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PK Patle
Guest Faculty, Department of Food Science & Technology, CoA, JNKVV, Jabalpur, Madhya Pradesh, India

Ishita Rajput
Ph.D. Scholar, Department of Food Science & Technology, CoA, JNKVV, Jabalpur, Madhya Pradesh, India

Ramcharan Patel
Young Professional, Department of Food Science & Technology, CoA, JNKVV, Jabalpur, Madhya Pradesh, India

A Singh
Professor, Department of Food Science & Technology, CoA, JNKVV, Jabalpur, Madhya Pradesh, India

Corresponding Author:
Ishita Rajput
Ph.D. Scholar, Department of Food Science & Technology, CoA, JNKVV, Jabalpur, Madhya Pradesh, India

Nutritional, antioxidant and sensory analysis of black rice value added product

PK Patle, Ishita Rajput, Ramcharan Patel and A Singh

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Abstract
Black rice has special medicinal components and high nutritional value. In recent years, the research on the nutritional value and application of black rice has become an important direction, and a series of important progress has been made. This research aims to investigate the nutritional and antioxidant composition of traditional food like "Laddu" to provide valuable insights into their potential health benefits. This is formulated with a focus on incorporating diverse and wholesome ingredients (Museli, Jaggery, Ghee, Dry Fruits, Semolina and Brown sugar) aiming to offer a balance between taste and nutritional value. The study employs various analytical methods to assess the macronutrient and micronutrient content, as well as the antioxidant capacity of the developed Laddu. In the case of Laddu according to the different sensory attributes during judge by the panel members, T_3 scores the best, regarding the color and appearance it gains 8.3, for body and texture it gains 9.0, for taste and flavor 8.6 and for overall acceptability it gains 8.6 scores Comparison of nutritive value of Laddu. The information regarding the antioxidant and nutritional content in the processed form is still lacking. This research aimed to analyze the antioxidant activity and nutritional content of organic black rice value added laddu. Proximate analysis and antioxidant content (DPPH and total phenol) were conducted in this experiment. Protein content was quite increased, 6.37g. Fat content was quite raised, 19.55. Calcium content was quiet raised, 35.85mg. Fiber content was found 0.81g. Energy content was found 440.8 kcal. Laddu are rich in iron 2.91mg respectively.

Keywords: Black rice, laddu, nutrition, proximate analysis, antioxidant, sensory attributes

Introduction
Black rice is an important part of the special rice family and one of India's rarest grains and oil crops. Black rice has a higher nutritional value than regular rice, and it generally has a higher concentration of nutrients and trace elements than premium rice. Black rice contains roughly 26.4% protein. Black rice has an average of 11.5 g of protein per 100 g, 6.8% more than regular rice, and 2.7 g of fat, which is 1.9 times more than rice. (Xie, L. H. *et al* 2003). Black rice has higher levels of Na, Mg, K, CA, Al, V, Mn, and Fe than white rice. It is also richer in iron, zinc, copper, and other trace elements. (Liang *et al*., 2015) [4]. The pigment found in black rice is part of the flavonoid anthocyanins class of plant polyphenols. Anthocyanins from the multi conjugated aromatic system are conjugated in three rings in black rice. Because of its strong biological activity, it improves visual acuity, reduces the incidence rate of heart crown, and has antioxidative and anticancer properties. (Wang *et al*., 2017) [10]. Breakfast cereals that are ready to eat fall into the category of foods that have a long shelf life and are naturally stable. Ready-to-serve or ready-to-eat breakfast foods have the advantage of saving time as well as eliminating all food preparation requirements. These benefits, along with the appealing flavour and crispiness of the products are what contribute to their widespread appeal. Breakfast cereals are widely available in the market; Granola, rice krispies, corn flakes, cheerios, muesli and other ready-to-eat cereals are examples. (Adeoye *et al*., 2019) [2]. Oats (*Avena sativa l.)* is an excellent source of dietary fibre. Thus promoting its use in functional food products based breakfast cereals, flakes and infant food. Oat β-glucan can be used to stabilize ice creams. Oat antioxidants are useful to stabilize milk and meat products sensitive to fat oxidation during storage. Oat proteins have been used in food products. The incorporation of oat has been found to improve the overall quality of the foodstuffs (Prasad *et al*., 2013). Muesli bars are a creative and appealing take on a traditional meal that is both practical and healthful. The need for growing the assortment line

