**Evaluation of Sensory attributes and Nutritional profile of Bamboo rice products**

**Abstract**

India is one of the largest bamboo-producing countries. Bamboo is a perennial tree that may grow up to 60 to 100 years. Bamboo rice is a special rice that is grown from a dying bamboo shoot. It has become an important and major source of income for tribal people living in the forest. The aim of the study was to develop value-added products from bamboo rice and evaluate the sensory acceptability and nutritional composition of the developed products. *Laddu* and *roti* were prepared and evaluated by using a 9-point hedonic scale by 21 semi-trained panel members. Sensory evaluation revealed that variation T2 for *laddu* and variation T1 for *roti* scored high for all attributes. Nutrient composition of the bamboo rice *laddu* revealed that moisture, protein, fibre, ash, iron and magnesium were higher in bamboo rice *laddu* than in the white rice *laddu*. Whereas, white rice *laddu* had a higher amount of fat, carbohydrate, energy, calcium and phosphorus than the bamboo rice *laddu*. Nutrient composition of bamboo rice *roti* revealed that moisture, protein, fibre, ash, calcium and iron were higher in bamboo rice *roti* than the white rice *roti.* However, fat, carbohydrates, energy, magnesium, and phosphorus were high in white rice *roti*. Thus, the study shows that the incorporation of bamboo rice increases the nutritional profile of the products.

**Keywords**: Bamboo rice, sensory acceptability, nutrient composition, value addition, developed products, perennial tree.

**1. Introduction**

India is one of the largest bamboo-producing countries, like other tropical countries. There are over 1,250 woody bamboos in the world in approximately 75 genera (Liese and Kohl, 2015). When the bamboo shoot breathes its last, it flowers into a rare variety of rice seeds, which are known as bamboo rice (Rana, 2017). The edible nature of bamboo rice was identified in some tribal areas. Although in the past, bamboo was considered “poor men’s timber” in rural areas due to its imprecise processing and underdeveloped utilisation, bamboo shoots have consistently held their status as a desired health food ingredient in traditional Asian cuisine, available in various forms such as fresh, dried and pickled (Zhang et al., 2024).

Bamboo rice harvesting and selling is a major source of income for some groups of the tribes in Southern and North Eastern India.

Bamboo seeds are not only used as food but also traded as medicines and commodities. However, there is a lack of information about the nutrient profile of bamboo seeds, in contrast to the abundant literature available with nutritional information on cereal crops such as rice, wheat, maize, and so on (Kiruba *et al.,* 2007). Bamboo rice is a special rice that is grown from a dying bamboo shoot. When the bamboo shoot breathes its last, it flowers into a rare variety of rice seeds, which are known as bamboo rice (Shruthi & Revanna, 2023). Bamboo rice is rich in carbohydrates, proteins, amino acids, fibre, vitamins and minerals (Singh, 2021). The protein content of bamboo seed is higher than that of rice and wheat. Other than protein, the rice also has vitamins including A, B1, B2, B3, B6 and minerals like calcium, iron, phosphorus, and magnesium (Bharathi, 2019). Bamboo rice controls blood sugar, cholesterol and it is recommended for pregnant women to overcome vitamin deficiency. It is very rich in fibre content, thus preventing constipation. Diabetic patients are recommended to consume bamboo rice due to its low glycemic index (GI) of 20 instead of normal rice (Selvarajan *et al.* 2016).

Bamboo seed is an underutilised species in India, especially bamboo rice or seed species offer enormous potential for contributing to the achievement of the Millennium Development Goal (MDGs), particularly in combating hidden hunger and offering medicinal and income generation options. They are also closely tied to cultural traditions and therefore have an important role in supporting social diversity (Manohari *et al*. 2016).

Bamboo rice is also known as Bidirakki in the Kannada language, Mulayri in the Malayalam language and Moongil Arisi in the Tamil language by the tribes of southern India. Farmers are facing several problems, including low yields due to adverse weather and natural disasters, besides poor prices. Climate change has simply made farmers face crop failure and, as a result, poor profits. Converting their produce into value-added products is the way to help farmers earn more profit, improve socio-economic status and also to save them from getting duped by middlemen (Kuboyama 1981).

