Studies on Storage Stability of Brown Rice Based Instant *Khichdi* Mix

Abstract

The objective of the current research was to formulate the instant *khichdi* mix from instant brown rice (IBR) and instant dehulled mungbean (IDM) and to evaluate its minerals, bioactive components, microbiological and organoleptic parameters during storage of 90 days. Six composite instant *khichdi* mixes were formulated by taking different proportions of instant brown rice and dehulled mungbean in the ratios of T_1 (100:00::IBR:IDM), T_2 (90:10:: IBR:IDM), T_3 (80:20::IBR:IDM), T_4 (70:30::IBR:IDM), T_5 (60:40::IBR:IDM) and T_6 (50:50::IBR:IDM). The prepared instant *khichdi* mix was packed in aluminum laminates and stored under ambient conditions (322for a period of 90 days. Results revealed that iron, calcium and potassium showed an increasing trend from 3.53 to 5.50, 26.65 to 67.82 and 256.40 to 700.68 mg per 100 g, respectively with the incorporation of instant dehulled mungbean. The maximum mean total phenolic content of 165.89 mg GAE per 100 g was recorded in treatment T_6 (50:50::IBR:IDM). However, the maximum mean antioxidant activity of 46.12 per cent was recorded in treatment T_1 (100:00::IBR:IDM). Sensory evaluation revealed that the highest mean overall acceptability scores of 7.91 was recorded in T_5 (60:40:: IBR:IDM) which was adjudged as superior among all the treatments of instant *khichdi* mix. The formulated instant *khichdi* mix retained its quality throughout the storage period of 90 days with total microbial count within safe limits.

Keywords*: Khichdi, brown rice, dehulled mungbean, composite, instant, aluminium laminates.*

1. Introduction

Convenience foods are a class of foods which impart convenience to the consumers by way of little or no requirements of major processing or cooking before their consumption. These foods require minimum handling, such as mild heating/warming for ready-to-eat products or rehydration in hot/cold water for dehydrated foods. Nutritionally rich convenience food formulations will have definite uprising and fulfills the market demands. In India, majority of food is consumed at home, but food consumption outside the home is increased due to the

increase in urbanization, changing lifestyle, increasing working women and less time to cook which increased the need for convenience foods (Monika, 2017). The requirement for ready to serve/instant foods has further gained importance in the light of COVID-19 pandemic, as they provide not only an easy solution to minimize handling and contact free delivery of food but also are a lunch option alternative for individuals who would have normally fed at restaurants that were largely shut down during the pandemic (Federici *et al*., 2021).

Khichdi is a convenient food which termed as super food because it contains very high nutritional density. In Ayurveda, *khichdi* classifies as '*Sattvic*' food. This means that it nourishes, purifies and strengthens both the body and mind (Shetti, 2022). *Khichdi* is a dish from Indian subcontinent made with a mixture of rice and legumes which is loaded with wholesome goodness, easy to digest and free of gluten, but the process is slight time consuming (Rahangdale *et al*., 2015). However, the process of making *khichdi*, using the instant mix involves bringing to boil the appropriate quantity of water, adding the mix to it and lightly heating. Due to ease in cooking, saving in time and labour, it provides convenience to consumers (Durgarao, 2017).

Brown rice is whole grain rice with intact bran layer and the inedible outer hull removed. It is the unmilled rice containing the pericarp, the seed coat and nucellus, the germ or embryo and the endosperm (Zhou *et al*., 2002). The nutritious, high fibre bran coating gives it a light tan colour, nut like flavour and chewy texture. The nutritional components in brown rice mainly exist in the germ and bran layers, which are mostly removed by polishing as an outcome (Mir *et al.,* 2016). It has a low glycemic index which indicate low digestibility of starch. Brown rice is an excellent source of functional components, bioactive components, vitamins and minerals (Babu *et al*., 2009). Thus, the utilization of brown rice in convenience foods could be a good strategy to exploit its nutritional value and also take out the burden of long cooking time (Mir *et al*., 2020).

