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Nutritional evaluation of decorticated finger millet (finger millet-rice) and its diversified nutri-rich products

Abstract

Background: Finger millet (*Eleusine coracana* L.) or ragi occupies significant position in India more so in Karnataka in terms of production and utilization. Ready-To-Use (RTU) and Ready-To-Eat(RTE) value added and convenient products from millets will not only help the producer in improving their socio-economic status but also help in improving the health of the nation.

Methods: The study was conducted to analyze the cooking quality and nutritional value of finger millet-rice and to find out the acceptability of products developed from finger millet-rice, finger millet-rice-semolina and finger millet-rice-flour.

Results: Percent nutrient content of macronutrients in finger millet-rice was observed to be 6.1, 84.4, 2.8 and 1.1 for protein, carbohydrate, fibre and fat, respectively. Micronutrients like Calcium and Phosporous content was 217mg and 139mg per 100g, respectively. Twenty six recipes were developed. The results of sensory evaluation indicated that for Sweet pongal there was a significant difference between control and experimental among all the parameters of sensory attributes and experimental product scored higher than the control. For kharapongal and puliyogare, the experimental group scored higher than the control. It was observed that for steamed products that, there was a significant difference between control and experimental for idli and non-significant difference for flavor and overall acceptability for kadabu. Among fried products like chakli, the experimental product (finger millet-rice chakli) was better accepted than control. A significant difference for upma and kesaribath was observed for all parameters of sensory attributes.

Conclusion: Thus finger millet-rice can be an alternate to rice, thus enhancing good nutrtition and acceptability by inclusion of diversified products in the diet.

Keywords: finger millet, processing, decortication, value addition

Volume 7 Issue 6 - 2017

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Received: April 18, 2017 | **Published:** July 13, 2017

Introduction

Finger-millet occupies significant position in India more so in Karnataka in terms of production and utilization. Finger millet is grown in Karnataka, Tamilnadu, Andhra Pradesh, Orissa, Bihar and Gujarat also. Karnataka occupies about 1 million ha area with production of 1.8 million tones. It is cultivated on varied soils and climatic conditions owing to wider adaptability and tolerance to stress situations. The grain is nutritionally superior to many cereals providing fair amount of proteins, minerals, vitamins.[1]

The concept of processing and product development of regional and traditional millets has benefited the non-consumers of millets with their specific nutrients, especially the phytochemical and micronutrients. Semi refined cereals and fibre rich foods are getting an edge over the refined foods. The physiological benefits of dietary fibre, micronutrients and phytochemical of millets offer better immune status and protection against infection, provide greater opportunities for the use of the millets in therapeutic foods, hence providing the consumer with Ready-To-Use and Ready-To-Eat value added and convenient products. These convenience foods from millets will not only help the producer in improving their socio-economic status but also help in improving the health of the nation. Ragi is decorticated and polished which could be used similar to rice. Ragi-rice a nutritious grain developed by CFTRI to promote and sustain its production.

The consumption of finger millet is limited in urban areas because of dark brown colour and the processed products, ready to eat products; health foods are limitedly produced at industrial level. Hence, not many finger millet based products are found in urban markets. In order to promote the nutritious grain and promote its sustainability in production, a process has been developed by CFTRI where the finger millet is decorticated and polished so that the seed coat is removed and the grain which will have creamish colour can be used similar to rice. Decortication is a very recent process developed for the finger millet. The deranging or Decortication methods followed for most of the cereals are not effective in the case of Finger millet owing to the intactness of bran or the seed coat with highly soft and friable endosperm. Hence to decorticate, the finger millet is hydrothermally processed (hydration, steaming and drying) to harden the millet endosperm. The decorticated millet is cream colored and devoid of seed coat and could be cooked as discrete grains similar to rice.[2] The Seed Coat Matter (SCM forms the major by-product of the decortications process is a rich source of health beneficial phenolic compounds, minerals and dietary fibre. The grain could also be converted to semolina and flour. However, by removing the seed coat the grain loses some amount of protein, calcium, dietary fibre and minerals. The processing is beneficial for availability of Carbohydrates and phosphorous and also reduces the polyphenols and phytates which will enhance the bioavailability of micronutrients.

