

**"PROCESS OPTIMIZATION FOR THE
MANUFACTURE OF RED RICE
(*Oryza Sativa L.*) KHEER"**

काशी हिन्दू
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Supervisor
Dr. Amrita Poonia

Submitted By
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Dear Sir,

I have great pleasure in forwarding the thesis entitled **“PROCESS OPTIMIZATION FOR THE MANUFACTURE OF RED RICE (*Oryza Sativa L.*) KHEER”** submitted by **Ms. Anjali Kumari I.D No.18412FST006** in partial fulfillment of the requirements for the degree of **Master of Science in Food Science and Technology**, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi and placing on record that she has completed the requisite residential requirements as contained in the ordinance of the University.

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Yours faithfully,

(Head of Department)

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"PROCESS OPTIMIZATION FOR THE MANUFACTURE OF RED RICE (*Oryza Sativa L.*) KHEER"

By

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Date:.....

Place: B.H.U, Varanasi

(ANJALI KUMARI)

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ABBREVIATIONS

ANOVA	Analysis of variance
AOAC	Association of Official Agricultural Chemists
g	Gram
°C	Degree Celsius
mg	Miligram
ml	Mililitre
DPPH	2,2-diphenylpicrylhydrazyl
FRAP	Fluorescence Recovery after Photobleaching
ABTS	2,2 azino-bis(3-ethylbenzothiazoline-6- sulphonic acid
GI	Glycemic Index
TPC	Total Phenolic Content
%	Percentage
Na ₂ CO ₃	Sodium Carbonate
GAE	Gallic acid equivalents
TW	Total weight

CHAPTER I

INTRODUCTION

Rice (*Oryza Sativa L.*) is one of the most popular and important cereal crops. More than two thousand rice varieties are grown throughout the world in which rice is considered as a staple food in 39 countries for more than three billion people. Around 2 billion people in Asia derive 80% of their energy needs from rice, which contains 7–8% crude protein, 80% carbohydrates, 3% crude fibre, 3% crude fat (Umadevi et al. 2012). Rice is mainly rich in starch (Champagne et al., 2006). White rice is one of the most common rice and is consumed by maximum number of people but there are different cultivars of rice that contain colour pigments which makes them special, such as red rice, black rice and brown rice but white rice is the most common rice and is consumed by maximum number of people. Due to the deposition of anthocyanin in different layers of the seed coat, pericarp, and aleurone, their name refers to the kernel colour (black, red or purple) (Chaudhary, 2003).

1.1 Red Rice

The origin of coloured rice is as old as rice itself. There are thousands of varieties of rice around the world among them rice with red bran layer is known as red rice. The red colour of the rice bran ranges from light to dark. The red bran layer contains 95% of the minerals and dietary fibre of the whole rice which contains Iron, Zinc Potassium Sodium, Manganese and so forth. Inner white portion contains predominantly carbohydrate and proteins. The bran layer contains polyphenols, anthocyanins and possesses antioxidant properties. The inner portion of red and white rice is alike and white in colour (Rood, 2000).

1.1.1 Health Benefits of Red Rice

Red rice is rich in fibre, zinc, manganese, iron, selenium, magnesium, calcium and different other nutrients. From the group of phytochemicals called anthocyanins, red rice variety gets their rich colours which are usually found in reddish or deep purple vegetables or fruits.

Red Rice is useful for patients with following ailments

- Red Rice helps in stabilising or maintaining blood sugar in a sustainable manner because it releases sugar slowly in the body unlike white rice. So ultimately this rice is helpful for the patients suffering with diabetes mellitus.
- Since magnesium is an important mineral for the Sodium balance in the body and for the regulation of blood pressure, red rice can highly be useful for the patients suffering from Hypertension due to its high magnesium content.
- Due to the high content of manganese and selenium red rice is highly be useful for the patients suffering from cancer because manganese and selenium helps against free radicals which is a major cancer-causing agent. Proanthocyanins, present in red rice, modulate the inflammatory response and protect against some cancers
- Due to the high magnesium content, red rice can prevent the risk of cancer.
- Due to the high fibre content red rice possess the ability to keep healthy metabolic function and bowel function also it can help in weight management due to anthocyanins present in it.
- Due to the presence of anthocyanidin red rice it helps to reduce allergy.

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. (RathnaPriya et al., 2019).

1.2 Coconut Sugar

Increasing threats of ailments such as obesity, diabetes mellitus, hypertension 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 (Chattopadhyay, Raychaudhuri, & Chakraborty, 2014). Production of sweeteners made naturally with low Glycemic Index (GI) can be a solution for such ailments. Coconut (*Cocos Nucifera L.*) was reported to have Glycemic Index of about 35 (Kusumawaty, Maharani, & Edwina, 2012) while the sugar from sugarcane (*Saccharum officinarum L.*) and palm sugar reported to have Glycemic Index of about 58-82 and 42. Since GI of Coconut Sugar is lowest than the GI of other sugars, it is highly preferable.

By the evaporation of coconut sap, coconut sugar is made. It tastes, looks, dissolves and melts almost same as regular sugar. It has a different but superior taste than other sugars

because it is made naturally and unrefined (Abdullah et al., 2014). Coconut Sugar can be also be used in place of regular sugar as its texture and flavour looks similar to brown sugar. (Appetit, 2014; Beck, 2014).

1.3 Kheer

Kheer is a rice-based dessert which is very famous in Middle east countries and Indian sub-countries. It can be prepared by cooking pre soaked rice in the boiling milk simultaneous concentration which results in reasonably thick consistency. Kheer is garnished with almonds, cashews, pistachios, raisins and flavoured with saffron and cardamom etc. (Borad et al., 2017).

Advancelykheer is starch-based dairy dessert which is basically formulated with milk, thickeners, sucrose, flavourants and colourants. The rheological and sensory properties of Kheer are strongly influenced by the characteristics of particular constituents, like fat, content of milk, type and amount of starch etc. Such imparts body and mouthfeel in the kheer. Kheer is an important part of the diet and holds the special position due to high nutritional and sensory properties. The word kheer derived from Sanskrit 'ksheer' for milk and 'kshrika' for any dish prepared with milk. Kheer is associated with festivities and special occasions and is popular in different parts of India by different names such as 'Payasam' in Southern India, 'Payas' in Eastern India, 'Phirni' in Northern India also 'kheech' in Mewar region of Rajasthan. (Mukhekar et. al., 2019).

Kheer is an immensely popular heat desiccated cereal based dairy dessert Other than the nutrients from milk, kheer also contain nutrients from rice and sugar and other additives which are added during garnishing in the end. Strong attempts have been lacking in developing a large scale production process of manufacture. (Sarode et. al., 2007).

Objectives of the Study:

The study has been done on the topic **“PROCESS OPTIMIZATION FOR THE MANUFACTURE OF RED RICE (*Oryza Sativa L.*) KHEER”** with following goals:

- To standardize the process of preparation of optimized product.
- To study the chemical properties of optimized product.
- To study sensory evaluation of finished product.

CHAPTER II

REVIEW OF LITERATURE

The research analysis on the topic “**PROCESS OPTIMIZATION FOR THE MANUFACTURE OF RED RICE (*Oryza Sativa L.*) KHEER**” was reviewed.

2.1 Preparation of kheer using various ingredients and milk

Jayathilkan et al. (2000) conducted an experiment on the Kheer for the development based on reconditioned vermicelli, milk powder, flavourants and sugar. It provided 386 Kcal per 100g of product, because it was considered to be a nutritious low fat and energy rich food. With respect to physical and chemical characteristics, drying and rehydration aspects, different vermicelli have been screened for its suitability. The product obtained at 37 degrees Celsius has enough chemical and microbiological stability for 6 months. 75g of vermicelli Kheer mix was required for a single serving, also 2-3g of vermicelli powder was also added to the mix for getting better consistency.

Jha (2000) studied and developed an instant Kheer mix and a process for long life Kheer. For the optimization of product formulation and process parameters employing in-package sterilization, studies were conducted in a pilot scale rotary retort. For achieving commercial sterility, the whole process was monitored with the help of advanced data logging and computing systems. Shelf life of 4 months at 37°C of product was recorded. For the manufacture of an instant rice-based kheer mix, a process was developed. And for the production of instant Kheer mix, the procedure involved separate preparation of instant milk-rice powder, which represented not only liquid fraction of kheer and instant rice but also the particulate phase. The Fresh buffalo milk was standardized to fat: SNF level of 5:9.1 was heated at 60°C for around 15 minutes in pre-heater of 3-effect evaporator and then concentrated to 35% TS. At the pressure of 183 bar, homogenization of milk concentration was done and 36 bar pressure was exerted during first and second stage. Ground rice mixed with homogenized milk concentration and sugar and then the resultant milk-rice-sugar slurry was heated to a temperature of 80°C for gelatinization. Powder was blended with ground sugar. Fluidized bed dryer helped in drying precooked rice and were packed separately in PE pouches. Shelf life of 6 months at 37°C of mix was recorded.

