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Development of composite millet flour incorporated rusk

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Abstract

An improvement in millet processing technology to provide millet based convenience food would help in increasing millet production, scope for millet utilization on industrial scale, maintain ecological balance, prevent malnutrition and ensure food security. Considering this, the study was designed to develop Ready-to-Eat rusk using millet flour. Composite Millet Flour (CMF) prepared using equal quantities of sorghum (*Sorghum bicolour L. Moench*), pearl millet (*Pennisetum typhoides*) and foxtail millet (*Setaria italica*) was substituted in refined flour at different levels (25, 50, 75 and 100 %) to develop rusk. The formulated rusk was assessed for its sensory acceptability, physico-chemical properties, nutrient content and storage stability. Of the different formulations, variation I with 25 per cent composite millet flour substitution recorded the highest mean sensory scores with 8.75 ± 0.46. The moisture, ash and acid insoluble ash content of the rusk (CMF – 25 %) were found to be 4.92, 1.22 and 0.05 % respectively. 100g of the CMF substituted rusk (25%) provided appreciable quantities of carbohydrates, protein, vitamin B_1, B_9, calcium and 354 kcals of energy. On storage (90 days), the moisture content (5.78 %) and the total plate count (<100 cfu/g) of the selected variation were within the FSSAI limits ($<10^5$) and it was organoleptically well acceptable. Utilization of composite millet flour for the development of Ready-to-Eat products like rusk would enhance the marketability of millets and improve the therapeutic value of formulated food products.

Keywords: Millet; Rusk; Value-Addition; Pearl-Millet; Foxtail-Millet; Sorghum

1. Introduction

Millets are cereals belonging to *Poaceae* grass family which are appraised as one of the oldest cultivated crops. Sorghum grains contain high fibre, starch and non-starchy polysaccharides with some unique characteristics. Protein quality and essential amino acid profile of sorghum is better than many of the cereals and is rich source of B-complex vitamins [1]. Pearl millet contains appreciable quantities of nutrients [2] which is equivalent or even superior to those of other cereals providing high levels of calcium, iron, zinc and lipids. Pearl millet has well-balanced protein, with high concentration of threonine and tryptophan and adequate leucine content making it suitable for developing products for people with celiac disease [3]. Foxtail millet is a good source of protein (12.3 per cent), β - carotene (126-191 μg/100g) and dietary fibre (14 per cent) whereas its carbohydrate content is low (60.9 per cent). Besides, it is rich in minerals (3 per cent) and phytochemicals [4]. This millet has been proved to be suitable for people suffering from metabolic disorders [5].

Besides numerous health benefits, these are underutilized and the difficulties in millet grain processing present a challenge towards meeting the consumer demand. A change in millet processing technology and availability of millets in ready-to-use or ready-to-eat convenience food form would help in increasing the cultivation area under millets,

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maintaining ecological balance, ensuring food security, prevent malnutrition and increase the scope for utilization of millet grains on industrial scale [6].

Incorporating millet foods into staple foods through various innovative technological approaches can provide substantial health benefits while retaining consumer appeal, whereas, the combination of low cost and nutrient rich millets has not been much explored [7]. In this context, an attempt was made to process different millets together to prepare ready-to-eat products which would enhance both its nutritional and economic value.

2. Material and methods

2.1. Preparation of Composite Millet Flour (CMF)

Millets grains such as sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum typhoides*) and foxtail millet (*Setaria italica*) were procured from the local shops of Coimbatore, Tamil Nadu, cleaned and roasted separately (80 – 90°C). The roasted millets were cooled to room temperature and ground into flour using Hammer mill. The individual millet flour was sieved (US 80 mesh) and equal quantities of each millet flour was mixed together to formulate composite flour which was used further for the formulation of rusk.

2.2. Formulation and sensory acceptability of CMF incorporated rusk

The composite millet flour was substituted in the standard rusk (refined flour – 100 per cent) at 25, 50, 75 and 100 per cent as I, II, III and IV respectively. The other ingredients added were sugar (125 g), dry yeast (5 g), custard powder (7.5 g) and water. The steps involved in the production of CMF rusk is presented in Figure 1 and the developed rusk is given in Figure 2.

