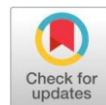


Research Article

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Development and Quality Evaluation of Minor Millet Based Ready to Cook Instant Khichdi Mixes



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ABSTRACT

Millets are ancient crops that have been cultivated for 10000 years. One of the dietary importance of millets are mainly due to its nutritional quality as well as its role in promoting health. Minor millets are underutilized and under-researched when compared to other millets. Hence, the present study has developed three differently treated (soaking-drying, autoclaving-drying and roasting) four minor millets (Proso, Barnyard, Little, and Kodo millets) based instant khichdi mixes to select the best treatment for sensory acceptability of each millet-based khichdi mix. Based on the sensory scores, autoclaved kodo, roasted proso, soaked little and barnyard millet-based khichdi were highly acceptable. The nutritional quality of developed instant khichdi mixes showed that they were good source of protein (12.50-17.92%), crude fiber (0.70-5.64%), iron (6.26-10.56mg/100g), zinc (3.51-5.07mg/100g) and phytonutrients like phenols (2.28-4.8mg GAE/100g) and tannins (0.43-0.57mg TAE/100g). The results show that kodo khichdi mix can be safely stored up to 60 days, whereas proso, little, and barnyard millet khichdi mixes can be stored up to 90 days at ambient conditions in LDPE pouches.

Keywords: Minor millets, Instant khichdi mixes, nutritional composition, shelf life

Introduction

Food is a dynamic entity classified as both fresh and processed categories. Ready-to-eat and ready-to-reconstitute foods are the major categories of processed foods. Instant foods are advantageous, especially for the armed forces and also for the common people, it adds variety to the diet in their authentic taste [1]. Nowadays, instant foods have become a part of the day-to-day life of Indians due to Western influence, urbanization, increased double-income nuclear families, changing life styles and food preferences. Currently, several varieties of instant foods are available in the market, which can be noted as a food revolution. In the Indian markets, instant foods have occupied a special shelf space among the different processed food segments. Food manufacturers are offering high quality and a wide range of suitable foods for households that are convenient to use [2]. In today's fast-moving world, instant foods provide great convenience, save time to cook, have uniform good taste and additionally, they have the advantage of long shelf life and easy portability [1].

Khichdi is a very popular pan Indian dish. Traditionally khichdi preparation is done with rice and pulse, preferably green gram dal, as they both complement each other nutritionally and provide a healthy nutritious meal. Preprocessed instant khichdi mix takes very little time for its preparation [1]. When compared to conventional cereals, millets popularly known as "Nutri-cereals," have certain advantages in terms of nutritional quality. They are good sources of protein, sulfur containing amino acids,

nutritional quality, dietary fiber, good fatty acid profile, micronutrients and phytochemicals with a low glycemic index and also act as a potential functional food ingredient and therapeutic agent [1; 3; 4].

Millets are termed as yesterday's coarse grains, today's nutriceals and are considered to be "future crops". They are climate-resilient crops and show resistance to most pests and diseases. After decades of negligence, millets are attaining a strong comeback in India, dominating global production of millets and standing first rank with a share of 40.62%. Most of the millets are 3-5 times more nutritious than the commonly consumed cereals so, they are called as superfoods [4].

Proso, barnyard, little, and kodo millets are referred to as minor millets. These millets together with finger and foxtail millets are used as an ingredient in the preparation of several multigrain and gluten-free cereal-based products, various traditional foods and beverages such as bread, porridges, and snack foods [5].

These minor millets are under researched and underutilized compared to other millets. Hence, the present study has attempted to standardize and evaluate the quality of minor millet based ready-to-cook instant khichdi mix to improve the nutritional quality of the breakfast component.

Materials and methods

Processing of millets

The four millets such as Proso, barnyard, little, and kodo millets were exposed to rotary drying to obtain the required amount of moisture (less than 12%). Then the selected grains were given different treatments like soaking, autoclaving (10 min at 15 PS), and roasting to select the best treatment for the instant khichdi mix production. The vegetables like beans, carrots, green chilies, and onions were cut into small pieces and blanched for 1 min at 100°C, tray dried at 60°C, and stored in an air tight container till use.

