Formulation And Evaluation Of Lotus Seeds Enriched Millet Flour Based Bakery Products

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Abstract
Millets are unique among the cereals because of their richness in calcium, dietary fiber, polyphenols and protein. Four millets such as Bajra (1mg), Barnyard (26.50 gm/100g), Foxtail (11.19mg) and Ragi (2.23 to 3.24mg) which are rich in flavonoids and total phenols were incorporated with lotus seed exhibited highest content of nutrients. Lotus seed is rich in major food components (Lipid, protein, starch, vitamins and minerals) and bioactive compounds and thus its used to develop value added products and bakery products with high protein and carbohydrates. The lotus seed flour is a good source of protein (19.25 ± 0.24g), fiber (4.25 ± 0.09g) and carbohydrates (65.02 ± 0.15(g)) with enhanced functional properties. This study revealed that had lotus seed incorporated composite flour was found that the flavonoids(730.95mg) content was also good in amount and it has immense health benefits for all age groups and it provides a sustainable diet to young generations while at the same time representing and important market for sustainable food products for the sustainable development.
Key words: *Millet flour- Lotus seed- Enhanced- Nutrients- Protein- Fiber- flavonoids*

INTRODUCTION

Millets are the oldest foods known to human beings. They are highly nutritious and easily digestible grains available in the world. Millets accounts for only 2% of the world cereal production and 95% of the world millet production come from Asia and Africa (FAO, 2018). Millets are superior to major cereals in terms of dietary fiber, resistant starches, vitamins, essential amino acids, storage proteins and other bioactive compounds (Gaikwad et al.,2021, Sharma et al.,2021, Bandyopadhyay et al.,2017). Millets are potential candidates of food and nutritional security for the vulnerable sections of the population. High amount of resistant starch in millets ensures the slow and sustained glucoses release into the blood stream and the supply of up to 2000-3000 calories per person per day (Muthamilarasan and Prasad, 2021). Foxtail millet as a sedative and laxative; barnyard millet is used in the disease of spleen; finger millet in the "Tridosha" blood disease; and little millet as a blood purifier (Gupta et al.2012). Finger millet is composed of carbohydrate with low Glycemix index and hence is recommended for diabetic patients (Nakarani et al.2021. The utilization of composite flour is a new and unique approach for the utilization of uncommon food products and crops for product preparation with good health benefits reported. The composite flour is enriched with bioactive compounds and has good nutritional composition. Little millet though nutritionally superior and compares well to stable cereals, the usage is limited due to increased production and availability of preferred cereals (such as wheat) as subsidized prices. Utilization of millet for novel product development will help in diversifying their use which will be beneficial for human health. Present study was an effort to convert little millet into a convenient ready to cook food products from composite flour and to explore the nutritional benefits and storage quality. The composite flour for stable foods such as baking items, it should be noted that there are two reasons for mixing the wheat with other flours i.e. economic and nutritional. "A flour made by blending or mixing varying proportion of more than one non-wheat flour with or without wheat flour and used for production of leavened or unleavened baked or snack products that are traditionally made from wheat flour and increase the essential nutrients in human diet is called composite flour". The study (Poshadri et al.2019), provides the information about a commercially viable application of increasing protein and fibre content in cookies

and also these can be solve the problem of malnutrition and other essential macro and micro nutrients deficiency among the population. The objective of the present study was also to expand the utility of millets, and lotus seed flour by value addition through incorporating with wheat flour to prepare the composite flour and used to develop the cookies, cake and pasta and their characterization.

