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

**Abstract**

India is one of the largest bamboo producing country. Bamboo is perennial tree that may grow even up to 60 to 100 years. Bamboo rice is special rice that is grown out of a dying bamboo shoot. It has become an important and major source of income for tribal living in the forest. The aim of the study was to develop value added products from bamboo rice and evaluation of the sensory acceptability and nutritional composition of the developed products. *Laddu* and *roti* were prepared and evaluated by using 9 point hedonic scale by 21 semi trained panel members. Sensory evaluation revealed that variation T2 for *laddu* and variation T1 for *roti* scores high for all attributes. Nutrient composition of the bamboo rice *laddu* revealed that moisture, protein, fiber, ash, iron and magnesium were high in bamboo rice *laddu* than the white rice *laddu*. Whereas, white rice *laddu* had higher amount of fat, carbohydrate, energy, calcium and phosphorous than the bamboo rice *laddu*. Nutrient composition of bamboo rice *roti* revealed that moisture, protein, fiber, ash, calcium and iron were high in bamboo rice *roti* than the white rice *roti.* However, fat, carbohydrates, energy, magnesium, phosphorous were high in white rice *roti*. Thus the study shows that 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 in to a rare variety of rice seeds, which are known as bamboo rice (Rana, 2017). The edible nature of bamboo rice identified from some tribal areas. 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 rich in carbohydrates, proteins, amino acids, fiber, vitamins and minerals (Singh, 2021). 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 fiber 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 underutilized 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 knowkn as Bidirakki in Kannada language, Mulayri in Malayalam language and Moongil Arisi in Tamil language by the tribal of southern India. Farmers are facing several problems, including low yield due to adverse weather and natural calamities, besides poor prices. Climate change has simply made farmers face crop failure and as a result poor profit. Converting their produce into value-added products is the way to help farmers to earn more profit, improve socio-economic status and also to save them from getting duped by middle men (Kuboyama 1981).

Bamboo seed is a rich source of protein and minerals. Nowadays tribal population is the main users of bamboo seeds. The health benefits of bamboo seed has gained importance and is widely used in the pharmaceutical industry. Bamboo seed being a rich source of protein and iron it 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 seed 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 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 dried under shade for 12 hours. Dried seeds were powdered and products were developed.

**2.3 Development of products**

Products *viz,* *laddu* and *roti* were standardized with different proportion of bamboo rice such as 25, 50, 75 and 100 per cent with white rice as control depicted in Table 1 and 2. The method of preparation of products is given in Fig.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 traditional flat bread from the Indian subcontinent and 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 analyzed for moisture, protein, fat, fiber, ash using Association of Official Agricultural Chemists (AOAC, 2004) method, CHO was calculated by difference method and energy content was determined by calculation method.

**2.6 Statistical analysis**

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

**3. Results and Discussion**

**3.1 Sensory evaluation of the developed products**

Bamboo rice products were standardized 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* were 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 established highest in T2 (8.09) and least found in T5 (7.80). The variation in the overall acceptability between treatments showed non-significant (p>0.05). Further four 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 highest in T2 and lowest in T4. It is evident from the results that the difference in the mean value of colour, texture found non-significant (p>0.05) between treatments. It can be concluded that other than white rice *laddu* T2 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 the 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 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 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 level (5g, 10g and 15g). Sensory analysis was done and the results revealed that the ladoo prepared by incorporating 15g rice flakes powder were highly acceptable in all attributes and it was almost similar to that control ladoo.

Singh and Mehra (2017) developed ladoo by adding pearl millet to find out acceptability at different level of incorporation (25, 50, 75 and 100%). It was revealed that incorporation of pearl millet above 50 percent was least acceptable in ladoo whereas, 25 percent incorporation showed highest acceptability. The sensory score for ladoo prepared with 25 percent incorporation of pearl millet flour were 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 established highest in T1 (8.10) followed by T3 (7.59), T4 (7.43), T2 (7.41) and the least found in T5 (7.14). The variation in the overall acceptability between treatments showed 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 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 found statistically significant (p<0.05) between treatments. Finally it can be concluded that other than white rice *roti* T3 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 |