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Preparation of instant ready-to-cook khichdi mix

All the required ingredients were weighed individually (Table-1). Cumin seeds were roasted in a pan greased with oil or ghee till they splutter. Then add the spice mixture (Turmeric, asafoetida, green chillies, black pepper powder, dehydrated curry leaves, beans, ginger powder, and salt) to it. Pretreated millet grain and pre-roasted green gram were mixed properly, cooled, and packed in airtight LDPE pouches for further analysis.

Table-1 Composition of instant minor millet khichdi mix

Ingredients	Quantity (g)	Ingredients	Quantity (g)
Treated Millet grain	56.88	Asafoetida	0.02
Green gram	30.00	Black pepper punched	0.20
Carrot	4.00	Onion (dried)	2.00
Beans	2.00	Green chilly	0.40
Jeera	1.00	Salt	3.00
Turmeric	0.10	Ginger powder	0.40

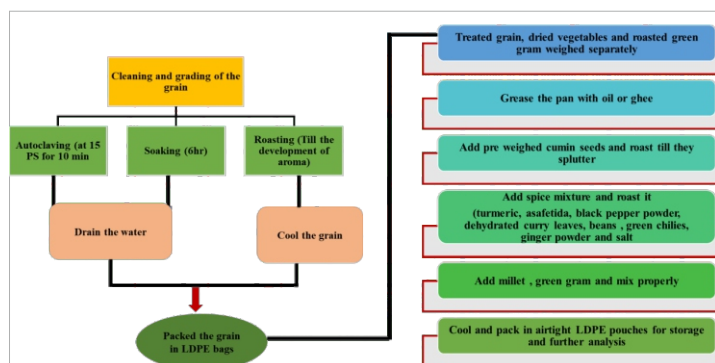


Figure-1: Development of millet based ready to cook khichdi mix

Sensory evaluation of the developed products

Instant khichdi mixes were prepared by boiling 3.5 cups of water and adding 25gm of khichdi mix, cooking on low flame till desired consistency, and subjected to sensory evaluation. The sensory assessments were conducted in a sensory evaluation laboratory. Semi-trained panel members (15) from the Foods and Nutrition Department at Post Graduate and Research Centre, PJTSAU, Rajendranagar, Hyderabad, were selected as panelists for the study. They were given written instructions and asked to evaluate the products for acceptability in terms of appearance, color, texture, taste, flavour, crispness and overall acceptability using a 9-point hedonic scale, where 1= dislike extremely, 2 = dislike very much; 3 = dislike moderately; 4 = dislike slightly; 5 = neither like, nor dislike; 6 = like slightly; 7 = like moderately and 8 = like very much 9= Like extremely [6]. The samples were presented in plates coded with three-digit numbers in individual booths in the sensory evaluation lab. Panelists rinsed their mouth with water after testing each sample. The acceptability index was calculated.

$$\text{Acceptability index (AI)} = \frac{\text{Total scores}}{\text{Maximum score}} \times 100$$

Cooking parameters

Cooking parameters like water uptake, cooking time, the weight of the cooked product, and rehydration ratio was assessed by standard procedures (7).

Functional properties of instant mixes

Water Solubility Index (WSI) [8], water holding capacity, water absorption capacity, oil retention capacity [9], were analyzed by standard procedure.

Nutritional and phytonutrient composition of the developed products

Moisture, ash, protein [10; 11; 12], fat [13], crude fiber [14], carbohydrate and energy [15] and minerals like calcium, iron, zinc, sodium, phosphorus and magnesium were analyzed by the standard procedures [16]. Phytonutrients like total phenols [17], antioxidant activity by DPPH [18] and tannins [19] were analyzed.

Storage studies

The sensorially best selected formulation was stored in polypropylene pouches and stored at ambient temperature for shelf-life studies. During storage, moisture [10], Total Bacterial Count (TBC) and Total Mould Count (TMC) [20] were analyzed on 30th, 60th, 90th, and 120th day of storage.