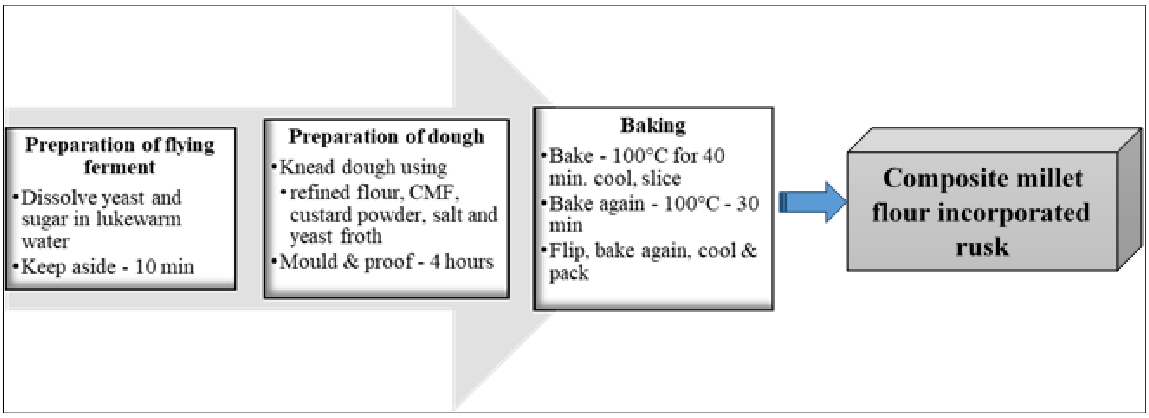

Figure 1 Processing of CMF Rusk

Figure 2 Developed Composite Millet Flour Incorporated Rusk

The samples of the formulated composite millet flour incorporated rusk were subjected to sensory evaluation using 9 – point Hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely) by a panel of 20 semi- trained members after due approval from Institutional Human Ethics Committee (IHEC), PSG Institute of Medical Sciences & Research

(PSG IMS&R), Peelamedu, Coimbatore, Tamil Nadu (Approval No. PSG/IHEC/2019/Appr/FB/015 dated 23/01/2019). The sensory scores were statistically analysed using mean, standard deviation, ANOVA and Duncan's Multiple Ranking Test (DMRT) to find the most acceptable variation.

2.3. Quality analysis of the CMF incorporated rusk

The developed control and selected CMF incorporated rusk were analysed for its physico-chemical properties (moisture, ash and acid insoluble ash), nutrient content (energy, carbohydrates, protein, fat, fibre, calcium, phosphorus, iron, vitamin B_1 and B_9) following the procedures provided by AOAC [8]. The rusks were packed in an air tight polyethylene pack and stored for a period of 90 days. The storage stability was assessed periodically (30 days) using moisture content, sensory tests and total microbial count.

3. Results and discussion

3.1. Flour recovery

Flour recovery percentage after milling and sieving of the individual millet flour is presented in Table 1.

Table 1 Flour Recovery (%) of the selected millets

S. No.	Flour	Milling and sieving loss (%)	Flour Recovery (%)
1	Sorghum	20.82 ± 0.86	79.19 ± 0.86
2	Pearl Millet	09.73 ± 2.21	90.25 ±2.21
3	Foxtail Millet	12.54 ± 0.64	0.64

On milling of sorghum, pearl millet and foxtail millet, the flour recovery was found to be 79, 90 and 87 per cent respectively. The milling and sieving loss accounts to be highest for sorghum (21 per cent), followed by pearl millet (10 per cent) and foxtail millet (13 per cent). The milling and sieving losses of foxtail millet and finger millet was 33 per cent and the flour recovery was 67 per cent in study conducted by Tiwari [9] which is lower than the flour recovery of the selected millets in the present study. Taylor and Kruger [10] states that milling of sorghum and other millets using hammer mill and sifting or aspirating the flour not only aids in removal of bran and other physical and chemical contaminants but it improves palatability of the food product which may also bring about some changes in its constituents.

3.2. Sensory acceptability

Table 2 Mean sensory scores of composite millet flour rusk

Formulated products	Mean sensory scores				
	Colour and appearance	Texture	Taste	Flavour	Overall acceptability
Control	8.80 ± 0.41^{c}	8.75 ± 0.55^{c}	8.75 ± 0.44^{c}	8.70 ± 0.57^{c}	8.75 ± 0.46^{c}
Variation I	8.20 ±0.83^{c}	8.30 ±0.64^{c}	8.20 ±0.59^{c}	8.10 ±0.79^{c}	8.10 ±0.60^{c}
Variation II	7.95 ± 0.99^{b}	7.60 ± 1.18^{b}	7.85 ± 1.08^{b}	7.85 ± 0.98^{b}	7.83 ± 0.92^{b}
Variation III	7.35 ± 0.93^{a}	6.75 ± 1.01^{a}	6.70 ± 1.12^{a}	7.00 ± 1.07^{a}	6.97 ± 0.92^{a}
Variation IV	7.65 ± 0.87^{ab}	6.90 ± 1.20^{a}	7.45 ± 1.05^{b}	7.65 ± 1.18^{b}	7.43 ± 0.95^{ab}
F value	14.868*	20.721*	19.518*	12.685*	20.752*
P value	0.000	0.000	0.000	0.000	0.000

