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Standardization and Nutritional Evaluation of Minor Millet Based Instant Upma Mixes

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Traditional dry mix Indian foods are very popular worldwide. Upma is one of the famous breakfast foods of the southern India, is usually prepared from wheat semolina. Minor millets are a group of underutilised cereal crop with high nutritional and phytonutrient properties. The present

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investigation examined the quality of four minor millets, proso, barnyard, little and kodo millets for developing ready-to-cook instant upma mixes using soaking-drying, autoclaving-drying and roasting methods. The best method for processing millets into instant upma mixes was determined by the sensory quality of the product. Based on the sensory evolution, roasted minor millet based instant upma mixes were selected for the further study. The nutritional quality of developed instant upma mixes showed that they were good source of protein (6.26-10.68%), ash (3.37-4.27%), iron (7.32-11.28mg/100g), zinc (3.65-5.73mg/100g) and phytonutrients like phenols (1.98-6.07mg GAE/100g) and tannins (0.45-0.58mg TAE/100g). Results show that instant upma mixes can be stored for up to 90 days at ambient conditions in LDPE pouches without spoilage.

Keywords: Instant upma mix; minor millets; shelf life; phytonutrients.

1. INTRODUCTION

The word 'Instant Food Mix' is food to which all the required ingredients are pre-processed and mixed, for convenience to consumers, who only need minimal inputs of cooking before consumption [1,2]. In the recent years there is an increased consumption of ready to eat and instant mixes due to rapid urbanisation, industrialisation, changes in the life style, food habits, culture and the phenomenon of working women. Currently, several traditional Indian foods are available in instant form in the market such as Instant Idli Mix, instant vada mix, Instant Kheer Mix, Instant Upma Mix, Instant Dhokla Mix. Majority of these instant mixes were prepared from wheat and rice. Other food grains like millets especially minor millets are underutilised because of lack of technology for developing them into ready to eat foods [3,2].

Upma is one of the famous breakfast foods of the South India, usually prepared in a short period of time from wheat semolina. Generally, it is freshly prepared before consumption, taking about 15-25 minutes for each preparation, depending on the quantity [3].

Millets are underutilised cereal grains, which in the recent years, have become an important component of several processed foods due its potential nutritional and functional properties. Millets are good sources of protein, energy, carbohydrate, dietary fibre, calcium, iron and also a rich source of phytochemicals. Presence of these nutrients and phytonutrients helps in the prevention of diet-induced metabolic disorders [4]. Minor millets including proso, barnyard, little, and kodo millet are used as essential ingredients in the preparation of several multigrain and gluten free cereal based products, various traditional foods and beverages [5]. These millets have unique superior health benefits. Minor millets are abundant source of vitamins, dietary fiber, micronutrients and other bioactive compounds like tannins, polyphenols and flavonoids [6].

Semolina made from minor millets could be a novel product that can provide natural health benefits of minor millets to consumers. Additionally, minor millets semolina adds dietary diversity and also presents new ways of using minor millets. Presently, widespread utilisation of minor millets was limited, owing to unavailability of various types of foods in the market. As minor millets are free from gluten protein, and so semolina from minor millets can be used to replace wheat semolina for individuals who are intolerant to wheat protein [7]. Previous studies have focused on the value adding major millets to mixes, but no study has developed minor millets like kodo, proso, little and barnyard millet for instant upma mixes. Hence, the goal of this study is to develop a ready-to-cook (RTC) instant upma mix and to assess its chemical composition and sensory properties for improving its use as a breakfast food.

2. MATERIALS AND METHODS

The study was conducted at Millet Processing and Incubation Center, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, India.

Processing of millets: Proso, barnyard, little, and kodo millets were dried in a rotary dryer to less than 12% moisture content. Then the selected grains were given different treatments like soaking, autoclaving (10 min at 15 psi) and roasting to select the best treatment for producing instant upma mixes. Beans, carrot, green chilies and onions were diced, blanched for 1 min at 100°C, tray dried at 60°C and stored in air tight container till use.

Process description of minor millet based instant upma mixes: All the required ingredients

including treated grain, dried vegetables and spices were weighed separately (Table 1). Oil, pre weighed mustard seeds, black gram, bengal gram were added to the pan and heated till they splutter. Then add jeera, treated grain and roast them followed by addition of dried vegetables and mix them properly to get uniform flavour. Then cool and pack in airtight LDPE pouches for further analysis.

