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Optimization, value addition and sensory evaluation of foxtail millet (*Setaria italica*) based *laddu*

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Abstract
Foxtail millet (*Setaria italica*) is the second-most widely planted species of millet. It is known for its health benefits. *Laddu* are ball-shaped sweets popular in the Indian Subcontinent. *Laddus* are made of flour, ghee and sugar with other ingredients that vary by recipe. They are often served at festive or religious occasions. Hence, an attempt was made to develop foxtail millet based value added *laddu*. Optimization of foxtail millet flour, ghee, sugar and roasting time was carried out. After optimization of every ingredient, sensory evaluation was done by nine point hedonic scale. Standardization trials indicated that acceptable foxtail millet *laddu* could be developed by incorporating 50 per cent foxtail millet flour, 50 per cent bengal gram dhal flour, 45 per cent ghee, 75 per cent sugar powder and 40 minutes of roasting time in the standard *laddu* recipe. The developed foxtail millet *laddu* was highly accepted. Foxtail millet *laddu* may have a good scope for enhancing nutrition security. At present there is demand for ready to eat foods and therefore it has opened challengeable avenue to start production of such foods at commercial scale to benefit innumerable population and it can be taken as income generating activity by the entrepreneurs.

Keywords: Optimization, foxtail millet flour, Bengal gram dhal flour, sensory evaluation and foxtail millet *laddu*

Introduction
Traditional food refers to foods that are passed through generations and also refers to foods consumed over the long-term duration of civilization that have been passed through generations. They are based on sound foundation of culture, custom, natural environment and consumed by people over long time. The traditional food of India has been widely appreciated for its fabulous use of locally grown crops. Indian traditional food is known for its large assortment like sweet, savoury and spicy traditional foods. Further, the significance of traditional foods is more appreciable when their nutritive value is known. In this regard, India has a rich treasure of traditional foods specifically prepared for festivals, rituals, and physiological conditions (Inamdar *et al.*, 2005) [6].

Foxtail millet (*Setaria italica*) is nutritious and important underutilized grain, grown in various parts of India. It grows well even under adverse agro climatic conditions. Foxtail millet is a good source of protein (12.3 g/100 g), dietary fibre (14 g/100 g) and carbohydrates (60.9 g/100 g). Besides, it is rich in minerals (3 g/100 g) and phytochemicals (Gopalan *et al*., 2010) [5]. Foxtail millet is a good source of ß carotene (126-191 µg/100 g, Goudar *et al*., 2011) [4].

Laddu is an Indian sweet made from a mixture of flour, sugar, and shortening and other ingredients that vary by recipe, which is shaped into a ball. Value addition to existing foods with foxtail millet is a simple and feasible way of enhancing nutritional values of foods and in turn the health benefits. The food products based on traditional food preparations easily become acceptable to people. Hence the present investigation is aimed to develop the foxtail millet based *laddu*.

Material and Methods
The present study was carried out in the Department of Food Science and Nutrition, College of Community Science, University of Agricultural Sciences, Dharwad Karnataka. The raw materials like foxtail millet, Bengal gram dhal flour, Ghee and sugar powder were purchased from the local market of Dharwad, Karnataka. The millet grains were washed, rinsed, shade dried and milled from the local commercial milling machine.

Besan laddu are popular sweet dish which often prepared and served during festivals and religious occasions. Standard recipe of *besan laddu* include Bengal gram dhal flour (150 g), ghee (75 g), sugar powder (128 g) and the roasting time 45 minutes. Fig. 1 represents the flow diagram for preparation of optimized *laddu.* Firstly, heat the ghee in frying pan. Add Bengal gram dhal flour and foxtail millet flour to it. Roast it till colour turns to golden brown and develops aroma. Allow it to rest to warm temperature. Add powdered sugar to the roasted flour mix with ghee (which turned to dough consistency). Mix well and make small balls by hands.

