PREPARATION AND QUALITY EVALUATION OF BROWN RICE AND *KHOA* INCORPORATED *YAMARI*

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Preparation and Quality Evaluation of Brown Rice and *Khoa* Incorporated *Yamari*

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Approval Letter

This *dissertation* entitled *Preparation and Quality Evaluation of Brown Rice and Khoa Incorporated Yamari* presented by Bijendra Lal Dangol has been accepted as the partial fulfillment of the requirements for the B. Tech. degree in Food Technology

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Abstract

The aim of this study was to prepare brown rice incorporated *Yamari* and evaluation of its physiochemical properties. *Yamari* making technology was studied by the survey through the people of the Newari community. The product formulation was based on the results obtained from the Design Expert v6.0.10. *Yamari* was prepared with the incorporation of brown rice flour in 0%, 12.5%, 25%, 37.5% and 50% concentration with white rice flour taking constant amount of *khoa* to assess the quality and acceptability of the *Yamari*. The proximate composition of prepared white rice flour, brown rice flour and *khoa* used in the preparation of *Yamari* were carried out. The sensory analysis was carried out which showed a significant difference at 5% level of significance in sensory attributes.

Yamari with the incorporation of 37.5% concentration of brown rice was selected as the best formulation and subjected for further physiochemical analysis. The moisture content, crude protein, total ash, crude fat, total carbohydrate and crude fiber were found to be 44.20%, 14.15%, 1.97%, 12.80%, 69.37% and 1.86% respectively. Furthermore, the best product was subjected for iron and calcium content evaluation. The iron content and calcium content were found to be 4.1 mg/100 g and 280 mg/100 g respectively which showed a higher range as compared with that of traditionally prepared *Yamari*. The calorific value of best formulated *Yamari* was found to be 449.28 Kcal/100 g. The overall study showed that brown rice incorporated *Yamari* at 37.5% incorporation would give a nutritionally enriched product with best acceptability.

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List of Abbreviations

Abbreviation	Full form
ANOVA	Analysis Of Variance
ASoN	Agronomy Society of Nepal
BOPP	Biaxially Oriented Polypropylene
CCT	Central Campus of Technology
CDD	Crop Development Directorate
DNA	Deoxyribonucleic acid
DOE	Design of Expert
FAO	Food and Agriculture Organization
FFA	Free Fatty Acid
LSD	Least Significant Difference
PEM	Protein Energy Malnutrition
SBMK	Skim Buffalo’s Milk *Khoa*
SD	Standard Deviation
TU	Tribhuwan University
UFA	Unsaturated Fatty Acid
WBMK	Whole Buffalo’s Milk *Khoa*
WCMK	Whole Cow’s Milk *Khoa*

Part I

Introduction

1.1 General introduction

Traditional food is a food of a specific feature or features, which distinguish it clearly from other similar products of the same category in terms of the use of ‘‘traditional ingredients’’ (raw materials or primary products) or ‘‘traditional composition’’ or ‘‘traditional type of production and/ or processing method’’. Traditional foods are an expression of culture, history and lifestyle. Despite the fact that we are living in a world of globalization, different dietary patterns between countries do exist. The study of traditional foods offers an important insight into dietary patterns and how these have been shaped through time (Trichopoulou *et al.*, 2007).

Food has been connected with festivals since time immemorial in Nepal, as one is incomplete without the other. People here regard festivals as opportunities to serve good food to the gods, and eat the same with their families as blessings. Also notable is that, every festival in Nepal has a distinct line of food. It is said that different foods eaten during different periods of festivals are not only culturally significant, but are scientifically remarkable, too. Festivals and food have been carved into the calendars in such a way that they seem to be season-friendly and health-friendly. There is a lot of science going on with what locals eat during the specific festivals such as *Yamari* for *Yamari punhi* of *Newari* community (Shrestha, 2017).

Yamari is the product prepared from cooked jaggery and lightly roasted sesame seed mixture enclosed within rice flour dough and steamed till cooked, indigenous to *Newari* community of Nepal. It is in especially made in the shape of Buddhist monastery. It is also prepared in other different shapes such as shapes of different animals, gods etc. It is artistic bread (Shrestha, 2012).

Yamari is a very popular festive dish, traditionally prepared during post-harvest celebration of *Yamari Punhi* or *Dhanya Purnima.* The celebration is observed during full moon from December to January. During the festival, the people of Kathmandu worship the goddess of grains, Annapurna for good harvest and enjoy a grand feast after all the hard work of the harvesting season. *Yamari* is prepared and offered ritualistically to the gods.

Although the festival has its roots in the Newar farming community, today it is observed in almost every Newari home in Kathmandu and surrounding areas. It is prepared during the celebration of children's birthdays, where a *Yamari* garland is used to honor the child. *Yamari* is widely prepared and served in many other auspicious occasions, such as rice feeding ceremony of a child (*paasne*), *Dhau-Baji* celebration of expectant mother (feast before child birth), as a *Sagun food* - (auspicious food, representing good luck, fortune, and good health), Janku celebration - (celebration of an old age), Indra Jatra, samaya-baji festival, new house moving celebration and many more (Pathak, 2015).

Brown rice is an unmilled rice or partly milled rice; it's a kind of whole grain. It has nutty flavor, chewier than white rice but become rancid more quickly, but is far more nutritious. Brown rice is made up of numerous layers even after a single step that remove husk from the paddy. If the brown rice is processed further to the extent that rice bran and part of the germ layers are removed we have white rice (Varshini *et al.*, 2013).

Khoa is a popular indigenous semi-solid milk product which is prepared by thermal evaporation of milk to 65– 70% solids in an open pan. The food value of *khoa* is very high as it contains fairly large quantities of protein, fat, lactose and bone-forming minerals, especially calcium. It is usually used for direct consumption or as a base material for sweets preparation in the Indo-Pak sub-continent. Storage life of *khoa* is only two to three days, under ambient conditions, and 15–20 days under refrigerated conditions (Rehman and Salariya, 2006).

1.2 Statement of the problem

Every country has its own indigenous food products which gives it cultural identity. In the context of our country, there are many indigenous foods which are concerned with specific ethnic group and place like *Yamari*, jand, gundruk, sel roti, sinki, etc.