Statistical analysis

All experiments were performed three times. All data were presented as mean $\pm$ standard deviation of the mean.

Results and Discussion

Sensory evaluation of instant khichdi mixes

In the present study, instant khichdi mixes were developed from the three differently treated (soaking, roasting and autoclaving) four minor millets to select the best treatment for the development of minor millet-based khichdi mixes based on sensory scores. The study found that the selected treatment has no significant effect on the sensory properties of kodo, proso and little millet-based khichdi mixes except for barnyard millet. Barnyard millet-based khichdi mixes showed significant differences among the treatments (Table-2), autoclaved barnyard instant mixes scored lowest in all the sensory properties when compared to other treatments of barnyard millet. Soaked treatment exhibited the highest scores for the barnyard millet mixes. All the scores were in the acceptable range for all the four millet-based khichdi mixes except for ABKM (autoclaved barnyard based khichdi mix). Therefore, the acceptability index was taken as a selection criterion. Among the different treatments, kodo millet autoclaved and dried sample khichdi mix was well accepted, whereas in little millet and barnyard millet, soaked and dried treatment got a high acceptability index score. In the case of proso millet, roasted khichdi mix got the highest score and was selected for further study.

Table-2: Mean sensory scores of developed instant khichdi mixes

Kodo millet based instant khichdi mixes						
Samples	Colour	Taste	Texture	Flavour	Overall acceptability	Acceptability index
RKKM	6.67a±0.66	6.56a±0.68	6.78a±0.78	6.89a±0.74	6.78a±0.78	74.8
SKKM	7.44ab±0.68	7.11a±1.10	7.00a±0.67	6.89a±0.57	7.22a±0.92	79.3
AKKM	7.78b±0.62	7.44a±0.68	7.55a±0.68	7.00a±0.82	7.22a±1.03	82.2
F-Value	5.96	2.25	2.52	0.06	0.63	
p-value	0.01*	0.13 ^{NS}	0.10 ^{NS}	0.94 ^{NS}	0.54 ^{NS}	
Proso millet based instant khichdi mixes						
RPKM	8.11a±0.74	8.00a±0.67	7.89a±0.99	7.33a±0.47	7.50a±0.88	88.6
SPKM	7.78a±0.92	7.78a±0.63	6.88a±0.74	7.44a±0.96	7.44a±0.68	84.8
APKM	8.33a±0.67	7.89a±0.56	7.11a±1.19	8.11b±0.74	8.00a±0.47	87.3
F-Value	1.02	0.25	2.23	4.19	1.53	
p-value	0.37 ^{NS}	0.78 ^{NS}	0.13 ^{NS}	0.03*	0.24 ^{NS}	
Little millet based instant khichdi mixes						
RLKM	7.67a±0.67	7.44a±0.83	7.33a±0.67	7.22a±0.92	7.44a±0.68	82.5
SLKM	8.11a±0.74	7.67a±1.15	7.78a±0.63	7.11a±0.87	7.55a±0.95	84.9
ALKM	7.78a±0.63	7.44a±0.81	7.55a±0.95	7.22a±1.03	7.33a±1.05	83.0
F-Value	0.93	0.14	0.68	0.04	0.12	
p-value	0.41 ^{NS}	0.86 ^{NS}	0.52 ^{NS}	0.96 ^{NS}	0.88 ^{NS}	
Barnyard millet based instant khichdi mixes						
RBKM	7.78b±0.92	7.78b±0.92	7.55ab±0.49	7.67b±0.67	7.56b±0.68	68.2
SBKM	8.00b±0.47	7.78b±0.78	7.77b±0.78	7.89b±0.87	7.78b±0.63	87.3
ABKM	5.67a±1.15	6.11a±0.99	6.66a±1.24	5.78a±1.22	6.00a±0.94	85.3
F-Value	16.62	9.09	3.43	11.89	12.84	
p-value	0.00**	0.00**	0.05*	0.00**	0.00**	

Note: The values are presented as the mean±SD of (n=15) replications. SEM-Standard error mean, CD-Critical Difference, NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different ($p \leq 0.05$).

