

**DEVELOPMENT OF ANTIOXIDANT RICH BLACK
RICE KHEER AND FORMULATION OF READY
TO COOK BLACK RICE KHEER.**

काशी हिन्दू
विश्वविद्यालय



BANARAS HINDU
UNIVERSITY

THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF

Master of Science
In
Food Science and Technology

Supervisor

Dr. Amrita Poonia

Submitted By

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**DEPARTMENT OF DAIRY SCIENCE AND FOOD
TECHNOLOGY**

**INSTITUTE OF AGRICULTURAL SCIENCES
BANARAS HINDU UNIVERSITY
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I.D. No. 18412FST008

2020

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Dear Sir,

I have great pleasure in forwarding the thesis entitled, "**Development of antioxidant rich black rice kheer & formulation of ready to cook black rice kheer**" submitted by **Ms. Bhavika Dhingra I.D No.18412FST008** 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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MASTER OF SCIENCE

(FOOD SCIENCE AND TECHNOLOGY)

FROM

DEPARTMENT OF DAIRY SCIENCE AND FOOD TECHNOLOGY,

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ACKNOWLEDGEMENT

I bow my head with great reverence in the pious feet of Bharat Ratna Mahamana Pandit Madan Mohan Malaviya Ji, a man of great vision and founder of the Banaras Hindu University, Varanasi, India, for his lifetime sacrifice and efforts in establishing such a temple of learning for the cause of the millions of student like me.

I bow my head in great reverence to the omnipotent and omnipresent Lord “Kashi Vishwanath” for their blessings and true love towards me and to every creature residing on this wonderful planet. In addition, I am highly obliged to this holy city Varanasi which is situated at bank of Maa Ganga.

It is my sublime privilege to express my deep sense of reverence and gratitude to my supervisor, Dr. Amrita Poonia Asstt. Professor, Department of Dairy Science and Food Technology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. for her inspiring and ingenious guidance, incisive and articulate criticism, cordial discussion, unending zeal and constant encouragement which assisted me to overcome every problem that come in my way during the period of this investigation and preparation of this manuscript. I shall always remain deeply indebted to her for her affectionate glances and generosity bestowed on me.

Words are fail to express my deep sense of gratitude to explain the help, affection, & constant encouragement rendered by Prof. Dinesh Chandra Rai , Head Of Department , Dairy Science and Food technology for providing the necessary facilities during the course of present study.

I am extremely thankful to my respected teachers Dr. Anil Kumar Chauhan, Asstt. Professor, Er. D. S. Bunkar, Asstt. Professor, Dr. Arvind Asstt. Professor, Dr. Amrita Poonia, Asstt. Professor and non-teaching staff Mr. Amaresh Singh, Mr. Chandrashekhar and other members of Department Of Dairy Science And Food Technology for extending their help during strenuous period.

I have no words to express my feeling about the contribution of my respected father Shri Kamal Dhingra for his blessings, sacrifice, and affection, and encouragement, moral and financial support throughout my life. I also express my heartfelt regard to my mother Smt.Manju Dhingra whose flawless love, blessings and guidance helped me to overcome all the barriers in life. I am also thankful to my brother Jatin Dhingra for his love and best wishes throughout my life. I am also thankful to all my family members along with relatives for their blessing and encouragement without which, I could not have achieved my task.

It is difficult to express the gratitude I owe to all my friends especially Kartik Kehar,Nidhi Tomar , Vini Kasturi Swarup and all my college friends for their immense love and affection which always animating me to face the challenges.

Without the help of seniors none can learn the lesson of life so, heartfelt and special gratitude to my senior Ms. Shikha pandhi, Mr. Abhinay Shahsank, Mr. Alok Kumar for their help and co-operation.

Last but not least, I record my sincere thanks to all respectable people and teachers who helped & guided me but could not find separate mention. I still solicit their benediction to proceed at every step of a perfect destined life.

Date:

Place: Varanasi

(BHAVIKA DHINGRA)

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ABBREVIATIONS

ANOVA	:	Analysis of variance
AOAC	:	Association of Official Analytical Chemists
TPC	:	Total Phenolic Content
DPPH	:	1,1-Diphenyl-2-picryl-hydrazyl
GAE	:	Gallic acid equivalents
HCl	:	Hydrochloric acid
K cal	:	kilocalorie
kg-1	:	per kilogram
mg	:	milligram
Min	:	Minute
ml	:	milliliter
°C	:	Degree Celsius
ppm	:	parts per million
sec	:	seconds
TPA	:	Texture Profile Analysis
TW	:	Total weight
β	:	Beta
%	:	Percent
γ	:	Gamma
XRD	:	X-ray Diffraction
WHC	:	Water Holding capacity
g sec	:	gram seconds
RTC	:	Ready to cook

CHAPTER I

INTRODUCTION

Rice is that the foremost staple food consumed by individuals in several countries .It is sensible supply of advanced carbohydrates and numerous alternative nutrients. Among totally different forms of rice; rice is that the most consumed rice followed by rice. Rice provide total 16% of global human per capita protein and 23% protein.(Clamped et al., 2002).

History & origin of black rice:

Black rice is addressed as Emperor's rice in china since ancient times because this black beauty was only consumed by royal families and kings of china to ensure good health, longevity & hence was used as tribute food. Also was named as Forbidden rice as only kings and emperor were allowed to consume this super food and was forbidden for everyone else

Black rice, species *Orzya sativa L.* is one in every of the sort of rice that's not extremely familiar to individuals and thence individuals area unit unaware of its health advantages and therapeutic effects. Black rice consist of high level of nutrients and antioxidants. The antioxidants found in black rice is more than the blueberries (that contain highest quantity of anthocyanin). Black rice is black because of anthocyanin content within the outer layer of its kernel. Interest in black rice from Manipur is as a result of its capability to combat and avert numerous health issues starting from cancer, diabetes, and allergies to cardio tube diseases. It conjointly promotes weight loss and liver health. Black rice contains Proteins (7.30g), macromolecule (77.40g), Fat (0.50g), Dietary atomic number 20 (6.0g), Phosphorus (50mg), Iron (2mg), and Antioxidants (1.62mg) per 100g. (Abdel-Aal et al., 2006)

There are currently different rice types available now a days with most common being the white rice. Out of all the types, however, black rice is found to be one containing the highest amount of nutrition that helps with growth.

Health Benefits Of Black Rice :**Table 1.1: Health Benefits of Black Rice**

S. No.	Health Benefits	Function
1.	Weight management	Since Black rice are unpolished rice, therefore rich in fiber and also it is low in fat, hence its consumption on regular basis helps in reducing weight.
2	Prevent Cardiovascular Disease	Due to presence of anthocyanin in blackrice, its consumption reduces LDL cholesterol levels and hence decreases chances of heart attack and keeps the heart healthy.
3	Reduces allergies	Bran of rice reduces release of histamines that causes allergies and also helps to alleviate inflammation and irritation that occurs in allergies.
4	Skin and hair care	Antioxidant in these rice prevents damage from free radicals and thus prevent premature ageing of skin and hair and promotes hair growth.
5	Anti-cancer effects	Free radical damage cause cancers, therefore black rice antioxidant component i.e. anthocyanin protects body from free radical damage and inhibit spread of cancers.

(Saha.2016)

Coconut sugar:

Coconut sugar is made by evaporation of coconut sap and is a nutrient-rich crystalline sugar/sweetener that looks, tastes, dissolves, and melts almost exactly the same as regular sugar, but it is completely natural and unrefined and has a far superior taste (**Abdullah et al., 2014**). The texture and flavor of coconut sugar are also similar to those of brown sugar. Increasing threats of diabetes, obesity, hypertension, and heart diseases have become real concerns for many people due to high consumption of sugar in food, beverage, and confectionery products (**Chattopadhyay, Raychaudhuri, & Chakraborty, 2014**). Thus some healthy alternative should be utilized to solve this problem. The lower GI value (GI-35) of coconut sugar (*Cocos nucifera L.*) in comparison to palm sugar (*Borassus flabellifer*) (GI-42) and sugarcane (*Saccharum officinarum L.*) (GI- 52-80) suggests that it can be a better source of healthier sugar. Coconut sugar undergoes little processing so it retains some of the natural vitamins, minerals (notably iron, zinc, calcium and potassium), fiber (inulin) and antioxidants. The nutrients in coconut sugar are likely to have a minimal effect unless you eat large amounts, when any benefit will be outweighed by all the sugar

you're eating. Coconut sugar has the same number of calories as table sugar (16 calories per teaspoon).(Appetite, 2018; Beck, 2014).

Kheer:

Kheer is one of the most common deserts that is simple preparation of rice and milk offered on various feasts and social events. This Indian dairy dessert is a cereal based heat desiccated product whose essential ingredients are milk and sugar ,but one can vary the kheer by replacing rice with semolina, vermicelli , makhana, carrot ,etc.Kheer is the traditional Indian dairy product which occupies special position in Indian diet since ancient times due to its high nutritional and sensory properties. Conventionally, it is prepared by partial dehydration of whole milk in a karahi over a fire together with sugar and usually rice or semolina (De et al, 1982.). Kheer is known by different names, in different parts of the country, such as ‘kheer’ in North Western region, ‘payasam’ in Southern region, ‘payas’ in Eastern region, ‘phirni’ in Northern region, ‘kheech in Mewar region and ‘payesh’ in Bengal, (Aneja et al., 2002).

Mani et al., (1955) in the earliest work on kheer studied the nutritional value of traditional kheer made from rice and milk containing 4.1% total solids. They reported that 100 g of kheer contained. 388 mg calcium, 237 mg phosphorus, 3-4 mg ascorbic acid, 118 mg thiamine, 242 IU vitamin A, 277 ug nicotinic acid and 353 ug riboflavin. So as to increase nutritional benefits from traditional Indian desert that is commonly consumed by people of India, black rice are alternatively used in place of rice and antioxidant rich kheer will be developed which will be a value added convenient product for dairy industry and may lead to product diversification. This may also let people consume this not very well known variety of rice and take advantage of its health promoting benefits.

Ready To Cook Food:

Ready to cook meals is a packaged meal that already cooked or just need to reheats it before use. Many research shows that the concept of ready to cook meal comes from during wars, military has limited resources to prepare food and it is available in pouches and tin cans. It is popularly used in US and Europe countries for ages and has a mature market in food industry. Also it has also captured a market share in Asian countries for past two decades.

Indian cooking and lifestyle have undergone tremendous changes in the last 15 years. Many major factors which impacts this change include, liberalization policy, dual income,

separate living of couples, Innovative kitchen applications, Media proliferation etc. The cooking style and eating habits in India varies drastically from southern part of India to northern part of India. Due to lifestyle pressure nowadays people prefer easy short way of cooking food rather spending too much time on spending in cooking. There are peoples, who are migrating to cities for job and education and these people have find the Ready-to-eat / cook products are comfortable to eat rather than depending on restaurants **Ramaswamy (2003)**.

Most of the dual income (both husband and wife are office goers) families want to spend much less time on cooking because of less availability of time. During weekends they want to spend time with their kids and outing, whereas in weekdays the office duration is large and these factors forced them to go for buying such products. Therefore, the food industry has prepared a concerted effort to meet up the desires of a time-hungry consumer through enlarged offerings of semi prepared and ready to cook meals. For working women it seems hectic to give time to cooking after a long working hours. It is quite tiring to plan and prepare a meal for working women, where every day office work have no avoidance. There are options available for the food that fills the empty tummies which are also healthy and take less time. And even some of them have pretty good taste too.