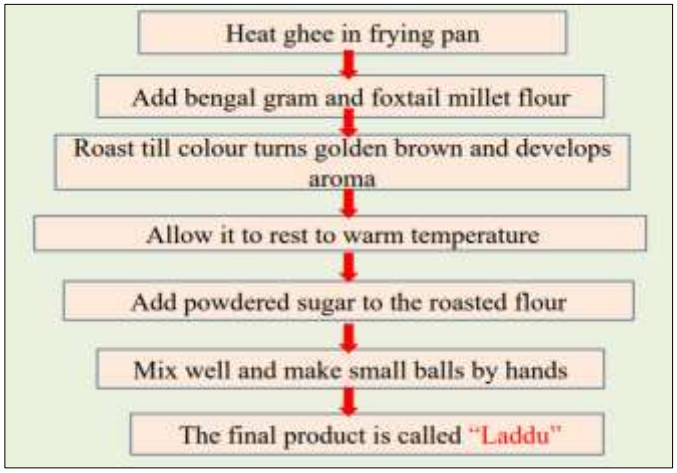

Fig 1: Flow diagram for preparation of optimized foxtail millet based *laddu*

Optimization of foxtail millet *Laddu*

A. Optimization for the incorporation of foxtail millet flour

The suitability of foxtail millet flour in the preparation of *laddu* was studied by incorporating foxtail millet flour in standard recipe. Bengal gram dhal flour was replaced by foxtail millet flour at 25, 50, 75 and 100 per cent level in the standard recipe and all other ingredients were kept constant. Roasting time was kept constant 45 minutes.

a. Sensory evaluation of the *laddu* prepared by incorporating the foxtail millet flour at 25 to 100 per cent level

Sensory qualities of the value added foxtail millet based *laddu* was conducted in comparison with *besan laddu*, control and developed foxtail millet *laddu*. A nine point hedonic scale was used, which describes sensory attributes *viz.*, appearance, colour, texture, taste and flavour on nine point hedonic scale. Sensory evaluation was done by a panel of 15 semi trained judges of Department of Food Science and Nutrition, College of Rural Home Science, UAS, Dharwad.

B. Optimization for the addition of ghee

The highly accepted *laddu* had the ingredients, bengal gram dhal flour (50%), foxtail millet flour (50%), ghee (50%) and time taken for roasting was 45 minutes. To this, level of ghee incorporation was studied by adding the ghee at 5% variation *i.e.* 60, 55, 50, 45, and 40 per cent.

b. Sensory evaluation of the *laddu* prepared by addition of ghee at 60 to 40 per cent level

The *laddu*s prepared by adding ghee at 5 per cent variation *i.e.* 60, 55, 50, 45 and 40 per cent were evaluated for sensory qualities. Sensory evaluation was carried out.

C. Optimization for addition of sugar powder

The level of sugar powder incorporation in the highly accepted (by sensory evaluation) foxtail millet based *laddu* (after optimisation of ghee incorporation) was studied by adding the sugar powder at 5% variation *i.e.* 95, 90, 85, 80 and 75 per cent.

c. Sensory evaluation of the *laddu* prepared by addition of sugar powder at 95 to 75 per cent level

The *laddu*s prepared by adding sugar powder at 95 to 75 per cent level were evaluated for sensory qualities. Nine point hedonic scale was used for sensory evaluation.

D. Optimization for the roasting time

The time required for roasting for *laddu* was done to the highly accepted (by sensory evaluation) foxtail millet based *laddu* (after optimisation of ghee and sugar powder incorporation) at 5 min variation *i.e.* 55, 50, 45, 40 and 35 min. It was mainly done to compare the colour after roasting with control.

d. Sensory evaluation of the *laddu* prepared by varying the roasting time

Sensory evaluation of foxtail millet *laddu* with roasting time variation of 5 minutes *i.e.* 55, 50, 45, 40 and 35 minutes was carried out. Sensory evaluation was carried out.