Bamboo seed is a rich source of protein and minerals. Nowadays tribal population is the main user of bamboo seeds. The health benefits of bamboo seeds have gained importance and are widely used in the pharmaceutical industry. Bamboo seed, being a rich source of protein and iron, can be used as a supplementary food for children and other vulnerable groups. As gluten is not present in bamboo seed, it can be recommended for people with gluten allergy. Bamboo seeds with low starch digestibility can also be recommended for diabetic patients. Incorporation of bamboo seed flour into food products can lead to the development of natural, nutritious and adaptable functional foods. (Shabna, 2010).

So, the study was taken up with the objective of nutritional and sensory evaluation of the products prepared by incorporation of bamboo rice.

**2. Materials and Methods**

**2.1 Procurement of samples**

Bamboo rice was procured from the local organic market, and other ingredients were purchased from the local shop. Bamboo rice was refrigerated until further use.

**2.2 Soaking and drying**

Bamboo rice was washed in running water and soaked overnight. Drain the water and dry in the shade for 12 hours. Dried seeds were powdered, and products were developed.

**2.3 Development of products**

Products *viz,* *laddu* and *roti* were standardised with different proportions of bamboo rice, such as 25, 50, 75 and 100 per cent, with white rice as control, depicted in Tables 1 and 2. The method of preparation of products is given in Figs. 1 and 2.

*Laddu* is an Indian sweet dish made from a mixture of flour and sugar, then it is shaped into balls. *Roti* is a traditional flat bread from the Indian subcontinent and is normally eaten with vegetables or curries.

**Table 1: Formulation of *laddu***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **White rice flour (g)** | **Bamboo rice flour  (g)** | **Peanut  grits (g)** | **Dry  coconut (g)** | **Jaggery  (g)** | **Cardamom  powder  (g)** |
| T1 | 100 | 00 | 30 | 30 | 60 | 2 |
| T2 | 75 | 25 | 30 | 30 | 60 | 2 |
| T3 | 50 | 50 | 30 | 30 | 60 | 2 |
| T4 | 25 | 75 | 30 | 30 | 60 | 2 |
| T5 | 00 | 100 | 30 | 30 | 60 | 2 |

T1- Control T2- 25% Bamboo rice flour: 75% White rice flour

T3- 50% Bamboo rice flour: 50% White rice flour

T4- 75% Bamboo rice flour: 25% White rice flour T5- 100% Bamboo rice

**Table 2: Formulation of Bamboo Rice *Roti***

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **White rice flour (g)** | **Bamboo rice flour (g)** | **Salt (g)** |
| T1 | 100 | 00 | 3 |
| T2 | 75 | 25 | 3 |
| T3 | 50 | 50 | 3 |
| T4 | 25 | 75 | 3 |
| T5 | 00 | 100 | 3 |

T1- Control T2- 25% Bamboo rice flour: 75% White rice flour

T3- 50% Bamboo rice flour: 50% White rice flour

T4- 75% Bamboo rice flour: 25% White rice flour T5- 100% Bamboo rice

Rice flour was roasted with little ghee till it turns aromatic

Groundnut and dry coconut was roasted

Jaggery was added to pan with little water and boiled till thickens

Roasted rice flour was added to pan and mixed thoroughly

Dry coconut, groundnut grits and cardamom powder was added to the pan

Mixed well and made into small balls

Bamboo rice *laddu* was s ready to serve

**Fig. 1: Flow chart for preparation of Bamboo rice *laddu***

Boiled the water in a pan

Little salt and oil was added

Rice flour was added to boiling water and mixed thoroughly

Dough was cooled for few seconds

Small balls were made from dough

Dough was pressed into circle

Pressed dough was roasted on both sides

Bamboo rice *roti* was ready to serve

**Fig. 2: Flow chart for preparation of Bamboo rice *roti***

**2.4 Sensory evaluation of developed products**

The products were evaluated by panel of semi-trained panel (n=21). The products were evaluated for the appearance, colour, taste, texture and overall acceptability on nine-point hedonic scales. Where scoring system: 9-like extremely, 8-like very much, 7-like moderately, 6-like slightly, 5-neither like nor dislike, 4-dislike slightly,   
3-dislike moderately, 2-dislike very much, 1-dislike extremely.

**2.5 Nutrient analysis of developed products**

Developed bamboo rice products were analysed for moisture, protein, fat, fibre, and ash using the Association of Official Agricultural Chemists (AOAC, 2004) method, CHO was calculated by the difference method and energy content was determined by the calculation method.

**2.6 Statistical analysis**

The data reported in the tables are the averages of triplicate observations. The data was analysed statistically for the mean, standard deviation, and ANOVA to test the significance among different levels of bamboo rice flour incorporation at a 5 per cent significance level.