The easiest way to fulfill the need and increase storage life of product was ready-to-cook meals. Ready to cook meals makes life easier that they are easy to make, ready to eat whenever you want to and you just have to do reheat it or reconstitute it. And it is all done, it is easy to store. These meals can be stored for long time like kept frozen for over three months and once it has cooked then can be stored up to three days in the refrigerator. So, it is a nice deal unlike the consumable commodities. Health conscious individuals want a high quality meal or try a new eating experience, they prefer to have natural food ingredients then ready to cook meal is a good choice for them, which is hygienic and healthy. Since cooked rice kheer has very less storage life therefor it was necessary to develop & render the product dry using the scientific principles of drying so as to decrease cooking time and increase shelf life of the product also keeping in consideration that product could resemble the conventional product upon reconstitution. Therefore along with development of antioxidant rich black rice kheer this research will also involve development of ready to cook black rice kheer to increase storage life of the product and

decrease its cooking time during this period of rapid urbanization in developing countries and therefore to develop a convenience food. (Manohar, 2005)

The outcome of this proposed study is expected to provide necessary details for large scale industrial production of ready to cook black rice kheer and its acceptability for long time.

In this context of the above stated facts, the present study was undertaken with broad objectives which are understated.

OBJECTIVES:

1. To optimize the process of cooked black rice kheer.
2. To develop and optimize ready to cook black rice kheer.
3. To study sensory attributes of cooked and ready to cook black rice kheer.
4. To determine the physico-chemical, antioxidant & microbiological properties of black rice kheer.

CHAPTER II

REVIEW OF LITERATURE

The present analysis study of the “**DEVELOPMENT OF ANTIOXIDANT RICH BLACK RICE KHEER AND FORMULATION OF READY TO EAT BLACK RICE KHEER.**” has been review underneath numerous aspects as follows:

1. An outline of black rice: its nutrition aspects, Health advantages & product optimization.
2. Summary and nutrition profile of coconut sugar.
3. Kheer /rice pudding & alternative milk based mostly deserts.
4. Importance of ready to eat milk based dessert and other products

2.1 Summary of Black Rice:

Scenario of pigmented rice production

Rice (*Oryza sativa L.*) is that the most significant cereal crop within the developing world and is that the staple food for over 1/2 the world’s population (Clamped et al., 2002). Rice is one in every of the foremost vital food commodities on the international market, with a worldwide production level of nearly 600 million tons in 2003, of that around ninety per cent was produced in Asia, with China producing 166 million tons and India 134 million tons (FAO, 2004).Rice production in India was eighty.65 million tons throughout the year 2010-2011, 92.75 million tons in 2011-2012 and 90.69 million tons in 2012-2013 (State of Indian Agriculture, 2012-2013).

Rice is that the principal cereal food in Asia, and therefore the staple food in several Asian countries (Osawa et al., 1992). The foremost common rice consumed by man is rice (about 85%), followed by rice and therefore the rest is pigmented rice.

The origin of black rice isn't well understood, however it absolutely was aforesaid that black rice might need originated from several Asian countries as well as China (Mingwei et al., 1995), India (Sastry, 1978), Japan (Natsumi and Noriko, 1994), and Vietnam (Quan, 1999). Chaudary and Tran (2001) reported that black rice might have originated from Sri Lanka, the Philippines, Bangladesh, Thailand, Asian country and Indonesia. Black rice has diversity in terms of color because of anthocyanin content and alternative morphological

characters. Colored rice genotypes with either red, purple or black bran layer are cultivated for a protracted time in Asia (Sutharut and Sudarat, 2012).

2.2 Physiochemical characteristics of pigmented rice: Physical characteristics

Screening of rice varieties for chemical science characteristics is critical for quality analysis and attainable food trade applications. (Ghrist, 1965). And Anon (1996) reported that the use of rice for food purpose involves edge of paddy to get rid of the husk, bran and germ from the surface of the grain. Edge of rice has profound result on its nutrient composition. Losses of nutrient, ensuing from edge and sharpening of rice, vary significantly relying upon the quantity of layers removed throughout process and on the inherent varietal quality.

Enormous variation in size and therefore the form of grain exists among the rice varieties (Murthy and Govindaswamy, 1967). Rice kernel length roughly varies from 5.0–7.5 mm and breadth from 1.9–3.0 mm. Some high yielding varieties from India vary between 5.2–6.8 mm long and mm.9–2.5 metric linear unit reported (Nanda et al., 1976). Japonica varieties are usually shorter and bolder grains. Generally, hulling out flip is mm to be within the range of 71–83 per cent. The varietal variation at intervals Indian varieties in relation to hulling share is discovered to be little, however it's additional within the case of Taiwan and Japanese varieties. Several Japonica rice varieties offer hulling out turns of over seventy nine per cent (Govindaswamy et al., 1969).

According to Ramiah (1993) there are regarding eleven completely different color rice varieties, varied from white (most common), to varied reminder red to purple (almost black). Rice with kernel colors of gold, burnt umber or gray are gift. Bandyopadhyay and Roy (1992) discovered that the edge quality or edge yield of paddy is tormented by selection, wet content, pretreatments like parboiling and process (milling) equipments and ways.

Abdel-Aal et al., (2006) and Rule et al., (2008) reported that the black rice may be a specialty rice selection with black bran covering the reproductive structure. The rice reproductive structure, that is semitransparent with grey to nearly black color, turns deep purple once Lyonnais. It sometimes higher in terms of pasty texture, takes longer time to cook, and is stickier than rice. Because of its uncommon color and sweet nutty flavor, black rice has become common for creating sweet snacks and desserts in several Asian countries. Anthocyanin's, notably cyanidin 3-glucosidase and peonidin 3-glucosidase, are responsible for the color of black rice.

Ganesan et al., (1998) reported that a thousand grain weight of rice varied from fifteen.76 to 29.24 g. The scientist additionally reported a moderate correlation between length of grain and grain weight. However Riccharia and Govindaswami (1990) found that the a thousand grain breadth of rice ranged from 12.0 to 47.5g. Grain quality is that the major concern in rice production in India and lots of alternative rice-producing areas within the world. The intake quality of rice, additionally called rice palatableness, is a crucial issue that determines the commercial worth of rice. For Asian markets, the hardness and viscosity are reported because the two most significant parameters for determinative the palatableness of cooked rice (Okabe, 1979). Information accumulated within the past decades indicates that the rice intake quality is directly associated with the chemical science properties of endosperm parts, such as amylose, protein, water content and gelatinization characteristics (Juliano, 1985).

2.3 Cooking quality

Rice quality may be a multi-faceted attribute composed of many elements like the physical look, preparation and consumption qualities and nutrition price. Every part consists of the many attributes whose values are determined not solely by their chemical science properties however additionally by the historical and cultural traditions of those that consume the rice (Unneverhr et al., 1992).

Specific data for colored rice originate to 2003, wherever Chaudhary (2003) quoted China as the richest country in black rice resources (62%) followed by state (8.6%), Indonesia (7.2%), India (5.1%), the Philippines (4.3%), Bangladesh (4.1%), and few in Asian nation, Thailand and Burma.

Assessment of the standard of roast rice was rumored to be additional exactly measured by a mixture of physical, chemical, and sensory properties (Koutroubas et al., 2004). Amylose content is that the most vital parameter to assess consumption and preparation quality of rice (Shi et al., 2005). Earlier analysis works have indicated that rice of high consumption quality possesses low amylose content (Juliano, 1985). In general, roast rice with low amylose content was rumored to be soft and sticky, whereas rice with high amylose content was comparatively firm and flossy (Rani and Bhattacharya, 1989). In keeping with Malik and Choudary (2001) amylose content is a crucial of determinant of the cohesiveness, tenderness, volume enlargement and look of roast rice.

Chen Xu et.al (2019) investigated the migration of water molecules and its impacts on consumption qualities of preparation black rice was using a LF-NMR, CLSM, Rheometer

and TPA. LF-NMR pictures showed that embryo of rice grain possessed high water content and water molecules bit by bit migrated from outer to interior of the grain throughout preparation method. Throughout gelatinization, the changes of starch grains might be divided into 3 periods: granule swelling, short chains leach out and grain adhesion. As a consequence of water migration, the amylose and amylopectin chains within the leachate created a chance for bonding and molecular interaction with water molecules, inflicting a coffee hardness, chewiness and a high adhesion, stickiness. The apparent viciousness of the preparation answer accrued markedly with the extension of preparation time, which can attribute to starch parts bit by bit leach out from preparation black rice. These many techniques paved the approach for a far deeper understanding the role of water molecules in preparation method and that they additionally offered new insights for understanding changes of consumption quality of black rice throughout preparation treatment.

No important loss of anthocyanin throughout preparation in black rice was rumored by Surh and Koh (2014). Preparation resulted within the greatest decrease (94%), followed by steaming (88%), pan-frying (86%) and boiling (77%). Contents of phenolic resin compounds weakened drastically once preparation, with considerably lower retention within the black rice variety that had higher amylose content. The DPPH radical-scavenging activity of black rice weakened once preparation. In distinction, metal-chelating activity accrued considerably once preparation. Anthocyanin's showed a high correlational statistics with total phenolic resin compounds ($r^2 = \text{zero.936}$) however a big correlational statistics with metal-chelating activity ($r^2 = \text{zero.6107}$). The amylose content of rice is usually rumored to vary from sixteen.99 to 23.27 per cent and therefore the enzyme activity from sixteen.33 mg to forty six.67 mg.

2.4 Biochemical, nutraceutical characteristics and health effects of pigmented rice:

Phenolic compounds (polyphenols) were also are found in grains and therefore the concentrations and kinds of compounds vary among totally different foods thanks to genetic factors environmental factors and process conditions (Kris-Etherton et al., 2002).Deng et al., (2013) rumored that the pigmented rice was chiefly black, red, and dark purple rice and contains a range of flavones, tannin, phenolic, sterols, tocols, γ -oryzanols, amino acids and essential oils.

Gema Pereira-Caro et.al (2013) conferred the phytochemical profiles of these prohibited rice and its popularization for health aware customers. , analyzed secondary metabolites in

dehulled black–purple rice cv. Asamurasaki were analyzed using HPLC–PDA–MS2 and finally results demonstrate that the black–purple rice within the dehulled kind during which it's consumed by humans contains an upscale heterogeneous mixture of phytochemicals which can offer a basis for the potential health edges, and highlights the attainable use of the rice as purposeful food.

Bolea & Vizireanu(2017) presented review on inhibitor properties polyphenolic content and of black rice flour & investigated seven black rice edge fractions obtained at laboratory scale so as to judge the phytochemical profile and inhibitor activities. For every fraction the inhibitor activity, anthocyanin, flavonoids and total polyphenolic content were determined. The very best content of bioactive compounds was recorded within the black rice edge fraction with particles starting from a hundred twenty five to one hundred eighty one hundred eighty.

Muntana & Parsong (2010) investigated total phenolic resin content (TPC) of three teams of Thai rice: white, red & black color. first of all rice brans were extracted using wood spirit so extracts were analyzed using Folin:Ciocalteau to calculate TPC so inhibitor activity of rice were analyzed using DPPH assay and thiocynate technique .Results showed highest TPC in black rice > red rice >white rice and antioxidant activity highest in red rice >black rice >white rice.

The phenolic compounds are found as a serious active part for antioxidants. For pigmented rice, the most substance of phenolic resin compounds has been rumored as anthocyanins (Iqbal et al., 2005). Anthocyanins in pigmented rice are known and that they are rumored as cyanidin-3-glucoside and peonidin-3-glucoside (Hu et al., 2003); Maldivian, pelargonidin-3, 5-diglucoside, cyanidin-3-glucoside and cyanidin-3, 5-diglucoside (Zhang et al., 2006); cyanidin-3-glucoside, pelargonidin -3-glucoside (Yawadio et al., 2007). The content of antioxidative substances, i.e. polyphenol in rice grain, is laid low with genotype and setting (Goffman and Bergman, 2004).Meng et al. (2005) have rumored that black rice contains iron, zinc, calcium, copper and Mn on top of those in red rice.