Yamari is being prepared from generations and the technology of production is being transferred from generation to generation with little or no change by verbal communication. Lack of research and development is the main problem for the promotion. Quality assurance with quality of the product is major concern. *Yamari* is prepared from rice flour, sesame and jaggery. Since it is prepared from rice, sesame and jaggery enriching with minerals and vitamins, it can be made more nutritious, which will certainly help to minimize protein energy malnutrition (PEM) from Nepal. However, the calorific value of the product was found to be low (Shrestha, 2012) due to the carbohydrate being the main nutrient of the product. Till date, no further research had been done to improve its nutritional status. At present, *Yamari* is made in household level for direct consumption in certain occasion. Still, it is not commercialized.

1.3 Objectives

1.3.1 General objective

The general objective of the work is to formulate and evaluate the quality of *Yamari* incorporating with brown rice and *khoa*.

1.3.2 Specific objectives

To fulfill the general objective, specific objective undertaken were as follows:

1. To carryout chemical analysis of white rice, brown rice and *khoa*.
2. To prepare *Yamari* incorporating brown rice and *khoa*.
3. To perform sensory and physiochemical analysis of *Yamari* being prepared.
4. To estimate the cost of *Yamari*.

1.4 Significance of the study

Yamari is a special kind of traditional food that is prepared especially by newar community on the day of *Yamari Purnima*. It is made of rice flour, sesame seed and chaku. In Newari, Yo means very much liked, and mari means bread. As such *Yamari* means a bread much liked by everyone. The unique taste of this delicacy is one factor that makes *Yamari* popular these days (Anon., 2012). *Yamari* is regarded as hot food item and it kills cold (Anon., 2017). Furthermore, the current existence of milled rice on the market reduces the rice's nutritional value and essentially turns it into a simple carbohydrate food. Thus, *Yamari* incorporating brown rice enriches with vitamins, minerals, all-important fiber and valuable nutrients known as phytochemicals which are cholesterol-lowering, heart disease and cancer-fighting ingredients. Such an approach would ultimately result in a sustainable enhancement of the essential nutrient supply in rice based traditional food *Yamari*. In addition to this, the incorporation of *khoa* also plays a supporting role in upgrading the calorific value of the final product.

This study helps in upgrading the nutritional status of *Yamari*. The present work helps to introduce *Yamari* to the people as an important indigenous food. It is a little step to promote the single indigenous food. Several such foods which are only limited to the house hold level can be promoted. Furthermore, this study brings us one step closer towards the commercialization of the product.

1.5 Limitations of the work

1. The shelf life of *Yamari* couldn't be studied due to the time constraint.
2. The samples of *Yamari* prepared couldn't be made uniform.

Part II

Literature review

2.1 *Yamari*

2.1.1 History of *Yamari*

Yamari has been prepared since antiquity. There is no any exact evidence of its introduction in Nepalese society. But it is believed to be introduced in the reign of Malla dynasty of Nepal. Historically *Yamari* were used by the people to express their happiness and grace on different occasions and festivals. They also believed that by eating *Yamari* they would get wisdom and self-knowledge. The name given *Yamari* is specific. According to newari language *Ya* means favourite and *Mari* means bread. So *Yamari* means favourite bread loved by all. It is also called *Yamari*, *yaha-mari, damphu roti* or *chaku roti* (Shrestha, 2012).

People of *Newari* culture use this *Yamari* in different occasion. Mainly it is prepared in *Manshir Sukla Purni* also called as *Yamari purnima.* People believe celebration of *Yamari* purnima brings them wealth, health and prosperity. People give different shapes to *Yamari*s. Mostly *Yamari*s are prepared in the form of gods and goddesses like Kumar, Ganesh, Laxmi and Kuber to get rid of poverty. In this festival parents bless good health and long life to the children up to two to twelve years offering *Yamari*s.During this festival kids perform customary Newari song and dance and ask for food and other gifts from the elders during the festival (Shrestha, 2009).

The festival is said to have started from panchal nagar(present day Panauti). Myth has it that Suchandra and Krita, a married couple, first experimented with fresh yield of rice from their field. And what took shape turned out came to be known as *Yamari*. The new delicacy was eventually distributed among the villagers. As the food was liked by all, the bread was named *Yamari*, which literally means 'tasty bread'. The myth further states that on the same day, the couple offered the god of wealth, Kuber, the new delicacy, who was passing by in a disguise. Following this Kuber disclosed, his real identity and blessed the couple with wealth. He also declared that whoever will prepare *Yamari* in the form of gods and goddesses on the full moon of December and observe four days of devotion to god, will get rid of poverty. The festival is celebrated on the second day when prayers are offered during which the *Yamari*s are stored and not eaten on that very day. On the fourth and the final day the people belonging to the Newar community consume the sweet bread as a gift from gods and this practise also marks the end of the festival (Lamichhane, 2018).

2.2 Importance

Some common historical importance of *Yamari* is discussed:

1. In Newar community during *Mangshir purnima*, Newari people organize a feast in which *Yamari* is the main food item.
2. This food is also important part of *Pasni* (child's first rice eating ceremony).
3. A garland of *Yamari* (number of *Yamari* in the garland indicating his age) is made and put on child's neck in the birthday until s/he is 10 which is considered most important in second birthday.
4. A pregnant woman in Newar community is fed with *Yamari* along with curd and beaten rice.
5. In any *Puja* of Newari community, *Yamari* used is prepared adding 5 number of grains of rice along with sesame and jaggery. 5 number of rice grain represent 5 elements of life (Land, Water, Sun, Air and soul) (Bajracharya, 2000).
6. In Newar community, it is served in many other auspicious occasions, such as, Janku celebration - (celebration of an old age), Indra Jatra, samaya-baji festival, new house moving celebration, as a *Sagun food* - (auspicious food, representing good luck, fortune, and good health) and many more (Pathak, 2015).

2.3 Ingredients used for preparation of *Yamari*

The major ingredients used for its preparation are rice, and *khoa.* Other ingredients which may be used are coconut, sugar, cashew nut etc. (Bajracharya, 2000).