of "sugar-free" muesli bars is theoretically supported as part of the scientific research work. It is great as a proper snack and has physico-chemical and organoleptic characteristics within normal range for this type of product. It also doesn't contain artificial colours or flavours. High nutritional value was found in muesli that included oat flakes, linseed, granulated bran, cranberries, apples, and white mulberry fruit. (Laricheva and Mikhailova 2020) [3]. A high content of dietary fibre and phytochemicals (phenolic acids and anthocyanins) found in black rice lowers or prevents the risk of developing heart disease, diabetes, obesity, and cancer. Studies have demonstrated that black rice extracts have a variety of useful qualities. As a result, researchers have published information about a unique cake recipe that uses black rice flour. (Mau *et al*., 2016) [5]

2. Materials and Methods

2.1 Development of value added food products

Preparation of value-added food product by incorporation of admixture of Museli, Oats, Black Rice Products was prepared for each product, the basic recipe Laddu. The standard recipe of selected products was served as control. The treatment combination was fixed on trial basis.

Table 2.2: Details of treatments of the black rice value added products (laddu)

Products	Treatments				Replication
	T_0	T_1	T_2	T_3	
Laddu					
Black Rice Flour	55	50	40	30	3
Muesli	-	5	10	15	
Semolina	-	5	10	10	
Jaggery	15	15	15	15	
Ghee	15	15	15	15	
Dry Fruits	10	10	10	10	
Brown Sugar	5	-	-	5	

2.3 Preparation of Laddu with incorporation of Black Rice Flour and Muesli

- **T_0 (control):** the product was prepared using 55g Black Rice Flour, 5g Brown Sugar, 15g Jaggery, 15g Ghee, 10g Dry Fruits.
- T_1The product was prepared using 50g Black Rice Flour, 5g museli, 5g semolina, 15g jaggery, 15g Ghee, 10g Dry Fruits.
- T_2 The product was prepared using 40g Black Rice Flour, 10g museli, 10g semolina, 15g jaggery, 15g Ghee, 10g Dry Fruits.
- T_3 The product was prepared using 30g Black Rice Flour, 15g museli, 10g semolina, 5g Brown Sugar, 15g jaggery, 15g Ghee, 10g Dry Fruits.

2.4 Sensory evaluation

Sensory evaluation of the food products for their acceptability was done by a panel of 5 judges. The score card based on the 9-point Hedonic Scale was used for sensory evaluation on the basis of evaluation of attributes like Color and Appearance, Body and Texture, Taste and Flavour, overall Acceptability

2.5 Proximate analysis

Proximate analysis procedure ware followed to estimate for moisture, ash, total carbohydrates, fat, and protein, calcium, Iron, fiber and total energy. AOAC (2005). Mineral-Calcium and Iron were estimated by method given by Ranganna (2001) [7].

2.6 Determination of total Phenol content and 2, 2-diphenyl-1-picryl-hydrazyl

Determination of total Phenol content Total polyphenol - Total polyphenol activity was measured by the modified method of calculate the concentration of total phenolics in the samples millimolar garlic acid per grant dry sample using UV spectroscopy, based on a calorimetric oxidation/reduction reaction. The oxidizing agent will used Folin-Ciocalteureagent. The sample was extract with pure methanol at 40° C by (Sembiring, *et al*. 2018) [8].

DPPH (2, 2-diphenyl-1-picryl-hydrazyl) free radical method is an antioxidant anay based on electron-transfer that produces a violet solution in methanol. This free radical, stable at room temperature, is reduced in the presence of an antioxidant molecule, giving rise to celourless. Methanol solution. The use of the DPPH assay provides an easy and rapid way to evaluate antioxidants by spectrophotometer, so it can be useful to assess various products at a time by (Sridhar *et. al*.2019) [9].

2.7 Statistical analysis

Statistical analyses were conducted with the SPSS software 17 (SPSS Institute, Chicago, USA). The mean and standard deviation of parameters from proximate analysis, physical properties, and color analyses were calculated and differences between the formulations were evaluated by analysis of variance (ANOVA) with significant level being considered at $P < 0.05$. Mean comparisons were assessed by Duncan's multiple range test, with the values expressed as means ± standard deviations.