Neutraceutical effect on lotus seed

Lotus seeds contain many bioactive compounds like alkaloid, flavonoids etc. Lotus seeds exert antiinflammatory, anti-cancer, hypoglycemic activity and others. Lotus seed contains a diverse range of phytochemicals including alkaloids, flavonoids, polysaccharides, essential oils, glycosides, polyphenols, triterpenoids, etc., which have a wide range of pharmaceutical properties (Chen et al.,2012,2019; Huang et al.,2009; Zhenjia et al.,2010). The pharmacological activities of lotus seeds on human health include antioxidant (Sujitha et al.,2013), antitumor (Menendez-Perdomo & Facchini,2020), analgesic (Rajput et al.,2019), anti-obesity(Sim et al.,2019), anti-inflammatory (Harishkumar et al.,2020), cardiovascular, hepatoprotective, immune regulatory, improving memory, hypoglycemia and anti-viral activities as well as for treating leprosy, halitosis, menorrhagia and fever (Zaidi & Srivastava,2019). Among all plant parts, lotus seed contains 61%-62% of carbohydrates,16%-21% of total proteins, 2.40%-3% of crude fat with 5%-9% of moisture content (Sathithon & Yan-bin 2012; Shahzad et al.,2021). One of the dominant components of carbohydrates present in lotus seed is starch. The retrograded starch or resistant starch3 of lotus seed demonstrated strong prebiotic effect with stimulating the growth of beneficial microbes (Bifidobacteria and Lactobacillus) in the gut (Zeng etal.,2018). Recently, hydrolysate produced using Flavourzyme from the lotus seed protein showed excellent antioxidant properties, suggesting their use as a health-promoting supplement and nutraceuticals (Yu et al.,2021). Among vitamins,vitamin C is found in maximum concentration (20-24mg/100g). Lotus seed also showed a good presence of minerals, namely iron (13-18mg/100g), calcium (30-31mg/100g), sodium (30-35mg/100g), and potassium (16-20mg/100g) (Zhang et al.,2015, Kaur et al.,2019). In the above context this study was done to standardize composite flour incorporated with non-conventional ingredients. The sensory evaluation of the various incorporation of the level of non-conventional ingredients Phase I, II, and III along with the changes in nutritional composition due to the incorporation of non-conventional ingredients. The microbial load of the product and antioxidant assay was studied and its influence due to the incorporation of nonconventional ingredients was investigated. The cost calculation of non-conventional incorporated food products was calculated to reveal the economics of the developed product.

MATERIAL & METHODS

Selected ingredients namely Wheat, Green gram whole, Barnyard, Bajra, Foxtail, Ragi, Makhana was procured from the Departmental store in Sivagangai. All the materials were cleaned properly without dirt and dust and any other foreign particle. .Roasted multi millets and Lotus seed were used for the preparation of standardization of composite multi millets were purchased cleaned and roasted flour and sprouting multi millet. Then all ingredients were roasted 60c for 30seconds (weighed) all the roasted millets are cooled, grind all multi millets (weighed) Sprouted flour prepared in Wheat, Green gram whole, Barnyard, Bajra, Foxtail, Ragi millets are used all millets are soaked in 3-4 hours, all millets are transfer in white clothes and the millets are overnight sprouted. The sprouted millets are dry in sunlight in one day and then all millets were milled to get the composite flour.

Composite flour is essentially a blend of various flours, aiming to improve nutritional value, functionality, or sensory qualities. Pilot studies are conducted to investigate these effects. The treatments are as follows:

Roaster Flour 1 = Wheat Flour 70g + Barnyard Flour 5g + Bajra Flour 5g + Foxtail Flour 5g + Ragi Flour 5g + Lotus Seed Flour 5g + Green Gram Whole 5g

Roaster Flour 2 = Wheat Flour 50g + Barnyard Flour 10g + Bajra Flour 10g + Foxtail Flour 10g + Ragi Flour 10g + Lotus Seed Flour 10g+ Green Gram Whole 10g

Sprouted Flour 1 = Wheat Flour 70g + Barnyard Flour 5g + Bajra Flour 5g + Foxtail Flour 5g + Ragi Flour 5g + Lotus Seed Flour 5g + Green Gram Whole 5g