RKKM: Roasted kodo millet-based khichdi mix	RLKM: Roasted little millet-based khichdi mix
SKKM: Soaked kodo millet-based khichdi mix	SLKM: Soaked little millet-based khichdi mix
AKKM: Autoclaved kodo millet-based khichdi mix	APKM: Autoclaved little millet-based khichdi mix
RPKM: Roasted proso millet-based khichdi mix	RBKM: Roasted little millet-based khichdi mix
SPKM: Soaked proso millet-based khichdi mix	SBKM: Soaked little millet-based khichdi mix
APKM: Autoclaved proso millet-based khichdi mix	ABKM: Autoclaved little millet-based khichdi mix

Cooking Parameters

The selected khichdi mixes were analyzed for cooking parameters such as water uptake, cooking time and rehydration capacity. The results of the study showed that SLKM showed low water uptake (350ml/25gm) and less cooking time (14min), but other mixes showed equal water uptake capacity (450ml/25gm). The highest cooking time was taken for cooking of proso and little millet-based khichdi mixes (19 and 18min respectively). The cooked weight and rehydration ratio was high in barnyard kichidi mix (4.32) followed by proso millet (RPKM), little (SLKM), and kodo millet (AKKM).

Functional properties

The functional parameters of instant khichdi mixes were analysed and presented in Table-3. The study found that the water solubility index of SLKM was high but no significant difference was found between the AKKM, RPKM, and SBKM. The highest swelling and water holding capacity was found in autoclave treated kodo millet based instant khichdi mix (AKKM) whereas soaking treated little millet khichdi mix (SLKM) scored the lowest. Water absorption capacities of AKKM, RPKM, SLKM and SBKM were 1.15, 0.19, 1.41 and 0.12g/ml respectively. The oil retention capacity of RPKM, SLKM and SBKM was almost similar and no significant difference was observed.

Table-3 Functional properties of instant khichdi mixes

Samples	Water solubility index (%)	Swelling power (%)	Water holding capacity (%)	Water absorption capacity (g/ml)	Oil retention capacity (g/ml)
AKKM	0.55±0.06 ^b	1.24± 0.01 ^a	132.00±11.13 ^a	1.15±0.04 ^a	0.83±0.03 ^b
RPKM	0.58±0.02 ^b	1.22±0.01 ^{ab}	123.26±3.22 ^{ab}	0.19±0.16 ^b	0.99±0.06 ^a
SLKM	0.82±0.04 ^a	1.05±0.01 ^c	114.60±1.30 ^b	1.41±0.47 ^a	0.98±0.03 ^a
SBKM	0.54±0.12 ^b	1.17±0.06 ^b	127.70±3.76 ^a	0.12±0.07 ^b	1.03±0.04 ^a
F-Value	33.84	29.91	4.43	20.85	14.08
SEM	0.13	0.09	7.44	0.66	0.09
CD	0.59**	0.40**	33.48*	2.97**	0.39*

Note: The values are presented as the mean±SD of three replications. SEM-Standard error mean, CD-Critical Difference, NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different ($p \leq 0.05$).

AKKM: Autoclaved kodo millet-based khichdi mix	SLKM: Soaked little millet-based khichdi mix
RPKM: Roasted proso millet-based khichdi mix	SBKM: Soaked little millet-based khichdi mix

Nutritional and phytonutrient composition of developed products

The proximate composition of all the instant kichdi mixes is presented in Table-4. Among the developed khichdi mixes moisture content was high in SBKM followed by RPKM, SLKM and AKKM. The fat content of developed products was ranged between 6.69-3.30%. The fat content of RPKM was significantly ($p \leq 0.05$) higher than the other samples. The protein content of RPKM (17.92%) was very high than the AKKM (12.5%), SLKM (14.3%) and SBKM (13.66%). High protein content of proso and little millet (10-15% & 10-13% respectively) than kodo and barnyard [21] might be responsible for the high protein of RPKM and SLKM. The crude fiber content of RPKM was high and SBKM was low. The ash content of SLKM was high followed by RPKM, AKKM and SBKM respectively.