Anonymous (2000) stated that further process modifications on acceptable of kheer was obtained by mixing sweetened condensed milk (diluted to 30% TS by adding buffalo milk) with precooked rice 6%. Narwade et al., (2003) prepared kheer from safflower milk blended with buffalo milk with different levels of sugar viz. 6,7 and 8% was studied. It was observed that though kheer was prepared from 75 parts of buffalo milk and 25 parts of safflower milk was closer to control samples.

Manjunatha et al., (2003) developed and evaluated the shelf like of carrot kheer mix. A kheer mix was formulated based on dehydrated carrot, skim milk powder, sugar and other ingredients and evaluated for shelf stability up to 9 months at 25-30 and 37°C in paper aluminium foil polypropylene laminate pouches. Qureshi et al., (2007) studied the manufacturing techniques of sterilized carrot kheer. For preparation of carrot kheer shredded carrot was cooked in presence of ghee to develop characteristic flavour. Other ingredients like milk, sugar and dry fruits were added to eat and the whole mass of was cooked till the desired consistency was obtained and then sterilized. Shredded carrot was added at 3 different levels of 20, 30 and 40% with 8% sugar.

Patel et al., (2011) developed a process for manufacture of long-life dairy dessert kheer and reported that kheer shelf life improved by developing a process based on in pouch thermal processing employing rotary retort in kheer. Barela (2011) studied qualitative evaluation of kheer from cow milk blended with coconut milk with a proportion of 100:0, 90:10, 80:20, 70:30, 60:40 and reported that the 80:20 proportion of cow: coconut milk was good quality kheer and 90:10, 70:30 and 60:40 prepared kheer had fair quality.

Gautam et al., (2013) prepared chana kheer with milk fat and 3 artificial sweeteners such Aspartame, Asulfame-k and sucralose with a level of 0.015% Asulfame-k and sucralose 0.05% were found to be most appropriate levels. For chana kheer replacing with conventional products

Kumar et al. (2005) reported about the desorption isotherms of Kheer. He obtained a rice based partially heat concentration and sweetened Indian milk dessert within a temperature range of 10-40°C. Curves of desorption exhibited the shape of sigmoid corresponding to type 2. Negative temperature effect on EMC at low a_w was recorded generally, whereas at the temperature of 25°C and 40°C, curves started showing inversion above water activity of 0.60 which implies higher equilibrium moisture content at higher

temperature. Among all the five sorption models, GAB model gave the best fit at all the three temperatures. Other than monolayer moisture, other different properties were also obtained such as properties of sorbed water viz., number of adsorbed monolayers, bound or nonfriable water, density of sorbed water and surface area of sorption. By applying Clausius-Clapeyron equation, isosteric heat of sorption was obtained. This Clausius-Clapeyron equation decreased exponentially with the increasing moisture content.

Choudhary (1989) studies the effects of rice variety, sugar level, fat content of milk, rice level and total solids on the sensory acceptability of kheer by using buffalo milk and by following steam kettle method. He figured out the suitable compositions of materials required which yielded the most acceptable kheer. It was found 5% milk fat, 5% basmati rice (soaked in water for 30 minutes) and 12% sugar (on the basis of milk) was the perfect composition and the concentration was so carried as the 38% TS in the finished product. Choudhary (1989) obtained a convenient product by mixing buffalo milk and sweetened condensed milk to bring down the solids level to 30% in his further attempts to modify Kheer making process. Precooked rice at the rate of 6% was added whereas SCM was heated to boiling. Contents were cooked for 5 minutes and cooled and stored at 5°C.

Bandyopadhyay (1995) conducted the rheological studies on kheer with respect to cooking time and the effects of the rice variety. Basmati rice Kheer has got the appreciably higher texture acceptability score due to its higher visual consistency and lower grain hardness. Viscosity of the milk-rice mix was found to be directly proportional to the TS. Hence, viscosity of the milk-rice mix increased logarithmically with increase in TS. Liquid phase viscosity and cooked grain tenderness determined the overall texture acceptability of the product.

Jha (2000) studied and developed an instant Kheer mix and a process for long life Kheer. For the optimization of product formulation and process parameters employing in-package sterilization, studies were conducted in a pilot scale rotary retort. For achieving commercial sterility, the whole process was monitored with the help of advanced data logging and computing systems. Shelf life of 4 months at 37°C of product was recorded. For the manufacture of an instant rice-based kheer mix, a process was developed. And for the production of instant Kheer mix, the procedure involved separate preparation of instant milk-rice powder, which represented not only liquid fraction of kheer and instant rice but

also the particulate phase. The Fresh buffalo milk was standardized to fat: SNF level of 5:9.1 was heated at 60°C for around 15 minutes in pre-heater of 3-effect evaporator and then concentrated to 35% TS. At the pressure of 183 bar, homogenization of milk concentration was done and 36 bar pressure was exerted during first and second stage. Ground rice mixed with homogenized milk concentration and sugar and then the resultant milk-rice-sugar slurry was heated to a temperature of 80°C for gelatinization of rice in a steam jacketed heating-cum-mixing vessel. Two stage spray dryers were used to dry the slurry. Powder was blended with ground sugar. Fluidized bed dryer helped in drying precooked rice and were packed separately in PE pouches. Shelf life of 6 months at 37°C of mix was recorded.

Unnikrishnan et al., (2003) developed a traditional delicacy of Kerala which was actually a dry mix for convenient preparation of paladapayasam. Payasam of desired consistency could be prepared by cooking and mixing about a half litre of toned milk with 200g of dry mix together for about 12 minutes. Packing pouches for keeping the quality of dry mix which were made up of polyethylene pouches which has the thickness of 75m was found to be as high as 1 year at room temperature. The payasam obtained after the preparation by using dry mix, which had been stored for a year was observed to have good sensory properties.

Srinivasan and Anantkrishnan (1964) proposed the method of Kheer making. The rice gets brownish after being fried with 1-2 tablespoons full of ghee and is being cooked with 2.5-3 times its weight of water then the partially cooking of rice will be taken out further when 100-200g of milk is poured at regular intervals. Now constantly stirring the solution while cooking to ensure the partial dissolution of the cooked rice into the milk.

Keogh (1970) described about the "creamed rice" which is almost a new dairy dessert. Not only he reported that it was very similar to kheer short grain rice but also that it releases starch during cooking, this creamed rice was used with homogenized milk and sugar. For sterilization plain cans were used. Now to abolish the localized heating, gradual heating and agitation were used. 12 months of shelf life was observed.

Keogh (1971) then further reported about the effects of processing conditions, additives and milk seasonality on the product of creamed rice. Ideal composition of 6% rice, 7% sugar and milk with 3.5-3.7% fat was observed in the final product. He prepared creamed

rice by mixing it with hot (74°C) pasteurized and homogenized milk into the can. The hot milk which contained not only sugar but also optimally stabilizer colouring, flavouring and fruits were sterilized at 121°C. Around 13-22 minutes required to heat the stabilize milk depending upon the stage of lactation (early to late).

Glicksman (1982) described that addition of hydrocolloids in the preparation of milk-based desserts in order to obtain the desired consistency and texture of the end product. For the selection of hydrocolloid different properties were taken into consideration such as protein content, pH and process condition applied during manufacturing.

Galle et al. (1984) reported Kheer as a typical Indian traditional product. Certain process was developed in the west which were similar to milk-rice and rice pudding. Rice grains were kept at higher pressure or the pressure more than atmospheric pressure (>0.03 bar) and were exposed to saturated steam in an autoclave for some time until a large portion of starch gets gelatinized. This major product could be mixed with milk in order to prepare Kheer as a product.

Chaudhary (1989) studied about the level of sugar required, level of rice required, effect of fat content of milk and the total solids on the sensory acceptability of Kheer. He figured out the suitable compositions of materials required which would yield the most acceptable Kheer. It was found 5% milk fat, 5% basmati rice (soaked in water for 30 minutes) and 12% sugar (on basis of milk) was the perfect composition and the concentration was so carried as the 38% TS in the finished product. Choudhary (1989) brought down solid levels to 30% by mixing buffalo milk and sweetened condensed milk together which resulted in obtaining an acceptable product.

