Process optimization for the manufacture of red rice (*Oryza sativa* L.) *kheer*

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Abstract: Red rice contained 13.92 ± 0.13 % moisture, 2.11 ± 0.07 % fat, 1.80 ± 0.01 % total ash and 144.45 ± 1.36 (mgGAE/100g) total phenolic content, respectively. The present study was aimed to prepare *kheer* using red rice @ 18g (T_1), 20g (T_2) and 22g (T_3). Coconut sugar was used @ 15 g in all the combinations. Fresh toned milk (3.0 % fat and 8.5 % SNF) was used with broken red rice (Half broken) grains. Cleaned broken rice was soaked in water (rice to water ratio as 1: 2.5) and cooked at 93°C for about 15 minutes. *Kheer* prepared using 20 g of rice (T_2) was selected as optimized one on the basis of sensory evaluation. The developed red rice *kheer* was acceptable upto 10 days of storage at refrigerated temperature. Optimized *kheer* contained 3.02 ± 1.21 % fat, 56.16 ± 2.11 % moisture and 43.84 ± 3.05 % total solids and 356.24 ± 3.45 Total Phenolic Content (mgGAE/100g)

Keywords: Red rice, *Kheer*, Coconut sugar, Shelf- life, Total phenolic content

Introduction

Kheer is very popular traditional dairy product consumed all over India. *Kheer* is considered as nutritious dairy dessert. But its production is limited to household level and unorganized sector only. Red rice is superior to white rice due to its nutritional

profile and health benefits. So, the use of red rice in place of white rice will not only offer opportunities to develop value added food products but also enhance the nutritional and functional properties of *kheer*.

Red rice is rich in antioxidant, minerals and protein as compared to white rice. Due to its lower glycemic index (63.15 ± 2.63 mg/dl) than white rice, red rice can be a part of the diets of diabetics as well as persons suffering from other non-communicable diseases. Red rice is a storehouse of nutritional excellence and is a healthier alternative to white or polished rice (Raghuvanshi et al. 2017). Due to the high fibre content, red rice possesses the ability to keep healthy metabolic function and bowel function also. It can help in weight management due to anthocyanins. Red rice is highly useful in treating and controlling different ailments due to its nutritional value and its use is very common among the practitioners of traditional medicines and communities. (Rathna Priya et al. 2019).

Increasing threats of ailments such as obesity, hypertension and diabetes mellitus etc. has become a serious concern for the people suffering with such ailments due to the high intake of sugar in food and confectionary products. Production of sweeteners made naturally with low Glycemic Index (GI) can be a solution for such ailments. Only red rice as a main ingredient won't serve the purpose of preparing a healthy *kheer*, so coconut sugar was incorporated in the *kheer* because of its nutritional profile. Coconut sugar was reported to have glycemic index of about 35 (Kusumawaty et al. 2012). Foods with low glycemic index (GI) are important for diabetes, obesity, heart disease and hypertension (Jenkins et al. 1981). Coconut sugar is a good source of minerals like zinc, iron, calcium, phosphorous, potassium and magnesium. Hebbar et al. (2015) also reported that coconut sugar is good source of vitamins, such as vitamin C, B complex, antioxidants, polyphenols and dietary fibres. Now- a -days, coconut sugar becomes very popular among health conscious consumers. Milk is deficient in iron, vitamin C and other minerals are also found in less quantity. So far no work has been carried out on the utilization of red rice for preparation of traditional dairy products; hence this work has been planned for optimization a process for manufacture of *kheer*. Therefore, red rice, coconut

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sugar and milk will formulate a perfect, balanced and healthy combination for *kheer*.

Materials and Methods

Red rice of Truefarm and coconut sugar of Tropicoco Kokos Natural was purchased via online from Flipkart. Toned milk of Amul with 3.0% fat and 8.5% SNF was purchased from the local market of Varanasi.

Proximate composition of red rice

By following the method of AOAC (2000), moisture and fat content was calculated by taking 5g of sample. The ash content of finely ground sample of red rice was estimated by following the protocol of (AOAC 2000). Total phenolic content was determined by using Folin Ciocalteu procedure of (Singleton and Rossi, 1965).

Formulation of red rice *kheer*

All the ingredients were mixed together in required quantities. Red rice was incorporated in three different quantities which were 18, 20 and 22g, respectively. Coconut sugar was incorporated @ 15 g. Fresh toned milk was used in constant quantity of 500 ml in all the three treatments. *Kheer* prepared by adding white rice 12.5g into 500ml of toned milk was taken as control. Notations for control and different treatments are shown below:

T_0 = White rice (12.5g) + Sugar (25g) + Toned Milk (500ml) as control

T_1 = Red Rice (18g) + Coconut Sugar (15g) + Toned Milk (500ml)

T_2 = Red Rice (20g) + Coconut Sugar (15g) + Toned Milk (500ml)

T_3 = Red Rice (22g) + Coconut Sugar (15g) + Toned Milk (500ml)

Preparation of *Kheer*

Initially, clean and dry red rice grains were broken (half) into a mixer grinder. *Kheer* was prepared by using the standard method (Kumar et al. 2005) with some modifications. Red rice was soaked in water at room temperature (rice: water as 1:2.5) for 30 minutes and precooked at 93°C for 10 min. Precooked red rice was added to boiled toned milk (3% fat and 8.5% SNF) with continuous agitation of the mixture (Fig.1 & Fig.2).