Irakli et .al (2018) incontestable optimize experimental conditions for max recovery of free and sure phenolic resin compounds from rice by-products that were determined using response surface methodology (RSM) supported ABTS radical scavenging activity , total phenolic content (TPC), and ferric reducing power (FRAP). The consequences of ethanol concentration, extraction time and temperature, and NaOH concentration, hydrolysis time and temperature for complimentary and bound fractions, respectively were investigated

using a Box-Behnken design. The optimum conditions for the free phenolic were 41–56%, 40°C, 10 min, whereas for bound phenolic were two.5–3.6 M, 80 °C, 120 min. under these conditions free TPC, ABTS and FRAP values within the bran were about 2-times more than within the husk. However, sure TPC and FRAP values within the husk were one.9- and 1.2-times more than those within the bran, respectively, whereas bran fraction determined the very best ABTS value. Ferulic acid was most evident within the bran, whereas p-coumaric acid was principally found within the husk. So Findings from this study incontestable that rice by-products might be exploited as valuable sources of bioactive elements that might be used as ingredients of purposeful food and nutraceuticals. Ghasemzadeh et.al (2015) relatively evaluated totally different Extraction Techniques and Solvents for the Assay of Phytochemicals and antioxidant Activity of Hashemi Rice Bran and obtained Secondary metabolite contents (total phenolic, flavonoid, tocopherol, and tocotrienol) and inhibitor activities of Hashemi rice bran extracts by ultrasound-assisted and ancient solvent (ethanol and 50:50 (v/v) ethanol-water) extraction techniques and thus were compared. Phenolic and, flavonoid compounds were known using ultra-high performance liquid activity and methodology validation was performed. Vital variations ($p < 0.05$) were determined among the various extraction techniques upon comparison of phytochemical contents and antioxidant activities. The extracts obtained using the ethanol-water (50:50 v/v) ultrasonic technique showed the highest amounts of total phenolic (288.40 mg/100 g dry material (DM)), total flavonoids (156.20 mg/100 g DM), and total tocotrienols (56.23 mg/100 g DM), and therefore the highest antioxidant activity (84.21% 1,1-diphenyl-2-picrylhydrazyl (DPPH), 65.27% 27th bleaching and 82.20% gas scavenging activity). Secondary substance contents and inhibitor activities of the rice bran extracts varied relying of the extraction methodology used, and in keeping with their effectiveness, these were organized in a decreasing order as follows: ethanol-water (50:50 v/v) ultrasonic, ethanol-water (50:50 v/v) maceration, ethanol ultrasonic and ethanol maceration ways. Ferulic, Gallic and chlorogenic acids were the foremost rich phenolic compounds in rice bran extracts. The results prompt phytochemical constituents of Hashmi rice bran and its antioxidant properties provides insights into its potential application to promote health.

Sukrasno et.al (2017) evaluated antioxidant activity from totally different polarities rice bran extract of 3 kinds of rice using 2 strategies of antioxidant testing that were metallic element reducing antioxidant power (FRAP) and a pair of, 2-diphenyl-1-picrylhydrazyl

(DPPH), and correlation of total phenolic, flavonoid and antioxidant content with their exhibitory concentration 50 (EC50) of FRAP and repressive concentration 50 (IC50) of DPPH antioxidant activities. Extraction was conducted by reflux using completely different polarity solvents. The extracts were evaporated using rotary evaporator. Determination of total phenolic, flavonoid and antioxidant content, inhibitor activities using FRAP and DPPH assays was performed by ultraviolet-visible spectrophotometry and its correlation with EC50 of FRAP capacities and IC50 of DPPH scavenging activities was analyzed by Pearson's methodology. Results demonstrated that ethanolic rice bran extract of black rice showed the lowest IC50 of DPPH scavenging activity 23.92 µg/ml, EC50 of FRAP capability 64.35 µg/ml and the highest phenolic content, flavonoid content, and antioxidant content were additionally given by ethanolic rice bran extract of black rice. There was considerably negative correlation between total phenolic content and antioxidant content in rice bran extract of red rice and black rice with their IC50 of DPPH. The nutritional composition of rice grain could be a major parameter influencing the standard of rice grains. The chemical composition, starch, protein, lipid, ash, mineral content, crude fiber and moisture content have an effect on the nutritional quality of rice grain.

A wide vary of range 6.56–12.86 per cent range content was reported in 40 rice varieties Kashmir in protein (Baba, 1971). Protein content and alternative constituents like amylose, starch, crude fiber, ash, and total fat are often present in different amounts in several rice varieties (Juliano, 1993). Accessible reports indicate that amylose content in rice varied from 0 to 37 per cent (Govindaswami, 1985).

Higher amylose contents (about 20–30%) are related to several south Asian varieties. Lower amylose levels (10–20%) are more common in East Asia, wherever a lot of cohesive boiled grain is usually most popular (Olsen and Purugganass, 2002). gluey or waxy rice has no or little amylose. The fat content of polished rice have been reported to have about 0.2–2.0 per cent fat (Zhou et al., 2002).

The volatile elements of volatile oil from red and black rice bran were analyzed by GC and GC-MS by Sukonthara et al., (2009). 129 volatile compounds were identified in red and black rice bran. myristic acid 6, 10, 14-trimethyl-2-pentadecanone, nonanal and (E)-β-ocimene were main compounds in red rice bran, whereas main compounds in black rice bran were myristic acid, nonanal, caproic acid, pentadecanal and pelargonic acid.

Guaiacol, conferred at 0.81 mg/100 g in black rice bran is liable for the characteristic component in black rice.

Suzuki et al., (2004) reported that black rice also contains higher levels of proteins, vitamins and minerals than common white rice. Compared to white rice, black rice is relatively richer within the mineral contents like iron, zinc, and manganese and phosphoric and therefore the higher variability in mineral content is reported to be depended upon varieties and soil types of the planting space (Zhang, 2000).

Saha (2016) extensively reviewed and mentioned health edges of Black rice, a brilliant nutritive variety of rice species *Oryza sativa L.* which is black coloured, glutinous, nutty seasoned, full of high levels of nutrients. Black color of this rice is due to the presence of flavonoids pigments known as “anthocyanin” that are powerful antioxidants similar to that of blue and black berries. Being a storehouse of antioxidants, fiber, mineral and amino acids it's capable of combating and preventing a good spectrum of health issues starting from cardio vascular disease, cancer, diabetes, allergies to Alzheimer's disease .Black rice is taken into account as nature's most well balanced “super food” by human and scientist. Because it continues to be less widespread than white and rice thus it's necessary to determine its totally different aspects that are helpful to human health. A major increase in black rice consumption could also be achieved by stressing and advertising its health promoting effects.

Guo Honghui et.al (2006) evaluated the impact of an anthocyanin-rich extract from black rice on hyperlipidemia and insulin resistance in fructose-fed rats. Rats fed fructose diet for four weeks exhibited considerably higher plasma hypoglycemic agent levels and lower insulin sensitivity. Than the management rats fed AIN-93G diet. Dietary supplementation with the anthocyanin-rich extract (5 g/kg of high-fructose diet) prevented the development of fructose-induced hypoglycemic agent resistance. After fructose induced insulin resistance had been established, 4-week treatment with the anthocyanin-rich extract (5 g/kg of high-fructose diet) or pioglitazone (270 mg/kg of high-fructose diet) ameliorated the glucose intolerance and hyperlipidemia, however the extract did not reverse the fructose-induced hyperinsulinemia as pioglitazone did.

Additionally, rats supplemented by the extract exhibited lower oxidative stress than the fructose-fed controls, as indicated by the lower concentrations of plasma thiobarbituric acid reactive substances and blood oxidized glutathione.

Pratiwi & Purwestri (2017) reported that black rice has several phytochemical variants which may contribute to its use as a functional food, as well as nutraceuticals and secondary metabolites like anthocyanin, oryzanol, and more. The aim of this article was to review literature describing black rice cultivars from country, with a specific focus on its potential use as a practical food. Our literature search disclosed many articles that describe black rice in relation to its nutraceutical properties and its role in reducing non-communicable diseases. Different studies describe the variety of local pigmented rice and its potential for lowering the danger of hyperlipidemia, hyperglycemia, and for cancer prevention. Black rice has been represented as a functional food in many countries; but, hyperglycemia nice diversity among cultivars and more. Research on Indonesian varieties can verify whether or not native variants are candidates also for the development of practical foods.

Asem et.al (2017) Specialty rice varieties with unique properties like unique color, flavor, aroma and nutraceutical qualities are increasingly in demand apart from the traditional rice varieties. Black rice has numerous nutraceutical properties with high anthocyanin content and therefore the anthocyanin antioxidants are important in preventing numerous diseases.

2.5 Summary and nutrition profile of coconut sugar

Gardner (2017) mentioned the sugar content in coconut sugar and provides connected oral health recommendation. Coconut sugar undergoes very little process thus it retains a number of the natural vitamins, minerals (notably iron, zinc, Ca and potassium), fiber (inulin) and antioxidants. The nutrients in coconut sugar are seemingly to possess a lowest impact unless you eat massive amounts, once any profit are going to be outweighed by all the sugar you are intake. Coconut sugar has a similar range of calories as table sugar (16 calories per teaspoon). Oral health impact: of these product contain high levels of possible carbohydrates thus are cariogenic. Advice for patients: Treat these product within the same approach as table sugar and use meagerly. Oral hygiene has to be maintained as they're harmful to teeth.

Asgha et.al (2019) carried out a study to check the inhibitor and nutritional properties of coconut (*Cocos nucifera L.*) sap with different natural sources of sugar like sugar palm (*Borassus flabellifer*) and sugarcane (*Saccharum officinarum L.*). Proximate composition, pH and total soluble solid (TSS), color, sugar profile, vitamin profile, antioxidant properties (total phenolic contents, DPPH, FRAP, and ABTS), and mineral content of Coconut sap and juice from sugar palm and sugarcane were analyzed .The results indicated

that coconut sap possesses high DPPH (23.42%), FRAP (2.09 mm/ml), and ABTS (21.85%) in comparison with the juices. Coconut sap conjointly had high vitamin c (116.19 µg/ml) and ash (0.27%) contents, particularly in potassium (960.87 mg/L) and Na (183.21 mg/L) that conjointly indicating high content of minerals. These proper-ties showed that coconut sap may be served as a possible healthier sugar supply compared with sugar palm and sugarcane juice.

Purnomo (2007) analyzed Volatile elements of coconut recent sap, sap sweetener and coconut sugar using GC-MS and known by matching the mass spectra obtained with those gift in the “NIST62 LIB” Library. The foremost copious volatile elements within the fresh sap, sap sweetener and coconut sugar were 2-butanol and acetic acid. Twelve volatile elements were known and there were totally different amounts of volatile elements found within the morning and afternoon tapping of fresh sap and its processed product.

Trinidad et.al (2015) gave a study that aimed to see coconut sap sugar and sweetener as a promising functional food/ingredient. Coconut sap sugar and sweetener were characterized in terms of nutrient composition, dietary fiber/sugar composition and its fermentability characteristics, and chemistry and microbiological properties using standard ways. Results showed that each product have acceptable water activity with time. Salmonella and coliform are within the acceptance criteria of the Philippine National Standards. The color was attributed to the consequences of temperature, ratio and pH. The wet of *Cocos nucifera* sugar was inside CODEX Standards (1.7– 1.8 g/100 g). Important amounts of minerals and vitamins were obtained. Both each contained sucrose, glucose, fructose and mannose. No dietary fiber was detected from coconut sap sugar however has vital amounts of polysaccharide (4.7 g/100 g). Coconut sap sweetener has each dietary fiber and inulin. Fermentable inulin made short chain fatty acids with propionate>acetate>butyrate ($p<0.05$). The significant amounts of inulin and propionate are supplementary values of coconut sap sugar/syrup and should be thought-about as a promising functional food/ingredient.