Mungbeans are a small, oval type of green bean that is high in fibre and when the bean is split in half it is referred to as dehulled mungbean or moong dal. Mungbean is the seed of *Vigna radiata* and is native to the Indian subcontinent (Singh *et al*., 2017). The bean is green with the husk and yellow when dehusked. Mungbeans are a high source of nutrients including manganese, potassium, folate, copper, zinc, magnesium and various B vitamins. They are also high in resistant starch, dietary fibre, protein and amino acid especially lysine and thus can

supplement cereal based human diets (Paul *et al*., 2011). Mungbean is also an excellent source of phenolics, flavonoids and other antioxidants (Gujral *et al*., 2013). In addition, mungbean is lower in phytic acid than pigeon pea, soybean and cereals. Because of their high nutrient density, they are considered useful in defending against several chronic and age-related diseases (Singh *et al*., 2017).

Brown rice and dehulled mungbean are considered as an excellent source of functional components which contains important nutrients such as bioactive components, B-complex vitamins, dietary fibre and minerals which can provide and promote human health. So, they can be processed into further forms to utilize them in the preparation of various value added food products.

2. Materials and Methods

2.1. Collection of raw materials

Brown rice was purchased from Jatinder Rice Mill, R.S. Pura, Jammu. Dehulled mungbean was purchased from local market of Jammu and used for experimentation. Basic raw materials used for the preparation of instant *khichdi* were garlic, ginger, onion, potato along with spices and salt. All the raw materials were transported to pilot plant of Division of Food Science and Technology, SKUAST-Jammu for further processing.

2.2. Sample preparation

2.2.1 Instant brown rice and Instant dehulled mungbean

The procured brown rice grains were cleaned manually and soaked in water at room temperature for 3 hours. After that, the samples were drained and cooked in pressure cooker (Toan and Vinh, 2018) followed by microwave drying. The procured dehulled mungbean was cleaned manually and soaked in water at room temperature. After that, dehulled mungbean was drained and cooked in pressure cooker (Durgarao, 2017). After cooking, rice and dal was subjected to microwave drying. For microwave drying, cooked brown rice and dehulled mungbean were frozen at -20 for 24 hours. The frozen brown rice and dehulled mungbean were then thawed and placed inside the microwave oven in the form of a thin layer on rotating glass

plate with a diameter of 400 mm and dried at 900 W till the required moisture content (below 10%) was achieved. Moisture loss of the sample was recorded at 5 minutes interval using an electronic moisture analyzer (Citizen MB 50C). The dried brown rice and dehulled mungbean obtained from microwave drying were packed separately in air tight containers for further use.

2.2.2 Instant vegetables (onion, potato, ginger and garlic)

Healthy vegetables (onion, potato, ginger and garlic) were selected and blanched at 95 for 2-3 minutes followed by cooling and surface drying at room temperature. After blanching, all the vegetables were subjected to hot air drying at 60 (Ninthiya *et al*., 2014) until the required moisture content was achieved. The dried vegetables were packed in air tight containers and stored for further use.

2.3 Formulation of Instant *Khichdi* Mix

For formulation of instant *khichdi* mix, instant brown rice and instant dehulled mungbean were mixed together in different proportions to make six treatment combinations viz., T_1 (100:00::IBR:IDM), T_2 (90:10:: IBR:IDM), T_3 (80:20::IBR:IDM), T_4 (70:30::IBR:IDM), T_5 (60:40::IBR:IDM) and T_6 (50:50::IBR:IDM). The instant *khichdi* mix was prepared from instant brown rice, dehulled mungbean, vegetables and spice mixture as per the procedure given by Durgarao (2017) with slight modifications. Six composite instant *khichdi* mixes were formulated along with other ingredients including dried garlic, onion flakes, potato cubes and spice mixture.