Sensory evaluation of red rice *kheer*

Sensory evaluation of red rice *kheer* was done by panel of 20 semi-trained judges in respect of colour & appearance, flavour, body & texture and overall acceptability. Score card was provided to all judges comprising 9 points Hedonic Scale.

Fig.1 Flow diagram for preparation of red rice *kheer*

Chemical composition of red rice *kheer*

By following the method of AOAC (2000), moisture content was calculated by taking 5g of sample. After the determination of moisture, the left residue was taken for calculation the total solid content.

Moisture content was calculated by the formula:-

$$\text{Moisture (\%)} = \frac{(W_2 - W_1)}{(W_1 - W)} \times 100$$

Where, _____

W = Weight of empty dish

W1 = Weight of dish with the sample

W2 = Final weight of dish

Statistical Analysis

Fig. 2 Different formulations of red rice *kheer*

Table 1 Proximate composition and total phenolic content of red and white rice

Constituents	White Rice	Red Rice
Moisture (%)	12.85±0.15	13.92±0.13
Crude fat (%)	0.67±0.01	2.11±0.07
Total Ash (%)	0.57±0.04	1.80±0.01
Total Phenolic Content (mgGAE/100g)	25.09 ± 1.10	144.45 ± 1.36

Data represents as mean ± Standard Deviation (n = 3) at (p>0.05)

The data obtained during the course of investigation were subjected to statistical analysis. One-way analysis of variance (ANOVA) was applied to analyze test of significance.

Results and Discussion

Shelf-life of red rice *kheer*

Based on the sensory characteristics of the different combinations T₂ was selected for shelf- life study with control sample of white rice *kheer*. *Kheer* was packed in polystyrene cups of 100 g capacity and stored at 6±2°C in refrigerator. The pH, acidity and microbial parameters of red rice *kheer* were determined at an interval of 2 days for a period of 10 days

Proximate composition of red rice

The moisture and fat per cent content of red rice was 13.92 ± 0.13, 2.11± 0.07 which was on the higher side then the control i.e. 12.85 ± 0.15 and 0.67 ± 0.01, respectively (Table 1). Similar results were reported by (Raghuvanshi et al. 2017). They found that red rice have 12.75% moisture, 1.53 % ash and 1.81% fat. The ash content of red rice was also higher than white rice as red rice is highly rich in fibre as compared to wheat and many other vegetables. (Gopalan et al. 2007). The total phenolic content of red rice was 144.45 ± 1.36 mg catechin equivalent/g observed higher than that of white rice 25.09 ± 1.10 mg catechin/g. Sompong et al. (2011) estimated the total phenolic content of total ten different red rice varieties ranging between 79.2 and 691.4 mg FA equivalent/100g. The total phenolic content and total flavonoids content of red rice was found to be 143.38 mg GAE/100 gm and 120 mg R.E./100 gm respectively (Raghuvanshi et al. 2017).

Sensory analysis

Table 2 depicts that the sensory score for body and texture of T₂ formulation was found to score highest i.e. 8.50 ± 0.24 which was found to be statistically non-significant over other treatments at (P>0.05). The sensory score for overall acceptability of T₂ formulation was highest 8.11 ± 0.19 which was found to be statistically non-significant over other treatments at (P>0.05). Therefore, T₂ was the optimized product on the basis of sensory evaluation. Addition of more than 20 g of red rice in *kheer* resulted in highly viscous product which results in poor score. Similar results were observed by Sandey et al. (2009). They found that flavour score of cereal based dairy product prepared with 10% and 20% of little millet flour were statistically at par and product with 10% addition of little millet resulted in smooth and soft body and texture.

Chemical composition of red rice *kheer*

Optimised red rice-based *kheer* has total solids content of 43.84± 3.0, whereas the total solids per cent of control was 44.57 ± 2.78. Similar results were reported by (Mor et al. 2017). The optimised product has the higher total solid content than that of control which was significantly not different from each other (Table 3). The statistical data shows non-significant difference between values (p>0.05). Deshmukh et al. (2017) estimated the total solid content of poppy seeds *kheer* which was observed as 41.42%.