Srikaeo, K. and Thongta, R (2014) evaluated wheat flours mixed with four kinds of sweeteners; sugarcane, palm sugar, coconut sugar and sorbitol for his or her in vitro starch digestibleness, estimated glycemic index (GI) and physicochemical properties. It absolutely was found that sorbitol that may be a sugar alcohol gave the simplest starch digestibility results providing very cheap calculable GI values. Palm and coconut sugars provided higher starch digestion rate and lower estimated GI values than those of

sugarcane, indicating their nutritional quality over the sugarcane. All the studied sweeteners influenced the physicochemical properties of flour and sweetener mixtures as examined by the DSC, RVA and texture instrument. The addition of sweeteners magnified gelatinization temperatures, attenuated viscosities and altered the gel textures. The studied sweeteners were used as an ingredient to produce the breads. The appearances of the product were similar however physicochemical properties and estimated GI values were varied consistent with the sweeteners used. The utilization of palm and coconut sugars in breads provided lower GI values than those of sugarcane.

2.6 Kheer /rice pudding & other milk based deserts

Kheer may be a heat-desiccated cereal-based sweet, condensed and nutrient Indian dairy dessert. It's ideally made up of buffalo milk. additionally to milk, kheer contains substantial amounts of non-dairy ingredients like rice or wheat or makhana, sugar, raisins, coconut powder, flavoring agents like saffron, cardamom and dry fruits like almonds, pistachio.

Mani et al., (1955) advised desert based on cereals such as rice and wheat is widespread throughout the country, and occupies a valued position suggested Indian diet, not just for their taste and delight of eating however conjointly for its high nutritional quality. The mixture of lysine-rich milk protein with lysine-deficient cereal macromolecule features a reasonably synergistic impact that imparts a high nutritional price to the mixed protein within the product. Kheer may be a rich supply of proteins, minerals, vitamins and different nutrients. it's maybe, the earliest ancient product made up of rice and milk a hundred g of Kheer contained calcium 3888 mg, phosphorus 237 mg, vitamin C 3.4 mg, B-complex vitamin 118 mg, axerophthol 242 I.U., B-complex vitamin 277 micrograms and vitamin B 353 micrograms.

De et al. (1976) Standardized methodology of preparation of Kheer. Fresh, sweet, clean milk (cow or buffalo) involves standardized to 4.0% fat and smartly cooked in an exceedingly jacketed chrome steel pan or kettle for three to five minutes in the middle of constant stirring-cum-scraping with Khunti (an iron stirrer). High grade (preferably Basmati) rice was @ a pair of.5% of milk, pre-cleaned and washed with cold water before use, was then added. The mixture was gently cooked, with periodical stirring-cum-scraping. Once the concentration was about 1.8:1, clean sensible quality sugar (preferably ground) was value-added @ 5% of milk. Mild heating was continued for an additional three to five minutes until a final concentration of concerning 2:1 was obtained. Heating

ought to be stopped somewhat before this stage, counting on the judgment of manufacturer. The Kheer should now be packed then kept under refrigeration.

Mani et al., (1955) in maybe within the earliest work on kheer studied the nutritional price of ancient kheer made up of rice and milk containing 4.1% total solids. They reported that a hundred g of kheer contained. 388 mg Ca, 237 mg phosphorus, 3-4 mg vitamin C, 118 mg B-complex vitamin, 242 IU axerophthol, 277 ug B-complex vitamin and 353 ug vitamin B.

Dastu (1956) cited kheer, as a product prepare by evaporating milk to concentrate it 4- five times by heating flaming. Srinivasan and Ananatakrisnan (1964), outlined it as a sort of milk ready by concentrating milk to an amount magnitude relation of 3:1 in an open pan.

Rangappa and Achaya (1974) represented kheer as a part desiccated product, almost like khoa, however the magnitude relation of concentration is three to four as compared to six for khoa , it's sometimes sweet before consumption, resembles sweet milk.

De et al., (1976) were the primary to review the strategy of manufacture of kheer exploitation the steam kettle method. They formulated kheer from cow milk with four-dimensional fat exploitation a pair of .4% rice (presoaked) and five-hitter sugar.

Kheer is AN Indian ancient course ready by partial dehydration of milk, with sugar and rice value-added thereto, in AN open pan over fire. It's therefore a product obtained by preparation of rice in milk at the same time concentrating the latter. Whereas kheer may be a typical Indian ancient product, bound processes developed within the west associated with similar or connected product like milk rice and rice pudding.

Extension of the period of kheer has been sought-after to be achieved by means that of preservatives, like B and metal metabisulphite with variable degree of success. (De et al., 1976; Singh et al., 1987; Chaudhary, 1989). The essential methodology of kheer creating has undergone a restricted modification therein the open pan method using direct fire has been successfully replaced by the steam – kettle one.

Galle et al., (1984) exposed rice grains to saturated steam at a pressure over atmospheric pressure (>0.03 bar) in an autoclave for decent time to gelatinize a significant portion of starch. The rice grain may then be reconstituted with milk for consumption within the sort of a kheer like product.

Chaudhary (1989) studied totally different integrative variables and ascertained that the most effective quality kheer might be ready from buffalo milk containing 5% fat and 9.5%.5 nothing SNF and additional with 5% rice and 12% sugar. In additional attempts to

switch the kheer creating making they obtained combining product by intermixture sweet milk (diluted to 30% TS by adding buffalo milk) with pre-cooked rice (6 %).

According to Aneja (1997) preparation of kheer involves immersion of pre – soaked rice in boiling milk (6 % weight) followed by sugar addition (6 to 8 %) and heating the mixture further until rice softens up and shows signs of gelatinization resulting in substantial thickening. shredded nuts and cardamom are then sometimes added.

2.6 Importance of based eat milk primarily based sweet and different products

Sarma et.al (2016) developed Ready to Cook Instant Kheer by the partial dehydration of milk usually with sugar and rice and is prepared only on auspicious and special days due to its long and tedious methodology of preparation. For preparation of one kg Kheer combine needed ingredients were Maida (1400g), refined oil (90 ml or 6 tbs) and water (350 ml). The instant Kheer mix was ready by adding 6 tbs of refined oil to 1400g of refined flour (Maida) and mixed properly followed by adding of 350 ml of cold water to create the dough manually. The ready dough was formed manually into just about 0.8 cm long and 0.2 cm thick structures, sun dried for 2 -3d by spreading in an exceedingly skinny layer over a fabric and covering with a clear plastic sheet. {The mix the combination the combo} ready were packed in airtight polypropene baggage and stored as ready-to-use Kheer mix. Study disclosed that the innovative technologies embrace the preparation of base material from refined flour and oil and is preservative free and doesn't need soaking for very long time. It had been ascertained that seventy per cent of the members liked extraordinarily, 25 per cent of the members liked much and five per cent of the members likeable moderately

Vijayabaskar & Sundaram (2012) explored and studied the marketplace for Ready-to-eat/cook products in Southern India. To search out what are the potent factors determining the market for such products, individual's perspective, financial gain level, life vogue changes, product reach are taken into thought to style the conclusion. The most aim for this study is to explore market potential for ready-to-eat merchandise and therefore the major forces decisive such section to grow and therefore the future potential of an equivalent. Research can offer America insights concerning the continued potential of the section and therefore the folk's preference to such merchandise. There's an incredible changes within the last 10 years in our country of individual's intense habits. The alternatives before them are lots and proliferation of small entrepreneurs will be influencing factors for this product section. Apart from convenience there are several hidden forces and future forces verify this market. Nevertheless there's no specific boundary for this market since this section

needs to be growing and wish to mature. Instead of handiness of western eatables merchandise, our own merchandise are inherit prepackaged things for sales during this market. This study can throw some light-weight on market boundary and its potential of ready-to-eat merchandise.

Kowsalya & Sathyapriya (2016) delineated a study that aims to understand the demand for able to eat & able to cook food merchandise, to understand the consumption pattern of ready RTE foods and to investigate the factors influencing the shopping for behavior of RTE food merchandise. In accordance with the higher than objectives, the study has used numerous applied math tools like proportion analysis, rank analysis and chi-square check. With this few introductory notes, the study has analyzed the patron procuring angle towards RTE food merchandise. The empirical results showed that place of purchase of RTE foods merchandise and health problems by intense RTE merchandise are considerably related to monthly financial gain and qualification of the respondents severally.

Jae et.al. (2000) used a sample of 39,025 urban families from the 1996 Korean Family financial gain and Expenditures Survey to look at the connection between family characteristics and expenditure on convenience foods. Results indicated that age and education of the family's head, range of kids, and presence of kids underneath the age of six, the wife's labor force participation, and space of residence were important in predicting the amount of expenditure on convenience foods. The current study pointed to and gave an explanation to variations in a number of the consequences as compared with those found in Western countries.

Sumathi (2003) analyzed & bestowed that India is presently witnessing change in lifestyle, shopping habits... Because the country is additionally marked by nice diversity in climate, religion, language, accomplishment level, customers and calendars, modus vivendi and economic standing, here customers gift a posh and off-the-wall cluster. Studies by the middle for observation Indian economy reveal that structural shifts are happening within the consumption pattern of Indian customers within the recent years and therefore the shift have gained bigger momentum since the launch of economic reforms.

Ramaswamy (2003) delineated convenience foods and ready-to-eat foods are currently common. With the family unit, there's additionally a shift within the women's angle to preparation and therefore the meals she serves. Teenagers also are changing into influences of amendment in their family's meal pattern.

Manohar (2005) presented that in recent years, the rise within the range of working women, increase in nuclear families, rising income, influence of media, increase in foreign travel and integration of ethnic foods into the native food habits and want for quality foods have resulted in demand for convenience foods. RTE have currently become an added possibility within the home-meal replacement section at the side of the conventional choices like restaurants, mess/ canteen and line of work services (especially throughout travel) and not-so-conventional nourishment joints and take-away/carry -home retailers (Rangarao, 2004).

Manohar (2005) mentioned Indian food shopping for behavior is dynamical step by step in response to the changes in social and economic patterns. The four elementary shifts which more emphasize growth within the convenience foods are:

1. Rapid climb in organized retail, a catalyst for the processed food development.
2. Convenience and enjoying life driven by demographic trends in age, income levels and additional ladies in work force
3. World shift to outsourcing from Asian nation across products/ services, as well as food.
4. De-regulation and liberalization of the Indian economy since from 1991.

With the dynamical socio-economic factors, the demand for convenience foods is increasing steady. India being one in every of the biggest food producers within the world is explicit to become a worldwide hub or production of food. Thus in India the food process is known as sun-rise business. The de-regularization and liberalization of Indian economy has boosted the food process business that is especially engaged in production of convenience foods.

Essays, UK. (November 2018) examined the results of quality perception of woman of the house towards their preference of use of able to cook meal and to grasp that that variables of quality perception have an impression on the preference to use. The variables we've taken for the study square measure style, freshness, storage life, hygiene, quality of ingredients. Primary knowledge has been collected through personal survey; we've used the form as an instrument for the information assortment. The convenience sampling methodology was followed. The questionnaires were stuffed by one hundred fifty respondents i.e. housewife. Best scaling or categorical regression was used that is applied mathematics technique wont to analyze the impact or result of the experimental variable on the dependent variable. The results show that there's no result of the experimental variable

(taste, freshness, storage life and quality of ingredients) on the preference to use of the able to cook meal. In different words we are able to say that the housewives don't seem to be influenced by these variables of quality perception i.e. they need no result on the preference to use.

CHAPTER III

MATERIAL AND METHODS

The present research project entitled “**DEVELOPMENT OF ANTIOXIDANT RICH BLACK RICE KHEER AND FORMULATION OF READY TO COOK (RTC) BLACK RICE KHEER**”, was undertaken in order to develop an antioxidant rich black rice kheer and also to develop its ready to cook formulation. All the physical, chemical technological & sensory evaluation, shelf life & statistical analysis has been described in this chapter. In the development of antioxidant rich and nutritious black rice kheer raw materials used were milk, black rice, coconut sugar & cardamom.

The developed product was then tested for its color & appearance, body & texture, flavor by sensory evaluation.

The materials used and methods employed for the studies are presented in this Chapter.