Sprouted Flour 2 = Wheat Flour 50g + Barnyard Flour 10g + Bajra Flour 10g + Foxtail Flour 10g + Ragi Flour 10g + Lotus Seed Flour 10g+ Green Gram Whole 10g

The selected composite flour combinations were studied in the proportion of roasted composite flour1, roasted flour = wheat flour 70g + barnyard flour 5g + bajra flour 5g + foxtail flour 5g + ragi flour 5g + lotus seed flour 5g+ green gram whole 5g, sprouted composite flour1 = wheat flour 70g + barnyard flour 5g + bajra flour 5g + foxtail flour 5g + ragi flour 5g + lotus seed flour 5g+ green gram whole 5g and roasted grain was selected for adai and pongal mix instead of sprouted grain.

Preparation of Composite Flour Products

Wheat, Green gram whole, Barnyard, Bajra, Foxtail, Ragi millet, Makhana (Lotus seed) Bakery food, Extruted food, Ready to prepare and Steamed foods are preparation of the composite flour products.

I. Cake

All composite flour and mixed wheat flour and another bowl sugar and butter together briefly after each addition mix in vanilla essence combine flour and baking powder in a separate bowl. Add to the wed ingredients and mix well pour butter into the prepared cake pan bake in the preheated oven until the top

springs back when lightly touched 30 to 40 minutes remove from the oven cool completely.

II. Cookies

Barnyard, Bajra, Foxtail, Ragi millet, Makhana, Wheat flour, Green gram whole (grind all flour) and butter, sugar. Then all composite flour mixed and wheat flour in a clean mixer bowl, with clean beater and then beat the butter and sugar make it as a cream consistency then add vanilla essence with composite flour in a soft dough. Then the dough was cut with the cookie cutter or even glass cover them on a baking tray allows, preheat oven at 190 c, Bake for 10 minutes or until golden brown colour, when it was cooked well carefully transfer to plates

III- Pasta

Barnyard, Bajra, Foxtail, Ragi millet, Makhana, Wheat flour, Green gram flour (grind all flour) are blended in the mixing compartment of the flour and blended with water for 30minutes and extruded using a pasta die. Wheat is added as the less gluten content of millets requires minimum percentage of wheat for preparing pasta.

RESULTS & DISCUSSION Cake

Sensory evaluation indicates that the acceptability of the products is shown in table 1. The acceptability of composite flour product cake was judged on a 9-point hedonic scale. The sensory evaluation was carried out based on appearance, texture, taste, colour, flavour and overall accepts of the developed products. The sensory evaluation of composite flour product cake samples revealed that there are significant differences among the variations for the sensory qualities. The quality was judged by the tasting panel team consisting of twenty members. The sample 1 was most similarly accepted by all sensory panels. The first one is better preparation selected by the sensory panel was sample 1 compare to sample 2 with overall acceptability.

Table 1- Cake Preparation (Roasted Flour)

SCORE	STORAGE DAYS		
	1st	15th	30th
Appearance	9	9.42	9.3
Colour	9	9.2	8.8
Flavour	9	9.5	9.2
Texture	9	9.7	9.1
Taste	9	9.3	8.8
OAA	9	9.42	9.04

Table 2- Cake Preparation (Sprouted Flour)

SCORE	STORAGE DAYS

	1st	15th	30th
Appearance	9	8.8	8.0
Colour	9	9.3	8.8
Flavour	9	9.2	8.2
Texture	9	8.7	8.3
Taste	9	8.8	8.5
OAA	9	8.96	8.36

