Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(5): 2573-2577
Received: 06-08-2018
Accepted: 14-09-2018

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Development of value added products from milled (decorticated) finger millet and analysis of cooking quality and sensory evaluation

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Abstract
The milled finger millet is a novel product which has potential to prepare diverse food products other than flour based products. The present study was to develop novel products such as cooked finger millet (similar to rice), ready to eat finger millet flakes and biscuits fortified with seed coat matter which was obtained after milling of the hydrothermally treated finger millet. The study also emphasizes the assessment of cooking quality of cooked finger millet and sensory characteristics of cooked sample of milled finger millet grains as compared with some other conventional methods of preparations. As well as processed ready to eat (RTE) flakes prepared from milled finger millet and biscuits prepared from composite flour having 10% seed coat matter of hydrothermally treated finger millet. It was concluded that the cooking time, swelling power, water uptake (on wet basis) and solid loss of milled cooked finger millet was 6.45 min, 1.95, 62% and 3.15% respectively. The sensory results of cooked sample of milled finger millet for overall acceptability, processed ready to eat (RTE) flakes for overall quality and biscuits prepared from composite flour for eating quality were 8.2, 8.2 and 7.6 respectively which indicated higher consumer acceptability of these novel products.

Keywords: Development, value added, products, from milled, (decorticated), finger millet

Introduction
The grain finger millet (*Eleusine coracana* L.) with its nutritionally superior qualities merely confined to floor based products only. Now a day, even though the importance for the millet has been increasing drastically, the consumption of flour based finger millet products was limited to only traditional consumers. Milled (decorticated) finger millet is one of the unique products from finger millet. The seed coat is removed to finger millet in order to bring it in grain form similar to rice. The milled finger millet is a novel food grain, which can be used to prepare cooked *ragi* rice, and *ragi* flakes. The seed coat of the millet, which forms about 15% of the kernel, is a rich source of calcium, dietary fibre and polyphenols (Chethan & Malleshi, 2007) [2]. Preparation of millet flour almost free from the seed coat by incipient moist conditioning, pulverising and sieving the native as well as the malted millet is being practiced generally, in addition the seed coat collected as a by-product upon milling of the finger millet after hydrothermal treatment. The seed coat is an edible portion which contains high amounts of dietary fibre that can be incorporated into the biscuits in order to prepare fiber rich biscuits. The main objective of the study is to prepare cooked milled grains, ready to eat (RTE) flakes from milled finger millet and biscuits fortified with finger millet seed coat matter

2. Material and Methods
2.1 Material
A popular variety of finger millet (PPR 2700, *Vakula*) procured from Agriculture Research Station, Perumalapalli of Acharya N.G Ranga Agricultural University, Andhra pradesh. Finger millet grains with membranous pericarp were dehulled in *ragi* pearler at Post Harvest Technology Centre, Bapatla. About 1 kg of finger millet was hydrothermally processed according to Rajasekhar *et al.*, (2018) [8] and milled using rice polisher (6704, INDOSAW, Osaw Industrial Products Pvt. Ltd., Haryana). The sound milled finger millet grains were used for further studies.

2.2 Cooking Quality of Finger Millet Grain
The cooking characteristics of experimental finger millet grain samples were determined by following procedures**.**

2.2.1 Cooking Time
The milled finger millet grain sample (10 g) was cooked in boiling water (70 mL) over a boiling water bath in a glass beaker (Dharmaraj *et al*., 2014) [3]. The cooking time of milled finger millet grain sample was determined subjectively by pressing the product between fingers periodically at 1 min intervals. When the product was completely soft and translucent when pressed between glass slides, the time was noted as optimum cooking time.

2.2.2 Water Uptake
20 g of milled finger millet was taken in beaker of 140 mL boiling water and cooked for predetermined cooking time. About 5 g of cooked grains were place in a muslin cloth for 3 to 5 sec to drain out the excess water. The moisture content of the cooked grains was determined by the oven drying method at 60 °C temperature for 24 hours (AACC, 2000) [1].