The total carbohydrate and available content of instant khichdi mixes was ranged from 62.65-74% and 57-70.7% respectively. The total energy content of khichdi mixes were almost similar and no significant differences was observed between them. The mineral content of instant khichdi mixes is reported in Table-5. The ascending order of iron content of chutney powder was 6.26(SLKM)<7.46(RPKM)<8.29(AKKM)<10.56 (SBKM). The zinc content of khichdi mixes was ranged from 3.51mg/100g (SBKM) to 5.07mg/100g (RPKM). AKKM found high phosphorus content followed by SBKM (763.33M=mg/100g), RPKM (740mg/100g) and SLKM (580mg/100g). The total mineral content of foxtail, little and barnyard millet was higher than commonly consumed cereals. The iron content of barnyard and little millet was very high 9-12% [21]. High iron content of these minerals significantly increased the iron content of instant khichdi mixes.

Table-4 Nutritional composition of instant khichadi mixes

Sample	Moisture (%)	Fat (%)	Protein (%)	Crude fibre (%)	Ash (%)	Total carbohydrate (%)	Available carbohydrate (%)	Energy (kcal)
AKKM	7.89±0.12 ^c	3.30 ±0.53 ^b	12.50±0.16 ^d	3.30±0.16 ^b	2.30±0.08 ^c	74.00±0.41 ^a	70.70±0.26 ^a	363±4 ^a
RPKM	9.05±0.32 ^{ab}	6.69 ± 0.36 ^a	17.92±0.06 ^a	5.64±0.06 ^a	3.69±0.11 ^b	62.65±0.45 ^c	57.00±0.40 ^d	360±3 ^a
SLKM	8.64±0.32 ^b	3.69 ± 0.15 ^b	14.30±0.03 ^b	2.05±0.03 ^c	4.64±0.47 ^a	68.73±0.70 ^b	66.68±0.68 ^c	357±4 ^a
SBKM	9.21±0.20 ^a	3.50 ± 0.30 ^b	13.66±0.03 ^c	0.70±0.07 ^d	4.10±0.17 ^b	69.53±0.52 ^b	68.83±0.56 ^b	361±2 ^a
F-Value	16.16	58.97	4023.61	1620.17	44.27	230.42	440.00	1.99
SEM	58.70	1.60	2.34	2.10	1.00	4.67	6.09	2.44
CD	264.17**	7.22**	10.52**	9.45**	4.49**	21.01**	27.41**	NS

Note: The values are presented as the mean±SD of three replications. SEM-Standard error mean, CD-Critical Difference, NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different ($p \leq 0.05$).

AKKM: Autoclaved kodo millet-based khichdi mix	SLKM: Soaked little millet-based khichdi mix
RPKM: Roasted proso millet-based khichdi mix	SBKM: Soaked little millet-based khichdi mix

Phytonutrients are the plant secondary metabolites that have protective effects against degenerative diseases. The total phenolic content of SLKM was high and RPKM was less. Roasting treatment given for proso millet may be responsible for the low phenolic content of developed khichdi mixes. The tannin content of khichdi mixes was ranged between 0.43-0.57mg GAE/100gm. The total antioxidant activity of developed khichdi mixes was estimated by DPPH and the results was mentioned in Table- 5. The highest antioxidant activity was found in AKKM and the lowest was seen SLKM.