2.4 Storage

The prepared instant *khichdi* mix was packed in aluminum laminates, sealed and stored under ambient conditions (322for a period of 90 days. The samples were analyzed periodically at an interval of 0, 30, 60 and 90 days of storage for minerals, bioactive, microbiological and organoleptic characteristics.

2.5. Sample analysis

2.5.1 Minerals

The mineral contents were determined after the ash determination. The ash residue of each formulation was digested with perchloric acid and nitric acid (1:4) solution (AOAC, 2012**)**. The samples were left to cool and contents were filtered through Whatman filter paper no. 42. Each sample solution was made upto a final volume of 25 ml with distilled water. The aliquot

was used separately to determine the mineral content of iron, calcium, potassium and magnesium by using an Atomic Absorption spectrophotometer (Spectra AA 220, USA Varian).

2.5.2 Bioactive components

2.5.2.1 Total phenolic content

Homogenized sample (1 g) was extracted three times with 80 per cent methanol. The extracts were centrifuged for 20 minutes and the supernatant collected was dried under nitrogen. Total phenols were determined by Folin-Ciocalteau assay (Ahmed and Abozed, 2015) which is an electron transfer based assay. To determine the total phenolics, the residue obtained was re-dissolved in 5 ml of distilled water followed by addition of 0.5 ml of Folin-Ciocalteau reagent. After 3 minutes, 2 ml of 20 per cent sodium carbonate solution was added. The mixture was mixed thoroughly and incubated for 2 hours at ambient temperature. The absorbance was measured at 765 nm against a reagent blank using a UV-visible spectrophotometer (Model UV4, Unicam and Cambridge, UK). A suitable calibration curve was prepared from different concentrations of standard Gallic acid solution and the total phenolic content of sample was expressed as mg of Gallic acid equivalents (mg GAE/100g) of samples.

2.5.2.2 Antioxidant activity

Antioxidant activity of samples was determined by DPPH (1, 1, diphenyl - 2 picrylhydrazyl) method. Five hundered micro liters of 0.5 Mm DPPH solution and 2 ml of 80 per cent methanol aqueous solution were mixed with 25 µl of methanolic extract of sample, and absorbance was determined at 517 nm using blank as 80 per cent methanol and tris buffer after maintaining at 20°C for 30 minutes. The free radical scavenging activity was evaluated by comparing the absorbance of the sample solution with control solution to which distilled water was added instead of sample (Luo *et al*., 2009).

$$\text{Antioxidant activity (\%)} = \frac{\text{Control OD (0 min.) - Sample OD (30 min.)}}{\text{Control OD (0 min.)}} \times 100$$

2.5.3 Microbiological Analysis (Total microbial count)

Spread plate technique, described by Palczar and Chan (1991) was followed. One gram of sample was aseptically transferred into test tube containing 9 ml of sterile water and was

mixed vigorously. After mixing, 1 ml of this mixture was again transferred to a test tube containing 9 ml sterile water for further dilution. The process was continued until 4^{th} diluents (10^4). Plate count agar media was inoculated with 0.1 ml of diluted sample (10^4), by spread plating technique and incubated at 37ºC for 24 hours. Colonies were counted and multiplied by dilution factor.

2.5.4 Sensory Evaluation

The samples were analyzed for overall acceptability on the basis of colour, taste and texture and by semi-trained panel (9-10 judges) using 9 point hedonic scale assigning scores 9-like extremely to 1-dislike extremely. A score of 5.5 and above was considered acceptable (Amerine *et al*., 1965).

2.5.6 Statistical analysis

All the experiments were performed in triplicates and the data is expressed as the mean values standard deviation derived from triplicate determination values. The statistical analysis of the experimental data was done by using the software IBM SPSS Statistics 26.0.

