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Nishu
Ph.D. Scholar, Division of Food Science and Technology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir, India

Monika Sood
Associate Professor, Division of Food Science and Technology, Sher-e- Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir, India

Julie D Bandral
Professor, Division of Food Science and Technology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir, India

Neeraj Gupta
Associate Professor, Division of Food Science and Technology, Sher-e- Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir, India

Duwa
Ph.D. Scholar, Division of Food Science and Technology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir, India

Corresponding Author:
Nishu
Ph.D. Scholar, Division of Food Science and Technology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir, India

Effect of drying methods on physico-chemical composition of instant brown rice

Nishu, Monika Sood, Julie D Bandral, Neeraj Gupta and Duwa

Abstract
The present investigation was carried out with the objective to study the effect of drying methods on physico-chemical composition of instant brown rice. Regardless of any drying technique (hot air oven and microwave drying), the instant dried samples demonstrated a significant increase in carbohydrates and energy content but decrease in moisture and crude fat as compared to the raw brown rice. The moisture and crude fat content (6.08 and 2.26 percent) of microwave dried instant brown rice was significantly lower in comparison to hot air dried instant brown rice (7.16 and 2.39 percent). A significantly higher protein content, crude fibre content, ash content, and energy content was observed in microwave dried instant brown rice (7.93, 1.17, 1.52 percent and 380.90 kcal/100 g) as compared to hot air dried instant brown rice. Further, microwave drying had the best results for the minerals and colour (L*, a* and b*) values. Therefore, according to the results obtained, it can be concluded that microwave drying was found superior in maintaining chemical composition and colour attributes during formation of instant brown rice when compared to hot air drying technique.

Keywords: Instant brown rice, hot air oven drying, microwave drying, colour attributes

1. Introduction
Brown rice is a superior to other polished rice as it has high dietary fibre which prevents gastrointestinal disorders (Krishnaveni and Dhanalakshmi, 2014) [10] and provides healthy food for diabetic patients (Panlasigui and Thompson, 2006) [15]. Brown rice has a mild, nutty flavour, chewier and is more nutritious than white rice. The nutritional components in brown rice mainly exist in the germ and bran layers, which are mostly removed by polishing in white rice (Mir *et al*., 2016) [13]. Brown rice is an excellent source of functional components which contains important nutrients such as bioactive components, B-complex vitamins, dietary fiber, and minerals which provide and promote human health (Upadhyay and Karn, 2018) [23]. It is a rich source of vitamins like thiamine (vitamin B_1), riboflavin (vitamin B_2), niacin (vitamin B_3) and minerals like manganese, phosphorous, iron (Babu *et al*., 2009) [2]. It is also high in the phytonutrients, plant lignan, which protect against various diseases including heart disease (Wu *et al*., 2013) [27].
Nowadays, the instant products seem to be preferred to deal with the modern lifestyle. So, instant or quick cooking brown rice is a food product that has marketing potential due to the life style of new generation (Prasert and Suwannaporn, 2009) [16]. Due to the advancement in the science of food technology, there is a tremendous increase in the processing techniques to make instant or ready-to-eat food products and methods of cooking of raw food material which increased the production of the convenience food for the peoples who do not have sufficient time for cooking of traditional food (Unika and Jaffar, 2014) [24]. Therefore, it would be interesting to process the brown rice to be a more convenient and preferable product, namely instant brown rice or quick cooking brown rice as it requires long cooking time of about forty-five minutes.
Drying is a simple preservation technique which increases the storage life. The removal of moisture from solids is an integral part of food processing, and drying is usually used to extend storage life. It can make packing, handling, and transportation of dried products easier and cheaper by reducing the weight and volume (Prothon *et al*., 2001) [17]. Hot-air drying, which is directly proportional to the temperature and time involved, is the most common drying method adopted in the production of dehydrated products (Luangmalawat *et al*., 2008) [11]. Microwave dehydration (MD) uses microwave energy to heat the product and evaporate water, which is energy-saving and highly effective.