Singh and Shaurpalekar (1989) reported about the ready-mix for kheer which was developed under an ideal temperature of 145°C in which 30% powdered sugar and 40% whole milk powder were used with 30% Wheat Soji (semolina). It could be processed in around 5 minutes. For enhancing the appearance and overall quality and acceptability, 5% raisins, 0.7% cardamom, and 25ppm of edible sunset yellow colour is included in ready-mix. Arya (1990) reported about the development of an instant porridge (Khichdi) which is prepared by wheat Dalia and milk solids. It was developed Defense food research laboratory in Mysore for Space astronauts.

Unnikrishnan (1997) reported about the dessert called Payasam, which is the south Indian version of north Indian kheer. It is made with different types having different taste, texture, appearance and characteristics ascribed to area-specific different traditional methods of preparation. Bodkin (1998) reported about the instant or the ready to eat breakfast cereal which contains instant milk powder, in which milk powder was equally distributed among the pieces of cereal. Equal proportion of cereal and liquid milk in each serving when water was added was observed after milk powder was uniformly distributed.

2.2 PHYSICO CHEMICAL PROPERTIES OF KHEER

Srinivasan and Anantkrishnan (1964) have given the composition of sweetened kheer, plain kheer and kheer prepared from skim milk as follows.

Table 2.1 Composition of 3 different types of kheer given by Srinivasan and Anantkrishnan

Particulars	Kheer (Plain)	Kheer (sweetened)	Kheer (skim-milk)
Water (%)	45-55	30-40	40-50
Total Solids (%)	45-55	60-70	50-60
Fat (%)	15-25	15-25	00-0.7
Lactose (%)	14-16	14-16	14-16
Protein (%)	12-13	12-13	12-13
Ash (%)	03-3.5	03-3.5	2.5-3.0
Sugar (%)	-	15-25	15-25

Whereas in 1974, Rangappa and Acharya has given the composition of plain kheer and sweetened kheer as follows.

Table 2.2 Composition of 2 different types of kheer given by Rangappa and Acharya

Particulars	Plain Kheer	Sweetened Kheer
Water (%)	50	45
Total Solids (%)	50	55
Fat (%)	26	20
Lactose (%)	20	16
Protein (%)	13	10

Ash (%)	3.3	2.6
Sugar (%)	-	15-25

Chemical composition of Kheer prepared from 4.0% fat milk with 2.5% rice and 5.0% sugar was reported by De et al., (1976) as: moisture, 67.02; fat, 7.83; protein, 6.34; lactose, 8.45 and ash, 1.41%.

Jha (2000) studied the proximate chemical composition of kheer mix powder and reported moisture, fat, protein, ash and carbohydrates content as 1.98, 18.2, 16.0, 2.64 and 65.8% respectively. Narwade et al., (2003) prepared kheer from safflower milk blended with buffalo milk with different levels of sugar viz. 6,7 and 8% was studied. It was observed that though kheer was prepared from 75 parts of buffalo milk and 25 parts of safflower milk was closer to control samples.

Manjunatha et al., (2003) developed and evaluated kheer mix. A kheer mix was formulated based on dehydrated carrot skim milk powder sugar and other ingredients and they gave chemical composition as 3.2 % moisture, 8.06% fat, 17.70% protein, 57.19% total solids, 10.19% reducing sugar, 2.5% ash, 0.2% soluble ash, 1.11% crude fibre and 23.09 mg % carotenoids. Singh et al., (2005) developed the kheer from clean and fresh buffalo milk, good quality, broken basmati rice and sugar and reported that the chemical composition of kheer were 56.79, 1.16, 6.40, 4.20, 14.808, 7.01, 8.28% moisture, ash, fat, protein, sucrose, starch, lactose, respectively.

Qureshi et al., (2007) developed and standardization of sterilized kheer with different levels of shredded carrot were added 20,30 and 40% with 8% sugar. They reported that the chemical composition of kheer 8.2% fat, 33.30% total solids, 0.17% acidity in terms of lactic acid and 21.10° brix total soluble solids. Patel et al., (2011) developed the process for manufacture of long-life dairy dessert kheer. They reported that the pH of the kheer was 6.04-6.10.

Barela (2011) studied qualitative evaluation of kheer prepared from cow milk blended with coconut milk with proportion of 100:0, 90:10, 80:20, 70:30, 60:40 and reported that the chemical composition as contains 86.5% moisture, 4.6% fat, 3.48% protein, 4.59% carbohydrates, 0.14% acidity, 0.12% ash and 13.4% total solids. While, coconut milk contains moisture 52.92%, 47.08% total solids, 40% fat, 2.40% protein, 1.10% ash and

3.58% carbohydrates. Changade et al., (2012) developed the process upgradation of bottle gourd and pumpkin kheer and reported that all vegetables kheer sample tested low level of fat and high level of carbohydrate than the control. The total solid and carbohydrate content was higher in kheer prepared from bottle gourd while the protein content was higher in control and kheer prepared from pumpkin.

Chaudhary (1989) developed kheer which was made from Buffalo milk, in which 5% fat, 5% rice and 12% sugar turned up during testing. The chemical composition will be $6.38 \pm 0.07\%$ fat, $61.77 \pm 0.13\%$ moisture, $38.23 \pm 0.13\%$ total solids, $6.49 \pm 0.02\%$ lactose, $17.74 \pm 0.08\%$ sucrose, $5.44 \pm 0.10\%$ protein, 4.45 ± 0.10 other carbohydrates and $0.74 \pm 0.01\%$ ash. Kumar et al., (2007) discussed about the development of ready-to-eat coconut kheer. He evaluated the changes in quality attributes (chemical, microbiological and organoleptic properties) during storage and also, he used retort pouch processing technique during the development of ready-to-eat coconut Kheer.

Qureshi et al., (2007) developed carrot halwa and kheer by using carrot, due to its good taste, high nutritional value and relatively low cost, it was used in the northern and central part of India. An attempt was made to develop and standardize a carrot kheer with long storage life to ensure year-round availability and popularity of kheer. To produce carrot Kheer with characteristic flavor, shredded carrot was cooked in ghee. It was cooked in milk and sugar until it reaches desired consistency. Shredded carrots of different levels were added, 20, 30 and 40% along with 8% sugar. By using 9-point hedonic scale for different attributes, sensory quality was evaluated. Carrot kheer with shredded carrot contained 8.2% fat, 33.30% total solids, 0.17% acidity in terms of lactic acid and 21.10 degrees Brix total soluble solids. Fresh samples of kheer had the overall acceptability of 7.5. Score was 6.5 after the end of 28 days storage period. Even after the 28 days of storage under room temperature, product was still accepted.

Deshmukh et al. (2017) observed that fat, total solids, protein and ash of kheer were found to be directly proportional to the poppy seeds because they were increasing with the increase in level of poppy seeds whereas moisture content was found to be decreased with the increase in level of poppy seeds, hence it was inversely proportional to poppy seeds. With the increase in level of poppy seeds, a significant increase in fat (7.59 to 11.04 percent), total solids (35.02 to 41.42 percent), protein (5.28 to 8.11 percent), and ash (1.37

to 1.65 percent) of kheer was recorded whereas on the other hand moisture content (64.98 to 58.40) was found to be decreased with increase in level of poppy seeds.

Desale et al. (2017) studied about the sensory evaluation and chemical quality of rice kheer. Rice with medicinal value and which is cultivated in tribal belt of Nashik and Thane districts of Maharashtra called 'Govindbhog' was used in this study. Sample evaluation of prepared rice kheer was done for chemical qualities such as fat, protein, total solids, reducing sugar, pH. The overall mean chemical composition of rice kheer was 2.50, 1.90, 1.83, 1.75 percent fat, 5.28, 5.33, 5.38, 5.65 percent protein, 38.85, 39.08, 39.30, 44.98 percent total solids, 6.24, 6.35, 6.40, 6.47 percent reducing sugar and 6.04, 6.76, 6.67, 6.56 percent pH.