The finger millet -rice can be cooked similar to rice and cooking time is much lesser. The grain on cooking possesses good sensory attributes and acceptable as such for consumption or utilizing in any rice based preparations. However, finger millet rice and its products will not be helpful to lower blood cholesterol and blood glucose level. Processed products from finger millet rice can also be manufactured at industrial level so that it will available in all urban markets for the benefit of urban community and also to provide higher nutrients compared to other cereals. In order to promote the utilization of nutri-rich finger millet-rice, finger millet-rice flour and finger millet-rice semolina in products which are consumed in the daily dietary recipes, the present study had been conducted with the main objective of nutritional evaluation of finger millet-rice and sensory evaluation of diversified finger millet-rice based products [3].

Material and methods

Procurement of sample

Finger millet-rice, finger millet-rice semolina and Finger millet -rice flour were obtained from AICRP on small millets, CFTRI, Mysore and other ingredients used in the preparation were procured from the local market.

Chemical analysis

The chemical analysis of the proximates like Moisture, Protein, Fat, Ash, Iron, Crude fibre, Calcium, Phosporous of finger millet-rice was done as per the AOAC procedures.[4] The Energy was computed and Carbohydrate was calculated by difference.

Formulation of diversified products from Finger millet -rice

In order to popularize the consumption of finger millet in the daily dietary. The study was conducted to find out the acceptability of products developed from finger millet-rice, Finger millet -rice semolina and finger millet -rice flour. The products developed from Finger millet-rice were with 100 percent incorporation, for flour and semolina products it was up to 50 percent level of incorporation. Twenty six recipes were developed among classes of Finger millet-rice based, Finger millet-rice flour based, and Finger millet -rice rava based.[5]

Sensory evaluation of the products

The products were evaluated for sensory parameters on five point hedonic scale.[6] by semi-trained panel of ten members.

Statistical analysis

The data obtained was subjected to analyses of variance.[7]

Nutritive value of the products

The nutrients like protein, fat, carbohydrate, energy, calcium and iron were computed.[8]

Results and discussion

Physical characteristics, cooking characteristics and nutritive value of finger millet-rice

The results of the Physical characteristics of finger millet-rice in comparison with Finger millet are presented in Table 1. Color of finger millet-rice was Garnet brown 00918D&A and that of Finger millet is Greyed Orange166A & C.

Color of finger millet-rice was Garnet brown 00918D&A and that of Finger millet is Greyed Orange166A & C. It was observed that 1000 kernel weight (1.92g) and 1000 seed volume (1.68ml) was less in finger millet-rice than Finger millet with values being 1000 kernel weight (2.88g) and 1000 seed volume (2.4ml), respectively. The physical characteristics like Hydration Index, Hydration capacity, Swelling capacity, Swelling Index and Specific gravity were lower in finger millet-rice than Finger millet as indicated in Table 1.The Grain/Flour Ratio is one of the important parameter that provides the estimation of the yield of the flour in comparison to grain. It was observed that finger millet-rice had lesser Grain/Flour ratio (95.23) in comparison with Finger millet (98.27).[9]

Table 1 Physical characteristics of finger millet-rice in comparison with Finger millet.

Characteristics	Finger millet-rice	Finger millet
Color	**^Garnet brown 00918D&A**	**^Greyed orange166A & C**
1000 kernel Weight(g)	1.92	2.88
1000 Seed volume	1.68	2.4
Hydration capacity	0.065	0.57
Hydration Index	0.033	0.19
Swelling capacity	0.7	1.195
Swelling Index	0.41	0.47
Specific gravity	1.09	1.12
Bulk Density(g/cc)	0.99	0.69
Grain/Flour Ratio	95.23	98.27

^RHS color chart

The time taken for cooking of finger millet-rice and milled rice were similar with 12 minutes. The kernel elongation ratio of decorticated finger millet was 1.66 and that of milled rice was 1.41. However finger millet -rice had absorbed more water than the milled rice during cooking with the water absorption ratio being 1: 2.7 and 1: 2.5, respectively. There was no leached out solids in cooking of milled rice but in decorticated finger millet, it was minimum (0.145) (Table 2).

Table 2 Cooking characteristics of finger millet-rice in comparison with rice

Characteristics	Finger millet-rice	Rice
Cooking time	12 min	12min
Kernel elongation Ratio	1.66	1.41
Water absorption ratio	1:2.7	1:2.5
Leached out solids(g)	0.145	Nil

The nutrient composition of finger millet-rice was analyzed as per AOAC methods are presented in Table 3 it was observed that moisture was 4.5 percent. Protein content was found to be 6.1g per 100 which is slightly lesser than finger millet (7.3gper 100g). Lowest fat was present in finger millet-rice (1.1g/100g) compared to finger millet (1.3g). Lowest Ash (1.1g) was observed in finger millet-rice when compared with finger millet (2.7g/100g). However highest carbohydrate (84.4g/100g) was observed in singer millet-rice in comparison with finger millet (72g/100g).