Table-5: Phytonutrient and mineral composition of khichdi mixes (100g)

Sample	Total Phenols (mg GAE)	Tannins (mg TAE)	Antioxidant activity (%)	Iron (mg)	Zinc (mg)	Phosphorus (mg)
AKKM	2.75±0.14 ^{bc}	0.45±0.03 ^{bc}	40.31±4.53 ^a	8.29±0.01 ^b	4.95±0.02 ^b	856.67±152.75 ^a
RPKM	2.28±0.09 ^c	0.43±0.01 ^c	24.53±0.44 ^{bc}	7.46±0.01 ^c	5.07±0.01 ^a	740.00±100.00 ^b
SLKM	4.53±0.41 ^a	0.57±0.01 ^a	21.64±0.30 ^c	6.26±0.01 ^d	3.69±0.03 ^c	580.00±100.00 ^c
SBKM	2.83±0.31 ^b	0.47±0.01 ^b	28.78±0.20 ^b	10.56±0.02 ^a	3.51±0.00 ^d	763.33±100.17 ^b
F-Value	40.70	38.69	49.15	74116.40	7780.61	2.97
SEM	0.99	8.20	0.06	1.82	0.82	114.97
CD	4.44 ^{**}	36.93 ^{**}	0.28 ^{**}	8.18 ^{**}	3.69 ^{**}	NS

Note: The values are presented as the mean±SD of three replications. SEM-Standard error mean, CD-Critical Difference, NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different ($p \leq 0.05$).

AKKM: Autoclaved kodo millet-based khichdi mix	SLKM: Soaked little millet-based khichdi mix
RPKM: Roasted proso millet-based khichdi mix	SBKM: Soaked little millet-based khichdi mix

Shelf-life studies: The shelf-life evaluation of the developed instant khichdi mixes stored at room temperature (15–34 degree C) was carried out based on the changes in the moisture content, TBC and TMC in the product during storage. The results show that kodo khichdi mix can be safely stored up to 60 days, whereas proso, little and barnyard millet khichdi mixes can be stored upto 90 days.

Table-6: Shelf-life studies of developed instant khichdi mixes

Sample	AKKM			RPKM			SLKM			SBKM		
Duration	Moisture (%)	TBC (Cfu/ml)	TMC (Cfu/ml)	Moisture (%)	TBC (Cfu/ml)	TMC (Cfu/ml)	Moisture (%)	TBC (Cfu/ml)	TMC (Cfu/ml)	Moisture (%)	TBC (Cfu/ml)	TMC (Cfu/ml)
		10 ⁻⁵	10 ⁻⁵		10 ⁻⁵	10 ⁻⁵		10 ⁻⁵	10 ⁻⁵		10 ⁻⁵	10 ⁻⁵
0 th Day	8.24	3	ND	10.29	8	ND	9.89	9	ND	10.82	7	ND
30 th Day	9.26	8	ND	10.87	13	ND	10.12	13	ND	11.56	15	ND
60 th day	10.25	21	2	11.67	26	ND	10.45	21	ND	12.65	21	ND
90 th day	11.77	27	4	12.02	35	3	11.12	27	ND	13.01	29	3
120 th day	12.35	32	7	12.57	43	7	11.95	31	5	13.45	36	7

Note: The values are presented as cfu per ml of the batter. TBC: Total bacterial count, TMC: Total mold count, ND: not detected.

Note: The values are presented as the mean±SD of three replications. SEM-Standard error mean, CD-Critical Difference, NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different ($p \leq 0.05$).

AKKM: Autoclaved kodo millet-based khichdi mix	SLKM: Soaked little millet-based khichdi mix
RPKM: Roasted proso millet-based khichdi mix	SBKM: Soaked little millet-based khichdi mix

Conclusion

The nutritionally rich millets are the best solution to reduce the rising incidences of metabolic disorders and can enhance nutrition and food security. The instant mixes from minor millets can help in adding variety to the diet and make the diet rich in micronutrients and satisfy the demand of small millets processed foods. Processing of small millets based instant food mixes would be a successful strategy to promote millet utilization. Hence, the present investigation was undertaken to standardize the nutritious instant khichdi mixes from small millets with other ingredients that were on par with traditional products in sensory properties and nutritional composition. Rapid industrialization and urbanization and consequent changes in the eating habits of people have led to the development of instant dry mixes and ready-to-eat convenience foods. Dry mixes of several traditional Indian foods such as khichdi mixes have gained worldwide popularity. Hence instant millet khichdi mixes have lesser preparation time, and can easily fit into the kitchen of modern urbanites as a healthy option.

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