Control (RF – 100 %), Variation 1 (RF: CMF – 75:25%), Variation 2 (RF: CMF – 50:50%), Variation 3 (RF: CMF – 25:75%), Variation 4 (RF: CMF – 0:100%) RF – refined flour; CMF – composite millet flour; Values are given in Mean ± Standard Deviation; *Significant at 1 % level (p<0.01%), ^{NS} Not Significant Mean followed by the same letter on the same column were not significantly different (P>0.05) by DMRT test

The mean scores of the rusk prepared with 25 per cent incorporation of composite millet flour was highly acceptable and comparable with the standard prepared with 100 per cent refined flour. The size of the rusk reduced on incorporation of higher proportion of composite millet flour. The texture was found to be hard in variation III and IV owing to the less concentration of refined flour in the rusk. It can be attributed to the fact that millet flour lack gluten proteins which are vital for holding the gas during fermentation and baking, thereby affecting the product raise and volume. It is important to note that there existed significant difference in the sensory characteristics of the composite millet flour rusk formulated (Table 2).

Hefnawy [11] developed rusk by substituting chick pea flour at 15 per cent in wheat flour which was appreciable than rusk having 30 per cent chick pea flour. The acceptability of the product is determined by the extensibility of the gluten which was greatly affected on increasing the concentration of chick pea flour which lacks gluten. Similarly, Nazni and Karuna [12] also noted that barnyard millet bran substituted rusk was acceptable only till 15 per cent since the texture of the rusk was greatly influenced by the incorporated barnyard millet bran.

3.3. Physico - chemical properties

The moisture content of the formulated rusk was 4.92 ± 0.096 per cent which was lesser than control rusk having 5.78 ± 0.175 per cent. Bam [13] reported the moisture content of the rusk prepared by composite flour of Dicoccum wheat as 2.82 per cent which is lesser than the moisture of the rusk in the present study. However, the study reveals that the moisture content of commercially available branded and unbranded rusk falls in the range of 1.76 – 4.11 and 1.27 to 4.48 per cent respectively where the moisture content of the developed CMF rusk is in close proximity. The ash and acid insoluble ash content of rusk were 1.22 per cent and 0.05 per cent respectively (Table 3).

Table 3 Physico – chemical properties of the millet flour

S. No.	Formulated product	Moisture (%)	Ash (%)	Acid Insoluble Ash (%)
1	Rusk – Control*	5.78 ± 0.175	1.19	0.05
2	Rusk – CMF **	4.92 ± 0.096	1.22	0.05

*Rusk – control – refined flour – 100 %; **Rusk – CMF – Composite Millet Flour – 25 %

3.4. Nutrient content

The nutrient content of the formulated rusk (Table 4) showed that the substitution of CMF at the level of 25 per cent in refined flour had improved the nutrient content of the formulated rusk. It was rich in carbohydrates, protein, vitamin B_1, B_9 and also calcium. The results of the present study are comparable with the study conducted by Bisht and Srivastava [14] reported that the cake rusk prepared with two different varieties of finger millet significantly increased the carbohydrate, protein and calcium content than the control cake rusk.

Table 4 Nutrient content of the formulated Rusk (100 g)

S. No.	Nutrients	Rusk	
		Control (*RF – 100 %)	CMF (25%)
1	Energy(kcal)	336	354
2	Carbohydrates (g)	61.3	62.8
3	Protein (g)	2.99	6.59
4	Total fat (g)	8.7	8.5
5	Vitamin B_1 (mg)	0.287	0.356
6	Vitamin B_9 (mcg)	23.78	43.20
7	Calcium (mg)	0.35	0.38
8	Phosphorus (mg)	102	101
9	Iron (mg)	< 1.0	< 1.0

RF – Refined Flour; CMF – Composite Millet Flour

From the present study, it is evident that the incorporation of composite millet flour containing sorghum, pearl millet and foxtail millet flour has remarkably improved the nutrient content of the formulated products.

3.5. Storage stability

The BIS standards for the moisture content in the bread rusk (IS: 8555 - 2005) should not exceed 10 per cent on storage. Though the moisture content of the rusk incorporated with CMF increased on storage from 4.92 to 5.55 per cent (Table 5) yet, it was found to be well within the limits suggested by BIS [15]. The increase in moisture content of the selected products could be due to the moisture vapour transmission rate of packaging material as quoted by Mamta [16].