2.3.1 Rice

Rice is the main crop of Nepal as well as of the world. The main diet of the Nepalese is also rice. Fifty-five percent of the cultivated land of Nepal is covered with rice. Rice is cultivated in the diverse eco-climatic ranges of Nepal at differing altitudes, topography and climate. More than half of the human population depends on rice for food. Ninety percent of the rice grown in the world is produced and consumed in Asia. There are different views about the origin of rice by different scientists. As early as 1930 Vavilov pointed out that the origin of the present rice is in the South- East Himalayan region. Therefore, according to him the origin place of rice is in the south-East Asia, India, China and IndoChina where different types of rice are found. If we consider his views the Himalayan range is also in Nepal. Rice belongs to gramineae family and *Oryza* genus. There are 25 species of rice, out of 25 species 23 are wild type and two species are cultivated. The rice of Asia, Europe and America is *Oryza glaberrima*. Rice cultivation has been done since the beginning of the civilization, so there are thousands of varieties in the world (Mallick, 1981).

Rice (genus *Oryza*) is a plant of the grass family, which is a dietary staple of more than half of the world's human population. Rice cultivation is well suited to countries with low labour costs and high rainfall, as it is very labor-intensive to cultivate and requires plenty of water for irrigation. However, it can be grown practically anywhere, even on steep hillsides. Rice is the world's third largest crop, behind maize (corn) and wheat. Although its species are native to South Asia and certain parts of Africa, centuries of trade and exportation has made it common place in many cultures. The modern English word 'rice' originates from ancient Greek word 'arizi' which in turn was borrowed from the Tamil word of the same pronunciation, strongly indicating trade relationship between ancient Greeks and Tamils (Pokhrel, 2008).

Rice has been one of the most commonly used grain products since ancient times. It is the stable food of the greatest number of people. Historian can’t be accurate about the first appearance of rice because rice cultivation is older than recorded events. Though a lack of historical records prevents accurate determination, botanical evidence suggests strongly that rice originated in southeast continental Asia. Rice is grown in all tropical countries in eastern and southern Asia including the larger nearby islands, especially Japan. The principal rice producing countries are China, India, Pakistan, Japan and Indonesia, Thailand, Indochina, Myanmar and Philippines also produce large quantities of rice. Many varieties of rice are produced throughout the world. It has been estimated that there are approximately 7,000 known varieties of rice (Johnson and Peterson, 1974).

There are only two cultivated species *Oryza glaberimma* and *Oryza sativa*. *Oryza glaberimma* is confined to West Africa but is being replaced by *Oryza sativa*. Morphologically there are only small differences between these species. Origin of *Oryza sativa* is South-East Asia, particularly India and Indo-China (Grist, 1975).

Rice cultivation is considered to have begun simultaneously in many countries over 6,500 years ago. Two rice varieties were domesticated: Asian rice (*Oryza sativa*) and African rice (*Oryza glaberrima).* It is believed that common wild rice, *Oryza rufipogon* was the wild ancestor of asian rice. *O. sativa* appears to have originated around the foothills of the Himalayas, with *O. sativa indica* on the Indian side and *O. sativa japonica* on the Chinese side. African rice has been cultivated for 3,500 years (Pokhrel, 2008).

2.3.1.1 Chemical composition of rice

The composition of rice differs with the variety, the nature of the soil, environmental conditions and the fertilizers applied. The fat content of rice is low and most of it is removed in the process of milling and is contained in the bran (Grist, 1975). The total fat content of milled rice remained constant in either ordinary or hermetically storage under a wide range of moisture and temperature conditions, but its gross composition nevertheless changed with an increase in free fatty acid and decrease in natural fats and phospholipids (Pillaiyar, 1988). The average composition of both husked and polished rice is given in Table 2.1.

Table 2.1 Nutrients content per 100 g of polished rice

Parameters	Amount	Parameters	Amount
Energy	1461 Kj (344 kcal)	Vitamin E	70 µg
Water	12.9 g	Vitamin B1	60 µg
Protein	6.8 g	Vitamin B2	30 µg
Lipids	0.6 g	Nicotinamide	1300 µg
Carbohydrates	77.8 g	Pantothenic acid	630 µg
Fiber	1.4 g	Vitamin B6	150 µg
Minerals	0.5 g	Biotin	3 µg

Source: Matthias (1999)

2.3.1.2 Uses of rice

Rice flour has historically been used in baby foods and extruded rice crispies. In recent years, more rice flour is being used in cereals, crackers, chips, snacks, and coating applications to provide different textures. Textures can be altered dramatically depending on the type of flour used. It is widely used in the preparation of sauces and gravies for the preparation of Soya rice to make fried rice, frozen cooked rice (Sagefoods, 2005).

2.3.1.3 Variety of rice for the preparation of *Yamari*

Taichin is the variety of rice used for the *Yamari* preparation. The coarse variety of rice is also used for its preparation. New rice is preferred to obtain the good quality of *Yamari*. The new rice gives soft and well puffed dough for the preparation of good quality of *Yamari (*Bhadel*, 2015).*

2.3.2 Rice flour

Like wheat or rye, white or brown rice can easily be ground into flour after hulling. The technical process for milling rice does not differ substantially from that used for other cereals and storage is the same. Rice flour is primarily made from polished broken rice and is therefore usually whiter than wheat or rye flour. In addition, it is usually ground more finely. Rice flour is made by grinding whole grains or broken rice. However, a mixture of pearling-cone milled from the residue left from polishing the rice grains and very small broken rice is also referred to as rice flour. This type of flour is used chiefly for animal fodder. There are two sorts of rice flour for human consumption which are distinguished by the type of rice and its starch components. The first type is made from glassy, hard grains, the type of rice most often cooked at home and the second, from glutinous or waxy rice. Because of its great ability to swell, the glutinous rice flour lends a slightly rubbery texture to dough. It is used for thickening white sauces and in desserts. Products made from glutinous rice flour are well suited to freezing because, unlike many other starches, it does not separate and lose moisture when thawing. There is a major difference between rice flour and most other grain flours. Rice flour cannot be used in baking. The reason for this has to do with its chemical composition (Pokhrel, 2008).

Although rice flour contains a great deal of starch, it does not contain the protein gluten, which is an important structural component in dough. The protein contained in rice has a different composition than wheat protein. In dough made with wheat flour, the gluten, a structural protein composed of gliadin and glutenin, runs through the dough in fine elastic strands. The gluten "traps" the expanding moisture/steam and enables the dough to rise. The protein in rice flour cannot build this net-like framework. Baked goods made from rice flour therefore do not rise and produce very few pores in the finished product. The very fine-grained rice flour, ground mainly from broken rice, is also used in special diets. Rice flour is easily digested by people with celiac disease (a gluten allergy) and is used in baby foods. It has been used as a cosmetic powder since ancient times. Rice flour from whole and broken rice forms the basis for rice noodles and thin rice paper. Rice paper and rice noodle leaves are ideal wrappings for fillings of all sorts. Egg rolls, for example, are often wrapped in rice paper. Snow white and powdery fine, rice flour provides the basis for many foods including puddings, rice noodles and many snacks (Pokhrel, 2008).

