and 7.2±0.89 respectively Figure 10, the highest taste score was observed on the 0$^{th}$ day whereas the lowest score was recorded on the 30$^{th}$ day of storage. The hedonic scores for all sensory attributes showed a gradual decrease during the storage period. The texture scores of the selected rusk samples on the 0$^{th}$, 15$^{th}$ and 30$^{th}$ day of storage were 7.8±0.61, 7.15±0.81 and 6.85±0.93 respectively Figure 11, the highest texture score was recorded on the 0$^{th}$ day whereas the lowest score was observed on the 30$^{th}$ day of storage.

**Table 3:** **Nutritional properties of control and experimental rusks.**

| Nutritional properties | T0 | T1 | T2 | T3 |
|---|---|---|---|---|
| Carbohydrate (%) | 80.22±0.36a | 77.54±0.55b | 73.05±0.71ce | 72.33±0.34de |
| Energy (kcal) | 397.74±0.33a | 384.80±2.74b | 367.73±0.57ce | 364.79±2.22de |
| Protein (%) | 9.62±0.11a | 10.48±0.10b | 11.0±0.07c | 11.6±0.15d |
| Fat (%) | 4.26±0.08a | 3.63±0.08b | 3.35±0.09c | 3.13±0.10d |
| Fiber (%) | 1.36±0.10a | 2.56±0.18be | 2.80±0.17ce | 3.24±0.08d. |
| Moisture (%) | 2.83±0.09a | 3.77±0.38b | 7.30±0.26ce | 7.52±0.41de |
| Ash (%) | 1.69±0.04a | 2.00±0.06ad | 2.14±0.11bd | 2.16±0.32cd |

Mean values followed by the different letters with subscript within the row are significantly different ($p<0.05$).

**Table 4:** **Effect of storage period on sensory analysis of selected rusk.**

| Sensory attributes | 0th day | 15th day | 30th day |
|---|---|---|---|
| Appearance | 7.95±0.88a | 7.35±1.03ac | 7.2±1.00bc |
| Colour | 7.85±1.03ad | 7.45±0.82ac | 7±0.79bcd |
| Flavour | 7.8±0.76a | 7.25±0.85ab | 7.1±0.85ab |
| Taste | 8±0.64a | 7.7±0.73a | 7.2±0.89b |
| Texture | 7.8±0.61a | 7.15±0.81bd | 6.85±0.93cd |
| Overall Acceptability | 7.7±1.03a | 7.45±1.23ac | 6.9±0.78bc |

Mean values followed by the different letters with subscript within the row are significantly different ($p<0.05$).