3. Results and Discussion

3.1 Effect of treatment and storage on mineral content of instant *khichdi* mix

Brown rice and dehulled mungbean are good sources of minerals which are present in varied amounts. The mean iron, calcium and potassium content were found to be higher in instant *khichdi* mix formulated from higher levels of instant dehulled mungbean in contrast to instant *khichdi* mix formulated from instant brown rice (Table 1 and Fig. 1). The highest mean iron, calcium and potassium content of 5.50 mg per 100 g, 67.82 mg per 100 g and 700.68 mg per 100 g were recorded in treatment T_6 (50:50::IBR:IDM), whereas the lowest mean iron, calcium and potassium content of 3.53 mg per 100 g, 26.65 mg per 100 g and 256.40 mg per 100 g were recorded in treatment T_1 (100:00::IBR:IDM), respectively. The increase in iron, calcium and potassium content among treatments might be due to higher iron, calcium and potassium content in instant dehulled mungbean. The results are in good agreement with Joshi and Srivastava (2016) in rice and millet based *khichdi,* Rana *et al*. (2015) in cereal and legume based *dalia* mix, and Khandekar *et al*. (2020) in rice and legume based *khichdi*.

Treatment	Iron (mg/100g)				Mean (Treatment)	Calcium (mg/100g)				Mean (Treatment)
	Storage period (days)					Storage period (days)				
	0	30	60	90		0	30	60	90	
T_1 (100:00::IBR:IDM)	3.60	3.56	3.51	3.44	**3.53**	26.73	26.68	26.62	26.55	**26.65**
T_2 (90:10::IBR:IDM)	3.97	3.92	3.86	3.81	**3.89**	34.95	34.89	34.83	34.76	**34.86**
T_3(80:20::IBR:IDM)	4.38	4.34	4.28	4.21	**4.30**	43.21	43.16	43.10	43.04	**43.13**
T_4 (70:30::IBR:IDM)	4.79	4.73	4.67	4.60	**4.70**	51.42	51.38	51.32	51.27	**51.35**
T_5 (60:40::IBR:IDM)	5.20	5.15	5.09	5.02	**5.12**	59.64	59.59	59.53	59.46	**59.56**
T_6 (50:40::IBR:IDM)	5.58	5.52	5.47	5.41	**5.50**	67.90	67.85	67.79	67.72	**67.82**
Mean (Storage)	**4.59**	**4.54**	**4.48**	**4.42**		**47.31**	**47.26**	**47.20**	**47.13**	
Effects		**C.D$_{(p\leq0.05)}$**				**Effects**		**C.D$_{(p\leq0.05)}$**		
Treatment (T)		0.03				Treatment (T)		0.15		
Storage (S)		0.03				Storage (S)		0.12		
Treatment x Storage		N.S.				Treatment x Storage		N.S.		

Table 1: Effect of treatment and storage on iron and calcium content (mg/100g) of instant *khichdi* mix

Fig. 1: Effect of treatment and storage intervals on potassium content (mg/100g) of instant *khichdi* mix

During storage period of 90 days, minerals (iron, calcium and potassium) decreased significantly from 4.59 to 4.42, 47.31 to 47.13 and 478.70 to 478.40 mg per 100g, respectively. The decrease in minerals might be due to the interaction between minerals and other compounds like carbohydrates and proteins (product of Maillard reaction) thus reducing the bioavailability of minerals (Akhtar *et al*., 2010). Similar findings have been reported by Rokhsana *et al*. (2007) in legume and vegetable based soup mix and Zeb *et al*. (2017) in rice and mungbean based complementary food mix.

3.2 Effect of treatment and storage intervals on bioactive components of instant *khichdi* mix

On analysing the total phenolic content in instant *khichdi* mix (Fig. 2), the lowest mean total phenolic content of 53.37 mg GAE per 100 g was recorded in T_1 (100:00::IBR:IDM) whereas, treatment T_6 (50:50:: IBR:IDM) recorded highest mean total phenolic content of 165.89 mg GAE per 100 g. There was significant increase in total phenolic content among the treatments which might be due to the higher total phenolic content possessed by instant dehulled mungbean. The results have been supported by the findings of Murugkar *et al*. (2013) in cereals and legume based multi nutrient mixes and Jan *et al.* (2018) in weaning food mix prepared from locally available raw materials.