Attribute	Day	Roasted Mean	Sprouted Mean	p-value
Appearance	Day 1	9.00	9.00	0.8769
Colour	Day 1	9.00	9.00	0.6677
Flavour	Day 1	9.00	9.00	0.4245
Texture	Day 1	9.00	9.00	0.8759
Taste	Day 1	9.00	9.00	0.6253
OAA	Day 1	9.00	9.00	0.7805
Appearance	Day 15	9.42	8.80	< 0.0001
Colour	Day 15	9.20	9.30	0.0040
Attribute	**Day**	**Roasted Mean**	**Sprouted Mean**	**p-value**
Flavour	Day 15	9.50	9.20	< 0.0001
Texture	Day 15	9.70	8.70	< 0.0001
Taste	Day 15	9.30	8.80	< 0.0001
OAA	Day 15	9.42	8.96	< 0.0001
Appearance	Day 30	9.30	8.00	< 0.0001
Colour	Day 30	8.80	8.80	0.4578
Flavour	Day 30	9.20	8.20	< 0.0001
Texture	Day 30	9.20	8.30	< 0.0001
Taste	Day 30	8.80	8.50	0.0001
OAA	Day 30	9.04	8.36	< 0.0001

No significant differences ($p > 0.05$); both flour types yielded equal scores. **Roasted flour cakes significantly outperformed sprouted flour cakes** in most attributes. The most consistent differences were seen in **texture, flavour, and overall acceptability (OAA)**. Colour showed minor or no difference at Day 30. Sensory evaluation scores for cakes prepared using roasted and sprouted flour were compared over 30 days of storage. On Day 1, no statistically significant differences ($p > 0.05$) were observed between the two flour types across all attributes, indicating comparable initial acceptability. However, from Day 15 onward, cakes made with roasted flour consistently outperformed those made with sprouted flour in most sensory parameters, including appearance, flavour, texture, taste, and overall acceptability (OAA), with several

comparisons yielding highly significant differences ($p < 0.001$). Texture and flavour showed the most pronounced decline in the sprouted flour samples, while roasted flour cakes maintained superior sensory quality throughout storage. The colour attribute exhibited minor or non-significant differences by Day 30. These results suggest that roasted flour is more effective in preserving the sensory qualities of cake products over time, making it a more suitable choice for extended shelf-life applications.

Table 3- Cookies Preparation (Roasted Flour)

SCORE	STORAGE DAYS		
	1st	15th	30th
Appearance	9	8.8	8.5
Colour	9	9.6	9.3
Flavour	9	9.7	9.5
Texture	9	8.5	8.2
Taste	9	8.8	8.3
OAA	9	9.08	8.76

Table 4- Cookies Preparation (Sprouted Flour)

SCORE	STORAGE DAYS		
	1st	15th	30th
Appearance	9	7.5	7.3
Colour	9	9.1	8.8
Flavour	9	9.4	9.2
Texture	9	7.6	7.3
Taste	9	7.9	7.5
OAA	9	8.3	8.02

Attribute	Day	Roasted Mean	Sprouted Mean	p-value
Appearance	Day 1	9.00	9.00	0.0601
Colour	Day 1	9.00	9.00	0.7323
Attribute	**Day**	**Roasted Mean**	**Sprouted Mean**	**p-value**
Flavour	Day 1	9.00	9.00	0.9595
Texture	Day 1	9.00	9.00	0.6897
Taste	Day 1	9.00	9.00	0.1098
OAA	Day 1	9.00	9.00	0.0605
Appearance	Day 15	8.80	7.50	< 0.0001
Colour	Day 15	9.60	9.10	< 0.0001
Flavour	Day 15	9.70	9.40	< 0.0001
Texture	Day 15	8.50	7.60	< 0.0001
Taste	Day 15	8.80	7.90	< 0.0001
OAA	Day 15	9.08	8.30	< 0.0001

Appearance	Day 30	8.50	7.30	< 0.0001
Colour	Day 30	9.30	8.80	< 0.0001
Flavour	Day 30	9.50	9.20	< 0.0001
Texture	Day 30	8.20	7.30	< 0.0001
Taste	Day 30	8.30	7.50	< 0.0001
OAA	Day 30	8.76	8.02	< 0.0001