3.1 Raw Materials Detail:

1. Milk-Amul Procured From BHU Campus, Varanasi
2. SMP Milk Powder-Anik Spray From BHU Campus, Varanasi
3. Black Rice–Chahao Procured From Shalimar Bagh, Delhi
4. Coconut Sugar-Kokos Procured From Amazon
5. Cardamom-Procured From BHU Campus, Varanasi

3.2 Location of experiment

This study was conducted in Department of Dairy Science and Food Technology, Institute of agricultural sciences, Banaras Hindu University, Varanasi.

3.3 Utensils and glassware

Stainless steel vessels of varying capacities were used at various product development stages of the study. Glassware such as conical flasks, beakers, volumetric flasks, measuring jars (Borosil, India) were used in the study. The glassware were cleaned using detergents and dried using hot air oven set at 160–180°C temperature for 2 hours and then used for analysis of the products

3.4 Chemicals

High purity commercially available chemicals AR grade chemicals were used in the investigation for different analyses.

3.5 Miscellaneous

Small and Medium Sized Petriplates, Distilled water, Distilled Ethanol, Chloroform, Weighing Balance, Vortex Machine, Cork Borer, Glass spreader etc.

Table 3.1 : Raw materials & their source of procurement

S. No.	Raw materials	Brand	Procured from	Figure
1	MILK	AMUL	BHU Campus , Varanasi	
2	SMP MILK POWDER	Anik spray	BHU Campus , Varanasi	
3	BLACK RICE	CHAAHO	Shalimar bagh , Delhi	
4	COCONUT SUGAR	KOKOS	Amazon	
5	CARDMOM		BHU Campus , Varanasi	

3.6 INSTRUMENTS USED:

1. Spectrophotometer UV-1800 Shimadzu corporation, Japan
2. Hot air oven 992 Perfit, India
3. Electronic weighing balance Labtech LCB 1201v Daihan Lab Tech India Pvt. Ltd
4. Centrifuge machine 3-30K Sigma, Germany Water bath VS-1205 wp Vision scientific co., Ltd, Korea
5. Vortex shaker MSW-308 (Deluxe Model) Macro Scientific works Pvt. Ltd, Delhi
6. Muffle Furnace SNOL 8,2/1100-1LZ PagamintaLietuvoje, Lithuania
7. Gerber Centrifuge Nova 12T Chadha sales Pvt. Ltd, Delhi
8. Incubator LTI-700 EYELA, China
9. Magnetic Stirrer from Spinot, India
10. Autoclave- High Pressure steam sterilizer(Autoclave) SX-500 TOMY
11. Polytron tissue homogenizer from Kinematica, Switzerland
12. Texture profile analyze TA.XT.Plus (Model) Stable Micro System Ltd,UK
13. pH meter Orion star series SN Thermo scientific, Singapor
14. Klensflo Laminar Air Flow
15. Superspin R Plasticrafts Centrifuge

3.7 Packaging material

LDPE pouches

3.8 Methods

3.8.1 Preparation of Extracts- Black Rice & Control (White Rice) Extract

Extraction is the most important step in isolating different types of bioactive compounds. The ideal extraction method should be quantitative and non-destructive.

1. Fifty gram Black rice/ Control were grounded in a blender to obtain fine powder. The powder of black rice was kept in an ambered colored bottle separately and in refrigerator for long time storage.
2. In beaker. 100 ml of distilled water was taken.
3. Then water was boiled and stirred on magnetic stirrer after this slowly 10g black rice / control powder was added in beaker of distilled water slowly with continuous stirring in magnetic stirrer for 1 hour.
4. Then sample was centrifuged at 10,000 rpm for 15 min and filtered by using filter paper no. 4.

5. Extracts of black rice / control prepared were 10% and were kept in conical flask and stored in refrigerator.

3.8.2 Biochemical Assays

Total phenolic content

The determination of Total Phenolic Content (TPC) was done using by the Folin-Ciocalteu procedure (Singleton and Rossi, 1965). The total phenolic content was expressed as catechin equivalent.

The Folin-Ciocalteu reagent is a mixture of phosphotungstate and phosphomolybdate and is used in the invitro assay of phenolic and polyphenolic antioxidants. The chemistry behind the assay relies on the transfer of electrons in alkaline medium from phenolic compound to phosphomolybdic phosphotungstic acid complexes to form a blue coloured complex which can be estimated spectrophotometrically at 725nm.

Table 3.2 : Protocol for Total Phenolic Content Determination

Diluted extract/standard	100µl
1:10 diluted 0.2N Folin-Ciocalteu reagent	750µl
Incubate at room temperature for 5 minutes	
6% sodium bicarbonate	750µl
Take absorbance at 725nm	

DPPH Radical Scavenging Activity

The DPPH radical scavenging method is widely used to evaluate the free radical scavenging ability of natural antioxidants. DPPH is a nitrogen based free radical which has a violet colour (in oxidised form) that changes to yellow after reduction by either the process of hydrogen or electron transfer. Substances which are able to execute this reaction can be considered as antioxidants and therefore radical scavengers, in radical form, the DPPH molecule has an absorbance at 517nm which disappears after the acceptance of an

electron or hydrogen radical from an antioxidant compound to become a stable diamagnetic molecule.

The percentage scavenging activity of the extract was calculated using the formula

$$\% \text{ DPPH scavenging activity} = \frac{A_{517 \text{ of control}} - A_{517 \text{ of sample}}}{A_{517 \text{ of control}}} \times 100$$

Where A is the absorbance at 517nm

Table 3.3 : Protocol for DPPH Radical Scavenging Activity

Diluted sample	1ml
DPPH	1ml
Vortex	
Incubate at room temperature for 20 minutes.	
Take absorbance at 517nm.	

3.8.3 Formulation and Development of Black Rice Kheer & Ready to Cook (RTC)

Black Rice Kheer:

Two products namely black rice kheer & RTC black rice kheer were made in laboratory Dairy Science and Food Technology Division, Institute Of Agricultural Sciences, Banaras Hindu University. Combinations were made by varying the range of black rice and keeping all other factors constant.

Ingredients for cooked black rice kheer

Milk, black rice, coconut sugar & cardamom.

Table 3.4 : Different Combination of black rice kheer

Sample	MILK (ml)	BLACK RICE (gram)	COCONUT SUGAR (gram)	CARDAMOM (pod)
K	500	40	15	1
K1	500	40	15	1
K2	500	30	15	1
K3	500	20	15	1

Where, K stands for control having 40 gram white rice.

K1 stands for Sample 1 having 40 gram black rice.

K2 stands for Sample 2 having 30 gram black rice.

K3 stands for Sample 3 having 20 gram black Rice

The samples were evaluated on the basis of color, texture/body, taste and overall acceptability by semi trained panel of 10 judges using 9 point hedonic scale assigning scores 9-like extremely to 1-dislike extremely (Appendix I). A score of 5.5 and above was considered acceptable. The scores rated by the panel of judges were then statistically analyzed. The samples were code numbered to avoid identification and bias.

Out of this based on sensory evaluation K3 sample was most accepted and therefore further this formulation was developed and further testing and analysis were done.

Table 3.5 : Procedure for preparation of optimized black rice kheer (K3)

Black rice (washed & cooked for 30min in boiling water)	20 gram
MILK (Milk is boiled and then black rice added)	500 ml
Cook until thick consistency is obtained for 20-25 min	
Coconut sugar + cardamom (after cooking till thick consistency add sugar and powdered cardamom)	15 gram coconut sugar +1 pod cardamom
Cook for 2-3 min and cool it at room temperature for 5 min	
Black rice kheer	



1. Cooking Of Black Rice



2. Boiling Of Milk



3. Black Rice added and mixture cooked For 20 min.



4. Mix coconut sugar and cardamom, cook for 2-3 min and cool it.



5. Black rice kheer is ready.

Figure 3.1: Preparation of black rice kheer

Ingredients for RTC black rice kheer :

Anik Spray Skim Milk Powder, Cooked and Oven Dried Black Rice, Coconut Sugar & Cardamom.

Recipe of antioxidant rich ready to cook black rice kheer :

1. Process for manufacture of precooked and dried rice :
2. Black rice were washed thrice and half quantity of rice was reduced in size and cooked in vessel with water 1:6 ratio till rice were cooked .
3. Then cooked rice was spread on surfaceplate and kept for hot air over drying at 180°C for 12 hrs. .

4. Dried cooked rice were segregated & half broken by grounding with pestal and motor and packed in LDPE pouches.
5. Now based on review of literatures in develops instant kheer optimization of quantity of rice, milk powder and sugar in ready to cook kheer.
6. Accordingly quantity of cooked rice, coconut sugar, cardamom and milk powder were mixed together and packed in LDPE pouches

Table 3.6 : Different Combination of RTC black rice kheer

Sample	MILK POWDER (gram)	BLACK RICE (gram)	COCONUT SUGAR (gram)	WATER TO RECONSTITUTE (ML)	CARDAMOM (pod)
S	20	30	15	500	1
S1	20	30	15	500	1
S2	20	25	15	500	1
S3	20	20	15	500	1

Where, S stands for control having 30 gram white rice.

S1 stands for Sample 1 having 30 gram black rice.

S2 stands for Sample 2 having 25 gram black rice.

S3 stands for Sample 3 having 20 gram black Rice

The samples were evaluated on the basis of color, texture/body, taste and overall acceptability by semi trained panel of 10 judges using 9 point hedonic scale assigning scores 9-like extremely to 1-dislike extremely (Appendix I). A score of 5.5 and above was considered acceptable. The scores rated by the panel of judges were then statistically analyzed. The samples were code numbered to avoid identification and bias.

Out of this based on sensory evaluation S3 sample was most accepted and therefore further this formulation was developed.

Table 3.7 : Procedure for preparation of optimized RTC black rice kheer

Black rice (washed & cooked for 30min in boiling water)	20 gram
Hot air oven drying of cooked rice at 180 C for 12 hours. (grounding of dried cooked rice with pestle and motor)	
SKIM MILK POWDER(ANIK SPRAY)	20 gram
Coconut sugar + cardamom	15 gram sugar +1 pod cardamom
Mix dried cooked rice, coconut sugar, cardamom and milk powder were mixed together and packed in LDPE pouches and vacuum packages.	
Ready to cook black rice kheer is prepared.	



1. Black Rice



2. Cooking Of Black Rice



3. Spreading Of Cooked Rice on Flat Surface.



4. Drying Of Rice in Hot Air Oven



5.Packed Dried Rice Mixed With Spray Dried Skim Milk Powder And Coconut Sugar.

Figure 3.2: Preparation of black rice kheer

Cooking Instructions: Boil 500 ml of water and empty the content of packed ready to cook kheer and cook for 8 minutes. Black rice kheer is ready for consumption in 8 minutes.

3.8.4 Physiochemical Analysis:

Determination of Moisture Content

Moisture content of the sample was estimated by oven drying method (A.O.A.C., 2005). The sample was taken in triplicates. 5 gram of powder was weighed in previously dried and tarred dishes with its lid underneath. These dishes were kept in an oven for 2 hours at 130°C. remove the dishes after 2 hours and placed in desiccator for cooling. And then weighed. The dishes were placed in oven for half an hour intervals till constant weight is achieved

The moisture content of the rice were determined using the formula:

$$\text{Moisture content of films \%} = \frac{W_1 - W_2}{W_1 - W} \times 100$$

Where,

W₁- Weight in gram of dish with black/white rice powder before drying.

W₂- Weight in gram of dish with black/white rice powder after drying.

W-Weight in gram of empty dish.

Total ash

Ash content was determined as per method described by **Rangana (2001)**. In clean moisture free silica crucible, 1 grams of rice sample was taken and heated on hot plate at temperature until the charring was completed. Thereafter, crucibles were transferred to muffle furnace maintained at a temperature of about 550°C ±50°C and kept for 6 h. The dish was cooled down in desiccators and weighed. The ash content was calculated by using the following formula.