2.2.3 Swelling Power
A known weight (10 g) of milled finger millet grain sample was cooked (in a glass beaker) with 70 mL of boiling water for predetermined time. After cooking, the water was strained out and the cooked grain was dried to remove surface moisture using filter paper and then the sample was weighed. From the initial and final weights of finger millet grain, the swelling power was calculated as:

$$\text{Swelling power } \left({}^{g}/_{g}\right) = \frac{W_2 - W_1}{W_1}$$

where

W_1 = Initial sample weight before cooking, g
W_2 = Sample weight after cooking, g

2.2.4 Solid Loss
Solid loss was determined by cooking milled finger millet grain samples in boiling water. After cooking, the cooked material was strained out and the whole filtrate was transferred quantitatively into a pre-weighed petri dish. It was evaporated over a water bath followed by drying in a hot air oven maintained at 105 ± 2 °C for 1 hour. The petri dish was again weighed with the dried solids. Then, the solid loss was calculated as:

$$\text{Solid loss (\%)} = \frac{W_2 - W_1}{W_0} \times 100$$

where,
W_0 =Initial weight of finger millet grain taken for cooking, g
W_1 =Weight of empty petri dish, g
W_2 =Weight of petri dish with dried solids after evaporation, g

2.3 Preparation of Ready to Eat (RTE) Flakes from Milled Finger Millet
2.3.1 Preparation of Flakes
Finger millet sample was soaked at 70 °C temperature, steamed at 2 $kgcm^{-2}$ pressure and dried at 40 °C to a 12.15% (w.b.) final moisture content was finally milled was used for preparation of flakes.
100 g of the milled finger millet was placed in glass container and then sprayed with 46 mL of additional water to raise the moisture content of the samples from 12.15% to 40% and left for equilibration for about 12 h with occasional mixing. Followed by that, the sample was passed through a heavy-duty roller flaker (Mathesis Engineers Pvt. Ltd, Hyderabad) to flatten the grains. The flattened grains were spread in a single layer and dried to safe moisture level (12%, wet basis) in a tray drier maintained at 42 °C. These samples were used for preparation of processed ready to eat (RTE) flakes.

2.3.2 Preparation of ready to eat (RTE) flakes
To prepare ready to eat (RTE) flakes, raw flakes prepared from roller flaker were placed in a strainer and dipped into hot vegetable oil at 160 °C for 4 seconds. After four seconds the strainer with flakes was removed from the oil and placed in a bowl to cool down to normal temperature. Finally 1 g of salt was added to flakes and mixed to complete the process.

2.4 Preparation of Biscuits from Finger Millet Seed Coat based Composite Flour
2.4.1 Preparation of Seed Coat Matter from Hydrothermally Treated Finger Millet
About 300 g of finger millet was soaked for about 1.45 h at 70 °C in excess distilled water and the excess water was removed by draining. The soaked finger millet was steamed in an autoclave (250×450 mm, Optics Technology, Delhi) at 2 kg cm^{-2} for 15 min. The steamed material was dried in a mechanical drier maintained at 40 °C to 12.15% (w.b.) final moisture content to prepare hydrothermally treated finger millet (HTM). The HTM was milled in a rice polisher (6704, Indosaw, Osaw Industrial Products Pvt. Ltd., Haryana). The yield of seed coat matter that passed through 600 µm sieve was calculated using the following formula

$$\text{Seed coat yield (g/100 g)} = \frac{\text{Weight of seed coat}}{\text{Weight of total sample}}$$

The seed coat matter from hydrothermally treated finger millet did not exhibit uniform particle size. However, for the preparation of composite flour, a meal of less than 105 µm particle size was required (Krishnan *et al.*, 2011) [4]. Hence, the seed coat matter was sieved again for formulating composite flour to prepare biscuits.

2.4.2 Formulation of Composite Flour and Preparation of Biscuits
The incorporation of the seed coat matter up to 20% level was desirable and beyond that, the quality of the biscuits was affected adversely as indicated by preliminary studies (Krishnan *et al.*, 2011) [4]. Accordingly, the wheat flour was supplemented with seed coat matter from hydrothermally treated finger millet at 10% level to prepare the composite flour.
To prepare the biscuits, sugar (90 g) and shortening (60 g) were creamed in a morphy richards hand mixer with a kneader, for 2 min at 61 rpm. To the cream, water containing sodium bicarbonate (1.5 g), ammonium bicarbonate (3 g) and sodium chloride (3 g) were added and mixed further for 5 more min at 125 rpm to obtain a homogeneous cream.
To the cream, composite flour (300 g) was added and mixed continuously to form homogeneous dough and sheeted using a rolling pin to a thickness of 4.5 mm. Biscuits were shaped with a cutter (moon shaped) of 51 mm diameter and baked on aluminium trays at 205 °C for 10 min in an oven (KEMI, Kadavil Electro Mechanical Industries, Kerala), then it is cooled for 30 min and stored in airtight tins for 24 h and evaluated for the quality characteristics and sensory attributes (Manohar and Rao, 1999) [5].