The comparative sensory analysis of cookies prepared with roasted and sprouted flour showed that on Day 1, both variations were statistically identical in quality across all evaluated attributes ($p > 0.05$), indicating equal initial acceptability. However, significant differences emerged during storage. By Day 15 and Day 30, cookies made with roasted flour consistently maintained superior sensory scores across all parameters—appearance, colour, flavour, texture, taste, and overall acceptability (OAA)—with p-values < 0.0001, indicating strong statistical significance. In contrast, the sprouted flour cookies experienced a notable decline in sensory quality over time, particularly in appearance, texture, and taste. These findings suggest that roasted flour is more stable and effective for preserving the sensory integrity of cookies during storage

Table 5- Pasta Preparation (Roasted Flour)

SCORE	**STORAGE DAYS**		
	1st	**15th**	**30th**
Appearance	9	9	8.5
Colour	9	8.3	7.9
Flavour	9	7.7	7.3
Texture	9	8.2	7.8
Taste	9	8.5	7.9
OAA	9	8.34	7.88

Table 6- Pasta Preparation (Sprouted Flour)

SCORE	**STORAGE DAYS**		
	1st	**15th**	**30th**
Appearance	9	8.6	8.3
Colour	9	9.2	8.5
Flavour	9	9	8.3
Texture	9	8.7	8.2
Taste	9	8.3	7.9
OAA	9	8.76	8.24

Appearance slightly declines for both, more noticeable in sprouted flour but still higher at Day 30 (8.3 vs. 8.5). Colour of sprouted flour pasta shows better retention (9.2 → 8.5) compared to roasted flour (8.3 → 7.9). Flavour of sprouted flour remains better maintained (9 → 8.3) vs. roasted flour (7.7 → 7.3). Texture of prouted flour pasta shows higher texture scores throughout storage. Taste of both decline, but sprouted flour scores remain slightly better at each stage. Shelf stability of both types of pasta show a decline in sensory scores over 30 days, which is expected due to staling or changes in flavour, texture, and freshness. Superior Sensory Retention: Sprouted flour pasta consistently. This suggests that sprouted flour is a more stable and preferable ingredient for pasta production when storage and shelf life are key considerations. Sprouted flour pasta is superior in maintaining sensory quality during storage, especially for flavour,

colour, and overall acceptability. This suggests that sprouted flour is a more stable and preferable ingredient for pasta production when storage and shelf life are key considerations.

Cost calculation of composite flour incorporated food product Table 7-

Comparative analysis of cost

Ingredients	Quantity	Roasted	Quantity	Sprouted
Wheat	70g	6	40g	3
Barnyard	5g	3	10g	6
Bajra	5g	0.2	10g	0.4
Foxtail	5g	0.2	10g	0.4
Ragi	5g	2	10g	4
Makhana	5g	10	10g	20
Green Gram	5g	1	10g	2
	100g	22.4	100g	35.8

Table 7 provides a cost calculation of composite flour ingredients incorporated into Roasted Composite flour and sprouted. The cost of the ingredients used in each sample is provided in two different quantities along with their respective costs in Indian Rupees. For the Roasted Composite flour and sprouted composite flour the following ingredients were used in Wheat, Barnyard, Bajra, Foxtail, Ragi, Makhana and Green Gram. The cost of 100g of this roasted flour was fund to be Rs. 22.4 and the cost of 100g of this sprouted flour was fund to be Rs.35.8. The cost of each ingredient is provided in two different quantities, and the total cost of 100gmof each flour is also provided for two different samples. This information can be useful for food manufacturers and researchers.

Table 8- Comparative analysis of cost

Ingredients	Quantity	Roasted	Quantity	Sprouted
Wheat Semolina	70g	5	70g	5
Barnyard	5g	3	5g	3
Bajra	5g	0.2	5g	0.2
Foxtail	5g	0.2	5g	0.2
Ragi	5g	2	5g	2
Makhana	5g	10	5g	10
Green Gram	5g	1	5g	1
	100g	21.4	100g	21.4

Table 8 provides a cost calculation of composite flour ingredients incorporated into Roasted Composite flour and sprouted. The cost of the ingredients used in each sample is provided in two different quantities along with their respective costs in Indian Rupees. For the Roasted Composite flour and sprouted composite flour the following ingredients were used in Wheat Semolina, Barnyard, Bajra, Foxtail, Ragi, Makhana and Green Gram. The cost of each ingredient is provided in two different quantities, and the total cost of 100gmof each flour is also provided for two different samples. This information can be useful for food manufacturers and researchers.