3. Results and Discussion

Finding of present study entitled "Preparation of value healthy snacks" by incorporating Muesli, Oats and Black Rice. The data obtained from different aspects during this study, have been analyzed and tabulated statistically as per the methodology to find out the relevant informational facts, and also the factual meaning behind them. The results were briefly illustrated with the help of suitable charts and diagrams.

Table 3.1: Average sensory scores for different attributes of control and treated samples of Laddu

Control & Treatment	Attributes			
	Color & Appearance	Body & Texture	Teste & Flavor	Overall Acceptability
T_0	6.6	7.3	6.3	6.6
T_1	7.6	8.6	8.3	8.1
T_2	7.0	8.6	8.0	7.8
T_3	8.3	9.0	8.6	8.6
F- Test	Significant	Significant	Significant	Significant
C.D @ 0.5	0.30	0.13	0.30	0.15

- Colour and Appearance F= 5.37 (4.76), Significant, $P \leq 0.05$ CD = 0.30
- Texture F= 11.88 (4.76) Non- significant, $P \leq 0.05$ CD=0.13
- Flavour and Taste F= 10.76 (4.76), Non-significant, $P \leq 0.05$ CD= 0.30
- Overall Acceptability F= 14.4 (4.76), Significant, $P \leq 0.05$ CD = 0.15

Color & Appearance
Table 3.1. shows that the mean of sensory scores obtained for Laddu in relation to color and appearance, express that T_3 has the highest score (8.3), followed by T_1 (7.6), T_2 (7.0) and T_0 (6.6). It indicates that the treatment T_3 (Black Rice Flour 30% + Muesli 15% + Semolina 10% + Brown Sugar 5% + Jaggery 15% + Ghee 15% + Dry fruits 10%.) was liked very much by the responders, whereas T_1 was liked moderately regarding the color and appearance of Laddu by the responders.

Texture
Table 3.1. shows that the mean of sensory scores obtain and analyzed for Laddu in relation to texture, shows that T_3 has the highest score (9.0), followed by T_1 (8.6), T_2 (8.6) and T_0 (7.3). It indicates that the treatment T_3 (Black Rice Flour 30% + Muesli 15% + Semolina 10% + Brown Sugar 5% + Jaggery 15% + Ghee 15% + Dry fruits 10%.) was liked very much by the responders, whereas T_2 and T_1 was liked moderately regarding the texture of Laddu by the responders.

Taste AND Flavor
Table 3.1. shows that the mean of sensory scores obtain and analyzed for Laddu in relation to taste and flavor, shows that T_3 has the highest score (8.6), followed by T_1 (8.3), T_2 (8.0) and T_0 (6.3). It indicates that the treatment T_3 (Black Rice Flour 30% + Muesli 15% + Semolina 10% + Brown Sugar 5% + Jaggery 15% + Ghee 15% + Dry fruits 10%.) was liked very much by the responders, whereas T_1 was liked moderately regarding the taste and flavor of Laddu by the responders.

Overall Acceptability
Table 3.1. shows that the mean of sensory scores obtain and analyzed for Laddu in relation to overall acceptability, shows that T_3 has the highest score (8.6), followed by T_1 (8.1), T_3 (7.8) and T_0 (6.6). It indicates that the treatment T_2(Black Rice Flour 30% + Muesli 15% + Semolina 10% + Brown Sugar 5% + Jaggery 15% + Ghee 15% + Dry fruits 10%.) was liked very much by the responders, whereas T_1 was liked moderately regarding the overall acceptability of Laddu by the responders.

Colour and appearance
Table 3.1 shows that the mean of sensory scores obtain and analyzed for Laddu in relation to color and appearance, express that that T_3 has the highest score (8.3), followed by T_1 (7.6), T_2 (7.0) and T_0 (6.6)). It indicates that there is a significant difference between the all three treatments of Laddu regarding their color and appearance, so it can be easily concluded that cookies incorporated with different level Black Rice Flour, Muesli, Semolina, Brown Sugar, Jaggery, Ghee, Dry fruits., has good color and appearance and is best in certain level of treatments.