2.1 Sensory Evaluation of the Developed Products

Instant upma mixes were prepared by boiling 2.5 cups of water and adding 25gm of upma mix, cooking on low flame till desired consistency and were subjected to sensory evaluation using 9-point hedonic scale [8] with semi trained panel members for selecting best formulation from each millet. Acceptability index was calculated by sum up of all the sensory scores of appearances, texture, flavour, taste and overall acceptability and it was divided by maximum score and multiplied by 100.

Acceptability index = total scores/maximum scores*100

Cooking parameters: Cooking parameters like water uptake, cooking time, weight of cooked product and rehydration ratio was assessed by standard procedures (Sharma *et al*., 2022).

Nutritional and phytonutrient composition of the developed products: Moisture, ash, protein AOAC, [9] fat AOAC, [10] crude fiber AOAC, [9] carbohydrate and energy AOAC, [11] and minerals like calcium, iron, zinc, sodium, phosphorus and magnesium were analyzed by the standard procedures AOAC, [12]. Phytonutrients like total phenols Slinkard and Slingleton, [13] and antioxidant activity by DPPH Tadhani et al., [14] tannins AOAC, [15] 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 AOAC, [16] Total Bacterial Count (TBC) and Total Mould Count (TMC) Tambekar et al., [17] were analyzed on 30th, 60th, 90th and 120th day of storage.

2.2 Statistical Analysis

All experiments were performed three times. All data were presented as mean ± standard deviation. The means were compared using the least significant difference (LSD) at 5% level.

Table 1. Formulation of minor millet based instant upma mix (g/100g)

Ingredients	Quantity	Ingredients	Quantity
Treated Millet grain	68.0	Ginger powder	0.50
Black gram	5.00	Salt	3.25
Bengal gram	5.00	Green chilli	1.75
Mustard	3.00	Onion(dried)	5.00
Beans	3.00	Curry leaves	0.50
Carrot	3.00	Jeera	2.0

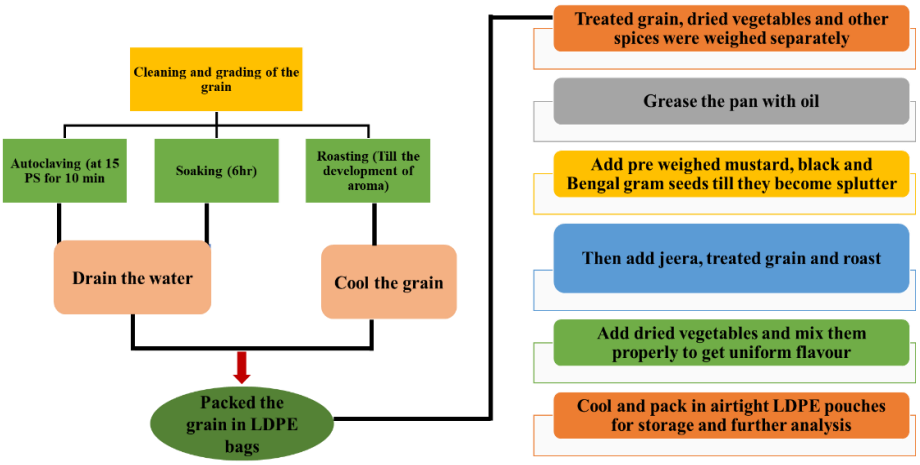

Fig. 1. Flow chart of minor millet based instant upma mix

3. RESULTS AND DISCUSSION

3.1 Sensory Evaluation of Instant Upma Mixes

Scores for colour, taste, texture, flavour and overall acceptability of the instant upma mixes, prepared by soaking, roasting and autoclaving of kodo, proso, little and barnyard millets, are presented in Table 2. Roasting appears to be the best method for processing instant upma mixes based on the highest acceptability indices of 84.9 kodo; 82.2, proso; 82.9, little and 88.2, for Barnyard millet upma mixes. Soaking, with an average acceptability index of 75.8 and 72.6 are in following orders of acceptability of product scores. Roasting consistently produced the best colour, taste, flavour and acceptability in upma mixes of the millet varieties. Flavour of little and barnyard millets were poorer, when autoclaved. Also, the taste of autoclaved barnyard millet upma mix, was significantly poorer than the taste of upma from the other two methods of processing. Therefore, the roasted upma mix products of the four millet samples were selected for further evaluation.