Coconut sugar also influenced the free radical capacity significantly (P<0.05). Low et al. (2015) studied the antioxidant activity of probiotic ice cream by incorporating different levels of cane sugar and coconut palm sugar. Total phenolic content of

Table 2 Sensory evaluation of red rice *kheer*

Treatments	Body and Texture	Colour and appearance	Flavour	Overall acceptability
T0	7.50±0.31	7.00±0.23	8.50±0.17	7.66±0.23
T1	7.50±0.26	7.50±0.29	7.50±0.14	7.50±0.24
T2	8.50±0.24	7.83±0.18	8.00±0.16	8.11±0.19
T3	6.88±0.31	7.25±0.25	7.00±0.26	7.04±0.27

Values are mean ± Standard Deviation (n=20)

Table 3 Chemical composition of optimized red rice *kheer*

Constituents	Control (T ⁰)	Optimised (T ²)
Fat (%)	2.45±0.89	3.82±1.21
Moisture (%)	55.43±2.88	56.16±2.11
Total Solids (%)	44.57±2.78	43.84±3.05
Total Phenolic Content (mgGAE/100g)	28.21±1.08	356.24±3.45

Data represented as mean ± Standard Deviation (n = 3) at (p>0.05)

Table 4 Changes in pH, acidity and microbial count of red rice *kheer* during storage

Storage duration(days)	pH	Acidity (%)	SPC (log CFU/g)
0	Control : 6.34±0.40 Optimized: 6.40±0.60	Control : 0.34±0.01 Optimized: 0.21±0.03	Control : Nil Optimized: Nil
2	Control : 6.30±0.42 Optimized: 6.37±0.53	Control : 0.36±0.03 Optimized: 0.22±0.10	Control : 1.08±0.40 Optimized: 1.02±0.20
4	Control : 6.23±0.72 Optimized: 6.32±1.01	Control : 0.40±0.12 Optimized: 0.21±0.40	Control : 2.45±0.12 Optimized: 2.32±0.42
6	Control : 6.24±0.71 Optimized: 6.27±0.50	Control : 0.45±0.03 Optimized: 0.20±0.08	Control : 3.40±0.22 Optimized: 3.53±0.23
8	Control : 6.20±0.22 Optimized: 6.24±1.01	Control : 0.50±0.06 Optimized: 0.22±0.20	Control : 4.35±0.21 Optimized: 6.12±0.20
10	Control : 6.10±0.64 Optimized: 6.20±0.65	Control : 0.54±0.05 Optimized: 0.21±0.31	Control : 4.90±0.31 Optimized: 4.42±0.45

Values mentioned as mean ± Standard Deviation, (n=3) at (p>0.05)

optimized *kheer* was significantly higher ($P<0.05$) as compared to control *kheer* i.e. 58.21 ± 1.08 and 356.24 ± 3.45 mgGAE/100g, respectively. Mudoi and Das (2019) analyzed sixteen varieties of red rice for various phytochemicals, antioxidant activities and a few mineral contents. They reported that the antioxidant activities were observed to be the highest $96.00 \pm 0.26\%$ in 'Negheribao' (for brown form of rice) and $86.35 \pm 3.88\%$ in 'Kenekuabao' (for polished form of rice) and the lowest $81.54 \pm 0.23\%$ in 'Betu' (for brown form of rice) and $59.65 \pm 4.64\%$ in 'Ranga Dariya' (polished rice), respectively. Red rice as well as coconut sugar has influenced the phenolic content of *kheer*. Similar results have been reported by Victor and Orsat (2018) who studied that palm sugar has appreciable amount of antioxidant activity and total phenolic content also.

Shelf- life of red rice *kheer*

During storage, the pH of red rice *kheer* was decreased and acidity was increased significantly ($P<0.05$) and their interaction effect

was found non-significant on pH and acidity of product (Table 4). Similar results were reported by (More et al. 2017). They reported that during storage, little millet *kheer* at refrigerated temperature ($6 \pm 1^\circ\text{C}$) the pH decreased significantly while acidity and viscosity increased. Standard plate count (SPC) count of *kheer* was increased significantly during storage. Yeast & mould count and coliform count was found nil during the storage period.

Economic Analysis

To assess and evaluate the overall impact of a project in monetary and quantifiable terms, cost analysis of red rice *kheer* was done by taking all the used ingredients into consideration. In order to determine the feasibility of the study, cost of production was calculated for optimized *kheer* (Table 5). Cost of raw materials was added along with packaging cost and marketing and distribution expenses. 100g (one cup) of red rice *kheer* was prepared in approximately Rs. 15.16. The profit margin at 25% of

Table 5 Cost analysis of red rice *kheer* (100g)

Ingredients	Quantity	Cost (Rs.)
Red rice	20g	4.0
Coconut Sugar	15g	13.5
Toned Milk	500ml	22.0
Total (Quantity of <i>kheer</i>)	300g	39.5
	Quantity/100g /cup	13.16
Packaging cost	1 cup + Aluminium foil	1.0
	Total	14.16
Processing cost	Per cup	1.0
	Total	15.16
Marketing and distribution expenses @25% of product	Per cup (100g)	3.29
	Total	Rs. 18.45

cost of product is also applied which took overall price of *kheer* to a very nominal price of Rs. 18.45.

Conclusion

Kheer is consumed by wide group of population. In the present study, red rice *kheer* with coconut sugar as a natural sweetener was prepared which has higher amount of protein, fiber, minerals as compare to white rice. It can be concluded that the treatment T₂ of red rice *kheer* prepared by mixing 20g of red rice and 15g of coconut sugar with 500 ml of toned milk (3% fat and 8.5% SNF) was found to be the most acceptable. Both red rice and coconut sugar has low glycemic index which is good for the consumers suffering from diabetes. This product was prepared with the aim to provide nutrition to consumers of every age group.

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