2.5 Sensory Analysis
Sensory analysis for three cooked samples of milled finger millet, milled flour mixed with rice and untreated whole

finger millet flour mixed with rice was conducted with 10 panel members based on nine point hedonic scale for the quality attributes of appearance, flavour, mouth feel, discreetness and taste (Peryam, 1957) [6].

Similarly, sensory analysis for ready to eat (RTE) flakes from milled finger millet was tested for the attributes of appearance, colour, texture, taste and overall quality. As well, sensory analysis for biscuits from finger millet seed coat based composite flour was conducted for the attributes of colour, crumb colour, surface characteristics and eating quality.

3. Results and Discussion

3.1 Cooked Milled Grains

3.1.1 Cooking Characteristics of Milled Finger Millet

The milled finger millet was cooked to soft texture in 6.45 min (Table. 1) after dropping in excess boiling water as indicated by the maximum spreadability of the grains when pressed between two glass slides (Fig. 1). The cooked sample shown in Fig. 2 clearly indicated the discreetness of grains. The colour of the water during cooking was slightly creamiest, indicating solubilisation of some of the constituents from the endosperm. Considerably lower cooking time (6.45 min) for the milled finger millet compared to parboiled rice (20-30 min) reveals the advantage associated with milled finger millet in terms of saving time and energy. This qualifies finger millet to classify it as quick-cooking millet. Probably the smaller size, freedom from the seed coat and overall large surface area and also the presence of pregelatinized starch might have contributed for the quick cooking properties of the milled finger millet.

Swelling power of milled cooked finger millet was 1.95. Water uptake of cooked finger millet was 62% on wet basis. The water uptake of cereals is largely influenced by the surface area as well as its protein and starch content (Dharmaraj *et al*., 2014) [3]. Solid loss in residual cooking water was only about 3.15%. Similar observations were made by Pillaiyar and Mohandoss (1981) [7] in case of parboiled rice.

Table 1: Cooking characteristics of milled finger millet

Cooking characteristics	Value
Cooking time, min	6.45 ± 1.0
Swelling power	1.95±0.03
Water uptake,% (w.b.)	62±2.0
Solid loss,%	3.15

Fig 1: Translucent endosperm indicating complete cooking of milled finger millet grain

Fig 2: Milled finger millet before and after cooking

3.1.2 Cooked Sample of Milled Finger Millet Grains

Cooked grains from milled finger millet were devoid of seed coat (Fig. 3a), and hence the attributes of these were found to be unique among the other general practices of cooking methods. The scoring given to cooked sample of milled finger millet was presented in Fig. 4. The milled finger millet was in creamiest-yellow colour of acceptable appearance (mean score of 8.4). The mean value score for flavour was 8.4, which means that the millet was cooked well and the bad odours from the seed coat was not felt as like previous whole meal product. The sensory score for mouth feel was 8.3 which indicated that the grain was cooked soft and some kind of acceptable chewiness was observed.

The discreetness of milled grain was observed by the panel and the average score was 8.1. This discreetness of milled grain was because of the improvement in hardness by hydrothermal treatment. Average score for taste was 8.4 which mean that non-traditional consumers and new generations will accept it to a large extent. Finally, the average score for overall acceptability of the product was 8.32 which means, the product is readily accepted by the public.

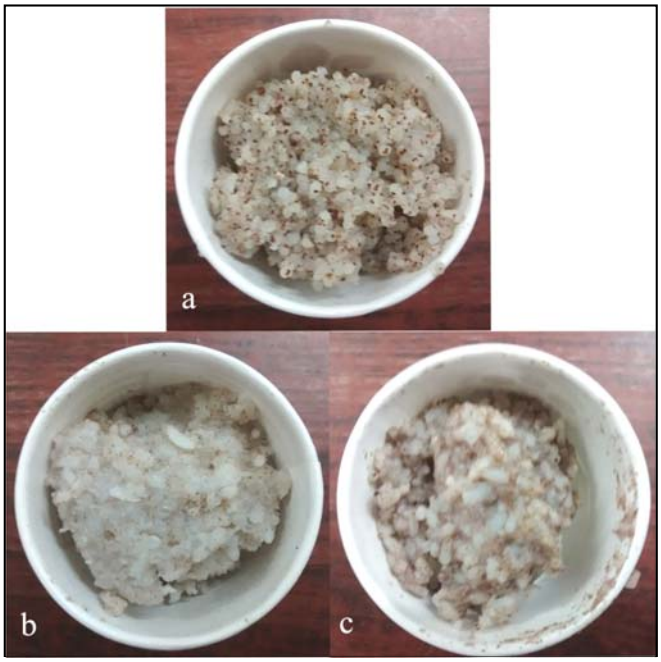

Fig 3: Cooked samples of (a) Milled finger millet, (b) Milled finger millet flour mixed with rice and (c) untreated whole finger millet flour mixed with rice