Table 2. Mean sensory scores of developed instant upma mixes

Kodo millet based instant upma mixes						
Samples	**Colour**	**Taste**	**Texture**	**Flavour**	**Overall acceptability**	**Acceptability index**
RKUM	7.5±0.85^{a}	7.90±0.87^{a}	7.80±1.03^{a}	7.40±0.97^{a}	7.60±0.69^{a}	84.9
SKUM	6.80±0.79^{ab}	6.80±0.92^{b}	7.20±0.63^{a}	7.10±0.99^{a}	6.70±0.67^{a}	76.9
AKUM	6.40±0.97^{b}	6.90±0.99^{b}	7.00±0.81^{a}	6.80±0.63^{a}	6.90±0.87^{ab}	75.6
F-Value	4.08	4.27	2.44	1.16	3.92	
p-value	0.03*	0.02*	0.11^{NS}	0.33^{NS}	0.03*	
Proso millet based instant upma mixes						
RPUM	7.20±0.92^{a}	7.80±1.03^{a}	8.10±0.87^{a}	6.80±1.54^{a}	7.10±1.45^{a}	82.2
SPUM	6.30±1.25^{a}	5.80±1.22^{b}	6.40±0.84^{b}	6.50±0.85^{a}	6.30±0.95^{a}	69.6
APUM	6.50±0.97^{a}	6.10±0.74^{b}	7.00±0.67^{b}	6.10±1.19^{a}	6.20±1.47^{a}	70.9
F-Value	1.99	11.17	11.60	0.81	1.41	
p-value	1.55^{NS}	0.00**	0.00**	0.45^{NS}	0.26^{NS}	
Little millet based instant upma mixes						
RLUM	8.20±0.78^{a}	7.30±0.95^{a}	7.10±1.28^{a}	7.50±0.97^{a}	7.20±1.13^{a}	82.9
SLUM	6.70±1.34^{b}	6.60±1.43^{a}	7.00±1.15^{a}	6.80±1.47^{ab}	6.90±0.87^{ab}	75.6
ALUM	6.60±0.97^{b}	6.40±0.84^{a}	6.90±0.87^{a}	6.00±1.15^{b}	6.00±1.33^{b}	70.9
F-Value	7.21	1.83	0.08	3.79	3.05	
p-value	0.00**	0.18^{NS}	0.92^{NS}	0.03*	0.06^{NS}	
Barnyard millet based instant upma mixes						
RBUM	7.80±0.92^{a}	8.10±0.74^{a}	7.80±1.03^{a}	8.10±0.74^{a}	7.90±0.99^{a}	88.2
SBUM	7.00±0.82^{ab}	7.30±1.25^{a}	7.60±0.96^{a}	7.30±0.94^{ab}	7.10±1.19^{ab}	81.1
ABUM	6.60±0.97^{b}	6.20±1.31^{b}	7.10±1.19^{a}	6.40±0.97^{b}	6.50±1.26^{b}	72.9
F-Value	4.28	7.10	1.14	9.12	3.67	
p-value	0.02*	0.00**	0.34^{NS}	0.00**	0.03*	

*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≤0.05).*

RKUM: Roasted kodo millet based upma mix
SKUM: Soaked kodo millet based upma mix
AKUM: Autoclaved kodo millet based upma mix
RPUM: Roasted proso millet based upma mix
SPUM: Soaked proso millet based upma mix
APUM: Autoclaved proso millet-based upma mix
RLUM: Roasted little millet based upma mix
SLUM: Soaked little millet based upma mix
APUM: Autoclaved little millet based upma mix
RBUM: Roasted little millet based upma mix
SBUM: Soaked little millet based upma mix
ABUM: Autoclaved little millet based upma mix