The mean total phenolic content decreased significantly from 109.87 to 109.31 mg GAE per 100 g during storage period of 90 days which might be due to the volatile nature of phenolic compounds which get easily oxidized or could also be due to their involvement in the formation of polymeric compounds, complexing of phenols with proteins and their subsequent precipitation during storage (Muzzaffar *et al*., 2016). Similar results have been reported by Oboh and Amusan (2009) in cereal gruels produced from maize and sorghum, Slathia *et al*. (2016) in mungbean based noodles and Jan *et al.* (2018) in weaning food mix prepared from brown rice and mungbean during 6 months of storage period.

Fig. 2: Effect of treatment and storage intervals on total phenolic content (mg GAE/100g) of instant *khichdi* mix

Antioxidant activity is an important component that scavenges free radicals which cause degenerative diseases. The maximum mean antioxidant activity of 46.12 per cent was recorded in treatment T_1 (100:00::IBR:IDM) whereas, the minimum mean antioxidant activity of 31.54 per cent was recorded in treatment T_6 (50:50::IBR:IDM) (Table 2). There were significant differences among treatments with respect to antioxidant activity which might be due to variation in composition of brown rice and dehulled mungbean. Similar results have been reported by Murugkar *et al*. (2013) in cereals and legume based multi nutrient mixes and Slathia *et al*. (2016) in mungbean based noodles.

Treatment	Antioxidant activity (%)				Mean (Treatment)
	Storage period (days)				
	0	30	60	90	
T_1 (100:00::IBR:IDM)	46.35	46.24	46.08	45.79	**46.12**
T_2 (90:10:: IBR:IDM)	43.42	43.28	43.12	42.83	**43.16**
T_3 (80:20:: IBR:IDM)	40.51	40.39	40.24	39.97	**40.28**
T_4 (70:30:: IBR:IDM)	37.63	37.51	37.33	37.05	**37.38**
T_5 (60:40:: IBR:IDM)	34.70	34.58	34.42	34.16	**34.47**
T_6 (50:50:: IBR:IDM)	31.78	31.64	31.50	31.23	**31.54**
Mean (Storage)	**39.07**	**38.94**	**38.78**	**38.51**	

Effects	**$C.D_{(p\leq0.05)}$**
Treatment (T)	0.06
Storage (S)	0.05
Treatment x Storage	0.12

Table 2: Effect of treatment and storage on antioxidant activity (%) of instant *khichdi* mix

The mean value of antioxidant activity decreased significantly from 39.07 to 38.51 per cent during 90 days of storage period. Phenolic compounds have been responsible for the antioxidant activity. Therefore, the loss in antioxidant activity could be attributed to oxidation and loss of phenolic compounds with passage of time (Jyoti *et al*., 2019). Similar decrease in antioxidant activity have been reported by Jan *et al.* (2018) in weaning food mix prepared from

brown rice and mungbean during 6 months of storage period and Joshi *et al*. (2020) in vegetable leaf powder soup mixes with the increase in storage period.

3.3 Effect of treatment and storage on microbiological analysis of instant *khichdi* mix

Initially no microbial growth was observed upto 30 days of storage (Table 3). The highest mean total microbial count of 0.90 × 10^4 cfu per g was recorded in T_6 (50:50::IBR:IDM), whereas lowest mean total microbial count of 0.56 × 10^4 cfu per g was recorded in T_1 (100:00::IBR:IDM). The increase in total microbial count among treatments might be due to increasing proportion of instant dehulled mungbean which possessed higher moisture content (Showkat *et al*., 2018). However, the values obtained for instant *khichdi* mix were within the acceptable BIS (Bureau of Indian Standards) limits and recommendations for products of this nature (4×10^4 cfu per g) (Monika, 2017). Similar results have been reported by Munasinghe *et al*. (2013) in yoghurt-based weaning food, Sharma (2013) in maize based convenience foods and Monika (2017) in instant rice and rajmash blended convenient mix.