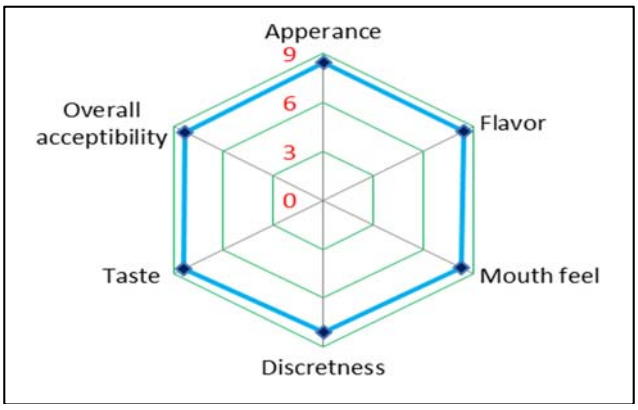

Fig 4: Sensory attributes of cooked sample of milled finger millet

3.1.3 Cooked Sample of Milled Finger Millet Flour Mixed With Rice

As of now, the general practice of finger millet usage was the whole grain flour mixed with the rice to prepare *ragi mudda.* The cooked sample of milled grain flour was mixed with the rice and was evaluated for the sensory attributes (Fig. 3b) (Fig. 5). Average score for appearance for this sample was 4.7 which indicated that it possessed very poor colour. The flavour score was 4 which indicated a slight dislike from the panel. The mouth feel of the sample scored an average value of 3.9 reflecting that the sample had bad chewiness.

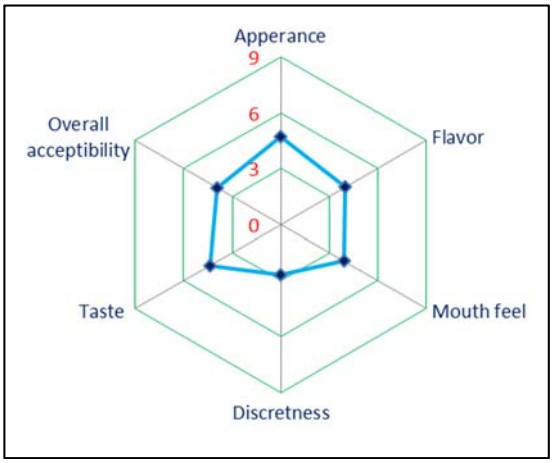

Fig 5: Sensory attributes of cooked sample of milled grain flour mixed with rice

Since the product was flour mixed composite, the attribute 'discreetness' was not so appreciably suitable (2.7). The score for the taste was 4.4 and overall acceptability scored 3.94.

3.1.4 Cooked Sample of Untreated Whole Finger Millet Grain Flour Mixed with Rice (*Ragi mudda*)

The appearance of the sample scored 6.9 which indicated the moderate likeness of the product (Fig. 3c) (Fig. 6). The score for the flavour was 6.7 which expressed the moderate likeness of the product. The mouth feel of the sample was 6.3 which was found better than the cooked sample of milled grain flour mixed with rice. Score for discreetness was 3.5 which mean that the grain was not discrete. The score for taste was 6.3 indicating that the sample was somehow acceptable and it was evident that traditional consumers will continue to consume it. The score for overall acceptability of the sample was 5.94, which means that non-traditional consumers are not habituated because of some off-flavours and taste due to the presence of seed coat and its characteristic odour.

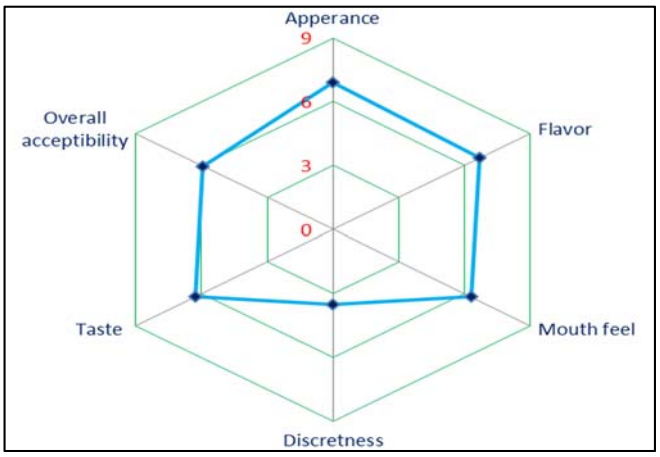

Fig 6: Sensory attributes of cooked sample of untreated whole finger millet grain flour mixed with rice