Citation: Mushtari BJ, Shamshad BS, Vidya K, et al. Nutritional evaluation of decorticated finger millet (finger millet-rice) and its diversified nutri-rich products. *Int J Complement Alt Med.* 2017;7(6):481–486. DOI: 10.15406/ijcam.2017.07.00244

Table 3 Nutritive value of finger millet-rice in comparison with finger millet and Rice

Nutritive Value Per 100g	Finger Millet	Finger Millet-Rice	Rice
Moisture (g)	13.1	4.5	10.2
Protein (g)	7.3	6.1	6.8
Fat (g)	1.3	1.1	0.5
Ash(g)	2.7	1.1	0.7
Crude fibre(g)	3.6	2.8	0.2
Carbohydrate (g)	72	84.4	78.2
Energy (Kcal)	328	371	345
Calcium (mg)	344	217	10
Phosphorous(mg)	283	139	100
Iron (mg)	3.9	4.7	0.7

The fiber (3.6g/100g), Calcium (344mg) and Phosphorous content (283mg) was found to be highest in finger millet than finger millet-rice with values being Crude fibre (2.8g/100g), Calcium (217mg/100g) and Phosporous content(139mg/100g). However, almost all nutrients except protein are more in finger millet-rice in comparison with Rice (Table 3).

Sensory evaluation of finger millet-rice based products

The results revealed that the products from finger millet -rice were well accepted compared with control products with good overall acceptability. Some products showed a significant difference for appearance, texture, between control and experimental. The results for 26 products are discussed in detail.

Table 4 shows sensory profile of finger millet-rice based preparations. There was a significant difference between controls and experimental for appearance and texture but a non-significant difference was observed for flavour and overall acceptability where the experimental product scored higher than the control group. For products like sweet pongal there was a significant difference between controls and experimental among all the parameters of sensory attributes and experimental product score higher than the control. For kharapongal and puliyogare, non-significant difference was found, the experimental group scored higher than the control. With respect to Plain finger millet-rice there was a significant difference between controls and experimental in all parameters of sensory attributes except for flavor which was non-significant. Finger millet-rice curds-rice showed a non-significant difference when compared to control in attributes such as texture, flavor and overall acceptability and significant difference for appearance.[10]

Table 4 Sensory profile of finger millet-rice preparations

Product	Variations	Appearance	Texture	Flavor	Overall Acceptability
	Control	4.4	4.0	4.0	4.1
Bisi bele bath	Experimental	4.1	4.5	4.2	4.2
	F-value	0.71*	2.64*^{S}	0.08^{NS}	0.13^{NS}
	Control	4.6	4.2	4.2	4.4
Chinese fried rice	Experimental	4.6	3.7	4.4	4.3
	F-value	0.0^{NS}	2.32*	0.90*	0.20^{NS}
	Control	5.0	4.6	4.4	4.6
Rice phirni	Experimental	3.8	4.0	4.4	4.0
	F-value	81.0*	5.06*	0.00^{NS}	13.5*
	Control	4.3	4.0	4.1	4.1
Vegetable pulao	Experimental	4.6	4.0	3.9	4.2
	F-value	1.8*	0.0^{NS}	0.94*	0.20^{NS}
	Control	4.6	3.9	4.0	4.0
Sweet pongal	Experimental	4.1	4.1	4.2	4.5
	F-value	3.08*	0.62*	1.0*	9.0*
	Control	4.0	3.8	3.9	3.9
Khara pongal	Experimental	4.2	3.7	3.8	3.9
	F-value	0.31^{NS}	0.15^{NS}	0.13^{NS}	0.0^{NS}
	Control	4.2	3.9	4.2	4.3
Lime Rice	Experimental	4.6	3.9	4.3	4.1
	F-value	1.80*	0.0^{NS}	0.11^{NS}	0.72*
	Control	4.1	3.7	3.9	3.9
Vangibath	Experimental	3.8	3.8	4.3	4.4
	F-value	1.24*	0.11^{NS}	2.88*	4.2*
	Control	4.5	4.1	3.7	4.2
Plain Rice	Experimental	3.3	3.9	3.5	3.9
	F-value	19.63*	0.94*	0.14^{NS}	1. 24*
	Control	4.3	4.1	4.4	4.4
Puliyogare	Experimental	4.4	4.0	4.5	4.5
	F-value	0.10^{NS}	0.31^{NS}	0.18^{NS}	0.18^{NS}
	Control	4.0	3.8	4.1	4.2
Curds rice	Experimental	4.5	4.0	4.0	4.2
	F-value	2.6*	0.26^{NS}	0.13^{NS}	0.00^{NS}