**3. Results and Discussion**

**3.1 Sensory evaluation of the developed products**

Bamboo rice products were standardised by incorporating soaked and dried bamboo rice flour with white rice flour at 25 (T2), 50 (T3), 75 (T4), 100 (T5) per cent and Control (T1) was prepared from 100 per cent white rice. The mean sensory score of bamboo rice *laddu* and *roti* was presented in Table 3 (Fig.3) and Table 4 (Fig.4), respectively.

**3.1.1 Sensory evaluation of the Bamboo rice *laddu***

The overall mean acceptability score was highest in T2 (8.09) and lowest in T5 (7.80). The variation in the overall acceptability between treatments showed a non-significant (p>0.05). Four further characteristics, namely appearance (7.66-8.19), colour (8.07-8.52), taste (7.85-8.35) and texture (7.71-8.09) also revealed to be highest in T2 and lowest in T4. It is evident from the results that the difference in the mean value of colour, texture is found to be non-significant (p>0.05) between treatments. It can be concluded that other than white rice *laddu,* T2 was found to be best accepted (8.09), *i.e.,* 75 per cent white rice flour and 25 per cent bamboo rice flour. A study conducted by Fatima and Rao (2019) showed that a product like *laddu,* incorporated with foxtail millet. Variation 2 *laddu* was more acceptable with the score of 8.75, followed by variation 1, *i.e*., 8.33. There is a significant difference observed between variation 1 and variation 2. Another study conducted by Verma *et al.* (2015) developed *laddu* with the incorporation of barnyard and foxtail millet. Sensory evaluation revealed that *laddu* showed a non-significant difference in colour, flavour, texture, appearance and overall acceptability among *laddu* on foxtail millet, barnyard millet and rice. All the sensory evaluation parameters of the three types of *laddu* were observed to be good.

**Table 3: Mean sensory scores of Bamboo rice *Laddu***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Mean sensory scores** | | | | |
| **Appearance** | **Colour** | **Taste** | **Texture** | **Overall acceptability** |
| T1 | 8.14 | 8.19 | 7.95 | 7.71 | 7.97 |
| T2 | 8.19 | 8.52 | 8.35 | 8.09 | 8.09 |
| T3 | 7.66 | 8.14 | 7.95 | 7.83 | 7.80 |
| T4 | 7.80 | 8.07 | 7.85 | 7.90 | 7.92 |
| T5 | 7.66 | 8.14 | 7.95 | 7.83 | 7.80 |
| F test | \* | NS | \* | NS | NS |
| SEm± | 0.116 | 0.118 | 0.129 | 0.137 | 0.130 |
| CD at 5% | 0.326 | - | 0.365 | - | - |

\*Significant at 5% level, NS: Non-significant

T1- 100 % white rice T2- 25% Bamboo rice: 75% White rice

T3- 50% Bamboo rice: 50% White rice T4- 75% Bamboo rice: 25% White rice

T5- 100 % Bamboo rice

Rana and co-workers (2019) developed ladoo using processed rice flakes powder at various levels (5g, 10g and 15g). Sensory analysis was done, and the results revealed that the ladoo prepared by incorporating 15g rice flakes powder was highly acceptable in all attributes, and it was almost similar to the control ladoo.

Singh and Mehra (2017) developed ladoo by adding pearl millet to find out acceptability at different levels of incorporation (25, 50, 75 and 100%). It was revealed that incorporation of pearl millet above 50 per cent was least acceptable in ladoo, whereas 25 per cent incorporation showed the highest acceptability. The sensory score for ladoo prepared with 25 per cent incorporation of pearl millet flour was equally acceptable as the control ladoo.

T1-Control, T2-25% BR: 75%WR, T3-50%BR: 50%WR, T4-75%BR: 25%WR, T5-100% BR

Fig. 3: Mean sensory score of Bamboo rice *laddu*

**3.1.2. Sensory evaluation of the Bamboo rice *roti***

The overall mean acceptability score was highest in T1 (8.10), followed by T3 (7.59), T4 (7.43), T2 (7.41) and the lowest in T5 (7.14). The variation in the overall acceptability between treatments showed a significant (p<0.05). Further four characteristics, namely appearance (7.19-8.38), colour (7.00-8.09), taste (7.16-7.85) and texture (7.19-8.09) also revealed as highest in T1, followed by T3, T4, T2, and T5 found lowest. It is evident from the result that the difference in the mean value of appearance, colour, taste and texture was found statistically significant (p<0.05) between treatments. Finally, it can be concluded that other than white rice *roti,* T3 was found to be the best accepted (7.59), *i.e.,* 50 per cent white rice and 50 per cent bamboo rice.