3.2 Ready to Eat (RTE) Flakes from Milled Finger Millet

From Fig. 9 indicates the sensory profile of the processed ready to eat (RTE) flakes prepared from milled finger millet (Fig 7&8). It was observed that the sensory score of processed ready to eat (RTE) flakes in terms of appearance was 8.2 on average. From this, it was well understood that milling enabled the finger millet to be accepted to large extent because of improved appearance over the raw finger millet. The colour of processed RTE flakes was creamy white to pale yellow and scored an average value of 8.1. The texture score was 8.4 which means a crisp mouth feel. Taste score was 8.5 and overall quality fetched a score of 8.2 on hedonic scale.

Fig 7: Flakes prepared from milled finger millet

Fig 8: Processed ready to eat (RTE) flakes from milled finger millet

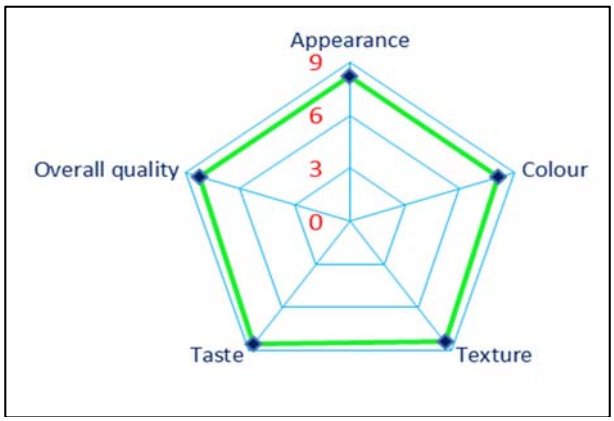

Fig 9: Sensory attributes of processed ready to eat (RTE) flakes from milled finger millet

3.3 Biscuits Fortified with Finger Millet Seed Coat Matter

Fig. 11 indicates the sensory profile of the biscuits prepared from composite flour having 10% seed coat matter of hydrothermally treated finger millet (Fig. 10). It was observed that the sensory score of the biscuits in terms of colour was 7 on average, where as crumb colour scored 6.1. In terms of surface characteristics, the score was slightly less i.e. 6.1 which was due to rough surface of the fibre incorporated. Texture scored 6.2, which meant that the biscuit was not so crisp; however an acceptable level was maintained. Eating quality scored 7.6, indicating good acceptability.

Fig 10: Biscuits fortified with finger millet seed coat matter

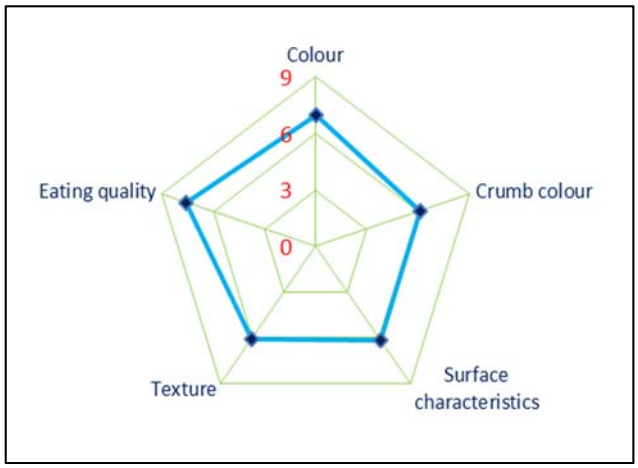

Fig 11: Sensory attributes of biscuits fortified with finger millet seed coat matter

4. Conclusions

Milled finger millet cooked to soft texture within 7 min (6.45±1.0) and it can be considered as a quick cooking cereal. Value added products developed from milled finger millet were; cooked milled finger millet, ready to eat (RTE) flakes and biscuits fortified with seed coat matter of finger millet. The sensory results of these products for overall acceptability, overall quality and eating quality were 8.2, 8.2 and 7.6 respectively which indicated higher consumer acceptability

5. Acknowledgement

The authors thank the Acharya N.G. Ranga Agricultural University, College of Agricultural Engineering, Department of Processing and Food Engineering, Bapatla, Andhra pradesh, India to provide the facility to carry out the experimental work and for the financial support during research work

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