Table 3. Nutritional composition of instant upma mix

Sample	Moisture (%)	Fat (%)	Protein (%)	Crude fibre (%)	Ash (%)	Total carbohydrate (%)	Available carbohydrate (%)	Energy (Kcal/100g)
RKUM	8.80±0.32^{b}	6.47±0.56^{a}	6.26±0.10^{d}	1.50±0.63^{a}	4.27±1.06^{ab}	74.21±1.64^{b}	72.71±0.01^{c}	374.08±1.91^{a}
RPUM	9.47±0.22^{a}	5.41±0.61^{b}	10.68±0.10^{a}	1.80±0.85^{a}	5.14±0.08^{a}	69.29±0.73^{c}	67.49±1.50^{d}	361.41±1.43^{b}
RLUM	7.89±0.21^{c}	4.86±0.19^{b}	7.87±0.10^{b}	1.39±0.16^{a}	3.37±0.22^{b}	76.00±0.14^{a}	74.61±0.08^{a}	373.70±1.75^{a}
RBUM	7.16±0.06^{d}	5.41±0.34^{b}	6.89±0.14^{c}	2.42±0.10^{a}	4.07±0.07^{b}	76.46±0.45^{a}	74.04±0.54^{ab}	372.45±1.52^{a}
F-Value	63.49	6.43	900.51	2.24	5.44	37.42	35.39	39.62
SEM	1.01	0.67	1.95	0.46	0.73	3.28	3.25	6.04
CD	4.56**	3.02*	8.79**	NS	3.05*	14.76**	14.61**	27.18**

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

RKUM: Roasted kodo millet based instant upma mix *RLUM: Roasted little millet based instant upma mix*

RPUM: Roasted proso millet based instant upma mix *RBUM: Roasted barnyard millet based instant upma mix*

Table 4. Antioxidants and mineral composition of instant upma mix (mg/100g)

Sample	Total Phenols (mg GAE)	Tannins (mg TAE)	Antioxidant activity (%)	Iron (mg)	Zinc (mg)	Phosphorus (mg)
RKUM	4.17±0.03^{b}	0.45±0.03^{b}	25.58±0.08^{a}	11.28±0.01^{a}	4.76±0.01^{b}	580.00±100.00^{a}
RPUM	3.28±0.04^{c}	0.46±0.03^{b}	11.42±0.43^{c}	7.32±0.01^{d}	5.73±0.01^{a}	583.33±15.28^{a}
RLUM	6.07±0.05^{a}	0.58±0.01^{a}	9.10±0.08^{d}	8.49±0.01^{b}	3.65±0.01^{d}	490.00±100.00^{a}
RBUM	1.98±0.21^{d}	0.46±0.03^{b}	17.05±0.05^{b}	7.77±0.01^{c}	4.57±0.77^{c}	493.33±20.82^{a}
F-Value	709.14	17.24	3221.11	94832.45	21832.59	1.57
SEM	1.71	7.33	0.06	1.78	0.85	52.00
CD	7.72**	33.00**	0.27**	8.00**	3.84**	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 1%. Values with a different superscript in the same column are significant.*

RKUM: Roasted kodo millet based instant upma mix

RPUM: Roasted proso millet based instant upma mix

RLUM: Roasted little millet based instant upma mix

RBUM: Roasted barnyard millet based instant upma mix

Cooking Parameters: The selected upma mixes were analysed for the cooking parameters such as water uptake, cooking time and rehydration capacity. Cooking time and cooked weight of RKUM, RPUM, RLUM and RBUM was 11 min & 138g, 12 min & 128 gm, 14 min & 160 gm and 15 and 170 gm respectively. Rehydration ratio (RR) is a measure of water absorption by the dehydrated product, rehydration ratio of RKUM, RPUM, RLUM and RBUM was 5.52, 5.12, 6.40 and 6.80 respectively. The results of the study showed that RBUM showed high water uptake (240ml/25gm), high cooking time (15min), high cooked weight (170gm) and high rehydration ratio (6.8) whereas RPUM has low cooked weight (128gm) and rehydration ratio (5.12).

Nutritional composition of instant upma mixes: The nutritional composition of developed upma mixes were presented in Table 3. Significant difference was observed in the moisture, fat, protein, energy, total and available carbohydrate content of developed instant upma mixes. Moisture content of RKUM, RPUM, RLUM and RBUM was 8.80%, 9.47%, 7.89% and 7.16% respectively. Ascending order of protein content of instant mixes were RKUM (6.26%) < RBUM (6.89%) < RLUM (7.87%) < RPUM (10.68%). Among the four products, highest moisture (9.47%) ash (5.14%) and protein (10.68%) content was found in RPUM. RLUM found high energy (373.70Kcal), total carbohydrate (76%) and available carbohydrate (74.61%). High fat content was observed in RKUM (6.47%) whereas RLUM scored lowest (4.86%). Crude fiber content of all the developed product was almost similar and no significant difference was observed between them.