2.3 SENSORY PROPERTIES OF KHEER

Narwade et al. (2003) prepared kheer from safflower milk blended with buffalo milk with different levels of sugar viz, 6 for 100:0, 75:25, 50:50; 25:75 and 0:100 for colour and appearance as 8.66, 8.17, 7.33, 6.33, 5.33 for flavour 8.83, 8.33, 7.33, 6.83, 5.33, for flavour 8.50, 7.83, 7.00, 6.33, 5.00, for body n texture as 8.70, 8.33, 7.00, 6.70, 5.20 and overall acceptability as 8.10, 7.11, 6.66, 5.16, and 7.11. For 7 percent as colour and appearance as 8.83, 8.40, 7.83, 6.83, 5.33, for flavour 8.83, 8.33, 7.50, 6.70, 5.00, 7.30 for body and texture as 8.83, 8.50, 7.20, 6.83, 5.33 and overall acceptability as 8.55, 7.82, 7.70, 5.44, and 7.53. For 8% as colour and appearance as 9.00, 8.83, 8.00, 7.17, 5.59 for flavour 8.83, 8.33 8.00 7.00 5.50, for body and texture as 8.83, 8.50, 7.50, 6.83, 5.33 and overall acceptability as 8.55, 7.82, 7.70, 5.44 and 7.53.

Chapke et al. (2005) carried out the study on suitability of Chhattisgarh aromatic varieties of rice such as Dubraj, Tulsimanjari Vishunbhog and millet Swan (Banyard Millet) and Tulsimanjari varieties was found superior than other varieties was found superior than the other varieties. The kheer procured from varieties Dubraj, Sawan, Tulsimanjari, varieties was found superior and has got more acceptability. Mouthfeel characteristics of the kheer prepared from swan Vishnubhog was also superior. In all respect the kheer prepared from Chhattisgarh aromatic varieties of rice and Millet Sawan Banyard Millet was found superior to that of Basmati rice.

Qureshi et al. (2007) developed and standardized of carrot kheer with three different levels of shredded carrot were added 20, 30 and 40% with 8% sugar. They reported that the carrot

kheer containing 30% shredded carrot was preferred mostly by the panel. The overall acceptability of the fresh sample of carrot kheer was 7.5. Barela (2011) studied qualitative evaluation of kheer prepared from cow milk blended with coconut milk with a proportion of 100:0, 90:10, 80:20, 70:30, 60:40 and reported that the overall acceptability of kheer prepared from cow milk blended with coconut milk in proportion 80:20 was good quality kheer and for 90:10, 70:30 and 60:40 preparation kheer had fair quality.

Aneja et al., (2002) stated that kheer prepared from buffalo milk was white and thick bodied and is therefore preferred over that obtained from cow milk. In addition to milk, kheer also contained substantial amount of non-dairy ingredients such as, sugar, sabudana, semolina, etc as well as nuts and spices. It was characterised by sweets, nutty and pleasant flavour that was highly acceptable. Colour of the product generally depends on the extent of heat treatments given and may range from almost white to slightly brownish. However, a rich creamy shade of kheer was highly preferred. Further, studies on the body and texture of kheer has found improvement in the sensory score from 6.9 to 8.5 (on a 9-point hedonic scale) when the fat content of milk was increased from 3-5%. The pre-soaking of rice at 30-50°C for 30 minutes improved the body and texture. Higher visual consistency and lower grain hardness contributed to an appreciably higher texture acceptability score for basmati rice kheer.

2.4 RED RICE

(Ramaiah and Rao, 1953)Rice with a red bran layer is called red rice. Though the color is confined to the bran layer, a tinge of red remains even after a high degree of milling. The color of the bran ranges from light to dark red. The bran layer contains polyphenols and anthocyanin, and possesses antioxidant properties. The inner portion of red and white rice is alike and white. The zinc and iron content of red rice is 2-3 times higher than that of white rice. (Kitano et al., 1993) In addition of being nutritive and having medicinal value, red rice possesses many other special features. It is common experience that red rice is comparatively more resistant to storage insect pests than brown-husked rice. Red rice too possesses this feature. In Japan, it has been reported that red rice grains stored since 1905 have remained intact and preserved their original status, as against white-colored rice that were seriously damaged.

(Krishnamurthy and Sharma, 1970; Dikshit et al., 2004). In an evaluation program for

biotic stresses conducted on around 12,750 entries under the auspices of the Directorate of Rice Research (Hyderabad, India), 28.31% of the entries were colored rice. Of these, 10.48%, 9.41%, and 8.40% had red, brown, and purple pericarps (Anonymous, 1998). The collection of the Central Rice Research Institute (CRRI, Cuttack, Orissa) of 2,960 entries, mainly from the eastern states of India, had a relatively higher number of red rices. Of 20% colored rice, 17.40%, 3.44%, and 2.50% were red, purple, and brown rice, respectively. A survey conducted by the National Bureau of Plant Genetic Resources (NBPGR) from 1991 to 1998, recorded about 35% and 21% red rice varieties in Orissa and Manipur.

(Gopalan et al., 2007). Red rice was found to be a rich mineral source. It had 13.45mg iron, 192.27 mg magnesium, 8.71 mg calcium, and 1.91 mg zinc while white rice was found to have 7.65 mg iron, 46.45 mg magnesium, 7.94 mg calcium and 1.49 mg zinc. Red rice has an iron content more than whole wheat (5.3mg). Thus, it can be recommended for the people suffering with iron deficiency as rice forms a major part of the diet. A high magnesium content in red rice seeks its importance in the diet of individuals suffering with various heart disorders, especially those related to elevated cholesterol level and hypertension.

(Rathna Priya et al., 2019). Red rice is rich in fibre, zinc, manganese, iron, selenium, magnesium, calcium and different other nutrients. From the group of phytochemicals called anthocyanins, red rice variety gets its rich colour which are usually found in reddish or deep purple vegetables or fruits. Red Rice helps in stabilising or maintaining blood sugar in a sustainable manner because it releases sugar slowly in the body unlike white rice. So ultimately this rice is helpful for the patients suffering with diabetes mellitus. Since magnesium is an important mineral for the Sodium balance in the body and for the regulation of blood pressure, red rice can highly be useful for the patients suffering from Hypertension due to its high magnesium content. Due to the high content of manganese and selenium red rice is highly be useful for the patients suffering from cancer because manganese and selenium helps against free radicals which is a major cancer-causing agent. Proanthocyanins, present in red rice, modulate the inflammatory response and protect against some cancers. Due to the high magnesium content, red rice can prevent the risk of cancer. Due to the high fibre content red rice possess the ability to keep healthy metabolic function and bowel function also it can help in weight management due to anthocyanins present in it. Due to the presence of anthocyanidin red rice it helps to reduce allergy.

2.5 COCONUT SUGAR

Coconut sap possesses high DPPH (23.42%), FRAP (2.09 mM/ml), and ABTS (21.85%) compared with the juices. Coconut sap also had high vitamin C (116.19 µg/ml) and ash (0.27%) contents, especially in potassium (960.87 mg/L) and sodium (183.21 mg/L) which also indicating high content of minerals. These properties showed that coconut sap could be served as a potential healthier sugar source compared with sugar palm and sugarcane juices.

The coconut tree is widely grown in tropical regions, especially in South Asia, Africa, South America, Australia, and other tropical countries and it is an important source of a refreshing drink called “coconut water” Watawana, Jayawardena, Gunawardhana, and Waisundara (2016). A coconut tree produces inflorescence throughout the year, and coconut sap is collected from unopened spadix of the coconut tree (Ghosh, Bandyopadhyay, Das, Hebbar, & Biswas, 2018; Hebbar et al., 2015). Kusumawaty et al. (2012) and Ysidor et al. (2015) reported that coconut sap records a greater economic value when used as nonfermented and fermented drinks, alcoholic beverages, vinegar, and acetic acid, etc. Ghosh et al., (2018). It is also used as a raw material for the production of coconut sugar. Barh and Mazumdar (2008) found that coconut sap is the richest source of nutrients compared with those of sugar palm juice and date palm sap. However, coconut sap is very susceptible to natural fermentation (Hebbar et al., 2015). Hence, it should be kept at low temperature ($-2 \pm 1^{\circ}\text{C}$) or should be processed immediately to preserve its nutrients.

CHAPTER III

MATERIALS AND METHODS

The present investigation entitled “**PROCESS OPTIMIZATION FOR THE MANUFACTURE OF RED RICE (*Oryza Sativa L.*) KHEER**” was carried out in the Department of Dairy Science and Food Technology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India. Different materials used and methodology employed during the period of investigation are described in sequence in this chapter.

3.1 MATERIALS

3.1.1 Red Rice

Red rice of Truefarm with 1.7% Fat, Protein 3.6% and 35g of Carbohydrate was purchased via online from Flipkart.