2. Materials and Methods

Brown rice was purchased from Jatinder Rice Mill, R.S. Pura, Jammu and were taken to the pilot plant of Division of Food Science and Technology, SKUAST-Jammu for further processing and analysis. The brown rice was then washed and soaked in water with a ratio of rice to water of 2: 3 (w/w) at room temperature for 3 hours. After that, the samples were drained and they were cooked in pressure cooker for about 30 min. (Toan and Vinh, 2018) [22]. After cooking, the rice was subjected to drying by two different methods *viz.* hot air drying and microwave drying. In case of hot air drying, cooked rice were evenly spread on drying trays and subjected to oven drying at 55 ℃ for 5-6 hours until the moisture content reduced to about 5% by weight. For microwave drying, cooked rice were evenly spread on microwave safe plate and subjected to microwave drying. The dried instant brown rice obtained from microwave and hot air drying methods were packed in air tight containers and used for further analysis.

2.1 Physico-chemical analysis

The raw and instant brown rice samples were analyzed for various physico-chemical parameters:

2.1.1 Hunter Colour Values

The colour analysis of samples was done by using Hunter Lab Calorimeter (Hunter Lab Colour Flex Reston VA, USA) as per method of Vargas *et al*., 2009. The equipment was calibrated using ceramic tiles of black and white standard. The sample was uniformly placed in clean petri plates with lid. In the Hunter's lab calorimeter, the colour of a sample is denoted by the three dimensions *viz*., L*, a*, b*. The a* value ranges from -100 (greeness) to +100 (redness), the b* value ranges from -100 (blueness) to +100 (yellowness), while the L* value, indicated the measure of lightness ranging from 0 (black) to 100 (white).

2.1.2 Proximate Analysis

The moisture content in the samples was determined by standard oven drying method given by AOAC 2012 [1]. The crude protein content was determined by micro Kjeldahl method, using the factor 6.25 for converting nitrogen content into crude protein (Sadasivam and Manickam, 2008) [18]. The crude fat content was determined by the Soxhlet extraction technique (AOAC 2012) [1]. The crude fibre content was determined by the method given by AOAC 2012 [1]. Ash content of the samples was determined by using muffle furnace (Wijewardana *et al*., 2006) [26]. The carbohydrate content was estimated by the difference method given by AOAC and it was calculated by subtracting the sum of percentage of moisture, crude fat, crude protein and ash contents from 100 (AOAC 2012) [1]. The total energy content was estimated as per the method given by Surendar *et al*., 2018 [21]. The energy value of the sample was calculated by multiplying protein, fat and carbohydrate values obtained from analysis by 4, 9 and 4, respectively and expressed in kcal per 100 g.

2.1.3 Minerals

The mineral contents were determined after the ash content determination. The ash residue of each formulation was digested with perchloric acid and nitric acid (1:4) solution (AOAC, 2012) [1]. 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).

2.2 Statistical analysis

All the experiments were performed in triplicates and the results obtained were reported as the mean values ± standard deviation (SD) 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 drying methods on hunter colour (L*, a* and b*) values of instant brown rice

The colour of the dried product is an important quality attribute that reflects the organoleptic attractiveness as well as quality of food product. The effect of different drying methods on hunter colour (L*, a* and b*) values of instant brown rice is shown in figure 1. From the results, it was found that the drying techniques significantly influenced the colour values in the instant brown rice.