Calculations:

$$\% \text{ Ash} = \frac{\text{Weight of ash (g)}}{\text{Weight of sample taken}} \times 100$$

Estimation of Total Minerals

The total mineral content of the sample was determined by the ashing method (A.O.A.C., 2005). Set the temperature of muffle furnace to 600°C and heat the empty crucible for 1 hour and transfer into desiccators and let them cool to room temperature. Then take the weight of the crucible as (W1). Weigh about 2-5gms of the sample into the pre-weighed crucible and take the weight again (W2). Heat the crucible cautiously at low flame until the materials begin to char and continue heating till the charring is complete. After charring transfer the crucible to the preheated muffle furnace (550-600°C), incinerate the sample for 4-6 hours until ash of white or light grey is obtained. Transfer the crucible into desiccators and let them cool to room temperature and weigh (W3). Repeat the procedure until two consecutive readings are obtained the same. Total mineral content of the sample was calculated by using the formula,

W3-W1

Percentage of ash in the sample (%) = ----- x 100

W2- W1

Where,

W1 = weight of the empty crucible

W2 = weight of the crucible with sample

W3 = weight of the crucible with ash

pH

The pH values were determined with the help of electronic pH meter, as recommended by **Ranganna (2001)**. The electronic pH meter was calibrated using 7 pH and 4 pH standard buffer solutions. The function selector switch was set to pH and reading of digital display was allowed to get stable before it was noted.

Determination of Protein Content

The protein content of the given sample was determined by micro- kjedhal method (**A.O.A.C., 1990**). The powdered sample was taken and 200mg of the sample is accurately weighed and transferred into digestion flask to which catalyst mixture and thoroughly mixed the sample. Then concentrated sulphuric acid and hydrogen peroxide is added

carefully and sample was digested in digestion chamber. The digestion of the sample is continued until the sample became colourless and clear. Then the flask was allowed to cool and to dissolve the solids the water is added in the flask. After cooling the contents were added to volumetric flasks. The digestion flask was washed 3-4 times and volume was made up to 50ml in the volumetric flask. Boric acid solution was pipette into a beaker and 6-8 drops of mixed indicator was added. The beaker was placed under condenser of distillation assembly. ml of digest was pipette into distillation flask and 10 ml of sodium hydroxide is added and mixed thoroughly. This process was done till the 50ml of the distillate was obtained and then tip of the condenser was washed to collect the ammonia and conformation of the distillation was made with the litmus paper. The distillate collected was then titrated with 0.02N Standard Hydrochloric acid. The color changes from pinkish red to bluish green and that the end point of the titration. Simultaneously, blank titration was also carried out each time. The percentage of nitrogen content was calculated from the volume of 0.02 N hydrochloric acid required during titration. The percentage of nitrogen was calculated by multiplying the nitrogen content by a factor 6.25 (A.O.A.C., 1990).

$$\text{Nitrogen (\%)} = \frac{(\text{S}-\text{B}) \times \text{N} \times 14.007}{\text{Volume taken}} \times \frac{\text{Volume made}}{\text{Weight of sample (gm.)}} \times 100$$

Where,

S: ml of hydrochloric acid required for sample titration.

B: ml of hydrochloric acid required for blank titration

N: Normality of HCl (0.02)

$$\text{Protein (\%)} = \text{nitrogen (\%)} \times 6.25$$

Determination of Total Fat Content

The total fat content of the sample was estimated by soxhlet method (A.O.A.C., 2005). The soxhlet flask of 250 ml was cleaned and dried in an oven. Record the weight of the empty flask. Add 5gms of sample in pre-weighed thimble and plugged with fat free cotton. Then

record the weight of the thimble with sample and place the thimble in the siphon portion of the soxhlet apparatus. The mixture of petroleum ether and diethyl ether was added in the round bottom flask of the soxhlet's apparatus and it was connected to siphon and condenser. The condenser was plugged with moistened cotton. It was refluxed for 5-7 times at 60°C. Then the ether was distilled off and the flask was placed on a hot plate for 3 hours at 105°C for drying, and then cooled in a desiccator and weighed. Total fat content of the sample can be calculated by the formula

$$\text{Fat content (\%)} = \frac{W_2 - W_1}{X} \times 100$$

Where,

W_1 = weight of empty round bottom flask

W_2 = weight of round bottom flask after extraction X = weight of the sample.

Determination of Total Carbohydrate Content

The total carbohydrate content was determined by enthrone method (N.I.N., 1983).

Standard preparation:

Stock solution was prepared by dissolving 100 mg of glucose in 100 ml beaker. Take working solutions of 0,0.2,0.4,0.6,0.8 and 1.0 ml and make up the volume for 1 ml by adding distilled water.

Sample Preparation:

Weigh accurately 100 gm. of sample into boiling tube and was hydrolyzed by keeping in water bath for 3hrs with 5 ml of 2.5 ml of HCl and cooled to room temperature. And neutralize the extract with solid sodium carbonate until the effervesces ceases. Make up the volume to 100 ml in a volumetric flask and centrifuge. Collect the supernatant solution and take 0.5 ml and 1.0 ml aliquots for analysis in to test tubes. Make up the volume to 1ml with distilled water.

Calibration of standard curve:

Add 4 ml of reagent to all the Standard and sample test tubes and heat in a boiling water bath for 8 minutes. Cool rapidly, a green to bluish green color develops and read at 630nm.

Plot the standard graph for different concentrations of the standard and derive the concentration of unknown sample by intercepting the graph.

mg. Of glucose

Amount of carbohydrates (mg %) = ----- x 100

Volume of test sample

(W₁-W₂)

Crude fiber content (g/100g) = ----- x 100

Weight of sample

3.8.5 Sensory evaluation

The samples were evaluated on the basis of color, texture/body, taste and overall acceptability by semi trained panel of 10 judges using 9 point hedonic scale assigning scores 9-like extremely to 1-dislike extremely (Appendix). A score of 5.5 and above was considered acceptable (**Amerine et al., 1965**). The scores rated by the panel of judges were then statistically analyzed. The samples were code numbered to avoid identification and bias.

3.8.6 Statistical Analysis:

Statistical analyses were performed using the Minitab 16 software and MS Excel. Data were analyzed by one-way ANOVA. The level of significance was set at P < 0.05.

CHAPTER IV

RESULTS AND DISCUSSIONS

The present investigation aims at ‘**DEVELOPMENT OF ANTIOXIDANT RICH BLACK RICE KHEER AND FORMULATION OF READY TO COOK BLACK RICE KHEER.**’ Initially black rice extracts were formed for biochemical assays (TPC& DPPH). Moisture and Ash content of rice were estimated. Then Black rice kheer and RTC kheer was developed and optimized. Sensory Analysis was& statistical analysis was done for different variants of product developed and therefore biochemical assays and proximate analysis was carried out for final products.

4.1 Sensory Evaluation:

Sensory Score for Black rice Kheer

Sensory evaluation was done to assess the overall acceptability of the product. The product was prepared under 4 different variations of black rice which was tested by 10 panel of judges. The sensory parameters were color& appearance, flavor, body & texture and overall acceptability. In table 4.4 mean scores from different variations of black rice are recorded.

Table 4.1 : Mean sensory score for kheer prepared by different levels of black rice

Level of Incorporation (%)	Color and Appearance	Body and Texture	Taste and Flavor	Overall Acceptability
K	6.55±0.09 ^a	6.14±0.07 ^a	6.55±0.05 ^a	6.41±0.07 ^a
K1	7.88±0.12 ^b	7.21±0.09 ^b	7.22±0.04 ^b	7.43±0.08 ^b
K2	8.34±0.11 ^c	7.38±0.13 ^b	8.54±0.08 ^c	8.08±0.11 ^c
K3	9.68±0.11 ^d	7.76±0.05 ^b	9.78±0.07 ^d	9.07±0.07 ^d

Values are expressed as Mean± Standard error of 3 replications.

Values in the same column with different letters are significantly different at $P < 0.05$.

Where,

K stands for control sample containing 40 g white rice

K1 stands for test sample containing 40 g black rice.

K2 stands for test sample containing 30 g black rice.

K3 stands for test sample containing 20g black rice.

In total 4 samples of kheer was made by incorporation of different variations of black rice namely. The mean score of the sensory evaluation is shown in the table 4.1

The result of sensory evaluation given in the form of table 4.1 show that the main sensory score was found to be highest in the sample K3 that is in the range of 7.7 to 9.8 . According to the sensory evaluation the K3 sample containing 20 gram Black Rice was found to have good color, appearance , taste, flavor and texture. The sensory score was in the range of 7.21 to 7.81 of K1 sample followed by sample K2 sample that has a sensory score ranging from 7.38 to 8.34 followed by sample K3 whose sensory score ranged from 7.76 to 9.68. Considering one attribute at a time the color and appearance was highly scored for sample K3 than K2 than K1 than K. This can be written as $K3 > K2 > K1 > K$. Body and texture was found to be best for K3 sample than K, K2 and K1 have the same score. This can be written as $K3 > K1 > K2 > K$. In Taste and flavor attribute K3 was the most liked one followed by K2 then K1 then K. This can be written as $K3 > K2 > K1 > K$. The overall acceptability of the sample K3 was highest as compared K1, K2 and K. This can be summarized as $K3 > K2 > K1 > K$. According to the sensory scores the sample which was most liked and accepted was sample K3 containing 20 g black rice having an overall acceptability score of 9.07 which is significantly higher than K, K1 & K2 sample .

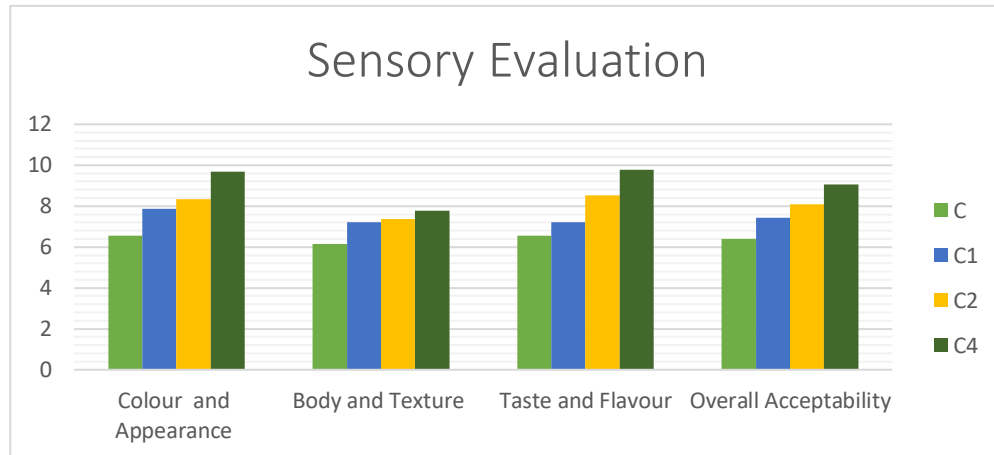


Figure-4.1 Graphical representation of sensory evaluation of black rice kheer

Where,

K stands for control sample containing 40 g white rice

K1 stands for test sample containing 40 g black rice.

K2 stands for test sample containing 30 g black rice.

K3 stands for test sample containing 20g black rice.

The result of sensory evaluation given in the form of graph shows that the sample K3 has the highest sensory score. According to sensory evaluation the K3 sample containing 20g black rice was found to have good appearance, taste & flavor and body & texture

The data obtained by sensory evaluation in the present study was analyzed for the significant difference in the treatments by subjecting to analysis of variance (ANOVA) technique (ONE WAY ANOVA) using Minitab 16. Each individual sensory parameter were analyzed (Refer Appendix IV)

Color: Statistical analysis of sensory data for color reveals that there is significant difference in sensory scores of the three *black rice kheer* variants as the p -value < 0.05.

Flavor: Statistical analysis of sensory data for flavor reveals that there is significant difference in sensory scores of the three *black rice kheer* variants as the p value < 0.05.

Body and Texture: Statistical analysis of sensory data for body and texture reveals that there is no significant difference in sensory scores of the three *black rice kheer* variants as the p -value > 0.05 .

The sensory parameters showing significant difference and were affecting the sensory scores of the product and consumer acceptability were Color & Flavor.