Minerals are essential micronutrients to the body, as body unable to generate its own minerals. Minerals are vital for the normal and healthy functioning of the body. Among all the minerals, iron and zinc are the major global concerns of public health [18]. Mineral content of instant upma mixes were analysed and reported in Table 4. Minerals like iron, zinc and phosphorus content of developed products was ranged between 7.32mg/100g (RPUM)-11.28mg/100g (RKUM), 3.65mg/100g (RLUM)-5.73mg /100g (RPUM) and 490.0mg/100g (RLUM)-583.33mg/g (RPUM) respectively. Among the developed products, highest zinc and phosphorus content was found in RPUM whereas highest iron content was seen in RKUM (11.28mg/100gm). 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% [4]. High iron content of selected minor millets significantly increased the iron content of instant upma mixes.

Phytonutrients are the plant secondary metabolites having protective effects against degenerative diseases. Millets are rich sources of phytochemicals and antioxidants, such as phenolic acids and flavonoids [19,7]. Development of instant upma mixes with minor millets significantly increased the phytonutrient content of developed upma mixes. Total phenol, tannin and antioxidant activity of developed products ranged between 1.98mg GAE/100g-6.07mg GAE/100g, 0.45mg TAE/100g-0.58mg TAE/100g and 9.10%-25.58% respectively. The results of the study found that total phenol and tannin content of RLUM was high whereas RKUM had the highest antioxidant activity.

Table 5. Microbial studies of instant upma mix

Sample	RKUM			RPUM			RLUM			RBUM		
Duration	**Moisture (%)**	**TBC (Cfu/ml) 10^{-5}**	**TMC (Cfu/ml) 10^{-5}**	**Moisture (%)**	**TBC (Cfu/ml) 10^{-5}**	**TMC (Cfu/ml) 10^{-5}**	**Moisture (%)**	**TBC (Cfu/ml) 10^{-5}**	**TMC (Cfu/ml) 10^{-5}**	**Moisture (%)**	**TBC (Cfu/ml) 10^{-5}**	**TMC (Cfu/ml) 10^{-5}**
0^{th} Day	7.69	11	ND	6.87	4	ND	7.01	17	ND	7.21	17	ND
30^{th} Day	8.22	17	ND	6.93	11	ND	7.22	23	ND	7.87	27	ND
60^{th} day	8.63	27	ND	7.15	26	ND	8.10	27	ND	7.96	36	ND
90^{th} day	9.07	30	2	7.41	33	ND	8.66	34	ND	8.42	47	ND
120^{th} day	9.88	42	4	7.93	41	8	9.11	40	3	9.23	59	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 1%. Values with a different superscript in the same column are significant.*

RKUM: Roasted kodo millet based instant upma mix
RPUM: Roasted proso millet based instant upma mix
RLUM: Roasted little millet based instant upma mix
RBUM: Roasted barnyard millet based instant upma mix

Storage stability of developed instant upma mixes: Shelf life of any food product is altered due to lipid peroxidation and enzymatic hydrolysis. Autooxidation of fats and oils is the major limiting factor that influences the shelf life of dehydrated instant mixes [20,3]. Developed minor millet based instant upma mixes were stored in airtight LDPE pouches at ambient conditions (20–35°C) and continuously monitored for moisture content, TBC and TMC content during storage (Table 5). Increase in moisture content and microbial load of all the products was observed during the storage period 0-120th day. Overall, the study found that all the developed instant upma mixes can be stored up to 90 days at ambient temperatures.

4. CONCLUSION

Millets are vital in the standardisation and development of modern meals such as multigrain and gluten-free cereals. The findings of this study are that minor millet based instant upma mixes have good sensory, nutritional and phytonutrient properties. Millet-based instant upma mixes are a good source of energy, protein, minerals and phytonutrients that can be included in the mid-day meal or other feeding programmes for additional dietary diversification and increase in the sales of minor millets.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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