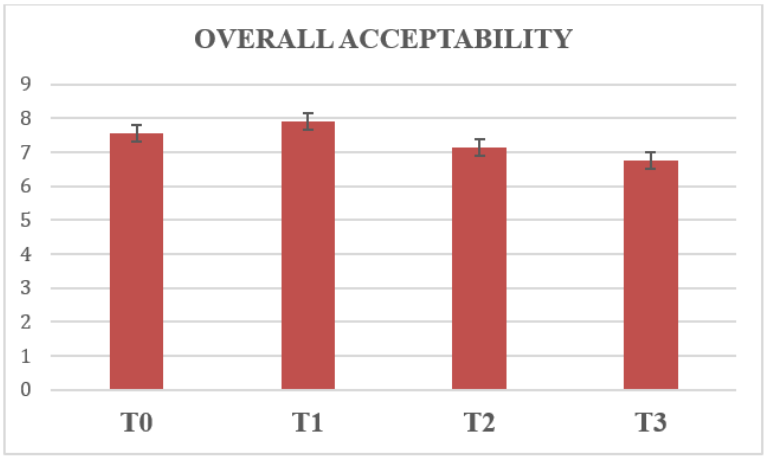


**Figure 6:** Overall acceptability of control and experimental rusk.

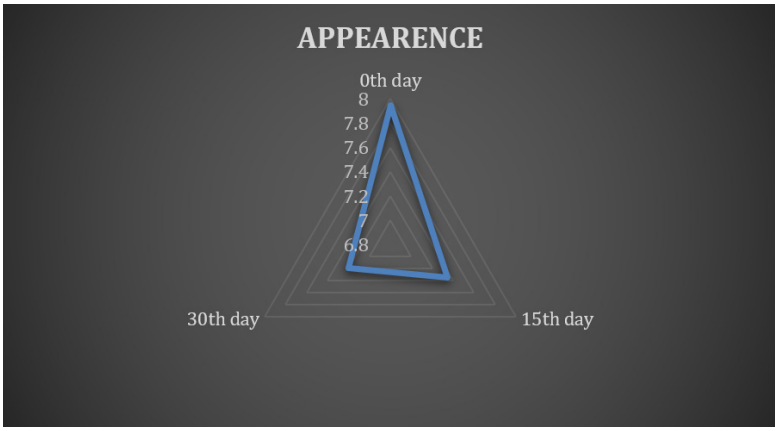


**Figure 7:** Effect of storage period on Appearance of selected rusk.

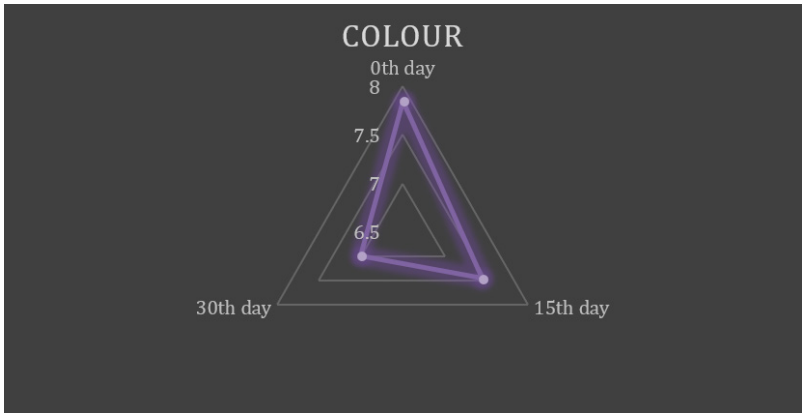


**Figure 8:** Effect of storage period on Color of selected rusk.


**Figure 9:** Effect of storage period on Flavor of selected rusk.

The hedonic scores for all sensory attributes showed a gradual decline during the storage period. The overall acceptability scores of the selected rusk samples on the 0$^{th}$, 15$^{th}$ and 30$^{th}$ day of storage were 7.7±1.03,7.45±1.23 and 6.9±0.78 respectively Figure 12, the highest overall acceptability score was recorded on the 0$^{th}$ day whereas the lowest score was observed on the 30$^{th}$ day of storage.

## DISCUSSION

An analogous result was reported by (Sahoo and Divakar, 2018), in which the control rusk had an advanced appearance score (49.45) than the experimental rusk (21.95). The lower appearance scores of the experimental samples may be because of the addition of crest gourd peel and plum millet flour (Neha *et al.*, 2023) reported that the similar findings, with the control rusk receiving a higher color score (8.40) than the experimental rusk (5.10). The addition of ridge gourd peel resulted in a decrease in the color scores of the experimental samples.

Abd El-Rahman, Nahed and Zein (2024) stated that the in which the experimental rusk had a higher flavor score (8.80±0.23) than the control rusk (8.30±0.37). The addition of ridge gourd peel improved the flavor of the experimental samples. Sakpal and Udachan (2018) reported that the experimental rusk recorded a higher taste score (8.7) than the control rusk (8.6). The addition of pearl millet flour and ridge gourd peel improved the taste of the experimental samples.

Sindhu and Radhai (2022) reported that the control rusk obtained a higher texture score (8.75±0.55) than the experimental rusk (6.90±1.20). The decrease in texture scores of the experimental samples may be due to the addition of pearl millet flour and ridge gourd peel. Similar findings were reported by Nazni and Karuna (2016), where the experimental rusk obtained a higher overall acceptability score (8.428±0.534) than the control rusk (8.285±0.487). The increase in overall acceptability of the experimental samples may be due to the addition of pearl millet flour and ridge gourd peel.

Similarly, Hasan *et al.* (2024) found that the carbohydrate content of the control rusk (73.53±0.17) was higher than that of the experimental rusk (68.17±0.16). The reduction in carbohydrate content in the experimental samples may be due to the incorporation of ridge gourd peel. According to (Sakpal and Udachan, 2018). The energy content of control rusk (426.86) was higher than that of experimental rusk (411.96). This difference may be caused because of absence of ridge gourd peel in the control rusk.

Similar findings were reported by (Abd and Zein, 2024) who observed that experimental rusk (16.30±0.16) had higher protein content than the control sample (10.10±0.15). The increased protein content indicates that incorporation of pearl millet flour and ridge gourd peel enhances the nutritional quality of the rusk. Similar findings were reported by (Melini *et al.*, 2025) who observed that the fat content of experimental rusk (3.44±0.10) was lower than that of the control sample (3.61±0.04). The higher fat content in the control sample may be due to the absence of ridge gourd peel.

(Neha *et al.*, 2023) stated that the fiber content of the experimental rusk (3.82±0.11) was higher than that of the control sample (0.72±0.05). The increased fiber content in the developed rusk may be due to the incorporation of ridge gourd peel and pearl millet flour, both of which are known to be rich sources of dietary fiber (Rehman *et al.*, 2013) who reported that the ash content of experimental rusk (2.83) was higher than that of the control sample (2.62). The increased moisture content in the experimental rusk may be because of the incorporation of ridge gourd Peel. Similar findings were reported by (Malik and Kulkarni, 2010) who observed that the ash content of the experimental rusk (1.9±0.23) was higher than that of the control sample (1.2±0.15). The increased ash content of experimental rusk may due to addition of pearl millet and ridge gourd peel.