3.1.2 Coconut Sugar

Coconut Sugar of Tropicoco Kokos Natural with protein 450mg, fat 0.05g, carbohydrate 92.5g was purchased via online from Flipkart.

3.1.3 Toned Milk

Toned Milk of Amul with 3.0% fat and 8.5% SNF was purchased from the local market of Varanasi.

3.2 Determination of Proximate composition of red rice

3.2.1 Moisture

As per the method of AOAC (1995), moisture content was calculated. Into a cooled and tare aluminium dish, approximately 5g of finely ground sample of red rice was taken and was accurately weighed. An oven which was maintained at $(102 \pm 2)^{\circ}\text{C}$ was used to heat the sample for around 4 hours. The dish was set to cool by putting it in a desiccator and was weighed. 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

(all the weights were in grams)

3.2.2 Ash

The Ash content of finely ground sample red rice was estimated by following the protocol of (AOAC 2000). Approximately 3g of finely ground sample was taken in clean, dry moisture free silica crucible and then note the weight of the crucible and to char the sample the initial ashing was carried out over a low flame. The crucible was then placed in muffle furnace at 550°C to get ash for 6 hours. The crucible was then cooled until a constant weight (W2) was achieved

$$\% \text{ Ash} = \frac{W2 - W1}{\text{Weight of sample}} \times 100$$

Where,

W1=Weight of sample + crucible before ashing

W2=Weight of sample + crucible after ashing

3.2.3 Fat

5g of finely ground sample of red rice was taken in a thimble and the thimble was placed in previously weighed Soxhlet beaker. The beakers were then placed in extractors (SocsPlus). After that extractor was filled with petroleum ether and their top were covered with cotton plugs. The Soxhlet apparatus (SOCS PLUS, SCS-4, Chennai) was then switched on with a set temperature of 70°C for 90 minutes. After completion of extraction, the temperature was increased up to 150°C again for 90 minutes, for the complete removal of moisture. The beakers were removed from the Soxhlet apparatus and cooled in desiccator. The cooled beakers were then weighed.

Calculation

$$\% \text{ Fat} = \frac{\text{Weight of residue}}{\text{Weight of sample}} \times 100$$

Where,

$$\text{Weight of residue} = \text{Weight of beaker after drying} - \text{Weight of empty beaker}$$

3.3 BIOCHEMICAL ASSAY

3.3.1 DETERMINATION OF TOTAL PHENOLIC CONTENT

By using Folin Ciocalteu procedure (Singleton and Rossi 1965; Kahkonen et al., 1999), the content of Total Phenolic compound has been determined. By mixing 0.1ml of methanol solution of dry extract (the concentration of 1mg/ml) or 0.1 ml of the standard solution of Gallic Acid (the concentration of 20,40,60,80 and 100mg/l), 7.5ml of distilled water, 0.5ml Folin Ciocalteu Assay and 1.5ml of Na₂CO₃, the reaction mixture was obtained. Instead of 0.1ml of investigated sample, blind probe was the sample with distilled water. Absorbance was measured at a wavelength of 765nm after two hours of incubation.

The content of total phenolic compounds in investigated dry extract has been expressed as g of gallic acid equivalents (GAE) per 100 g of the dry extract sample (%; w/w), i.e. %GAE.

3.4 Optimization of red rice kheer

Table 3.1: Ingredients and their preparation used in formulation of red rice kheer

Ingredients	Control (T ₀)	T ₁	T ₂	T ₃
Red Rice(g)	0	18	20	22
Coconut Sugar(g)	0	8	10	12
Toned Milk(ml)	500	500	500	500

Where,

T₀ = Control containing 0g of red rice

T₁ = Treatment containing 18g of red rice

T₂ = Treatment containing 20g of red rice

T₃ = Treatment containing 22g of red rice

3.5 METHODOLOGY

The methodology adopted for the preparation of Red Rice Kheer is presented below in the form of flow chart.

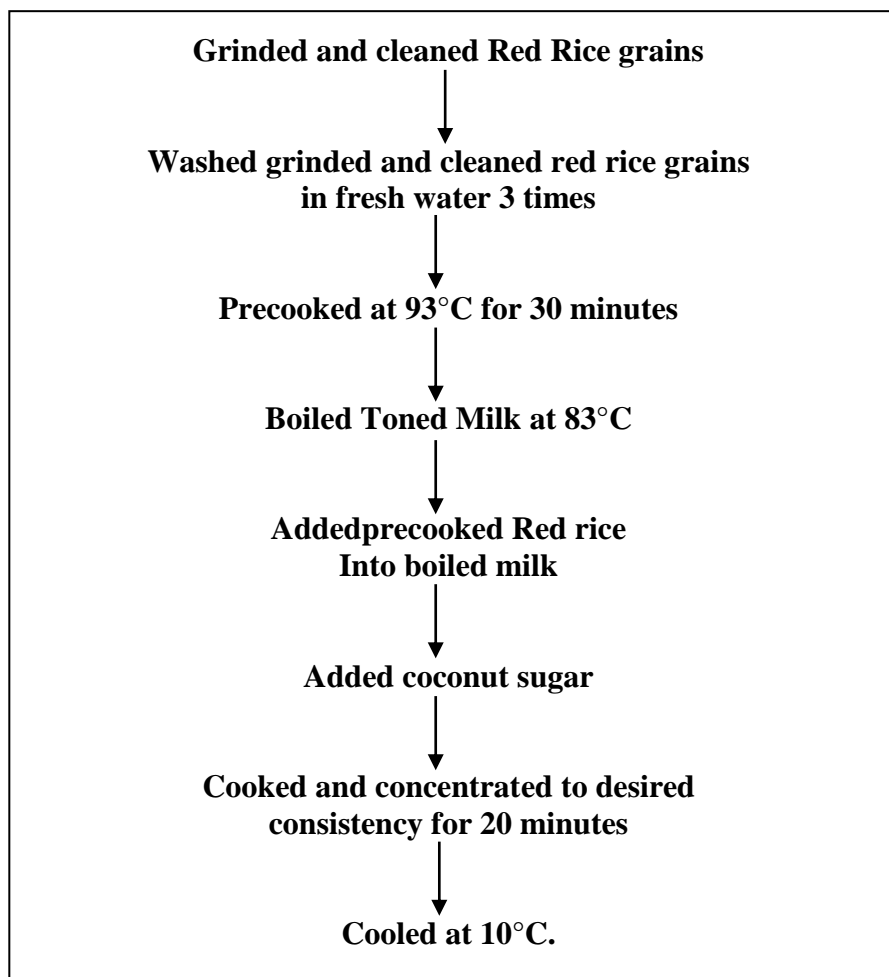


Figure 3.1 FLOW DIAGRAM FOR PREPARATION OF RED RICE KHEER

Preparation of Red Rice kheer

- Initially, clean and dry red rice grains were grinded a little bit into mixer grinder and cleaned.
- Grinded red rice grains were washed in fresh water 3 times.
- Precooked red rice grains at 93°C for 30 minutes.
- The Toned Milk was heated gently until it reaches to its boiling temperature (83°C).
- Then precooked Red Rice was added into the boiled milk.
- After this, a measured amount of coconut sugar was added into the mixture and was stirred at low flame.

- Finally, on a low flame stirring, mixture was heated until desired consistency and concentration was obtained.
- Kheer was taken out and was cooled at 10°C



Figure 3.2 T₀ containing 0g of red rice



Figure 3.3 T₁ containing 18g of red rice



Figure 3.4 T₂ containing 20g of red rice



Figure 3.4 T₃ containing 22g of red rice

3.6 SENSORY EVALUATION OF RED RICE KHEER

Sensory evaluation of Red Rice Kheer carried out by panel of 10 judges in respect of colour and appearance, flavour, body and texture and overall acceptability. Score card was provided to all judges comprising 9 points Hedonic Scale developed by Gupta (1976).

The sensory quality parameters are:

- Color and appearance
- Flavor

- Body and texture
- Overall acceptability

3.7 DETERMINATION OF CHEMICAL COMPOSITION OF RED RICE KHEER

3.7.1 DETERMINATION OF MOISTURE

As per the method of AOAC (1995), moisture content was calculated. Into a cooled and tare aluminium dish, approximately 5g of well mixed sample was taken and was accurately weighed. An oven which was maintained at 102 ± 2 degrees Celsius was used to heat the sample for around 4 hours. The dish was set to cool by putting it in a desiccator and was weighed. 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

(All the weights were in grams)

3.7.2 DETERMINATION OF TOTAL SOLIDS

After the determination of moisture, the left residue was taken to calculate the Total Solid content, the weight of residue was taken and the total solids content was calculated by using formula

$$\text{Total Solids (\%)} = 100 - \text{Moisture Content}$$

3.8 STATISTICAL ANALYSIS

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. Further, observations are presented in bar graph.