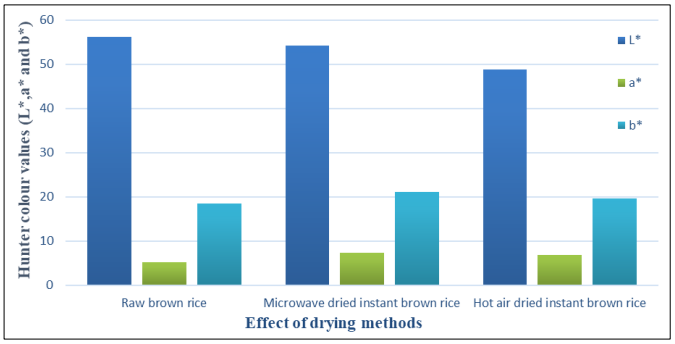

Fig 1: Hunter colour values (L*,a* and b*) of raw brown rice, microwave dried instant brown and hot air dried instant brown rice

The color (L*, a*, and b*) values of the raw brown rice were found to be 56.23, 5.12 and 18.41, respectively. Similarly, the L*, a*, and b* values of the microwave dried instant samples were 54.18, 7.39 and 21.17, respectively, whereas for hot air dried instant samples, the values were recorded as 48.91, 6.87 and 19.62, respectively. Similar findings of colour values were reported by Mir *et al*., 2013 [12] and Sirisoontaralak *et al*., 2015 [20].

The highest L*, a*, and b* values were obtained in the microwave dried instant brown rice as it prevents the browning in the samples, although, the hot air oven dried samples had the lowest L*, a*, and b* values. This might be due to the higher drying temperature with longer drying time in case of hot air oven drying method. The development of a discoloration during hot air oven drying is likely to be related to pigment destruction and non-enzymatic browning reaction. The results were in accordance with the findings of Durgrao, 2017 [6] who studied the effect of drying treatments on the colour values of rice.

3.2 Effect of drying methods on proximate composition of instant brown rice

The effect of different drying treatments on the proximate composition of instant brown rice is shown in Table 1. The

moisture content of raw brown rice, microwave dried and hot air dried instant brown rice was 9.64, 6.08 and 7.16 percent, respectively. The moisture content in raw brown rice observed in the present study was found in agreement with the findings of Islam *et al*., 2012 [8] and Toan and Vinh, 2018 [22]. The lower moisture content in microwave dried instant brown rice may be due to application of faster heat transfer that leads to subsequent reduction in moisture content. The higher crude protein content was observed in microwave dried instant brown rice having value as 7.93 percent, whereas the lower crude protein content of 7.63 percent was found in hot air dried instant brown rice. The crude protein content of raw brown rice was found to be 8.29 percent. The similar findings for crude protein content was observed by Chen *et al*., 2012 [3] and Islam *et al*., 2012 [8]. The higher protein content in microwave dried instant brown rice as compared to hot air dried instant brown rice could be attributed to the phenomena of uniform and rapid heating in microwave drying. The results were in support with the finding of Durgrao *et al*., 2017 [6] and Daomukda *et al*., 2011 [4].

The crude fat content in raw brown rice, microwave dried and hot air dried instant brown rice was recorded as 2.72, 2.06 and 2.39 percent respectively. The findings of the present investigation indicate that crude fat content in the microwave dried instant brown rice decreased in comparison to hot air dried samples. It might be due to the fact that microwave drying eliminate oil and concentrated lipids like trans fatty acids. The similar findings of crude fat were reported by Moongangarm and Sateung, 2010 [14] and Islam *et al*., 2012 [8]. Crude fibre values in raw brown rice, microwave dried and hot air dried instant brown rice were found to be 1.19, 1.17 and 1.14 percent, respectively. No significant difference in crude fibre content was observed in raw brown rice and instant brown rice. The values obtained in the present study were in agreement with the findings of Moongangarm and Sateung, 2010 [14].