CONCLUSION

Sprouted composite flour with lotus seed flour is nutritionally superior for health-conscious consumers, while roasted flour offers certain advantages for energy needs and storage. Both have potential applications in functional food formulations tailored to specific dietary goals. The sensory evaluation of cake, cookies and pasta demonstrated that each product has distinct strengths in terms of sensory appeal and consumer preference. Trained panelists identified clear and measurable sensory characteristics, while consumer testing revealed a high degree of acceptability, particularly for the sweet products. The results suggest that continued refinement of flavor and texture attributes could enhance the marketability of the savory products. The use of both trained and consumer panels provided a comprehensive understanding of the products' sensory qualities, making this approach valuable for product development and quality assurance.

REFERENCES

1. A. Bernard de Raymond, A. Alpha, T. Ben-Ari, B. Daviron, T. Nesme, G. Tétart Systemic risk and food security. Emerging trends and future avenues for research Global Food Security, 29 (2021),
2. A. Phaniendra, D.B. Jestadi, L. Periyasamy Free radicals: Properties, sources, targets, and their implication in various diseases Indian Journal of Clinical Biochemistry, 30 (1) (2015), pp. 11-26
3. C.B. Ahn, W.K. Jung, S.J. Park, Y.T. Kim, W.S. Kim, J.Y. Je Gallic acid-g-Chitosan modulates inflammatory responses in LPS-stimulated RAW264. 7 cells via NF-κB, AP-1, and MAPK pathways Inflammation, 39 (1) (2016), pp. 366-374
4. Chandra, S.; Singh, S and Kumari, D. (2015). Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. Journal of Food Service and Technology, 52(6): 3681-3688.
5. I. Cisneros-Garcia, L. Dorantes-Alvarez, E. Parada-Arias, L. Alamilla Beltran, Z A. Ortiz-Moreno, H. NecoecheaMondragon, G.F. Gutierrez-Lopez Recommended food supplies under conditions of natural and provoked catastrophes Innovative Food Science & Emerging Technologies, 83 (2023), Article 103218.
6. I. Cisneros-Garcia, L. Dorantes-Alvarez, E. Parada-Arias, L. Alamilla Beltran, A. Ortiz-Moreno, H. NecoecheaMondragon, G.F. Gutierrez-Lopez 2023 Recommended food supplies under conditions of natural and provoked catastrophes

Innovative Food Science & Emerging Technologies, 83 (2023), Article 103218

7. Rajput, M. A. , Zehra, T. , Ali, F. , & Kumar, G. (2019). Assessment of analgesic activity of Nelumbonucifera fruit ethanol extract. International Journal of Pharmacy and Pharmaceutical Sciences, 11, 1–5.
8. S. Das *et al.*Beyond bird feed: Proso millet for human health and environment Agriculture (2019)
9. Shan, L. (2016). Grading alcohol precipitation of resistant starch derived from Lotus seeds and its probiotic effects, Fujian Agriculture and Forestry University (FAFU), China.
10. Shinde BG. Isolation and characterization of starch horse grain. Rahuri (India): Unpublished M.Sc. Thesis. Mahatma PhuleKrishiVidyapeeth; 2001. pp. 16–17.
11. Yasumatsu K, Sawada K, Maritaka S, Toda J, Wada T, Ishi K. Whipping and emulsifying properties of soy bean products. AgriBiol Chem. 1972;36:719–727. doi: 10.1271/bbb1961.36.719.