The results of the study was analysed statistically to ascertain its significance. The results obtained in this study were analysed by the following statistical methods using SPSS statistical package (Version 16.0). All the sensory scores were performed in triplicate and the data was presented as mean ± SD. Analysis of variance was used to test the significance differences in sensory evaluation and paired 't' test was used to compare the sensory scores of *besan* (control) and foxtail millet *laddu.*

Results and Discussion

Organoleptic (sensory) evaluation revealed that *laddus* prepared from 50 per cent incorporated foxtail millet flour had the highest overall acceptability scores followed by 75:25, 100:0 and 25:75 level. From Table 1 it can be observed that the overall acceptable scores of 50:50 was not significant from control (100:0) and 75:25. However 25:75 and 0:100 were having significantly lower overall acceptable scores *viz.*, 7.4 and 5.3 respectively. The most acceptable *laddu* also had the highest scores for appearance (8.7), colour (8.7), texture (8.9), taste (8.5) and flavour (8.6). There was not much change in the organoleptic scores of *laddu* prepared by 100:0 and 75:25 proportions. *Laddu*s prepared with 100 per cent foxtail millet flour had the lowest scores for overall acceptability (5.3), appearance (4.9), colour (5.1), texture (5.2), taste (5.5) and flavour (5.6) and was significantly lower compared to all other formulations except in taste. As the incorporation of foxtail millet flour increased in *laddu*, there was increase in grainy texture ie mouth feel and *laddus* could not retain the shape. This was due to the high fibre content and low oil absorption capacity of foxtail millet flour (Sudha *et al.*, 2021) [9]. In some of the other value added products like foxtail millet based burfi, muffin, bread, vermicelli, pasta and extruded snacks upto 50 per cent incorporation of foxtail millet was carried out and were highly acceptable (Srivastava and Singh, 2003, Garwadhiremath 2011, Deshapande and Poshadri, 2011, Balloli *et al.*, 2014, Ranganna *et al.*, 2014) [8, 3, 2, 1, 7].

As the 50 per cent incorporated foxtail millet *laddu* had the highest overall acceptability score and all other parameters, it was considered as optimum level of incorporation. Sensory evaluation indicated 50 per cent incorporation of foxtail millet flour in preparation of *laddu* was highly accepted (Yenagi *et al.*, 2010) [10].

Laddus were prepared from 150 g of flour mix containing 1:1 proportion of bengal gram dhal flour (75 g) and foxtail millet flour (75 g), sugar powder (128 g), 45 minutes roasting time and with ghee variation from 90, 83, 75, 68 and 60 g of ghee (which accounts 60% to 40% variation). Table 2 shows the overall acceptability score was highest (7.7) in 45 per cent ghee incorporated *laddu* and was significantly higher when compared to 40, 45, 50, 55 and 60 per cent ghee incorporation (6.4, 7.7, 6.4, 5.1, 1.8 respectively). For appearance, the score were 6.6, 8.2, 6.4, 6.4 and 2.5 for the incorporation 40, 45, 50, 55 and 60 per cent ghee. The scores for colour were 6.4, 7.7, 6.1, 5.6 and 1.9 for the incorporation 40, 45, 50, 55 and 60 per cent ghee. For incorporation of 40, 45, 50, 55 and 60 per cent ghee, the scores for texture were 6.4, 7.8, 6.4, 4.4 and 2.2. For taste, the score were 6.4, 7.8, 6.6, 5.2 and 1.6 for the incorporation 40, 45, 50, 55 and 60 per cent ghee. For incorporation of 40, 45, 50, 55 and 60 per cent ghee, the scores for flavour were 6.6, 7.8, 6.2, 4.8 and 1.5. As the quantity of ghee increased, the *laddus* turned to flat shape. And hence shape was not retained. Similar findings were reported by Garwadhiremath (2011) [3] in the optimization of foxtail millet based muffin where 5 per cent decrease in addition of fat was made.

Hence, from table 2 it was observed that 68g (45%) of ghee addition was optimal for development of foxtail millet based *laddu*.