Table 1: Proximate composition of raw brown rice, microwave dried instant rice and hot air dried instant rice

Treatment	Proximate Composition (%)						
	Moisture	Crude Protein	Crude fat	Crude fibre	Ash	Carbohydrates	Energy (kcal)
Raw BR	9.64±0.08	8.29±0.12	2.72±0.08	1.19±0.03	1.58±0.11	77.77±0.68	368.72±2.16
MWD	6.08±0.03	7.93±0.09	2.26±0.04	1.17±0.03	1.52±0.08	82.21±0.70	380.90±2.20
HAD	7.16±0.05	7.68±0.06	2.39±0.05	1.14±0.02	1.39±0.04	81.38±0.69	377.75±2.18

Values are the mean ± standard deviation of at least 3 determinations
BR= Brown Rice, MWD= Microwave Dried, HAD= Hot Air Oven Dried

The ash content in raw brown rice, microwave dried and hot air dried instant brown rice was found to be 1.58, 1.52 and 1.39 percent, respectively. Similar results were reported by Islam *et al*., 2012 [8] and Zhou *et al*., 2002 [28]. The higher ash content in microwave dried instant brown rice could be due to the reason that the higher organic matter present in the product is decomposed and the inorganic components such as oxide, carbonate and silicate remained which increases the ash content (Daomukda *et al*., 2011) [4].

The carbohydrate content in raw brown rice, microwave dried and hot air dried instant brown rice was found to be 77.77, 82.21 and 81.38 percent, respectively, whereas the energy content was found to be 368.72, 380.90 and 377.75 kcal per 100 g, respectively. Similar findings were observed by Islam *et al*., 2012 [8], Zhou *et al*., 2002 [28] and Upadhyay and Karn, 2018 [23]. The higher carbohydrate and energy content in microwave dried instant brown rice could be attributed to its moisture, crude protein, crude fat and ash content. This is in good agreement with the findings of Gasmalla *et al*., 2014 [7] who reported higher carbohydrate and energy content in microwave dried bertoni leaf than the hot air dried samples.

3.3 Effect of drying methods on minerals composition of instant brown rice

The mineral content in raw brown rice, microwave dried and hot air dried instant brown rice is given in Table 2. The minerals *viz*., iron, calcium, potassium and magnesium in brown rice were 3.43, 24.36, 236.04 and 138.10 mg per 100 g, respectively. Similar results were reported by Saleh *et al*., 2019 [19] and Upadhyay and Karn, 2018 [23].

Table 2: Minerals content (mg/100 g) of raw brown rice, microwave dried instant rice and hot air dried instant rice

Treatment	Minerals (mg/100g)			
	Fe	Ca	K	Mg
Raw BR	3.43±0.12	24.36±0.17	236.04±1.00	138.10±1.01
MWD	3.35±0.08	23.86±0.12	235.97±0.71	138.02±0.95
HAD	3.28±0.05	23.74±0.10	235.89±0.63	137.96±0.84

Values are the mean ± standard deviation of at least 3 determinations.
Fe= Iron, Ca= Calcium, K=Potassium, Mg= Magnesium
BR= Brown Rice, MWD= Microwave Dried, HAD= Hot Air Oven Dried

The minerals *viz*., iron, calcium, potassium and magnesium were found higher in microwave dried instant brown rice having values as 3.35, 23.86, 235.97 and 138.02 mg per 100 g, respectively, whereas lower values were found in hot air dried instant brown rice as 3.28, 23.74, 235.89 and 137.96 mg per 100 g, respectively. The results are in agreement with the findings of Jaroenkit *et al*., 2013 [9] and Durgrao, 2017 [6].

4. Conclusion

The present study examined the effect of microwave drying and hot air oven drying on the proximate composition, colour and minerals composition of instant brown rice. The results obtained revealed that the nutrients *viz*., crude protein, crude fibre, ash content and mineral compositions (Fe, Ca, K and Mg) are maintained to a maximum extent in microwave

drying. The microwave drying also resulted in improved colour values (L*, a* and b*) as compared to hot air oven drying and thus can be considered as best drying method. Therefore, from the present study, it can be concluded that microwave drying was found superior in maintaining chemical composition and colour attributes during formation of instant brown rice when compared to hot air drying technique.

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