A comparable reduction in sensory quality during storage was also reported by (Ahlawat and Ahlawat, 2017) in experimental rusks where the appearance score decreased from 7.77±0.13 on the 0$^{th}$ day to 6.75±0.20 on the 45$^{th}$ day. This decrease in appearance score on 15$^{th}$ and 30$^{th}$ day of storage may be because of addition of ridge gourd peel. A similar reduction in sensory quality during storage was reported by (Ahmad and Mushtaq, 2012) in experimental rusks where the highest color value was recorded on the 0$^{th}$ day (178.93) and the lowest value was observed on the 30$^{th}$ day (178.40). This decrease in color score during 15$^{th}$ and 30$^{th}$ day of storage may be because of incorporation of ridge gourd peel.

A similar decrease in sensory quality during storage was reported by (Sindhu and Radhai, 2022) in experimental rusks where the highest color score was observed on the 0$^{th}$ day (8.10±1.48) and the lowest score was recorded on the 90$^{th}$ day (6.20±1.51). This reduction in flavor score during 15$^{th}$ and 30$^{th}$ day of storage may be due to incorporation of ridge gourd peel (Neha *et al.*, 2023) stated that the experimental rusks where the highest taste score

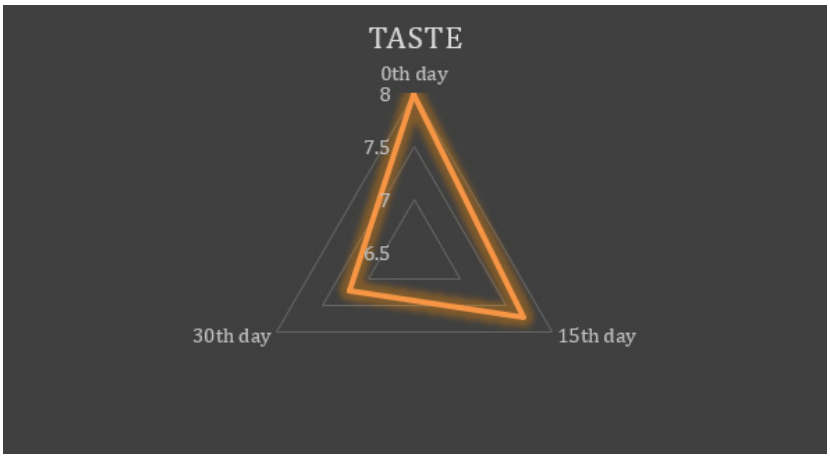


**Figure 10:** Effect of storage period on Taste of selected rusk.

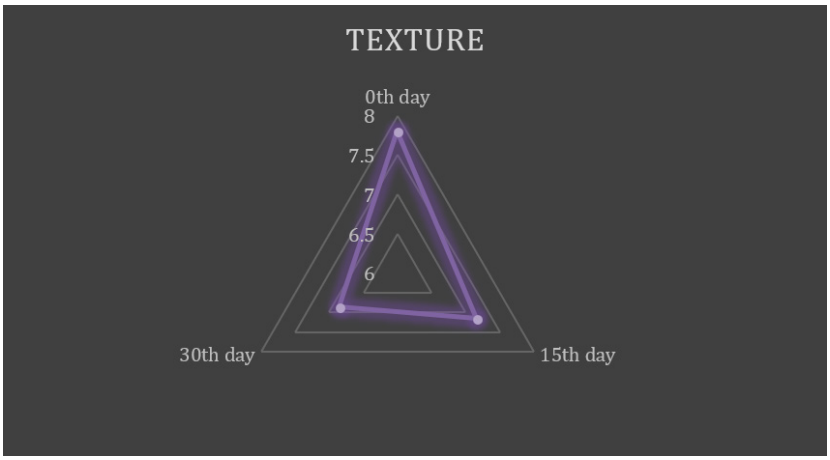


**Figure 11:** Effect of storage period on Texture of selected rusk.

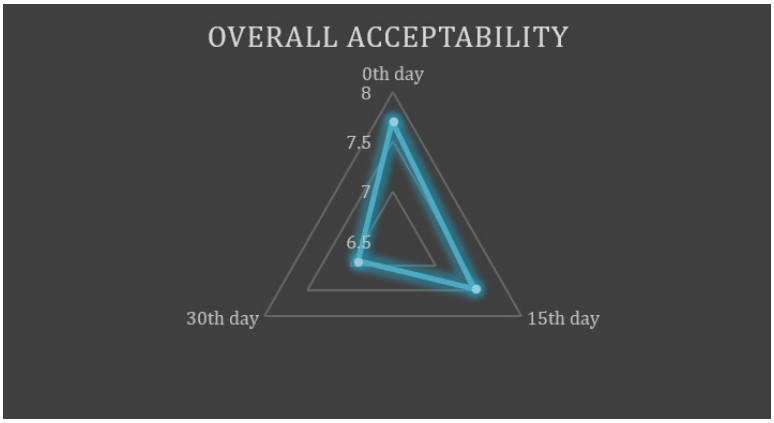


**Figure 12:** Effect of storage period on Overall acceptability of selected rusk.

was noted on the 0th day (4.6) and the lowest score was observed on the 90th day (3.4). The reduction in taste scores during the 15th and 30th day of storage may be due to the incorporation of ridge gourd peel in the rusk samples.

A similar decline in sensory quality during storage was reported by (Ahmetxhekaj and Filipović, 2017) in experimental rusks where the highest texture score was observed on the 0th day while the lowest score was recorded on the 360th day. The reduction in texture scores during the 15th and 30th day of storage may because of the addition of ridge gourd peel. A similar decrease in sensory quality during storage was reported by (Malik and Kulkarni, 2010) in experimental rusks where the highest taste score was observed on the 0th day (7.2±0.04) while the lowest score was recorded on the 90th day (7.2±0.01). The reduction in overall acceptability during the 15th and 30th day of storage may be due to the incorporation of ridge gourd peel and pearl millet flour.