Bengal gram dhal flour and foxtail millet flour in 50:50 proportion with 68 g (45%) of ghee and 45 minutes roasting time was used in preparation of *laddu* with varying quantity of sugar powder which ranged from 143 to 113 g (*i.e.* 95 to 75%). The varied quantity of sugar powder addition also resulted in the difference of organoleptic characteristics (Table 3). The scores for overall acceptability, appearance, colour, texture and taste ranged from 6.3 to 8.2, 7.3 to 8.7, 7.2 to 8.8, 6.7 to 8.7, 7.1 to 8.5 and 7.0 to 8.8 respectively. With 113 g of sugar powder, the *laddus* had the highest overall acceptability (8.2), and also had the highest scores for appearance (8.7), colour (8.8), texture (8.7), taste (8.5) and flavour (8.8). The lowest scores of overall acceptability (6.3) was in *laddu* prepared with highest amount (143 g *i.e.* 95%) of sugar. It also scored less in all the other parameters *i.e.* appearance (7.3), colour (7.2), texture (6.7), taste (7.1) and flavour (7.0). Sweetness increased with addition of sugar and it reduced (lightness) the colour of *laddu*. Statistical analysis showed that there was significant difference in scores for appearance, colour, texture, taste and overall acceptability among 95 to 75 per cent addition of sugar powder to foxtail millet flour *laddu* ($p< 0.01$).

Addition of 113 g sugar powder was selected and considered as optimal level for development of foxtail millet based *laddu*. *Laddus* were prepared from 150 g flour mix containing 1:1 proportion of Bengal gram dhal flour and foxtail millet flour, ghee (68 g), sugar powder (113 g) and with roasting time variation from 35 to 55 minutes. The scores for organoleptic characters varied with varied level of roasting time and the scores ranged for overall acceptability from 3.5 to 8.1, appearance from 3.3 to 8.5, colour from 3.5 to 8.4, texture from 3.5 to 8.0, and taste from 3.3 to 7.9 and flavour from 3.4 to 6.5. *Laddu*s prepared by roasting for 45 minutes had the highest overall acceptability scores (8.1) and it also had the highest scores for appearance (8.5), colour (8.4), texture (8.0), taste (7.9) and flavour (6.5). The *laddu*s prepared from the roasting time 55 and 50 minutes scored lowest for all the parameters (Table 4). Charring (dextrinization) was observed as the roasting time increased, which affected the appearance, colour and taste.

Hence, from table 4 can observe that roasting for 40 minutes found to be optimal for development of foxtail millet *laddu.*

Sensory scores of developed foxtail millet and *besan laddu*

The *Besan laddu* was prepared by 100 per cent bengal gram dhal flour (150 g), ghee 75 g (50%), sugar powder 128 g (85%) and the time taken for roasting was 45 minutes. The optimised foxtail millet based *laddu* was prepared by incorporating the foxtail millet flour (75 g) to bengal gram dhal flour (75 g), ghee (68 g) and sugar powder (113 g). The time taken for roasting was 40 minutes. The score was 8.5 for the colour, flavour and overall acceptability of foxtail millet *laddu*. However for appearance and taste the score was 8.4. For texture the score was 8.6. Overall acceptability score of *besan laddu* was 8.5. Texture (8.9) of *besan laddu* score higher and then followed by the flavour (8.6). And for appearance, colour, taste the score was 8.5. However, there was no significant difference between the foxtail millet *laddu* and *besan laddu* (Table 5).

Table 1: Mean organoleptic scores[#] of *laddu* prepared by varying proportion of foxtail millet flour to Bengal gram dhal flour

Flour (%) Bengal gram dhal: Foxtail millet	Appearance	Colour	Texture	Taste	Flavour	Overall acceptability
100: 0	$8.3^{a} \pm 0.48$	$8.3^{ab} \pm 0.67$	$8.4^{a} \pm 0.69$	$8.5^{a} \pm 0.84$	$8.2^{a} \pm 1.03$	$8.6^{a} \pm 0.51$
75: 25	$8.5^{a} \pm 0.52$	$8.6^{a} \pm 0.51$	$8.3^{a} \pm 0.94$	$8.5^{a} \pm 0.52$	$8.0^{ab} \pm 0.94$	$8.6^{a} \pm 0.51$
50: 50	$8.7^{a} \pm 0.48$	$8.7^{a} \pm 0.48$	$8.9^{a} \pm 0.31$	8.5a ± 0.52	$8.6^{a} \pm 0.51$	$8.7^{a} \pm 0.48$
25: 75	$7.3^{b} \pm 0.82$	$7.4^{b} \pm 0.96$	$7.2^{b} \pm 0.78$	$7.4^{a} \pm 1.07$	$7.0^{b} \pm 0.66$	$7.4^{b} \pm 0.69$
0: 100	$4.9^{c} \pm 1.96$	$5.1^{c} \pm 1.79$	$5.2^{c} \pm 2.14$	$5.5^{b} \pm 2.12$	$5.6^{c} \pm 2.11$	$5.3^{c} \pm 1.94$
F	23.28**	22.02**	16.22**	12.34**	10.14**	20.28**
S.Em	0.21	0.21	0.22	0.22	0.23	0.21
CD	0.92	0.90	1.04	1.06	1.07	0.90