**Table 4: Mean sensory scores of Bamboo rice *Roti***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Mean sensory scores** | | | | |
| **Appearance** | **Colour** | **Taste** | **Texture** | **Overall acceptability** |
| T1 | 8.38 | 8.09 | 7.85 | 8.09 | 8.10 |
| T2 | 7.42 | 7.61 | 7.21 | 7.40 | 7.41 |
| T3 | 7.71 | 7.59 | 7.52 | 7.52 | 7.59 |
| T4 | 7.52 | 7.50 | 7.26 | 7.45 | 7.43 |
| T5 | 7.19 | 7.00 | 7.16 | 7.19 | 7.14 |
| F –Test | \* | \* | \* | \* | \* |
| SEm± | 0.113 | 0.125 | 0.124 | 0.130 | 0.118 |
| CD at 5% | 0.313 | 0.347 | 0.344 | 0.360 | 0.327 |

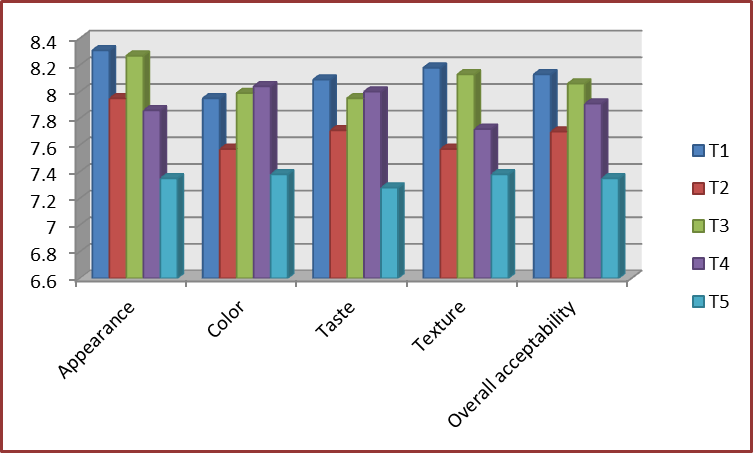
\*Significant at 5% level,

T1- 100 % white rice T2- 25% Bamboo rice: 75% White rice

T3- 50% Bamboo rice: 50% White rice

T4- 75% Bamboo rice: 25% White rice T5- 100 % Bamboo rice

Test *roti* was well accepted in terms of appearance (8.08), colour (7.97), texture (7.39), aroma (7.36), taste (7.78) and overall acceptability (7.72). Control roti scores slightly lower values for all sensory attributes (Gopika, 2016). According to Roopa (2021), who developed *roti* with the incorporation of kodo millet flour. Sensory evaluation results revealed that control *roti* scored highest for all the sensory parameters. Among the variations highest scores for appearance, colour, flavour, texture, taste and overall acceptability (7.95, 7.93, 7.60, 8.01, 7.83 and 7.62 respectively) were recorded for 50 per cent kodo millet flour incorporated *roti* and least scores was for 100 per cent kodo millet flour incorporated variation (7.61, 7.70, 7.67, 7.55, 7.77 and 7.64 respectively). However, the difference in scores for all the sensory parameters among the variations was found to be statistically significant (p<0.05). Another study conducted by Kulkarni and Sakhale (2018) developed the sorghum-rich multigrain flour with four millets, namely finger millet, pearl millet, sorghum, foxtail millet and prepared *roti* out of them and reported that multigrain *roti* had the highest acceptability compared to the control (Jowar *roti*).



T1-Control, T2-25% BR: 75%WR, T3-50%BR: 50%WR, T4-75%BR: 25%WR, T5-100% BR

Fig 4: Mean sensory score of Bamboo rice *roti*

**3.2. Nutrient composition of developed products**

Nutrient composition of the *laddu* and *roti* was analysed and depicted in Tables 5 and 6, respectively.