Rice flour is finely granulated powder made by grinding and sifting a long grain variety of rice, unless otherwise specified, which is hard milled and electronically sorted to insure whiteness. The proximate composition of rice flour is given below in Table 2.2

Table 2.2 Proximate composition of rice flour

Chemical Composition	Range	Average
Protein	6.0-9.0%	7.5%
Fat	0.4-1.0%	0.8%
Crude fiber	0.3-1.0%	0.7%
Ash	0.6-0.9%	0.7%
Moisture	8.5-13.0%	11.0%

Source: Pokhrel (2008)

2.3.2.1 Different products from rice flour

Rice flour does not contain gluten and therefore its dough cannot retain gases during baking as wheat flour does. Therefore, rice flour is widely used in making baby foods, breakfast cereals, unbaked biscuits, snack foods, pancakes, and waffles. For example, a composite baking flour, made by adding 10 percent rice flour to wheat flour, is used to make pastry products in Italy (Grist, 1975) Rice flour offers potential for new and traditional baked products. It can be produced with a wide assortment of functional properties and factors affecting that properties are the varieties and types used milling and grinding methods employed, and pretreatment of rice or flour before use. Certain inherent properties have been identified as providing the most suitable flours for traditional products or as substitutes for wheat flour in breads and cakes (Bunde *et al.*, 2010).

Rice-flour products are exemplified by the following foods: *yuan zi* (or *tong yuan*) is a popular food in China. It is made from glutinous rice flour and water by adding sweet or savory fillings to the rice dough. The quality of *yuan zi* preparation depends on the amylopectin content, the flour particle size, and the recipe for the fillings. (The higher the amylopectin content, the softer and stickier the rice flour becomes when the same amount of water is added). *Yuan zi* is fried with vegetable oil or thoroughly cooked in boiling water and served with sugar or other condiments. Rice bread is a good substitute for other gluten-containing cereal flour, as some people are allergic to these flours. The medium-and short-grain rice varieties are preferable to the long-grain type for making rice bread. Formulation is important in making rice bread by adjusting the levels of sucrose, yeast, water, nonfat dry milk, and other additives (Luh, 1991).

2.3.2.2 Processed foods

1. Rice noodles

Rice noodles are called *mi fen* in Chinese, *sen mee* in Thai, and *harusame* in Japanese. *Mi fen* is often produced from non-glutinous rice by soaking, grinding, steaming, kneading, and drying. If dehydrated, it can be stored up to two years. In Thailand, mung bean is added to rice to make a special rice noodle called *fung-shu* (or *tong-fun*) that is more resistant to texture changes during reconstitution. In Asia, rice noodles are consumed in soups or as snacks. *Mi fen* is served with water, meat or chicken, green vegetables, soy sauce, and other ingredients (Alford *et al.*, 1998).

2. Rice snacks

Rice snacks have an attractive taste; flavor, texture, and aroma. They are often made from glutinous rice because of its sticky characteristics and easy expansion into a porous texture. However, non-glutinous rice also can be used for making some rice snacks (Pokhrel, 2008).

The rice cracker is a typical rice snack. The Japanese soft rice cracker made from glutinous rice is called *arare* or *okaki* in comparison with the less popular and tougher *senbei* (the rice cracker made from non-glutinous rice). The production process involves washing, grinding, steaming, kneading, cooling, pounding, drying, baking, seasoning, cutting, and packing. The production of rice crackers is now developed as a continual process that takes place within 3– 4 h. To add flavors and color to rice crackers, the following ingredients are often added: seaweed, sesame, red peppers, sugar, food pigments, and spices. Moreover, high-quality, refined oil should be used for oil-fried crackers (Pokhrel, 2008).

Rice fries can even compete with the French fries made from potatoes because rice fries have a crisp exterior crust and fluffy interior. To make rice fries, rice should be fully cooked with butter, salt, and other seasonings (Pokhrel, 2008).

3. Rice cakes

Rice cakes are popular in China, Japan, and other Asian countries. They can be made either from glutinous or non-glutinous rice by soaking and steaming. Before steaming, various ingredients can be added for more flavor, such as sugar, salt, monosodium glutamate, crushed radish, crushed mung bean (for *lu du gao*, a special cake in China), and crushed taro. Glutinous or waxy rice is very sticky when cooked and is mainly consumed in northern Burma, northern Thailand, Laos, and Vietnam. It is often used to make rice cakes. However, fermented rice cakes, such as *fakau* in China and *bibingka* in the Philippines, can also be made from non-glutinous rice. There are many other types of rice cakes made in Asia. For example, *biko*, *cuchinta* (or *kutsinta), puto, suman*, and other rice cakes are made in the Philippines (Pokhrel, 2008).

4. Rice puddings

Rice can be made into creamy puddings by mixing cooked rice with milk and sugar. Indian consumers sweeten rice pudding with palm sugar. Rice puddings were served to the rich during the time of the ancient Romans. Now, rice pudding has become a popular dish for children. A delicious Chinese pudding is the Eight Jewel Rice Pudding, prepared from eight different kinds of fruit and steamed glutinous rice with honey (Shrestha, 2012).

5. Quick cooking rice

The preparation and cooking of conventional rice take about one h. Now, quick cooking rice product is popular in developed countries, such as Japan, the United States, and other Western countries. Completely precooked rice requires no further cooking. However, quick-cooking rice often requires five to fifteen minutes for cooking. To produce quick-cooking rice, rice should be precooked by gelatinizing the rice starch in water and/or steam and then dried. Quick-cooking rice mainly is produced by the soak-boil-steam-dry, freeze-thaw-drying, expansion–pre-gelatinization, and gun puffing methods (Lewis *et al.*, 1997).