Note: [#]Mean of 10 panellists. Sensory scores were based on 9 point hedonic scale.

** Significant at 0.01%

Each value is mean of three replications

Values with same superscript are not significantly different

Table 2: Mean organoleptic scores[#] of *laddu* prepared by varying the quantity ghee

Ghee (%)	Appearance	Colour	Texture	Taste	Flavour	Overall acceptability
40	$6.6^{b} \pm 0.51$	$6.4^{b} \pm 0.51$	$6.4^{b} \pm 0.51$	$6.4^{b} \pm 0.51$	$6.6^{b} \pm 0.51$	$6.4^{b} \pm 0.51$
45	$8.2^{a} \pm 0.78$	$7.7^{a} \pm 0.82$	$7.8^{a} \pm 0.63$	$7.8^{a} \pm 0.91$	$7.8^{a} \pm 0.78$	$7.7^{a} \pm 0.48$
50	$6.4^{b} \pm 0.51$	$6.1b^{c} \pm 0.99$	$6.4^{b} \pm 0.51$	$6.6^{b} \pm 0.51$	$6.2^{b} \pm 0.63$	$6.4^{b} \pm 0.51$
55	$6.4^{b} \pm 0.51$	$5.6^{c} \pm 0.96$	$4.4^{c} \pm 0.96$	$5.2^{c} \pm 1.39$	$4.8^{c} \pm 0.91$	$5.1^{c} \pm 0.99$
60	$2.5^{c} \pm 0.70$	$1.9^{d} \pm 0.73$	$2.2^{d} \pm 1.03$	$1.6^{d} \pm 0.84$	$1.5^{d} \pm 0.70$	$1.8^{d} \pm 0.63$
F	115.543**	69.523**	80.932**	69.874**	111.114**	117.765**
S.Em	0.16	0.19	0.18	0.20	0.18	0.17
CD	0.55	0.74	0.69	0.81	0.65	0.59

Note: [#] Mean of 10 panellists. Sensory scores were based on 9 point hedonic scale.
** Significant at 0.01%
Each value is mean of three replications
Values with same superscript are not significantly different

Table 3: Mean organoleptic scores[#] of *laddu* prepared by varying the quantity of sugar powder

Sugar powder (%)	Appearance	Colour	Texture	Taste	Flavour	Overall Acceptability
75	$8.7^{a} \pm 0.48$	$8.8^{a} \pm 0.63$	$8.7^{a} \pm 0.48$	$8.5^{a} \pm 0.52$	$8.8^{a} \pm 0.42$	$8.2^{a} \pm 0.42$
80	$7.9^{bc} \pm 0.73$	$8.0^{ab} \pm 0.81$	$7.5^{b} \pm 0.52$	$7.8^{abc} \pm 1.13$	$7.6^{bc} \pm 0.84$	$7.4^{b} \pm 0.69$
85	$8.1^{ab} \pm 0.73$	$8.2^{a} \pm 0.78$	$8.0^{b} \pm 1.15$	$8.3^{ab} \pm 0.67$	$8.2^{ab} \pm 0.63$	$7.8^{b} \pm 0.91$
90	$8.1^{ab} \pm 0.73$	$8.1^{a} \pm 0.73$	$7.6^{b} \pm 0.69$	$7.6^{bc} \pm 0.84$	$7.7^{bc} \pm 0.82$	$7.5^{b} \pm 0.52$
95	$7.3^{c} \pm 1.15$	$7.2^{b} \pm 1.39$	$6.7^{c} \pm 0.82$	$7.1^{c} \pm 1.10$	$7.0^{c} \pm 0.94$	$6.3^{c} \pm 1.05$
F	3.92**	3.91**	8.88**	3.96**	8.01**	13.79**
SEM	0.18	0.20	0.18	0.19	0.18	0.18
CD	0.72	0.82	0.69	0.80	0.68	0.68