## CONCLUSION

The present study was conducted to develop value-added rusks by incorporating pearl millet flour and ridge gourd peel powder and to evaluate their sensory characteristics, nutritional composition and storage stability. Sensory evaluation revealed that the T1 sample showed the highest acceptability among all experimental samples. The developed rusks showed enhanced nutritional properties compared to the control sample. Protein, fiber, moisture and ash contents increased significantly with incorporation of pearl millet flour and ridge gourd peel, while carbohydrate, energy and fat contents decreased. The highest protein (11.6±0.15), fibre (3.24±0.08) and ash (2.16±0.32) contents were observed in T3, indicating improved nutritional value. Reduced energy (364.79±2.22 kcal) and fat content (3.13±0.10) make the developed rusks suitable for health-conscious consumers. Storage studies revealed that sensory qualities gradually declined during the 30-day storage period. Appearance decreased from 7.95±0.88 to 7.2±1.00, colour from 7.85±1.03 to 7±0.79, flavour from 7.8±0.76 to 7.1±0.85, taste from 8±0.64 to 7.2±0.89, texture from 7.8±0.61 to 6.85±0.93 and overall acceptability from 7.7±1.03 to 6.9±0.78. Despite this decline, the developed rusk remained organoleptically acceptable throughout storage. Therefore, incorporation of pearl millet flour and ridge gourd peel can be considered an effective approach for developing nutritionally enriched and acceptable rusks with good storage stability.

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## ABBREVIATIONS

**RGPP:** Ridge Gourd Peel Powder; **PH:** Potential of Hydrogen; **SPSS:** Statistical Package for Social Science; **LSD:** Least Significant Difference; **DPPH:** 2 2-Diphenyl-1-picrylhydrazyl; **TPP:** Tomato Peel powder; **GA:** Gallic Acid; **ANOVA:** One-Way Analysis of Variance; **ARR:** Amylose Rich Wheat Flour Rusks; **CLP:** Coffee Leaf Powder; **BHT:** Butylated hydroxytoluene.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

## FUNDING

There are no available funding sources.

## ETHICAL STATEMENT

The sensory evaluation followed institutional guidelines, and informed consent was obtained from all participants.

## AUTHOR CONTRIBUTIONS

Conceptualization: KJ and DPK; Experiments: NV; Data analysis: KJ, NV, PJJ, DPK and KG; Supervision: KJ; Funding: NV, PJJ and KG; Manuscript writing: PJJ, KJ and DPK.

## SUMMARY

Pearl millet and ridge gourd peel powder were used to develop a nutrient-rich functional rusk. Ridge gourd peel, an underutilized by-product, was incorporated at 5%, 10%, and 15% levels. $T_1$ (5% ridge gourd peel powder) achieved the highest overall sensory acceptability (7.9±1.02). Protein content increased from 9.62±0.11% ($T_0$) to 11.60±0.15% ($T_3$) with increasing peel powder. Crude fiber increased from 1.36±0.10% to 3.24±0.08% across formulations. Carbohydrate, fat, and energy values decreased as the level of ridge gourd peel powder increased. All rusk formulations remained sensorially acceptable during 30 days of storage. Incorporation of ridge gourd peel powder enhanced the nutritional quality, especially protein and dietary fiber.

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