**3.2.1 Nutrient composition of the Bamboo rice *laddu***

Nutrient analysis of *laddu* was carried out and theresults revealed that moisture, protein, crude fiber, ash, iron and magnesium were high in bamboo rice *laddu* (21.36 g, 19.59 g, 13.12 g, 3.65 g, 5.58 mg and 202.31 mg respectively) than the white rice *laddu* (20.16 g, 18.49 g, 11.14 g, 3.57 g, 5.57 mg and 183.16 mg respectively). Whereas, white rice *laddu* had a higher amount of fat, carbohydrate, energy, calcium and phosphorus (31.72 g, 137.70 g, 916.91 Kcal, 112.36 mg and 321.55 mg respectively) than the bamboo rice (31.69 g, 127.49 g, 871.86 Kcal, 105.71 mg and 275.22 mg respectively).

Rana and co-workers (2017) developed ladoo by incorporating different levels of rice flakes powder. Nutrient analysis (moisture, protein, fat, fibre, ash and iron) was carried out, and the results showed that there was not much difference observed in all attributes, whereas iron content was increased by incorporating rice flakes powder.

**Table 5: Proximate composition of Bamboo rice *laddu***

|  |  |  |
| --- | --- | --- |
| **Parameter** | **White rice *laddu*** | **Bamboo rice *laddu*** |
| Moisture (g) | 20.16 | 21.36 |
| Protein (g) | 18.49 | 19.59 |
| Fat (g) | 31.72 | 31.69 |
| Crude fiber (g) | 11.14 | 13.12 |
| Ash (g) | 3.57 | 3.65 |
| Carbohydrate (g) | 137.70 | 127.49 |
| Energy (Kcal) | 916.91 | 871.86 |
| Calcium (mg) | 112.36 | 105.71 |
| Iron (mg) | 5.57 | 5.58 |
| Magnesium (mg) | 183.16 | 202.31 |
| Phosphorous (mg) | 321.55 | 275.22 |

**3.2.2 Nutrient composition of the Bamboo rice *roti***

Nutrient analysis of *roti* was carried out and the results evident that moisture, protein, crude fiber, ash, calcium and iron were high in bamboo rice *roti* (10.86 g, 8.78 g, 5.88 g, 0.72 g, 8.95 mg and 0.69 mg) than the white rice (9.93 g, 7.94 g, 2.81 g, 0.56 g, 7.49 mg and 0.65 mg respectively). However, fat, carbohydrate, energy, magnesium and phosphorus were higher in white rice (0.52 g, 78.24 g, 356.00 Kcal, 19.30 mg and 108.00 mg respectively) than the bamboo rice *roti* (0.51 g, 68.23 g, 313.00 Kcal, 16.85 mg and 49.50 mg respectively).

Veena *et al.* (2003) developed traditional foods viz, idli, chakli and roti by incorporating barnyard millet flour in different levels of incorporation (0, 25, 50, 75 and 100%). After incorporation of barnyard millet flour, alter the nutritional composition without affecting the organoleptic characteristics. Addition of barnyard millet in rice-based foods increased the nutrients per serving in terms of dietary fibre and minerals, but reduced the calorific value.

**Table 6: Proximate composition of Bamboo rice *Roti***

|  |  |  |
| --- | --- | --- |
| **Parameter** | **White rice *roti*** | **Bamboo rice *roti*** |
| Moisture (g) | 9.93 | 10.86 |
| Protein (g) | 7.94 | 8.78 |
| Fat (g) | 0.52 | 0.51 |
| Crude fiber (g) | 2.81 | 5.88 |
| Ash (g) | 0.56 | 0.72 |
| Carbohydrate (g) | 78.24 | 68.23 |
| Energy (Kcal) | 356.00 | 313.00 |
| Calcium (mg) | 7.49 | 8.95 |
| Iron (mg) | 0.65 | 0.69 |
| Magnesium (mg) | 19.30 | 16.85 |
| Phosphorous (mg) | 108.00 | 49.50 |

Hence, the study indicated that the *laddu* at 25 per cent and *roti* at 50 per cent levels were found to be best accepted when compared with the other variations by the panellists. The nutritional value of the final products was increased because of the incorporation of bamboo rice.

**4. Conclusion**

The study showed that *laddu* and *roti* prepared from soaked and dried bamboo rice flour incorporation at 25 and 50 per cent levels were found to be best accepted when compared with other variations, including control, by the panellists. Proximate composition of the developed products revealed that protein and crude fibre were better because of the incorporation of bamboo rice flour. Acceptable value-added products like *laddu* and *roti* from bamboo rice can be developed, and the health benefits of bamboo rice can be exploited.

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