Note: [#]Mean of 10 panellists. Sensory scores were based on 9 point hedonic scale.
** Significant at 0.01%
Each value is mean of three replications
Values with same superscript are not significantly different

Table 4: Mean organoleptic scores[#] of *laddu* prepared by varying the roasting time

Roasting time (min.)	Appearance	Colour	Texture	Taste	Flavour	Overall acceptability
35	$6.60^{b} \pm 0.51$	$6.70^{b} \pm 0.48$	$6.40^{b} \pm 0.51$	$6.80^{b} \pm 0.42$	$6.50^{b} \pm 0.52$	$6.60^{b} \pm 0.51$
40	$8.50^{a} \pm 0.52$	$8.40^{a} \pm 0.51$	$8.00^{a} \pm 0.81$	$7.90^{a} \pm 0.73$	$8.30^{a} \pm 0.48$	$8.10^{a} \pm 0.56$
45	$6.50^{b} \pm 0.52$	$6.50^{b} \pm 0.52$	$6.40^{b} \pm 0.51$	$6.80^{b} \pm 0.42$	$6.40^{b} \pm 0.51$	$6.60^{b} \pm 0.51$
50	$3.36^{c} \pm 0.52$	$3.55^{c} \pm 0.69$	$3.51^{c} \pm 0.48$	$3.38^{c} \pm 0.52$	$3.43^{c} \pm 0.84$	$3.52^{c} \pm 0.51$
55	$3.60^{c} \pm 0.51$	$4.00^{c} \pm 0.66$	$3.50^{c} \pm 0.70$	$3.50^{c} \pm 0.52$	$3.60^{c} \pm 0.84$	$3.50^{c} \pm 0.52$
F	169.50**	117.84**	108.02**	145.47**	94.93**	156.17**
S.Em	0.15	0.16	0.16	0.15	0.17	0.15
CD	0.47	0.52	0.56	0.48	0.59	0.47

Note: [#]Mean of 10 panellists. Sensory scores were based on 9 point hedonic scale.
** Significant at 0.01%
Each value is mean of three replications
Values with same superscript are not significantly different

Table 5: Sensory scores of *besan laddu* and developed foxtail millet *laddu*

Parameters	*Besan laddu*	Foxtail millet *laddu*	*'t'* value
Appearance	8.50±0.52	8.40 ± 0.69	0.36^{NS}
Colour	8.50±0.52	8.50 ± 0.52	0.00^{NS}
Texture	8.90±0.31	8.60 ± 0.51	1.56^{NS}
Taste	8.50±0.70	8.40 ± 0.84	0.28^{NS}
Flavour	8.60±0.51	8.50 ± 0.52	0.42^{NS}
Overall acceptability	8.50±0.52	8.50 ± 0.52	0.00^{NS}

NS – Non Significant

Conclusion

With improvement in food technology, convenience food and ready to eat foods are emerging in market. Standardization trials indicated that acceptable foxtail millet *laddu* could be developed by incorporating 50 per cent foxtail millet flour, 50 per cent bengal gram dhal flour, 45 per cent ghee, 75 per cent sugar powder and 40 minutes roasting time in the standard *laddu* recipe. The developed *laddu* had good binding property and was highly acceptable by sensory evaluation. Foxtail millet *laddu* may have a good scope for enhancing nutrition security. At present there is demand for ready to eat foods and therefore it has opened challengeable avenue to start production of such foods at commercial scale to benefit innumerable population and it can be taken as income generating activity by the entrepreneurs.

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