Treatment	**Total microbial count (x10^4 c.f.u/g)**				**Mean (Treatment)**
	Storage period (days)				
	0	**30**	**60**	**90**	
T_1 (100:00::IBR:IDM)	ND	ND	0.38	0.73	**0.56**
T_2 (90:10:: IBR:IDM)	ND	ND	0.45	0.81	**0.63**
T_3 (80:20:: IBR:IDM)	ND	ND	0.53	0.86	**0.70**
T_4 (70:30:: IBR:IDM)	ND	ND	0.60	0.92	**0.76**
T_5 (60:40:: IBR:IDM)	ND	ND	0.67	0.99	**0.83**

T_6 (50:50:: IBR:IDM)	ND	ND	0.74	1.06	**0.90**
Mean (Storage)	**ND**	**ND**	**0.56**	**0.90**	
Effects	**$C.D_{(p\leq0.05)}$**				
Treatment (T)	0.02				
ND: Not Detected					

Table 3 Effect of treatment and storage on total microbial count ($x10^4$ c.f.u/g) of instant *khichdi* mix

The total microbial count showed an increasing trend during 90 days of storage period which might be due to increase in moisture content of instant *khichdi* mix that provides favourable environment for microbial growth during storage (Chakroborty and Chakroborty, 2017). Munasinghe *et al*. (2013) also reported an increase in microbial load during storage of brown rice, mungbean and soybean blended weaning food, Yadav *et al*. (2016) in bengal gram (*Cicer arietinum*) based spiced snacks during storage period of 4 months and Durgarao (2017) in instant *khichdi* during storage period of 45 days.

3.4 Effect of treatment and storage intervals on overall acceptability of instant *khichdi* mix

With the addition of 40 per cent instant dehulled mungbean, the mean scores for overall acceptability increased from 7.42 to 7.91, respectively, whereas, addition of instant dehulled mungbean beyond 40 per cent resulted in decreasing trend of overall acceptability (Fig.3). Among all the treatments, the overall acceptability scores were rated highest in T_5 (60:40:: IBR:IDM) with mean score of 7.91.

Fig. 3: Effect of treatment and storage intervals on overall acceptability (Hedonic score) of instant *khichdi* mix

Significant decrease in overall acceptability score was observed with the progress in storage period. The interaction between treatment and storage was found to be significant at 5 per cent level of significance. The decrease in sensory scores for different characteristics of the product, irrespective of treatments during storage might be attributed to non-enzymatic browning reaction (Maillard reaction) (Munasinghe *et al*., 2013). Semwal *et al*. (2001) also reported that

the sensory scores of instant pulav mix decreased during storage of 90 days, Rahangdale *et al*. (2015) in kodo millet fortified *khichdi* during 90 days of storage and Kokani *et al*. (2019) in instant brown rice kheer mix.

Conclusion

It is evident that the iron, calcium, potassium and phenolic content of instant *khichdi* mix was greatly influenced as the ratio of incorporation increased. For the formulation of nutritious instant *khichdi* mix, instant brown rice and dehulled mungbean can be blended in the ratio of 60:40:: instant brown rice: instant dehulled mungbean. The best composite instant *khichdi* mix i.e. T_5 (60:40::IBR:IDM) exhibited 5.12 mg per 100g iron, 59.56 mg per 100g calcium, 611.87 mg per 100g potassium and 143.43 mg GAE per 100g total phenolic content as compared to control instant *khichdi* mix having values for the same constituents as 3.53 mg per 100g, 26.65 mg per 100g, 256.40 mg per 100 g and 53.37 mg GAE per 100g, respectively. Sensory evaluation revealed that the highest mean overall acceptability scores of 7.91 was recorded in T_5 (60:40::IBR:IDM) which was adjudged as superior among all the treatments of instant *khichdi* mix. The formulated instant *khichdi* mix retained its quality throughout the storage period of 90 days with total microbial count within safe limits.

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