CHAPTER IV

RESULTS AND DISCUSSIONS

In this study “**PROCESS OPTIMIZATION FOR THE MANUFACTURE OF RED RICE (*Oryza Sativa L.*) KHEER**” was carried out. The prepared product was further tested for Sensory and chemical quality.

The results obtained have been presented and discussed in the subsequent pages and are discussed under following heads.

Table 4.1 Proximate composition of white rice and red rice

Nutritional Parameters	White rice	Red Rice
Moisture Content (g/100gram)	12.85 ± 0.15	13.92 ± 0.13
Crude Fat Content (g/100gram)	0.67 ± 0.01	2.11± 0.07
Total Ash Content (g/100gram)	0.57 ± 0.04	1.80 ± 0.01

The moisture content obtained for red rice (13.92 ± 0.13) was observed a little bit than that of moisture content of white rice (12.85 ± 0.15), also the fat content of red rice (2.11± 0.07) was slightly more than the fat content of white rice (0.67 ± 0.01). 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)

4.1 Antioxidant Property of Red and White Rice

Table 4.2 Table Antioxidant property of White and Red rice

Extract	Total Phenolic Content (mg GAE/100g of phenol)
White rice	25.09 ± 1.10
Red Rice	144.45 ± 1.36

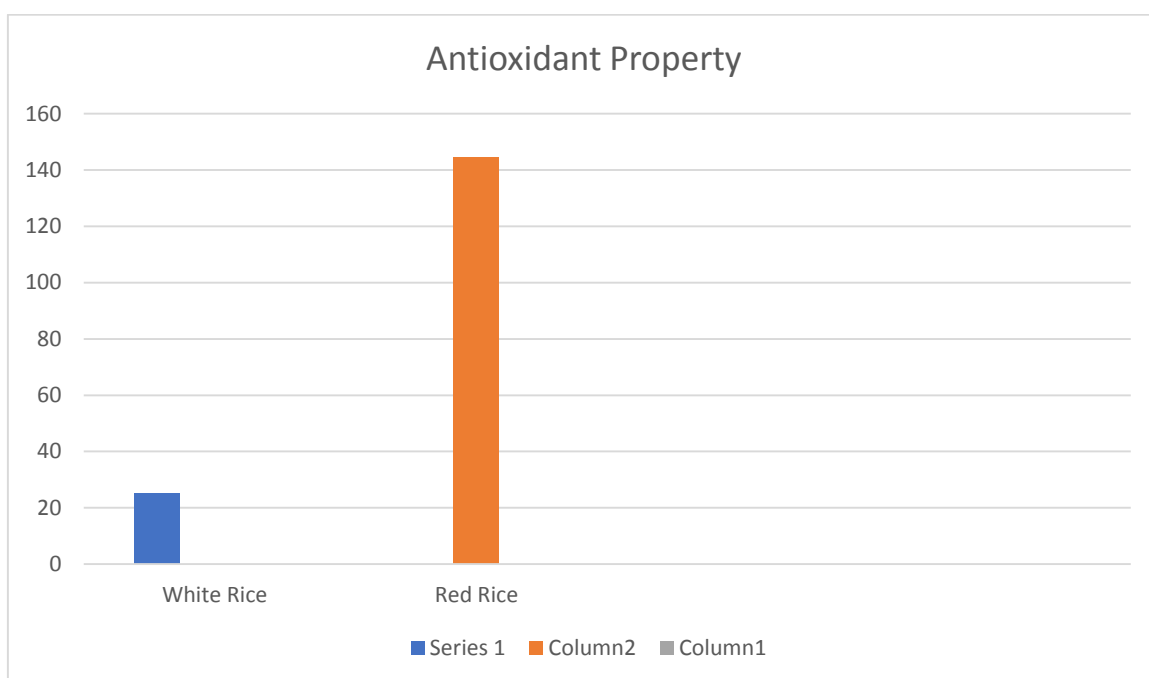


Figure 4.1 Graphical representation of Antioxidant property of white and red rice.

The Total Phenolic content of red rice (144.45 ± 1.36) (mg GAE/100g of phenol) was observed higher than that of white rice (25.09 ± 1.10) (mg GAE/100g of phenol). 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/100gm.

4.2 SENSORY SCORE FOR RED RICE BASED KHEER

Table 4.3 SENSORY SCORE FOR RED RICE BASED 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

Data is represented as mean \pm standard error (n = 3) at (p>0.05)

Table 4.1 depicts that the sensory score for Body and texture of T₂ formulation was highest (8.50 ± 0.24) which was found to be statistically nonsignificant over other treatments (P>0.05). The sensory score for Colour and appearance of T₂ formulation was highest (7.83 ± 0.18) which was found to be statistically nonsignificant over other treatments

($P > 0.05$). The sensory score for Flavour of T_2 formulation was also the highest among all the treatments (8.00 ± 0.16) which was also found to be statistically nonsignificant over other treatments ($P > 0.05$). Since the result shows that score for overall acceptability is the highest for T_2 treatment (8.11 ± 0.19) and is statistically nonsignificant among all the treatments. Therefore, T_2 is the optimised treatment on the basis of sensory evaluation. The present study has agreement with (Gautam et al., 2013) made chana kheer with milk fat and three sweeteners 'Aspartame', 'Asulfame-k' and Sucralose flavour.

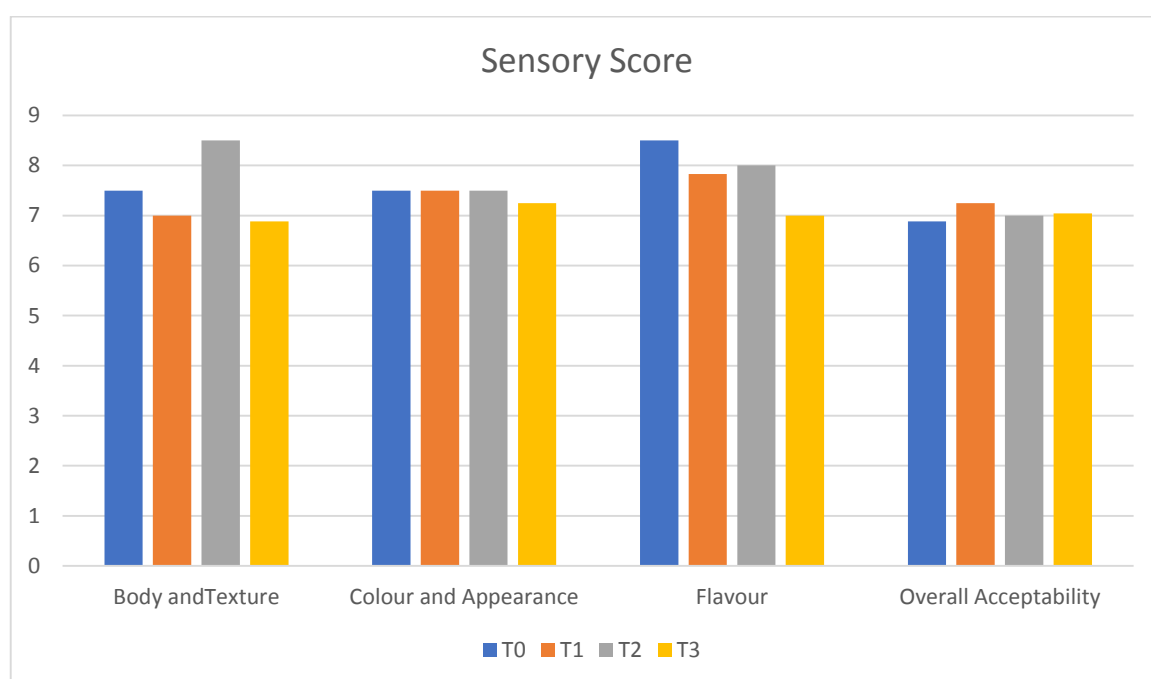


Figure 4.2 Sensory Score for Red Rice Kheer

On the basis of sensory evaluation treatment (T_2) was found to be optimized Red Rice based kheer was taken for further study.