6. Canned and Frozen rice

For convenience of consumption, canned and frozen rice are produced in Japan, Korea, the United States, and other countries. After precooking, canned rice is sold by wet pack and dry pack. The preparation of frozen cooked rice includes soaking, draining, steaming, boiling, and freezing. To serve the frozen cooked rice, microwave heating is a common practice. Frozen rice also can be made into freeze-dried rice by sublimation under high vacuum. This rice has a long storage life of one to two years (De Datta, 1987).

7. Rice breakfast cereal

Some rice breakfast cereals require cooking before eating, while others can be eaten directly. They commonly are fortified with minerals and heat-stable vitamins, such as niacin, riboflavin, and pyridoxine. The ready-to-eat breakfast cereals include oven-puffed, gun-puffed, extruded, and shredded rice. Oven-puffed rice is made from short-grain rice with sugar and salt by cooking, drying, tempering, enriching, and packaging. Gun puffing is a traditional method and is still practiced in some Asian countries, such as China. The procedure consists of heating, cooking with high pressure in a sealed chamber or gun, and suddenly releasing the high pressure. Because of the lack of continuity in processing, gun puffing is less popular in developed countries. Instead, making extruded rice has high and continuous production rates, great versatility in product shape, and ease of controlling product density. The production of extruded rice can be accomplished by extruding superheated and pressurized dough. Shredded rice is produced by washing, cooking, drying, tempering, shredding, fortifying, and packing (Chang, 2000).

8. Baby foods

Rice has highly digestible energy, net protein utilization, and low crude fiber content. Therefore, it is suitable for baby food. Although baby foods can be in the form of rice flour or granulated rice, precooked infant rice cereal is the most common use of rice for baby food. The key to making this type of cereal is ensuring the ease of reconstitution with milk or formula without forming lumps. The starch is converted from crystalline to amorphous form by the addition of amylase, which breaks down starch into dextrin and oligosaccharides. Ingredients in this baby food include rice flour, rice polishing, sugar, dibasic calcium phosphate, glycerol monostearate (emulsifier), rice oil, thiamine, riboflavin, and niacin or niacin amide. Sometimes, fruit is added to these precooked rice cereals (Wood, 1999).

2.3.2.3 Some nepalese traditional foods from rice

1. *Bhakka*

Bhakka is indigenous food of Nepal. It is prepared from rice flour. Mainly it is consumed by the low class family in the market and also consumed specially by Morangia Tharu. They serve it as breakfast, lunch, dinner as stable food. It is hot served with Chutney, Salt, Milk, tea, vegetable curry, tomato and chili sauce, meat, fish, salad etc. it may also be stored for two to three days and hot served after re-steaming. It is generally prepared and sold in during winter season, generally Mangsir 1st to Falgun 1st. they specially prepared for guests during these days. The weight of *Bhakka* for selling was found to be 25 g to 50 g (Pokhrel, 2008).

2. *Selroti*

It is a doughnut-shaped, deep fried rice confection indigenous to Nepal. Normally, it is prepared in festive occasions and rituals like *Tihar, Pooja, Bratavanda, and Kajkriya*. But, these days it is available almost all the time at hat-bazaars (local market) and cities. The main ingredients used for the preparation of *selroti* are rice flour, sugar, ghee and refined oil. The process of manufacturing of and the ingredients used depends on the availability of raw materials and differ from place to place. In some places people use ripe banana, *dahi and* cream as an improver. Finely ground rice flour, sugar and ghee are mixed properly and fried in ghee or *vanaspati* (hydrogenated vegetable oil) (Pradhan, 2005).

3. *Kasaar*

Kasaar is an oval- or a ball-shaped confection made from jaggery (25-30% by mass) and roasted rice (70-75% by mass). This food is especially prepared in the Brahmin and Chettry communities and is considered an indispensable item in wedding ceremony and other similar ceremonies. Since, the product is an intermediate moisture food; it has a shelf life of several months. Each ball weighs about 40-50 g. Depending on the enormousness of the ceremony, some 10-30 kg of rice may be used for *kasaar* preparation (Kharel *et al.*, 2010).

4. *Chiura*

Chiura or beaten rice flakes is a very common food item in Nepal. It is precooked, has crispy texture and is in a ready to serve form. It is eaten as a snack or as a full meal with *achar* (pickle), chutney, meat, eggs, vegetables, beans, etc. It is famous in all communities especially in Newar, Brahmin, Chhetri, rajbanshi, choudhary, etc. Special course variety of rice is suitable for *chiura* production. Researchers shows that *chiura* making incurs loss of minerals like calcium and iron (Kharel *et al.*, 2010).

5. *Bhuja*

Bhuja or *murai* is a puffed rice product. It is mainly consumed snack in the terai belt of Nepal. The term *murai* is derived from the term *murra*, which mean 'puffed'. The nutritional value is similar to that of rice. It is mainly used by the Tharu and Chaudhary ethinic groups of Nepal. For them it is very important food items in marriage ceremony, festivals and other occasions. *Murai* is also used for the preparation of *chatpate*, a peppery snack sold by vendors in local markets. The food goes well with all types of dishes. It is generally prepared from long variety rice *Oryzae indica (*Kharel *et al.*, 2010*)*.

2.3.3 Brown rice

Brown rice is unpolished whole grain rice that is produced by removing only the hull or husk using a mortar and pestle or rubber rolls. It may be distinctly brown, reddish or purplish. The embryo may or may not be left intact depending on the hulling process. It becomes milled or white rice when the bran layer is stripped of in the milling or 'whitening' process. Thus, the distinguishing factor should be its unpolished feature and not the color. It has a mild nutty flavor, is chewier than white rice and becomes rancid more quickly, but is far more nutritious. Any rice, including sticky rice, long-grain rice, or short-grain rice, may be eaten as brown rice. In much of Asia, brown rice is associated with poverty and wartime shortages and in the past was rarely eaten except by the sick, the elderly and as a cure for constipation. This traditionally denigrated kind of rice is now more expensive than common white rice, partly due to its relatively low supply and difficulty of storage and transport (Babu *et al.*, 2009).