Table 3.2: Analysis of variance of average scores for color and appearance of Laddu

Source	D.F.	SS	MSS	F Cal.	F Tab. 5%	Result
Treatments	3	4.92	1.64	5.37	4.76	S
Replication	2	2.17	1.085	3.55	5.14	NS
Error	6	1.83	0.305			
Total	11	8.92	3.03			

S= Significant NS= Non-Significant

The ANOVA table 3.2. indicates that calculated value of F i.e. 5.37, due to treatments is greater than the tabulated value of F i.e. 4.76 on 3 and 6 degree of freedom, at 5% of probability level. It expresses that there is a significant difference between the all three treatments of Laddu regarding the color and appearance, so it can be easily concluded that cookies incorporated with different level Black Rice Flour, Muesli, Semolina, Brown Sugar, Jaggery, Ghee, Dry fruits., has improved the color and appearance and is best in certain amount of treatments.

The data is further analyzed by using critical difference and the results are presented in this table

Table 3.2 (a): Comparison between the color and appearance of the control and treatments of Laddu against C.D.

Treatments	Average	T_0	T_1	T_2	T_3
		6.6	**7.6**	**7.0**	**8.3**
T_0	6.6	-	-	-	-
T_1	7.6	1	-	-	-
T_2	7.0	0.4	-0.6	-	-
T_3	8.3	1.7	0.7	1.3	-
C.D.@5%	0.30				

C.D. 0.30: *S= Significant (P<0.05)

On comparison between the average sensory scores analyzed for color and appearance of Laddu against the critical difference in the ABOVE table 3.2.(a), the variations between the scores for color and appearance of Laddu can be summarized as follows. The difference between the mean values of (T_1-T_0), (T_2-T_0), (T_2-T_1); (T_3-T_0), (T_3-T_1), (T_3-T_2) were higher than critical difference (0.30), hence, the difference is significant.

Texture
Table 3.1. shows that the mean of sensory scores obtained and analyzed for Laddu in relation to Texture, shows that T_3 has the highest score (9.0), followed by T_1 (8.6), T_2 (8.6) and T_0 (7.3). It indicates that there is a significant differences between the all three treatments of Cookies regarding their Texture, so it can be easily concluded that Laddu incorporated with different level Black Rice Flour, Muesli, Semolina, Brown Sugar, Jaggery, Ghee, Dry fruits, has improved good Texture and is best in certain level of treatments.

Table 3.3: Analysis of variance of average scores for texture of Laddu

Source	D.F.	SS	MSS	F Cal.	F Tab. 5%	Result
Treatments	3	4.92	1.64	11.88	4.76	S
Replication	2	1.17	0.585	4.23	5.14	NS
Error	6	0.83	1.138			
Total	11	6.92	2.363			

S= Significant NS= Non-Significant

The ANOVA table 3.3. indicates that calculated value of F i.e. 11.88, due to treatments is smaller than the tabulated value of F i.e. 4.76 on 3 and 6 degree of freedom, at 5% level of probability level. It expresses that there is a significant difference between the all three treatments of Laddu regarding the color and appearance, so it can be easily concluded that cookies incorporated with different level Black Rice Flour, Muesli, Semolina, Brown Sugar, Jaggery, Ghee, Dry fruits in certain amount of treatments.

The data is further analyzed by using critical difference and the results are presented in this table:

Table 3.3 (a): Comparison between the texture of the control and treatments of Laddu against C.D.

Treatments	Average	T_0	T_1	T_2	T_3
		7.3	**8.6**	**8.6**	**9.0**
T_0	7.3	-	-	-	-
T_1	8.6	1.3	-	-	-
T_2	8.6	1.3	0	-	-
T_3	9.0	1.7	0.4	0.4	-
C.D.@5%	0.30				

C.D. 0.13: *S= Significant ($P<0.05$)

On comparison between the average sensory scores analyzed for texture of Laddu against the critical difference in the above table 3.2. (a), the variations between the scores for texture of Laddu can be summarized as follows. The difference between the mean values of (T_1-T_0), (T_2- T_0), (T_2-T_1); (T_3-T_0), (T_3-T_1), (T_3-T_2) were higher than critical difference (0.13), hence, the difference is significant.

Taste and Flavor

Table 3.1. shows that the mean of sensory scores obtained for Laddu in relation to taste and flavor, shows that T_3 has the highest score (8.6), followed by T_1 (8.3), T_2 (8.0) and T_0 (6.3). It indicates that there is a significant difference between the all three treatments of Laddu regarding their taste and flavor, so it can be easily concluded that Laddu incorporated with different level Black Rice Flour, Muesli, Semolina, Brown Sugar, Jaggery, Ghee, Dry fruits, has improved the taste and flavor and is best in certain amount of treatments.