Sensory Score for RTC Black rice Kheer:

Sensory evaluation was done to assess the overall acceptability of the product. The product was prepared under 4 different variations of black rice which was tested by 10 panel of judges. The sensory parameters were color & appearance, flavor, body & texture and overall acceptability. In table 4.4 mean scores from different variations of black rice are recorded

Table 4.2 : Mean sensory score for RTC kheer prepared by different levels of black rice

Level of Incorporation (Gram)	Color and Appearance	Body and Texture	Consistency	Taste and Flavor	Overall Acceptability
S	8.07±0.06 ^a	9.11±0.09 ^c	9.05±0.07 ^c	7.21±0.05 ^b	8.41±0.07 ^a
S1	7.05±0.12 ^b	7.17±0.09 ^b	7.01±0.04 ^b	8.01±0.04 ^a	7.15±0.08 ^b
S2	7.27±0.11 ^b	7.23±0.13 ^b	7.25±0.08 ^b	7.14±0.08 ^b	7.27±0.11 ^b
S3	9.02±0.14 ^c	8.07±0.05 ^a	9.08±0.07 ^c	8.09±0.07 ^a	8.54±0.07 ^a

Values are expressed as Mean± Standard error of 3 replications.

Values in the same column with different letters are significantly different at $P < 0.05$.

Where,

S stands for control sample containing 30 g white rice

S1 stands for test sample containing 30 g black rice.

S2 stands for test sample containing 25 g black rice.

S3 stands for test sample containing 20g black rice.

In total 4 samples of kheer was made by incorporation of different variations of black rice namely. The mean score of the sensory evaluation is shown in the table 14

The result of sensory evaluation given in the form of table 14 show that the main sensory score was found to be highest in the sample S3 that is in the range of 8.07 to 9.08. According to the sensory evaluation the S3 sample containing 20 gram black rice was found to have good color, appearance, taste, flavor and texture. The sensory score was in the range of 7.01 to 8.11 of S1 sample followed by sample S2 sample that has a sensory score ranging from 7.14 to 7.27 followed by sample S3 whose sensory score ranged from 8.07 to 9.08. Considering one attribute at a time the color and appearance was highly scored for sample S3 than S than S2 than S1. This can be written as $S3 > S > S2 > S1$. Body and texture was found to be best for S sample than S3 than S2 than S1. This can be written as $S > S3 > S2 > S1$. In Taste and flavor attribute S3 was the most liked one followed by S1 then S then S2. This can be written as $S3 > S1 > S > S2$. The overall acceptability of the sample S3 was highest as compared S1, S2 and S. This can be summarized as $S3 > S > S2 > S1$. According to the sensory scores the sample which was most liked and accepted was sample S3 containing 20 g Black Rice having an overall acceptability score of 8.54 which is significantly higher than S1 & S2 sample.

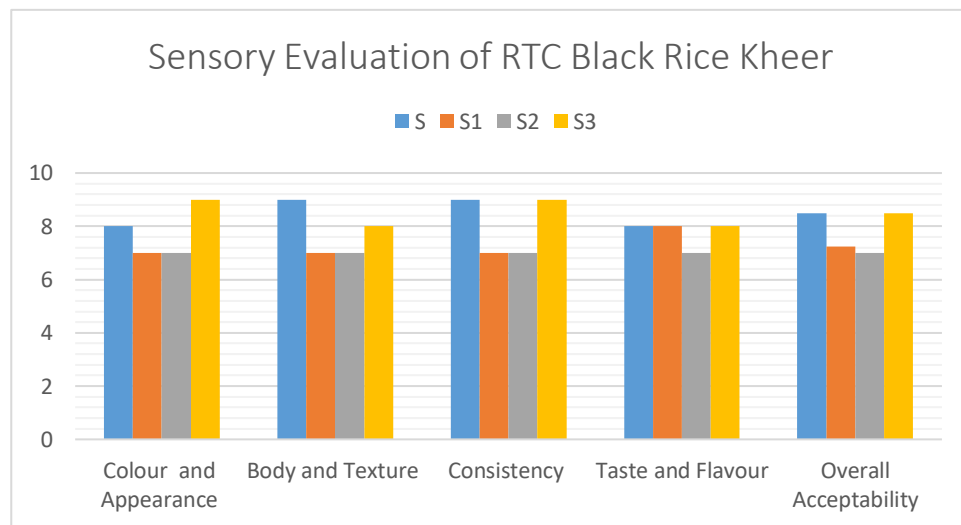


Figure-4.2 Graphical representation of sensory evaluation of RTC black rice kheer

Where,

S stands for control sample containing 30 g white rice

S1 stands for test sample containing 30 g black rice.

S2 stands for test sample containing 25 g black rice.

S3 stands for test sample containing 20 g black rice.

The result of sensory evaluation given in the form of graph shows that the sample S3 has the highest sensory score. According to sensory evaluation the S3 sample containing 20g black rice was found to have good appearance, taste & flavor and body & texture.

The data obtained by sensory evaluation in the present study was analyzed for the significant difference in the treatments by subjecting to analysis of variance (ANOVA) technique (ONE WAY ANOVA) using Minitab 16. Each individual sensory parameter were analyzed (Refer Appendix V)

Color: Statistical analysis of sensory data for color reveals that there is significant difference in sensory scores of the three RTC *black rice kheer* variants as the $p\text{-value} < 0.05$.

Flavor: Statistical analysis of sensory data for flavor reveals that there is significant difference in sensory scores of the three RTC *black rice kheer* variants as the $p\text{-value} < 0.05$.

Body and Texture: Statistical analysis of sensory data for body and texture reveals that there is no significant difference in sensory scores of the three RTC *black rice kheer* variants as the $p\text{-value} > 0.05$.

The sensory parameters showing significant difference and were affecting the sensory scores of the product and consumer acceptability were Color& Flavor.

4.2 Quantitative analysis of control & black rice extract:

Total Phenolic Content:

Plant phenolic are important constituents that contribute to functional quality, colour and flavour and have significant roles both as singlet oxygen quencher and free radical scavengers, helping to minimize molecular damage (Tanvir et.al., 2017).2014).Phenolic contents were expressed as mg catechin equivalent per gram of black rice extract.

Table 4-3 :Total Phenolic Content of Rice Extract

Extract	Total Phenolic Content (mg catechin equivalent/gram)	DPPH(%)
White rice (Control)	51.94 ± 1.97 ^a	11.67 ± 1.18 ^c
Black rice	75.59 ± 7.28 ^b	56.23 ± 3.56 ^d

Values are expressed as Mean± Standard deviation of 3 replications.

Values in the same column with different letters are significantly different at $P < 0.05$.

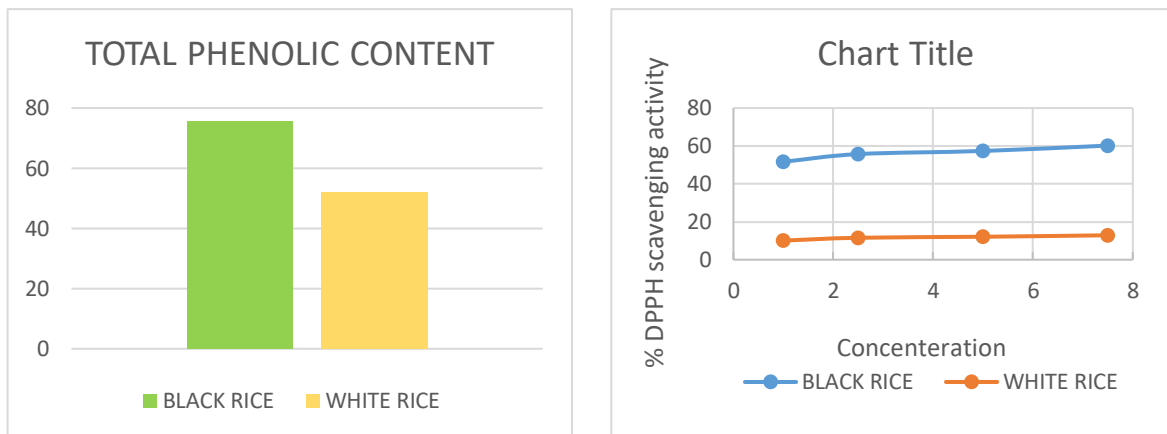


Figure-4.3 Graphical representation of TPC& DPPHof control & black rice extract .

Using the standard curve, total phenolic content of the extract was determined. The Total Phenolic Content of the black and white rice extracts were found to be 75.59 ± 7.28 & 51.94 ± 1.97 mg catechin equivalent per gram of black rice extract & control extract, respectively. The results indicate that the black rice extract contains higher total phenols as compare to the white rice extracts. The phenolic constituents of rice are mainly distributed in rice pericarp (Paiva et al., 2014), their content may be related to grain size, color and weight (Shen et al., 2009) and controlled by genetic factors. These may be the reason for higher phenolic contents in black rice than the white rice. The main form of phenolic compounds present in rice is bound form (Saikia et al., 2012). The free radical scavenging activities of the extracts were determined by using 2, 2- Diphenyl-1-

picrylhydrazyl (DPPH) free radical scavenging method. DPPH in oxidized form gives a deep violet color in ethanol. An antioxidant compound donates the electron to DPPH thus causing its reduction and in reduced from its color changes from deep violet to yellow (Shirazi et.al, 2014).

Based on DPPH assay the antioxidant capacity of the extracts were found to be 56.23 ± 3.56 & 11.67 ± 1.18 for black and control extract respectively. From Fig 4.4 it can be concluded that antioxidant capacity of Black Rice is much more than that of White Rice. These results were comparable with the observations given by Sampong et al. (2011) and Walter et al. (2013) i.e. DPPH value ranged from 59.02 to 75.52 % for black rice varieties. The lowest value of antioxidant activity was observed in white rice. It may be due to reduction in polyphenol content as the concentration of the total soluble phenolic contents was related to lower antioxidant activity (Walter et al., 2013). Junet *al.* (2012) evaluated the antioxidant activities and phenolic compounds of pigmented rice (black, red, and green rice) and brown rice brans and reported similar results i.e. black and red rice bran shows high antioxidant activities and they contain high amount of phenolic compounds. Indeed, black could be better raw materials for manufacturing the food with high antioxidant activity.

4.3 TPC & DPPH ACTIVITY OF OPTIMISED BLACK RICE KHEER (C3)

TPC & DPPH of optimized product and control was calculated using same methodology which was used while calculating TPC & DPPH of raw Black & White Rice...

Table 4.4 : TPC & DPPH of Kheer

Product	TPC(mg catechin equivalent/gram)	%DPPH
White rice kheer(Control)	27.65 ± 0.54^a	9.7 ± 0.55^c
Black rice kheer	54.46 ± 0.56^b	47.9 ± 0.52^d

Values are expressed as Mean \pm Standard deviation of 3 replications.

Values in the same column with different letters are significantly different at $P < 0.05$.