Table 4.4 Chemical composition of Control and Optimised Red Rice kheer

Constituents	Control (T_0)	Optimised Product (T_2)
Moisture	55.43 ± 2.88	56.16 ± 2.11
Total Solids	44.57 ± 2.78	43.84 ± 3.05

Data is represented as mean \pm standard error ($n = 3$) at ($p > 0.05$)

The ANOVA table is presented in Appendix from the (Table 4.2) it can be observed that the difference among all groups were known to be nonsignificant ($p>0.05$)

Based on proximate analysis, optimised red rice-based kheer has moisture content of 56.16 ± 2.11 , whereas the moisture content of control is 55.43 ± 2.88 . This is because the moisture content of white rice (rice used for control) is almost equal to the red rice (rice used to make optimised product). Since the quantity used to prepare the control was higher than that of optimised product, moisture content of control was observed higher which was significantly not different from each other ($p>0.05$). Srinivasan and Anantkrishnan (1964) reported that the plain kheer has moisture content of about 45-55% whereas skim milk kheer has 40-50% of moisture content. Rangappa and Acharya (1974) estimated the moisture content of plain and sweetened kheer which was 50% and 45%.

Based on proximate analysis, optimised red rice-based kheer has Total Solid content of 43.84 ± 3.05 , whereas the Total Solid content of control is 44.57 ± 2.78 . The optimised product has the higher total solid content than that of control which was significantly not different from each other. The statistical data shows nonsignificant difference between values ($p>0.05$). Unnikrishnan et al. (2006) estimated the total solid content in rice paysam which was about 38.4%. Deshmukh et al. (2017) estimated the total solid content of poppy seeds kheer which was observed as 41.42%.

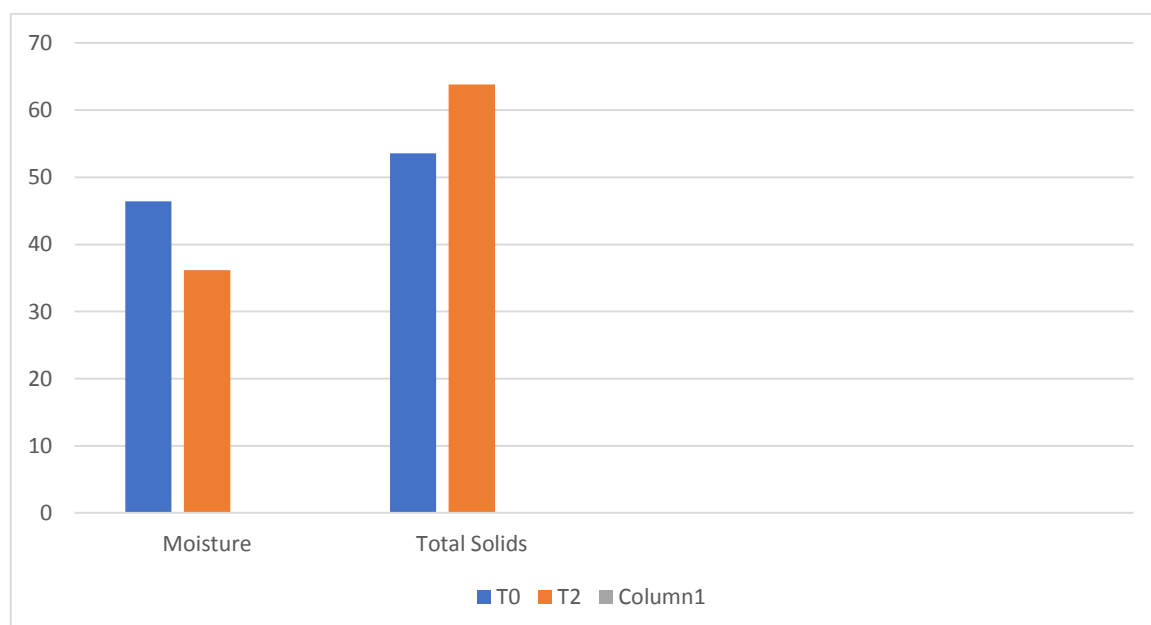


Figure 4.3 chemical composition of optimized and control Red Rice Kheer

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

The research based on “**PROCESS OPTIMIZATION FOR THE MANUFACTURE OF RED RICE (*Oryza Sativa L.*) KHEER**”. The optimum condition for red rice kheer with addition of natural sweetener coconut sugar, toned milk resulted in soft body and texture. Red rice and coconut sugar used in combination of (20 gm red rice and 10 gm coconut sugar) were most acceptable in terms of color and appearance, body and texture, flavor and overall acceptability. Red rice kheer is highly nutritious and red rice kheer is widely consumed by seeing the various health benefits. The main ingredients of red rice kheer were red rice, coconut sugar and toned milk. Three red rice kheer samples were judged for organoleptic qualities.

ANOVA was used to optimize for final product ; trials were used as optimization tools. The overall score consisting (color and appearance, body and texture, flavor and overall acceptance) of treatments containing different composition were observed in this study.

5.2 Overall acceptability of prepared red rice kheer

- The maximum score was obtained in combination of 20 gm of red rice and 10 gm of coconut sugar.
- The maximum (T_2) and minimum (T_0) scores obtained for color and appearance were (7.83 ± 0.18) and (7.00 ± 0.23) respectively.
- The maximum (T_2) and minimum (T_3) scores obtained for body and texture were (8.50 ± 0.24) and (6.88 ± 0.31) respectively.
- The maximum (T_0) and minimum (T_3) scores for flavor were (8.50 ± 0.17) and (7.00 ± 0.26) respectively.

Results revealed that there was nonsignificant ($p > 0.05$) differences in color and appearance among the prepared red rice kheer samples, since the p value is more than 0.05. The color and appearance of T_2 (7.83 ± 0.18) was most acceptable among all other samples.

In case of flavor preference among the entire prepared red rice kheer sample, Flavour of T_2 (8.0 ± 0.16) was nonsignificantly better than T_1 and T_2 . In body and texture preference

among all the prepared samples of kheer, T₂ (8.50±0.24) was highly acceptable than T₁ and T₃.

It is apparent from the results that there was nonsignificant ($p>0.05$) difference in overall acceptability among the prepared kheer samples. The result showed that the overall acceptability of T₂ (8.11±0.19) was most preferred.

5.3 Chemical Analysis of optimized red rice kheer

Based on proximate analysis, optimized red rice kheer has moisture content of 56.16 ± 2.11 , whereas the moisture content of control is 55.43 ± 2.88 . This is because the moisture content of white rice (rice used for control) is almost equal to the red rice (rice used to make optimised product). Since the quantity used to prepare the control was higher than that of optimised product, moisture content of control was observed higher. Based on proximate analysis, optimised red rice-based kheer has Total Solid content of 43.84 ± 3.05 , whereas the Total Solid content of control is 44.57 ± 2.78 . The optimised product has the higher total solid content than that of control.

5.4 Conclusion

In the present study on preparation of red rice kheer with coconut sugar as a natural sweetener where red rice has higher amount of protein, fiber, mineral compare to other normal rice. Both red rice and coconut sugar has low glycemic index which is good for diabetic people. Kheer is consumed by wide group of population. This product is prepared with the aim to provide nutrition to every age of people.

BIBLIOGRAPHY

- Austin J. (1978). Cereal Fortification Reconsidered. *Cereal Foods World* **23**: 233.
- AOAC (2000). Official Methods of Analysis of the Association of Official Analytical Chemists. 17th ed. Washington D.C., U.S.A.
- AOAC (1980). Official Methods of Analysis. In W. Worwitz (Ed.), Association of Official Analytical Chemists. 13th ed. Washington D.C., U.S.A.
- Azeez MA and ShafiM. (1996). Quality in rice. Dept Agric. West Pakistan Tech Bull. No. 13, pp.50.
- Bhattacharjee P, Singhal RS and Kulkarni PR. (2002). Basmati rice: A review. *International Journal of Food Science and Technology*, **37**(1):1-12.
- Brand W, Cuvelier ME and Berset C. (1995). Use of free radical method to evaluate antioxidant activity. *Lebensm. Wiss. Technol.* **28**: 25-30.
- Chaudhary RC and Tran DV. (2001) Specialty Rices of the World: Breeding, Production, and Marketing. FAO, Rome, Italy; and Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India, 3-14.
- Champagne ET, WoodDF, JulianoBO and BechtelDB. (2006). The rice grain and its gross composition. In Champagne, E.T. (Ed.), *Rice chemistry and technology*, 3th Ed. American Association of Cereal Chemists, St. Paul, Minnesota, USA, 77-108 PP.
- Devi G N, Padmavathi G, Babu V R and Waghay K (2015). Proximate Nutritional Evaluation of Rice (*Oryza Sativa L.*). *Journal of Rice Research*, Vol 8(1).
- FAO (2004). Rice and human nutrition. International year of rice, Rice is life. Food and Agriculture Organization of the United Nations Viale delle Terme di Caracalla Rome, Italy.
- Gopalan C, Rama Sastri B V and Balasubramaniam S C (2007). Nutritive Value of Indian Foods. National Institute of Nutrition. Indian Council of Medical Research, Hyderabad.