Table 3.4: Analysis of variance of average scores for taste and flavor of Laddu

Source	D.F.	SS	MSS	F Cal.	F Tab. 5%	Result
Treatments	3	9.7	3.23	10.76	4.76	S
Replication	2	0.2	0.1	0.33	5.14	NS
Error	6	1.8	0.3			
Total	11	11.7	3.63			

S= Significant NS= Non-Significant

The ANOVA table 3.3. Indicates that calculated value of F i.e. 10.76, due to treatments is greater than the tabulated value of F i.e. 4.76 on 3 and 6 degree of freedom, at 5% level of probability. It expresses that there is a significant difference between the all three treatments of Laddu regarding the Taste and flavor, so it can be easily concluded that Laddu incorporated with different level of Black Rice Flour, Muesli, Semolina, Brown Sugar, Jaggery, Ghee, Dry fruits, has improved the taste and flavor and is best in certain amount of treatments.

The data is further analyzed by using critical difference and the results are presented in this table

Table 3.4(a): Comparison between the taste and flavor of the control and treatments of *Laddu* against C.D.

Treatments	Average	T_0	T_1	T_2	T_3
		6.3	**8.3**	**8.0**	**8.6**
T_0	6.3	-	-	-	-
T_1	8.3	2	-	-	-
T_2	8.0	1.7	- 0.3	-	-
T_3	8.6	0.6	0.3	0.6	-
C.D.@5%	0.30				

C.D. 0.30: *S= Significant ($P<0.05$)

On comparison between the average sensory scores analyzed for taste and flavor of Laddu against the critical difference in the above table 3.2.(a), the variations between the scores for taste and flavor of Laddu can be summarized as follows. The difference between the mean values of (T_1-T_0), (T_2-T_0), (T_2-T_1); (T_3-T_0), (T_3-T_1), (T_3-T_2) were higher than critical difference (0.30), hence, the difference is significant.

Overall Acceptability

Table 3.1. shows that the mean of sensory scores obtained for Laddu in relation to overall acceptability, indicates that T_3 has the highest score (8.6), followed by T_1 (8.1), T_3 (7.8) and T_0 (6.6). It indicates that there is a significant difference between the all three treatments of Laddu regarding their overall acceptability, so it can be easily concluded that Laddu incorporated with different level of Black Rice Flour, Muesli, Semolina, Brown Sugar, Jaggery, Ghee, Dry fruits, has good in overall acceptability.

Table 3.5: Analysis of variance of average scores for overall acceptability of Laddu

Source	D.F.	SS	MSS	F Cal.	F Tab. 5%	Result
Treatments	3	6.5	2.16	1.44	4.76	S
Replication	2	0.7	0.35	2.3	5.1	NS
Error	6	0.9	0.15			
Total	11	7.29	2.66			

S= Significant NS= Non-Significant

The ANOVA table 3.5. indicates that calculated value of F i.e. 1.44, due to treatments is greater than the tabulated value of F i.e. 4.76 on 3 and 6 degree of freedom, at 5% level of probability. It expresses that there is a significant difference between the all three treatments of Laddu regarding the overall acceptability, so it can be easily concluded that Laddu incorporated with different level of Black Rice Flour, Muesli, Semolina, Brown Sugar, Jaggery, Ghee, Dry fruits, has good in overall acceptability.

The data is further analyzed by using critical difference and the results are presented in this table

Table 3.5 (a): Comparison between the overall acceptability of the control and treatments of *Laddu* against C.D.

Treatments	Average	T_0	T_1	T_2	T_3
		6.6	8.1	7.8	8.6
T_0	6.6	-	-	-	-
T_1	8.1	1.5	-	-	-
T_2	7.8	1.2	- 0.3	-	-
T_3	8.6	2	0.5	0.8	-
C.D.@5%	0.30				

C.D. 0.15: *S= Significant (P<0.05),

On comparison between the average sensory scores analyzed for overall acceptability of Laddu against the critical difference in the above table 3.5. (a) the variations between the scores for overall acceptability of Laddu can be summarized as follows. The difference between the mean values of (T_1-T_0), (T_2-T_0), (T_2-T_1); (T_3-T_0), (T_3-T_1), (T_3-T_2) were higher than critical difference (0.15), hence, the difference is significant.