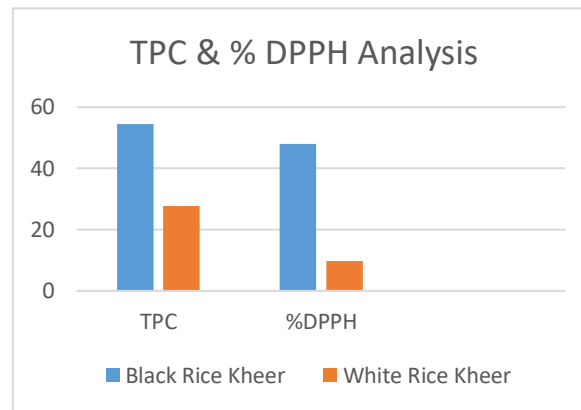


Figure-4.4 Graphical representation of TPC& DPPH of Optimized Black Rice Kheer

Based on evaluation TPC was found to be 54.46 ± 0.56 & 27.65 ± 9.70 for optimized black rice kheer and control. Similarly %DPPH capacity was found to be 47.9 ± 0.52 & 9.7 ± 0.55 for optimized & control kheer respectively. Therefore from graph it can be concluded that TPC & DPPH activity of Kheer made from Black rice is 3 times higher than that of normal conventional kheer made from white rice. These results were comparable with the observations given by Jun *et al.* (2012) i.e. the phenolic content & DPPH activity of different black rice products ranged from 20.87-64.13 mg GAE/ 100 g & 49.56 %– 11.27% respectively. The polyphenol content & DPPH activity of the rice products decreased when compared to raw black rice. These could be attributed due to the soaking, cooking and thermal processing involved in preparation of the kheer as these compounds are sensitive to heat treatments (Ismail *et al.*, 2004). Zhang and Hamazu (2004) reported that the losses in phenolic during cooking may be due to breakdown or conversion of phenolic to other products as well as into vapor during cooking. On cooking the cellular breakdown facilitated release of these phenolic compounds and they might replace the free phenolic which may get destroyed during cooking (Saikia *et al.*, 2012). These could be the reason for decreased in antioxidant activity of black rice kheer in comparison to raw black rice.

4.4 Physico-chemical analysis of optimized black rice kheer:

Traditional foods are foods that were consumed throughout history before modernization and industrialization of the food supply. Traditional foods were defined by as “products frequently consumed or associated with specific celebrations and/or seasons, normally transmitted from one generation to another, made accurately in a specific way

according to the gastronomic heritage, with little or no processing/manipulation, distinguished and known because of their sensory properties and associated with a certain local area, region or country.”

Table 4.5 : Physico-chemical analysis of optimized black rice kheer:

Composition (%)	Black Rice	Black Rice Kheer
Moisture	10.8± 0.04	6.5± 0.04
Ash	2.8 ± 0.09	1.84± 0.05
Protein	9.05 ± 0.14	13.54± 0.36
Fat	1.9 ± 0.01	5.11± 0.26
Crude Fiber	1.4 ± 0.01	1.51± 0.18
Total Carbohydrate	75.3 ± 0.12	72.57± 0.51
pH	6.71± 0.02	6.81± 0.44
MINERAL CONTENT (mg/100 gram of black rice kheer)		
Zinc	6.20± 0.1	1.65± 0.05
Iron	3.43± 0.05	3.44± 0.05

Values are expressed as Mean± Standard deviation of 3 replications.

The data given in Table 12 depicts the proximate composition of black rice kheer. Black rice kheer contains 6.5±0.04% moisture, 1.84±0.05% ash. , 5.11±0.26% fat, 13.54±0.36% protein. Chung & Lim, (1999). Chanu & Yenegi (2015) reported similar composition of raw material and product nutrient contents of black rice i.e. moisture content of rice products prepared from black rice was in the range of 6.34% to 9.14%. The moisture content of food products plays an important role in extending shelf life of kheer. The fat content of the kheer (5.11± 0.26 %) prepared from black rice was found higher than the raw black rice (1.9 ± 0.01%). The fat values are comparable with those given by Chung & Lim, (1999); Sampong et al. (2011) & Saikia et al (2012). Protein influences the nutritional quality of rice .The high content of protein is reported in kheer (13.54± 0.36) prepared from black rice in comparison to raw black rice (9.05 ± 0.14), this may be due to the incorporation of protein rich

ingredients specially milk. Sampong et al. (2011) also observed the protein content black rice varieties in the range of 8.44% to 10.84%.

The amount of ash present in food product plays important role while determining the levels of essential minerals. The ash content of black rice products was on par with the raw rice. The kheer were good source of ash. There was not much difference in crude fiber content of black rice kheer from that of raw black rice. The values of crude fiber are comparable with those given by Yodmanee et al. (2011) for different black rice products in the range of 1.63% -2.06% The kheer prepared from black rice were good source of carbohydrate. They can be used as a source of energy.

Mineral composition of the kheer prepared from black rice was found to be differ significantly in comparison to raw black rice . Processing like soaking could decrease the mineral contents of the rice kheer. Noreen et al. (2009) found the same observation that zinc content was lower in soaked rice, boiled rice of brown rice than the raw brown rice. The reason may be due to soaking process as soaking could leach the iron and zinc ions into the soaking medium (Saharan et al., 2001). Viadel et al. (2006) found that cooking processes affect mineral contents and their solubility and also the contents of other components that can affect mineral solubility.

4.5 Future line of work

1. Microbial analysis & Shelf life testing of Black Rice Kheer.
2. Further study & evaluation of developed Ready to Cook Black Rice Kheer.

CHAPTER V

SUMMARY AND CONCLUSIONS

Current trends and changing consumer needs indicates a great opportunity for development of new value added products that possess many health enhancing and disease preventing properties. The food and dairy industry are gearing up to bring natural remedies which are safe and effective. Incorporation of various plant constituents such as Phenols, alkaloids, flavonoids and glycosides possessing good therapeutic potential into dairy products are gaining popularity in the world market.

Summary:

With this in view, Present study aims at “**DEVELOPMENT OF ANTIOXIDANT RICH BLACK RICE KHEER AND FORMULATION OF READY TO COOK (RTC) BLACK RICE KHEER**” that was conducted in Centre of Dairy Science & Food Technology Institute of Agricultural Sciences, Banaras Hindu University, and Uttar Pradesh, India. Extraction of bioactive compounds from black rice was done & phytochemical characterization of the extracts was done quantitatively. The first objective was to optimize the process of black rice kheer. The second objective was to develop and optimize RTC black rice kheer. The third objective was to study sensory attributes of black rice kheer and RTC black rice kheer. The fourth objective was to determine the physico-chemical, & antioxidant properties of black rice kheer.

Sensory Evaluation

The result of sensory evaluation presented in the study shows that the sample C3 (optimized black rice kheer)& S3 (optimized RTC black rice kheer)has the highest sensory score & are the most accepted product based upon color & appearance, taste & flavor and body & texture. The data obtained by sensory evaluation in the present study was analyzed for the significant difference in the treatments by subjecting to analysis of variance (ANOVA) technique (ONE WAY ANOVA) using Minitab 16. The results concluded that there was significant difference

in various sensory parameters and were affecting the sensory scores of the product and consumer acceptability.

Biochemical Assay/ Quantitative Analysis

TPC of control extract & black rice extract was found to be 51.94 ± 1.97 & 75.59 ± 7.28 , respectively. Similarly TPC of optimized black rice kheer (C3) & control (C) was found to be 54.46 ± 0.56 & 27.65 ± 9.70 , respectively. Based on DPPH assay the antioxidant capacity of control extract & black rice extract was found to be 11.67 ± 1.18 & 56.23 ± 3.56 , respectively. Similarly %DPPH of optimized black rice kheer (C3) & control (C) was found to be 47.9 ± 0.52 & 9.7 ± 0.55 , respectively. From graph it can be concluded that TPC & DPPH activity of Kheer made from Black rice is much more than that of normal conventional kheer made from white rice. From results it can be concluded that the polyphenol content & DPPH activity of the rice products decreased when compared to raw black rice. These could be attributed due to the soaking, cooking and thermal processing involved in preparation of the kheer as these compounds are sensitive to heat treatments

Physicochemical Analysis

The physicochemical analysis of optimized product revealed that it comprised of $6.5 \pm 0.04\%$ moisture, $1.84 \pm 0.05\%$ ash, $5.11 \pm 0.26\%$ fat, $13.54 \pm 0.36\%$ protein, 1.65 ± 0.05 mg/100g zinc & 3.44 ± 0.05 mg/100g iron. Total carbohydrates was found to be 72.57 ± 0.51 . The pH of the optimized product was found to be 6.81 ± 0.44 .

Conclusion

In present study on Development of antioxidant rich black rice kheer and formulation of ready to cook (RTC) black rice kheer, coconut sugar is used in place of normal sugar for healthy sugar alternative due to increasing threats of diabetes, obesity, hypertension, and heart diseases because of high consumption of sugar in food, beverage, and confectionery products. Black rice consist of high level of nutrients and antioxidants. & has capability to combat and avert numerous health issues starting from cancer, diabetes, and allergies to cardio tube diseases. It conjointly promotes weight loss and liver health. Therefore black rice kheer is prepared with aim to provide nutrition & RTC black rice kheer is formulated to decrease cooking time, increase shelf life of the product & to develop a convenience food.

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APPENDICES

APPENDIX – I

Sensory analysis score sheet

SENSORY EVALUATION PERFORMA

NAME: DATE:

PRODUCT: ANTIOXIDANT RICH BLACK RICE KHEER

TIME:

INTRODUCTION:

The given 3 samples of BLACK RICE KHEER were prepared with three different concentration of black rice in kheer formation. You are requested to assess the product in terms of general acceptability on the basis of nine point hedonic scale given below:

Hedonic Scale Score

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

SAMPLE CODE	Color and Appearance	Body and Texture	Taste and Flavor	Overall Acceptability

Remarks

Signature

APPENDIX – II

Sensory analysis score sheetSENSORY EVALUATION PERFORMA

NAME: DATE:

PRODUCT: RTC BLACK RICE KHEER

TIME:

INTRODUCTION:

The given 3 samples of BLACK RICE KHEER were prepared with three different concentration of black rice in kheer formation. You are requested to assess the product in terms of general acceptability on the basis of nine point hedonic scale given below:

Hedonic Scale Score

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

SAMPLE CODE	Color and Appearance	Body and Texture	Consistency	Taste and Flavor	Overall Acceptability

Remarks

Signature

APPENDIX-III

ANOVA for TPC of white and black rice

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>
Between Groups	839.0035	1	839.0035	29.48472	0.05
Within Groups	113.8221	4	28.45553		
Total	952.8256	5			

APPENDIX-IV

APPENDIX-IVA.

ANOVA for Color of C, C1, C2, C3

Source DF	Adj SS	Adj MS	F-Value	P-Value
Factor 2	5.879	2.9394	6.14	0.03
Error 30	14.364	0.4788		
Total 32	20.242			

APPENDIX-IVB

ANOVA for Bodyand Texture of C, C1, C2, C3

Source DF	Adj SS	Adj MS	F-Value	P-Value
Factor 2	2.364	1.1818	2.05	0.146
Error 30	17.273	0.5758		
Total 32	19.636			

APPENDIX-IVC

ANOVA for Flavorof C, C1, C2, C3

Source DF	Adj SS	Adj MS	F-Value	P-Value
Factor 2	5.879	2.9394	3.39	0.047
Error 30	26	0.8667		
Total 32	31.879			

APPENDIX-IVD**ANOVA For overall acceptability of C, C1, C2, C3**

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	5.879	2.9394	6.14	0.006
Error	30	14.364	0.4788		
Total	32	20.242			

APPENDIX-V**APPENDIX-VA.****ANOVA for Color of S, S1, S2, S3**

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	5.879	2.9394	6.14	0.03
Error	30	14.364	0.4788		
Total	32	20.242			

APPENDIX-VB**ANOVA for Bodyand Texture of S, S1, S2, S3**

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	2.364	1.1818	2.05	0.146
Error	30	17.273	0.5758		
Total	32	19.636			

APPENDIX-VC**ANOVA for Flavor of S, S1, S2, S3**

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	5.879	2.9394	3.39	0.047
Error	30	26	0.8667		
Total	32	31.879			

APPENDIX-VD**ANOVA for overall acceptability of S, S1, S2, S3**

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	5.879	2.9394	6.14	0.006
Error	30	14.364	0.4788		
Total	32	20.242			

APPENDIX-VI**APPENDIX-VIA**

Source of Variation	SS	MS	F	P-value
Between Groups	3.715095	3.715095	0.129473	0.048
Within Groups	229.5519	28.69399		
Total	233.267			

ANOVA for moisture content of C3**APPENDIX-VIA****ANOVA for ash content of C3**

Source of Variation	SS	MS	F	P-value
Between Groups	2.861119	2.861119	10.23685	0.012622
Within Groups	2.235938	0.279492		
Total	5.097058			