Table 5 Changes in the moisture content of formulated products on storage

Product	**Moisture content (%)**		**Total Plate Count (cfu/g)**	
	Day 1	Day 90	Day 1	Day 90
Rusk - Control	05.08 ± 0.04	05.78 ± 0.17	<100	<100
Rusk - CMF	04.92 ± 0.09	05.55 ± 0.02	<100	<100

*Rusk – control – refined flour – 100 %; **Rusk – CMF – Composite Millet Flour – 25 %

The total microbial count of the rusk was negligible (< 100 cfu/g) during the storage period of 90 days. The microbial load of the prepared products was found to be lesser than the acceptable standards ($<10^5$) specified by FSSAI. This shows that the prepared rusk does not show microbial contamination and are safe for consumption for a period of three months. It is acknowledged that roasting and cooking at high temperature has aided in elimination of microorganisms due to which the microbial counts of the products were insufficient to cause any food spoilage and food borne diseases.

Table 6 Changes in mean sensory scores of the selected CMF rusk on storage

Sensory Characteristics	**Days of storage**				**P value 0th day vs 90th day (P < 0.05)**
	0	30	60	90	
Colour and Appearance					
Rusk - Control	8.40 ± 1.23	8.10 ± 1.12	7.65 ± 0.81	6.00 ± 1.72	0.000 ^{NS}
Rusk - CMF	8.20 ± 1.01	8.05 ± 1.32	7.00 ± 1.26	6.60 ± 1.90	0.019 ^{NS}
Texture					
Rusk - Control	8.05 ± 1.32	7.70 ± 1.42	7.55 ± 0.69	5.40 ± 1.23	5.422*
Rusk - CMF	8.15 ± 1.27	7.80 ± 1.44	7.00 ± 1.17	5.80 ± 1.51	0.000 ^{NS}
Taste					
Rusk - Control	8.30 ± 1.30	8.00 ± 1.17	7.35 ± 0.49	6.00 ± 0.00	2.014 ^{NS}
Rusk - CMF	8.10 ± 1.48	7.80 ± 1.58	7.45 ± 0.69	6.00 ± 1.72	0.000 ^{NS}
Flavour					
Rusk - Control	8.30 ± 1.30	7.90 ± 1.29	7.55 ± 0.69	6.40 ± 1.39	0.000 ^{NS}
Rusk - CMF	8.10 ± 1.48	8.00 ± 1.59	6.90 ± 1.12	6.20 ± 1.51	0.001 ^{NS}
Overall acceptability					
Rusk - Control	8.26 ± 1.27	7.93 ± 1.20	7.53 ± 0.63	5.95 ± 0.68	1.624 ^{NS}
Rusk - CMF	8.10 ± 1.35	7.95 ± 1.30	7.09 ± 1.03	6.15 ± 1.60	0.001^{NS}

*Rusk – control – refined flour – 100 %; **Rusk – CMF – CMF – 25 %

The initial mean organoleptic scores (Table 6) decreased during the storage period of 90 days. The mean colour and appearance, taste and flavour scores of the control rusk were 8.40 ± 1.23, 8.30 ± 1.30 and 8.30 ± 1.30 respectively and the composite millet flour incorporated rusk were 8.20 ± 1.01, 8.10 ± 1.48 and 8.10 ± 1.48 respectively which was found to be decreased to 6.00 ± 1.72, 6.00 ± 0.00 and 6.40 ± 1.39 respectively for control and 6.60 ± 1.90, 6.00 ± 1.72 and 6.20 ± 1.51 respectively for the formulated rusk at the end of 90 days. Even after the study period, the formulated rusk was acceptable with no off flavour and after taste. The sensory qualities of the composite millet flour rusk did not reveal any significant difference on storage of about 90 days.

The results of the present study is in par with the study conducted by Chandrashekar *et al* [17] and Yaseen [18] where the rusk made using partially defatted coconut flour, maize, wheat bran and barley respectively showed a significant decrease in its mean overall acceptability scores during the storage period of 30 days.

4. Conclusion

Utilization of sorghum, pearl millet and foxtail millet for the development of novel products like rusk would help to improve the production and commercialization of the millets thereby improving the utilisation of millets among people. This would also satisfy the demand for nutritious food products enhancing the consumption of traditional grains to improve the health of the people. Hence, it has become imperative to reorient the efforts on millet processing to generate demand through value-addition of processed foods through diversification of processing technologies, nutritional evaluation and creation of awareness.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this document.

Statement of ethical approval

The sensory evaluation of the products was done among human subjects after approval from Institutional Human Ethics Committee (IHEC), PSG Institute of Medical Sciences & Research (PSG IMS&R), Peelamedu, Coimbatore, Tamil Nadu, India. (Approval No. PSG/IHEC/2019/Appr/FB/015 dated 23/01/2019).

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