Chemical analysis of value added product

Table 3.6: The average nutritional composition of control and the best treatment sample of "Laddu" per 100g.

Nutrients	Control (T_0)	(T_1)	(T_2)	(T_3)	T. Cal	T. tab	Results
Moisture (%)	10.15	9.65	8.53	7.44	331.90	4.76	S
Ash (%)	2.89	7.2	7.86	6.41	46.95	4.76	S
Protein	6.22	6.72	6.8	6.37	18.37	4.76	S
Fat	18.99	19.21	19.4	19.55	69.81	4.76	S
Fiber	0.19	0.4	0.61	0.81	78.38	4.76	S
Carbohydrates	63.49	61.69	61.0	61.54	141.70	4.76	S
Energy	449.9	444.2	4441.37	440.8	110.22	4.76	S
Iron	2.34	2.64	2.82	2.91	69.8	4.76	S
Calcium	27.6	30.35	33.2	35.85	142.35	4.76	S
Total Phenolic content (mg)	1.3	1.64	1.49	1.46	171.46	4.76	S
DPPH (%)	1.38	1.62	1.24	1.87	19.59	4.76	S

Table 3.6. shows that T_0 (10.15) a high content of moisture followed by T_1 (9.65), T_2 (8.53) and T_3 (7.44). T_2 (7.86) a high content of ash followed by T_1 (7.2), T_3 (6.41), and T_0 (2.89). T_2 (6.8) a high content of protein followed by T_1 (6.72), T_3 (6.37) and T_0 (6.22). T_3 (19.55) a high content of fat followed by T_2 (19.4), T_1 (19.21), T_0 (18.99). T_3 (0.81) a high content of fiber followed by T_2 (0.61), T_1 (0.4) and T_0 (0.19). T_0 (63.49) a high content of carbohydrate followed by T_1 (61.69), T_3 (61.54) and T_2 (61.54). T_0 (449.9) a high content of Energy followed by T_1 (444.2), T_2 (441.37) and T_3 (440.8). T_3 (2.91) a high content of iron followed by T_2 (2.82), T_1 (2.64) and T_0 (2.34). T_3 (35.85) a high content of calcium followed by T_2 33.2), T_1 (30.35) and T_0 (27.6). In Laddu T_1 (1.64) has the high content of Total Phenolic Content followed by T_2 (1.49), T_3 (1.46), T_0 (1.3) and T_3 (1.87) high content of DPPH Radical scavenging followed by T_1 (1.62), T_0 (1.38), T_2 (1.24).

4. Summary and Conclusion

There were three different preserved products that is Laddu was made by incorporating Muesli, Oats and Black Rice at three different levels with control T_0, T_1, T_2, T_3. Each treatment was replicated three times and the different attributes of each replication were evaluated by sensory analysis, which was done by the panel of five judges, using 9 points Hedonics' scale, ranges from likes extremely to dislikes extremely. The data gained by the judges were analyzed statistically using ANOVA tables with two-way classification with one observation per cell. Overall mean and critical difference calculated.

Black rice value added product according to the different sensory attributes judged by the five panel members, T_3 scores the best, regarding the color and appearance it gains 8.3, for body and texture it gains 9.0, for taste and flavor 8.6 and for overall acceptability it gains 8.6 scores Comparison of nutritive value, protein content was quite increased, 6.37g. Fat content was quite raised, 19.55. calcium content was quiet raised, 35.85mg. Fiber content was found 0.81g. Energy content was found 440.8 kcal. Laddu are rich in iron 2.91mg respectively.

On the basis of findings, it is concluded that Museli and Black Rice found to be rich in energy, carbohydrates, protein, crude fiber and iron, and good source of healthy omega-3 fats and Calcium content and it was successfully incorporated in preparation of the products like Laddu. Museli and Black Rice can be successfully incorporated to the products for enhancement of nutritional qualities as well as for better sensory properties. Chemical analysis of this study concludes that the preserved products Laddu made by the incorporation of Museli and Black Rice were good sources of energy, calcium, fiber, protein and fat content. Nutritional analysis reveals that nutritive composition of the prepared products significantly increased as incorporation level increased including their Protein, iron, carbohydrates, fats.

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