- Hiziroglu, S; Piyawade B; Vllayuth F; Workait S; Songklod J. (2007). Selected properties of medium density fibreboard (MDF) panels made from bamboo and rice straw. *Forest Products Journal*. **57**(6): 46-50.
- Juliano B O (1985). *Rice Chemistry and Technology*. American Association of Cereal Chemists, USA; 757pp.
- Kumar T T (1988). *History of Rice in India*. Gian Publishers, Delhi, India. 241 pp.
- Krishnamurthy K S (1991). *The Wealth of Susruta*. International Institute of Ayurveda, Coimbatore, Tamil Nadu, India. 582 pp.
- Krishnaiah K and Janaiah A (2000). The role of rice in Indians food security – projections and future directions. *India Grains*, **2**(11), 27.
- Little R R, Hilder G B, and Dawson E H (1958). Differential effect of dilute alkali on 25 varieties of mild white rice. *Cereal Chemistry*. **35**:111-126.
- Liu RH (2007). Whole grain phytochemicals and health. *Journal of Cereal Science*. **46**:207-219.
- Moldenhauer K A K, Gibbons J H, and McKenzie K S (2006). *Rice chemistry and technology*, 3th Ed. American Association of Cereal Chemists, St Paul, Minnesota, USA ,49-76 pp.
- Onyeike E N, Olungwe T and Uwakwe A A (1995). Effect of Heat Treatment and Defatting on the Proximate Composition of some Nigerian Local Soup Thickeners. *Food Chemistry* **53**:173-175.
- Potty, V.H. (1996). Physio-chemical aspects, physiological functions, nutritional importance and technological significance of dietary fibres- a critical appraisal. *J. Food Sci. Technol.* **4**:21-24.
- Rghuramulu N, Nair K M and Kalyansundaram S (2003). *A manual of laboratory techniques*. National Institute of Nutrition, ICMR, Hyderabad.
- Anonymous (1998). *Evaluation of rice germplasm for biotic stresses*. ICAR Ad-Hoc Research Network Programme, (1993-1998). Directorate of Rice Research, Hyderabad, Andhra Pradesh, India. 284 pp.

- Arumugasamy, S., Jayashankar, N., Subramaniam, K., Sridhar, S., and Vijayalakshmi, K. (2001). Indigenous Rice Varieties. Centre for Indian Knowledge Systems (CIKS), Chennai, Tamil Nadu, India. 74 pp.
- Ayachit, S.M.(Tr.) (2002). Kashyapiyakrishisukti (A Teatise on agriculture by Kashyapa). Agri-History Bulletin No. 4. Asian Agri- History Foundation, Secunderabad. Andhra Pradesh, India. 158 pp.
- Ghate, V. S. and Sane, H. (2004). Non – conventional food plants associated with ritual of Rishi Panchami. *Asian Agri-History* **8**:129-134.
- Ismani. (1985). Rice culture, viewed from myths, legends, rituals, customs, and artistic symbolism relating to rice cultivation in Indonesia. *East Asian Studies* **26**:117-130.
- Krishnamurthy, A., and Sharma, A.C. (1970). Manipur- rich in rice germplasm. *Oryza* **7**:45-50.
- Kumar, T. T. (1988). History of rice in India, Gian Publishers, Delhi, India. 241 pp.
- Matsuo, T. and Hoshikawa, K. (Eds.) (1993). Science of the Rice Plant. Vol. 1. Food and Agriculture Policy Research Center, Tokyo, Japan. 254 pp.
- Raychaudhary, S.P. (1964). Agriculture in Ancient India. Indian Council of Agricultural Research, New Delhi, India. 167 pp.
- Rood, M.A. (2000). Red menace. *Rice Journal* 103 (March):18-20.
- Sharma, R.D. (1991). Story of Rice. National Book Trust, New Delhi, India. 64 pp.
- Singleton V L., Orthofer R and Lamuela-Raventos R.M. (1999)/Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. *Methods Enzymol.* **299**: 152-178.
- Sompong R, Siebenhandi E.S., Linsberger M.G. and Berghofer E. (2011). Physicochemical and antioxidative properties of red and black rice varieties from Thailand, China and Sri Lanka. *Food Chemistry.* **124**: 132-140.

- Shen Y, Jin L., Xiao P, Lu Y and Bao J S. (2009). Total phenolics, flavonoids, antioxidant capacity in rice grain and their relations to grain color, size and weight. *Journal of Cereal Science*. **49**: 106-111.
- Watt, G. (1896). A Dictionary of Economic Products of India. Vol. V. Cosmo Publications, New Delhi, India. (Reprint).
- Bhattacharya, K. R. (2009). Physicochemical Basis of Eating Quality of Rice. *Cereal Food World*, **54**(1): 18-28.
- Itani, T., Tamkai, M, Arai, E., Horino, T. (2002). Distribution of amylase , nitrogen, and minerals in rice kernels with various characters. *Journal of Agricultural and Food Chemistry*. **50**:5326-5332.
- Lee, J. c., Kim, J. D., Hsieh, F.H., Eun, J.B. (2008). Production of black rice cake using ground black rice and medium- grain brown rice. *International Journal of Food Science and Technology*, 2008, **43**(6), (1078-1082).
- Mudoi, T. and Das, P., Nutritional composition of traditional coloured rice cultivars of Assam, India. *Bull. Env. Pharmacol. Life Sci.*, (2018), **7**(7),10-14.
- Reddy, C.K., Kimi, L., Haripriya, S. and Kang, N., Effects of Polishing on Proximate Composition, Physico- chemical characteristics, Mineral Composition and Antioxidant Properties of Pigmented Rice. *Rice Science*, (2017), **24**(5), 241-252.
- Reddy,M., Turaidar, V., Krupa, K. N., Ramachandra, A., Subhash Bharani, S., Dalawani,N, Enhancement of Iron and Zinc in Rie Grain through Biofortification Approach. *Int. J. Curr. Microbial. App. Sci.*, (2018), **7**, 628-637.

APPENDIX-I

Name of the Product: Red Rice Kheer

Time

Instruction: Given below are the samples of “Red Rice Kheer” you are requested to judge the sample on the 9-point hedonic scale for the parameters listed below.

Liked Extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

Characteristics	Sample Number		
	1	2	3
Body and Texture			
Color and Appearance			
Flavour			
Overall Acceptability			

Remarks if any:

Name of the panelist:

Date:

Signature

APPENDIX-II

ANOVA For Body and Texture

ANOVA Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	0.666667	2	0.333333	6.372093	0.699417	4.256495
Within Groups	8.0625	6	0.895833			
Total	8.729167	8				

ANOVA for Colour and Appearance

ANOVA Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	0.888889	2	0.444444	6.666667	0.148382	5.143253
Within Groups	1	6	0.166667			
Total	1.888889	8				

ANOVA for Flavour

ANOVA Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	0.388889	2	0.194444	9.7566	0.629738	5.143253
Within Groups	2.333333	6	0.388889			
Total	2.722222	8				

ANOVA For Overall Acceptability

ANOVA						
<i>Source of Variation</i>	<i>SS</i>	<i>Df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.722222	2	0.361111	6.444444	0.307547	5.143253
Within Groups	1.5	6	0.25			
Total	2.222222	8				

APPENDIX-III

ANOVA For Moisture

<i>Source of Variation</i>	<i>SS</i>	<i>Df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	222.9956	2	111.4978	17.57408	4.73E-06	5.143253
Within Groups	3.806667	6	0.634444			
Total	226.8022	8				

ANOVA For Total Solids

<i>Source of Variation</i>	<i>SS</i>	<i>Df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	21.76889	2	10.88444	27.3949	9.65E-05	5.143253
Within Groups	1.046667	6	0.174444			
Total	22.81556	8				