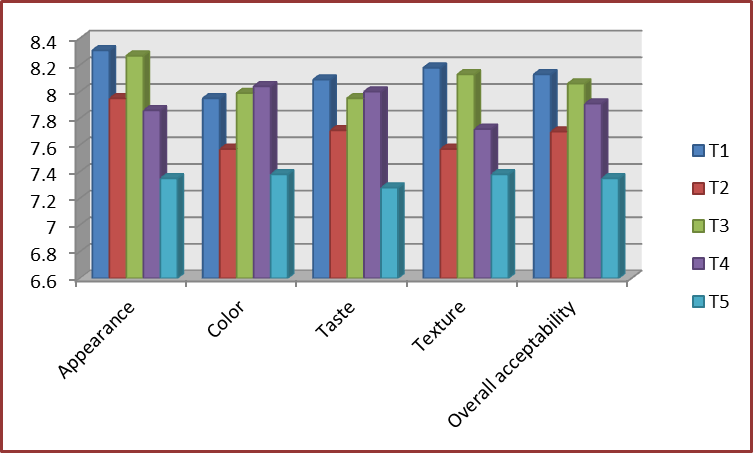
\*Significant at 5% level,

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* 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 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) who 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 highest acceptability compared to 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* were analysed and depicted in Table 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 higher amount of fat, carbohydrate, energy, calcium and phosphorous (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, fiber, ash and iron) was carried out and the results showed that there was no much difference were 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 phosphorous were high 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 servings in terms of dietary fiber 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 percent and *roti* at 50 percent level was found to be best accepted when compared with the other variations by the panelists. The nutritional value of the final products was increased because of 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 level were found to be best accepted when compared with other variations including control by the panelists. Proximate composition of the developed products revealed that protein and crude fiber were better because of incorporation of bamboo rice flour. Acceptable value added products like *laddu* and *roti* from bamboo rice can be developed and health benefits of bamboo rice can be exploited.

**REFERENCES**

A.O.A.C., 1980, Official methods of analysis, 13th edition. *Association of Official Agricultural Chemists,* Washington, D. C. 2004.

Bharathi, M., 2019, Health Benefits of Bamboo Rice and Recipes. *Simple Indian Mom*, Updated on 25th November 2019.

Fatima, Z. and Rao, A., 2019, Development, organoleptic evaluation and acceptability of products developed by incorporating foxtail millet, *J. Food Nutr. Res.* **2**: 128-135.

Gopika, C. Muttagi, 2016, Study of selected traditional rice varieties for the development of functional foods. *Ph.D. Thesis* (unpub.), Univ. Agric. Sci., Bangalore. Karnataka, India.

Kiruba, S., Jeeva, S., Sam Manohar Das, S. and Kannan, D., 2007, Bamboo seeds as a means to sustenance of the indigenous community. *Indian J. Tradit. Knowl*., **6** (1): 199-203.

Kulkarni, D. B. and Sakhale, B. K., 2018, Development of sorghum rich multigrain flour for preparation of roti. *Int. J. Chem. Studies*, **6**(5): 3436-3440.

Kuboyama, N., Fujji, A. and Tamura, T., 1981, Anti-tumor activities of bamboo leaf extracts and its lignin, *Nippon Yakurigaku Zasshi*, **77**(6): 579-596.

Liese, W. and Kohl, M., 2015, Bamboo the plant and its uses, Chapter 2, Priority Species of Bamboo. *Tropical Forestry*, Spinger.

Manohari, R. G., Saravanamoorthy, M. D., Vijayakumar, T. P. and Vijayan, B., 2016, Preliminary Phyto chemical Analysis of Bamboo Seed. *World J. Pharm.Pharm. Sci.,* 5 (4): 1336 - 1342.

Rana, S., 2017, Bamboo rice: everything you need to know about the tribal savory, NDTV Food, Updated On May 1st 2017.

Rana, R., Kaur, P. and Narwal, N., 2019, Nutritional evaluation and development of value added products rice flakes powder to improve iron status, International Journal of Home Science, 5(2): 348-351.

Roopa, B. P., 2021, Processing, nutritional quality and value added products of kodo millet (*Paspalum scrobiculatum*), *Ph.D Thesis*, UAS, GKVK, Bengaluru, India.

Selvarajan, S., Annie Jasmine Swapna J. J., Gayathri Devi, V., Arya, A. B., Aswathy, S., Thampan, Athira, C., Raju, Geethu, K. B., Harsha, R., Hitha Shyam, M. S. and Jyothi, S. D., 2016, Influence of rice varieties in diabetics among Indian population - a review, European J. Pharm. Med. Res. **3**(8): 184-188.

Shabna, K., 2010, Quality evaluation of bamboo seed and its products, *M.Sc. Thesis*, Kerala Agric. Univ. Thrissur, Kerala.

Singh, S. A., 2021, Bamboo Rice: The Next Super Food that Can Boost Your Health and Wellbeing. The Free Press Journal, Updated on Sunday, January 24, 2021.

Singh, U. and Mehra, A., 2017, Sensory evaluation of *ladoo* prepared with pearl millet, International Journal of Home Science., 3(2); 610-612.

Veena, B., Chimmad, B. and Naik, R., 2003, Barnyard millet (*Echinochloa frumentacea)*: A future food for health. In: poster abstracts of 5th IFCON, 5-8 December, CFTRI, Mysore, India. P: 278.

Verma, S., Srivastava, S. and Tiwari, N., 2015, Comparative study on nutritional and sensory quality of barnyard and foxtail millet food products with traditional rice products, *J. Food Sci. Technol*., **52**(8): 5147-5155.