Milling is the process that can differentiate brown from white rice. The difference is not only by milling but also by the nutrients. During polishing 15% of protein, 85% of the fat, 90% of the calcium, 75% of the phosphorus, 80% of thiamine, 70% of riboflavin and 68% of niacin are removed (Karna and Upadhyay, 2017). By discarding and disregarding the bran of rice, we are discarding a bag of benefits that help us to grow. Now a day's nutritionist and dieticians are increasingly recommending brown rice as an excellent source of all-round nutrition. Like white rice, brown rice is also gluten free and contains no trans-fat and cholesterol. Besides the nutritional benefits of consuming brown rice, there are two economic importance's (Bloch, 2007):

1. Forgoing polishing and whitening reduces the power demand of milling by as much as 65%.
2. With the bran and the nutrient-rich embryo intact, and with fewer broken grains, whole grain milling recovery is as much as 10% higher than white rice.

So, if all the rice grown in India, for example were consumed as brown rice, there would be about 20 million more tons of rice available for human consumption. The total cost saving due to this would be around Rs. 20,000 crores. Promoting brown rice is a formidable challenges because most of the Asians are acquired a taste for polished white rice. The loss of nutrients is broad and substantial. Plain white rice has far less Vitamin E, Riboflavin, Niacin, Vitamin B6, Folic acid, Potassium, Magnesium and over dozen other nutrients. Added to that, the dietary fiber contained in white rice is around a quarter of brown rice. Enriched white rice has some of B-Vitamins rushed in to the grain, but is still lacking in fiber and several nutrients present in brown rice. So, brown rice certainly appears to be healthier, There's also the issue of the synthetic vitamins added back in produced in laboratories and factories from a variety of chemicals; and these sorts of processes are well known for their negative impact on the environment (Varshini *et al.*, 2013).

2.3.3.1 Difficulties of brown rice

After the bran layer is removed from the endosperm during milling, the individual cells are disrupted, and the rice bran lipids come into contact with a highly reactive enzyme. The bran contains oil composed of glycerides, about 2-3% of unsaturated Fatty Acids (UFA) and 1.6% phospholipids. Double bonds of unsaturated Fatty Acids are susceptible to oxidation, forming oxides and peroxides causing rancidity (Varshini *et al.*, 2013).

Freshly milled rice bran has a short shelf life because of decomposition of lipids into free fatty acids (FFA) (hydrolytic rancidity), making it unsuitable for human consumption and the economical extraction of edible rice oil. In rice bran, the hydrolysis is catalyzed by endogenous enzyme activity (lipases) and, to some extent, by microbial enzymes if the material is of poor quality (Barnes and Galliard, 1991). The hydrolysis of lipids in rice bran becomes apparent in several ways: off-flavor such as a soapy taste, increased acidity, reduced pH, changes in functional properties, and increased susceptibility of fatty acids to oxidation (Varshini *et al.*, 2013).

2.3.3.2 Comparison of nutrient contents of brown rice and white rice

Bran contains several things of major importance - two major ones are fiber and essential oils. Fiber is not only filling, but is implicated in prevention of major diseases in this country such as certain gastrointestinal diseases and heart disease. The cancer Institute recommends 25 g of fiber a day, a cup of brown rice adds nearly 3.5 g, while an equal amount of white rice not even 1 g (Alice and Wan Rosli, 2015). Also, components of the oils present in rice bran have been shown in numerous studies to decrease serum cholesterol, a major risk factor in heart disease (Kuriyan *et al.*, 2005; Most *et al.*, 2005). The comparison of nutrient contents of brown rice and white rice is given below in Table 2.3

Table 2.3 Comparison of nutrient contents of brown rice and white rice

Parameters	Brown Rice	White Rice
Calories	232	232
Protein	4.88 g	4.10 g
Carbohydrate	49.7 g	49.6 g
Fat	1.17 g	0.205 g
Dietary Fiber	3.32 g	0.74 g
Thiamine (B1)	0.223 mg	0.176 mg
Riboflavin (B2)	0.039 mg	0.021 mg
Niacin (B3)	2.730 mg	2.050 mg
Vitamin B6	0.294 mg	0.103 mg
Folacin	10 µg	4.1 µg
Vitamin-E	1.4 mg	0.462 mg
Magnesium	72.2 mg	22.6 mg
Phosphorus	142 mg	57.4 mg
Potassium	137 mg	57.4 mg
Selenium	26 mg	19 mg
Zinc	1.05 mg	0.841 mg

Source: Babu *et al.* (2009)

2.3.3.3 Health benefits

Brown rice is a complex carbohydrate that provides 15 essential nutrients, including B-vitamins, niacin and potassium. In the olden days, paddy used to be hand pounded and winnowed to remove the husk and consumed as such. Nowadays whole rice is milled minimally to remove the husk to get the brown rice (Varshini *et al.*, 2013).

1. Helps reduces asthma

Brown rice has antioxidants and phytonutrients that boosts the immune system, lowers cholesterol, reduces risk of heart disease, stroke and colon cancer, and reduces severity of asthma (Varshini *et al.*, 2013).

2. Helps prevent cancer

Brown rice can substantially reduce the risk of colon cancer, as it is a very good source of selenium, a trace mineral that induces DNA repair and synthesis in damaged cells and inhibits the proliferation of cancer cells. Selenium is an antioxidant and is essential for thyroid hormone metabolism and immune function (Anon., 2004). Selenium plays a critical role in cancer prevention as a cofactor of glutathione peroxidase, which is one of the body's most powerful antioxidant enzymes and is used in the liver to detoxify a wide range of potentially harmful molecules. When levels of glutathione peroxidase are too low, these toxic molecules damaging their cellular DNA in which they contact and promoting the development of cancer cells (Vogt *et al.*, 2003).

3. Helps increase energy levels

Brown rice is a concentrated source of fiber; so it minimizes the amount of time cancer causing substances spend in contact with colon cells. Brown rice is an excellent source of manganese and magnesium. Just one cup of brown rice will provide 88.0% of the daily value for manganese. This trace mineral helps produce energy from protein and carbohydrates and is involved in the synthesis of essential fatty acids. Manganese is also a critical component of a very important antioxidant enzyme called superoxide dismutase that is found inside the body's mitochondria where it protects against damage from the free radicals produced during energy production (Varshini *et al.*, 2013).

4. Helps in Healthy bone formation

Diet low on magnesium, calcium can gain entry into the nerves and over activate it. Magnesium helps regulate nerve and muscle tone by blocking the entry of calcium into the nerve, preventing its contraction and keeping it relaxed (Jiamyangyuen and Ooraikul, 2008).