Control: Rice based products; Experimental: finger millet-rice based products; Maximum score-5; ^{NS}, Non-significant; *Significant at 5 percent level

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The data regarding Sensory evaluation of finger millet-rice-flour based preparations is presented in Table 5. The results revealed that there was a significant difference between control and experimental products among all sensory parameters. Finger millet-rice dosa was better accepted than control. However for steamed products, there was a significant difference between control and experimental for idli and non-significant difference for flavor and overall acceptability for kadabu. Among fried products like chakli the experimental was better accepted than control and significant difference at 5% level for all the parameters.[10]

Table 5 Sensory profile of finger millet-rice-flour preparations

Product	Variations	Appearance	Texture	Flavor	Overall Acceptability
	Control	4.4	4.4	3.8	4.2
Idli	Experimental	3.8	3.5	3.7	3.7
	F-value	2.70^{NS}	10.56*	0.11^{NS}	3.94*
	Control	3.9	3.4	3.6	3.3
Dosa	Experimental	4.2	4.0	4.0	4.2
	F-value	0.95^{NS}	2.61*	2.25*	7.51*
	Control	4.5	4.2	4.6	4.5
Kadabu	Experimental	4.3	4.5	4.5	4.5
	F-value	0.41*	1.0*	0.18^{NS}	0.0^{NS}
	Control	3.9	4.0	3.5	4.0
Soft roti	Experimental	3.9	3.7	3.8	3.9
	F-value	0.0^{NS}	3.8^{NS}	1.3*	1.00*
	Control	3.8	4.2	4.5	4.6
Poushtik roti	Experimental	4.0	4.4	4.3	4.5
	F-value	1.0*	0.6*	0.34^{NS}	0.13^{NS}
	Control	3.9	3.2	3.5	3.7
Nankhatai	Experimental	3.8	4.5	3.9	4.3
	F-value	0.05^{NS}	10.7*	1.07*	5.22*
	Control	3.8	4.0	3.8	4.1
Chilly biscuit	Experimental	3.8	3.8	3.7	3.9
	F-value	0.00^{NS}	0.31^{NS}	0.06^{NS}	0.46^{NS}
	Control	3.4	3.8	2.4	3.1
Chakli	Experimental	3.9	4.2	4.4	4.2
	F-value	3.08*	1.09*	33.33*	8.71*
	Control	4.6	3.5	3.4	3.7
Chatpat (Khara)	Experimental	3.6	3.7	3.6	3.8
	F-value	13.23*	0.15*	0.19^{NS}	0 05^{NS}
	Control	4.2	4.9	4.4	4.4
Chatpat (Sweet)	Experimental	4.2	3.6	4.2	4.0
	F-value	0.00^{NS}	20.83*	0.36^{NS}	10.28*

Control: Rice based products; Experimental: Finger millet-rice based products; Maximum score-5, ^{NS}: on-significant; * - Significant at 5 percent level

The sensory profile of finger millet-rice-semolina based products is indicated in Table 6. The statistical evaluation of sensory attributes depicted that there was non-significant differences in all parameters for rava-idli and cutlet. A significant difference at 5% level for upma and kesaribath for all the parameters of sensory attributes where the experimental product was better scored than control. For patties there was a significant difference for flavour but non- significant difference for all other sensory attributes.[10]

Table 6 Sensory profile of finger millet-rice-semolina based preparations

Product	Variations	Appearance	Texture	Flavor	Overall Acceptability
	Control	4.4	4.4	4.4	4.4
Patties	Experimental	4.2	4.4	4.1	4.3
	F-value	0.30^{NS}	0.0^{NS}	1.11*	0.13^{NS}
	Control	4.6	4.2	4.0	4.2
Rava idli	Experimental	4.6	4.0	4.0	4.1
	F-value	0.0^{NS}	0.47^{NS}	0.00^{NS}	0.13^{NS}
	Control	4.0	3.4	3.8	3.6
Cutlet	Experimental	4.0	3.3	3.7	3.6
	F-value	0.00^{NS}	0.04^{NS}	0.11*	0.00^{NS}
	Control	4.3	3.6	3.7	3.7
Upma	Experimental	3.8	3.9	4.2	3.9
	F-value	3.94*	1.11*	3.94*	0.51*
	Control	4.3	4.1	4.2	4.1
Kesaribath	Experimental	4.2	4.2	4.4	4.4
	F-value	0.09^{NS}	0.20^{NS}	0.90*	2.45*