5. Helps prevent atherosclerosis

In addition to the niacin it supplies, brown rice may also help raise blood levels of nitric oxide, a small molecule known to improve blood vessel dilation and prevent development of atherosclerotic plaques (Panlasigui and Thompson, 2006).

6. Helps prevent gallstones

Eating foods high in insoluble fiber, such as brown rice, can help women avoid gallstones (Tsai *et al.*, 2003).

7. Constipation

Magnesium and fiber are very helpful in providing relief from constipation because they can help normalize bowel function (Varshini *et al.*, 2013).

8. Weight loss

Brown rice a good ideal for losing weight is because it stays in our stomach for a longer time compared to other food substances. This allows slower digestion, thus making us feel fuller longer. So instead of consuming two bowls of white rice, eating one bowl of brown rice help you become full already. Fiber also moves fat through our digestive system faster so that less of it is absorbed. It controls blood sugar level (Varshini *et al.*, 2013).

2.3.4 *Khoa*

Khoa is an indigenous milk product which is also called *Kurauni* (in Nepali).It is produced in different regions for selling and domestic consumption. *Khoa* is a product of great commercial importance as it forms an important base material for the preparation of varieties of indigenous milk based sweets throughout the country (Rajorhia, 2002). The *Khoa* is produced in small to large scale by using the milk of different locations. So there is a large variation in product quality (Solanki *et al.*, 2002). *Khoa* has a low shelf-life (three days in summer and six to seven days in winter) because of the unhygienic conditions at rural production centers, lack of low temperature chain, inherent high water activity and absence of protective packaging favor high microbial contamination. Thus, it is necessary to maintain a cool chain, preferably around -20ºC during storage and shipping. For export, milk of excellent quality should be used for *Khoa* making and produced hygienically followed by instant chilling are considered essential (Rajorhia, 2002).

2.3.4.1 Composition of *Khoa*

The proximate composition of *Khoa* made from cow's milk differs from cow's milk (FAO, 2013). The composition of *Khoa* depends mainly on the initial composition of milk, the degree of concentration of milk solids and the losses or gains in handling as shown in Table 2.4 (Gopalan *et al.*, 2012).

Table 2.4 An average composition of *Khoa* (per 100 g of *khoa*)

Constituent	WBMK	SBMK	WCMK
Moisture (g)	30.6	46.1	25.2
Proteins (g)	14.6	22.3	20.0
Fat (g)	31.2	1.6	25.9
Lactose	22.1	-	25.5
Ash	3.6	-	3.8
Iron (mg)	5.8	2.7	-
Minerals (g)	3.1	4.3	4.0
Carbohydrates (g)	20.5	25.7	24.9
Energy (kcal)	421.0	206.0	413.0
Calcium (mg)	650.0	990.0	956.0
Phosphorus (mg)	420.0	650.0	613.0
Vitamin C (mg)	-	-	6.0

Source: Gopalan *et al.* (2012)

Note:

WBMK= Whole Buffalo’s milk *Khoa*

SBMK= Skim Buffalo’s milk *Khoa*

WCMK= Whole Cow’s milk *Khoa*

2.3.4.2 Classification of *Khoa*

Depending upon the end use and the quality of the milk used, mainly three types of *Khoa* are identified namely *Pindi*, *Dhap* and *Danedar* which differs in composition, texture and quality (Sawhney *et al.*, 1984). All of these varieties are in demand and are required for specific types of sweets as shown in Table 2.5.

Table 2.5 Fat and Moisture variation of three types of *Khoa*

Types	Fat	Moisture	Specific sweets prepared
Pindi	21-26%	31-33%	*Burfi*, *Peda*, etc.
Dhap	20-23%	37-44%	*Gulabjamun*, *Pantooa*, etc.
Danedar	20-25%	35-40%	*Kalakand*, Gourd *barfi*, etc.

Source: De (1991)

2.3.4.3 Nutritional value of *Khoa*

Milk is considered to be an adequate source of valuable macronutrients (fat, protein, lactose), vitamins and micronutrients (minerals), making it a ‘wholesome food’. It can serve as an excellent carrier product for extra nutrient, and if enriched or fortified it can satisfy the nutritional needs of the population (Krupa *et al.*, 2011). *Khoa* contains milk solid in approximately four-fold concentration, the food and nutritive value of *Khoa* is very high. It fairly contains large quantities of muscles building proteins, bone-forming minerals and energy giving fats and lactose. It is also expected to retain most of the fat, large quantities of water soluble B-vitamins contained in the original milk (De, 1991).

2.3.4.4 Production technology

Khoa is a partially dehydrated whole buffalo, cow, or mixed milk product. It is traditionally manufactured by boiling fresh milk in an open pan kept directly on a fire with continuous agitation and scraping to avoid burning and overheating. The traditional method of *Khoa* manufacture is followed by unorganized traders for the production of *Khoa* on a small scale. It involves boiling 3–4 kg of milk in a small, shallow, open, round, and thick-bottomed iron pan placed over a brisk non smoky fire. The milk is stirred vigorously and constantly with a circular motion using an iron stirrer. During this operation, all parts of the pan with which milk comes in contact are scraped lightly to prevent burning and overheating of milk. Constant evaporation of water takes place and the milk thickens progressively at a certain stage of concentration (2.5 and 2.8 times for buffalo and cow milk respectively). The average yield of *Khoa* from buffalo's milk is 21–23% and from cow's milk is 17–19% (Bansal, 2011).

The trade practices involve boiling 2 to 3 kg of milk (preferable Buffalo) per batch in a *karahi* (of different size and shape) over a brick of non-smoky fire. The milk is stirred vigorously and constantly with a circular motion by a *khunti*. During this operation all part of the pan with which the milk comes into contact are lightly scraped to prevent the milk from scorching. Constant evaporation of moisture takes places and the milk thickens progressively. So far the process is similar to *kheer* making. However no sugar is added and milk dehydration continuous. At the certain concentration heat coagulation of milk proteins begins and the concentrate can be seen. This stage is marked by an abrupt change in color. The heating is continuous with greater control hereafter and the speed of stirring–cum-scrapping increased. Soon the viscous mass reaches a semi solid / pasty consistency and begins to dry up. Very close attention is paid to the last stages. The final product is ready when it shows signs of leaving the bottom and sides of the *karahi* and sticking together. The *Khoa* pat is invariably made after removing the pan from the fire and working the contents up and down into a single compact mass. It is generally marketed in different sizes and shapes (De and Ray, 1952). The manufacturing process of *Khoa* is as shown in Fig. 2.1.