Control: Rice based products; Experimental: finger millet-rice based products; Maximum score-5, ^{NS}: Non-significant; * Significant at 5 percent level

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The computed nutritive value of the foods prepared from finger millet-rice is presented in the Table 7 the results revealed that the protein is highest in finger millet-rice-flour idli (10.8 g) and the lowest being in Chinese fried ragi-rice and kesaribath (3.0 g). Finger millet-rice-flour chilli biscuits (29.5 g) had highest fat content followed with finger millet-rice-flour soft roti with lowest fat (0.7 g) respectively. The highest amount of carbohydrate was found in soft roti (72 g) followed with (24 g) nankhatai had highest energy value (482 Kcal) the lowest being in Chinese fried finger millet-rice (152 Kcal). Calcium content was highest in plain finger millet-rice (180 mg) followed with lowest being in (40 mg). It is evidenced that iron being highest in Dosa (8.5 mg) in finger millet-rice-semolina patties followed with (1.5 mg) in dosa being the lowest.[10]

Table 7 Nutritive value of finger millet-rice recipes

Product	Protein (g)	Fat (g)	Carbohydrate (g)	Energy (Kcal)	Calcium (mg)	Iron (mg)
Finger millet-rice preparations						
Bisibelebath	6.8	20.2	30.0	329	76.5	2.9
Chinese fried rice	3.0	4.0	25.0	152	78.0	6.0
Rice phirni	3.5	9.9	30.0	222	99.0	2.3
Vegetable pulao	3.5	8.3	30.0	204	83.5	3.6
Sweet pongal	5.4	7.4	48.0	280	96.0	2.6
Khara pongal	10.1	15.1	51.0	381	142.0	3.6
Lime Rice	5.0	9.0	37.0	176	135.0	2.8
Vangibath	5.0	20.0	28.0	313	119.0	3.0
Plain Ragi-rice	6.3	0.9	66.0	299	180.0	3.8
Puliyogare	5.9	12.2	52.0	342	157.0	4.1
Curds rice	4.8	7.8	24.0	183	149.0	2.3
Finger millet-rice-rava preparations						
Patties	10.5	1.0	40.0	210	161.7	8.5
Rava idli	5.0	7.0	29.0	196	131.0	2.4
Cutlet	4.0	8.1	26.0	190	48.0	3.0
Upma	5.0	7.0	31.0	202	83.0	3.0
Kesaribath	3.0	7.0	47.0	261	78.0	2.0
Finger millet-rice-flour preparations						
Idli	10.8	0.8	71.0	334	80.2	2.3
Dosa	5.0	9.0	32.0	234	40.0	1.5
Kadabu	3.7	5.3	40.0	226	87.0	2.5
Soft roti	7.0	0.7	72	322	95.0	2.0
Poushtik roti	8.0	12.5	44.0	320	136	5.2
Nankhatai	4.1	24.2	62.0	482	52.0	2.5
Chilly biscuit	5.3	29.5	44.0	465	77.4	2.8
Chakli	6.0	7.0	45.0	270	97.0	3.0
Chatpat(Khara)	7.0	17.0	56.0	403	89	3.0
Chatpat(Sweet)	4.8	17.1	67.0	440	60.0	2.6

The highest amount of carbohydrate was found in soft roti (72 g) followed with (24 g) nankhatai had highest energy value (482 Kcal) the lowest being in Chinese fried finger millet-rice (152 Kcal). Calcium content was highest in plain finger millet-rice (180 mg) followed with lowest being in (40 mg). It is evidenced that iron being highest in Dosa (8.5 mg) in finger millet-rice-semolina patties followed with (1.5 mg) in dosa being the lowest.[10]

Conclusion

The products with finger millet-rice, finger millet-rice-flour and finger millet-rice-Semolina were well accepted with good overall acceptability scores ranging from 3.7 to 4.5.Thus finger millet-rice or decorticated finger millet and its diversified products will help to promote the utilization of nutri-rich finger millet-rice among non-consumers of Ragi. It can also be manufactured at industrial level and can also be made available in all urban market for the benefit of urban community and also to provide higher nutrients compared to other major cereals.

Conflict of interests

The authors declare that there is no conflict of interests.

Acknowledgments

None.

Funding

None.

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