Boiling of milk in steam jacketed kettle (*Khoa)*

↓

Continuous stirring and boiling of milk up to T.S

↓

Continuous *khoa* making machine up to T.S 70%

↓

Cooling and packaging

↓

Khoa

Fig. 2.1 Manufacturing process of *Khoa*

Source: EMC (2016)

2.4 Method of *Yamari* preparation

The general method of preparation of *Yamari* is as shown in Fig. 2.2.

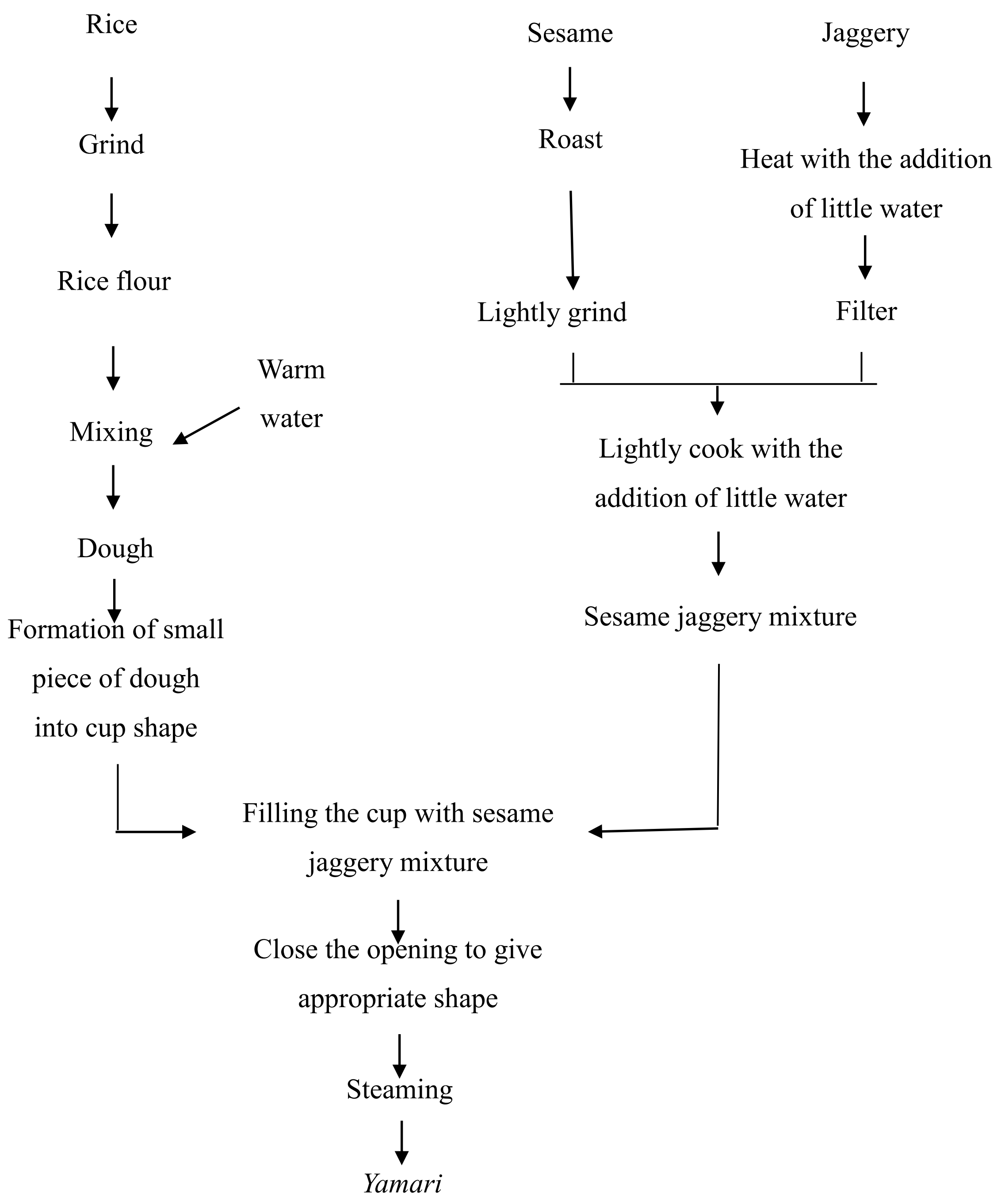

Fig.2.2 General Method of preparation of *Yamari*

Source: Shrestha (2012)

Part III

Materials and methods

3.1 Raw materials

3.1.1 White rice

Taichin variety of white rice (new), was bought from local market of Dharan. It was packed with plastic sheets as a primary packaging material and it was covered with jute bag as a secondary packaging material.

3.1.2 Brown rice

Taichin variety of brown rice (new), was bought from local market of Dharan. It was packed with plastic sheets as a primary packaging material and it was covered with jute bag as a secondary packaging material.

3.1.3 *Khoa*

Khoa was placed in the plastic container and was kept in the refrigerator to prevent from its deterioration.

3.2. Glassware and equipment

1. Steaming aluminum pan
2. Frying pan
3. Weighing balance
4. Mixer grinder
5. Heating arrangement

3.3 Methodology

3.3.1 Preparation of rice flour

Both white and brown rice were taken. Stones, husks and paddy were separated from it. Clean rice was soaked in water at the ratio of 2:1 (water: rice) for 1 h at 30ºC luke warm water (Tarino and Loza, 1984). After soaking the water was drained completely for 15 min. The complete drained wet rice was ground into flour with the help of electric grinder. Flour was then sieved through the sieve of different size to obtain various sized flour. The flour particle size 225 μm was used for the *Yamari* making. It was then packed in the low density polyethylene and placed in refrigerator which is use for further processing.

3.3.2 Making of dough

Calculated amount of water should be added to the flour and kneaded by hand for about 3-5 min for proper mixing of flour and water. The amount of water required to be added was calculated as:

$G_w = G_m (W_d - W_f) / (100 - W_d)$

Where, G_w= Amount of water to be added

G_m = Flour in kg.

W_d = Moisture content of the dough

W_f = Moisture content of the flour

Source: Rai (2004)

3.3.3 Formation of *Yamari* ball

An appropriate amount of dough was taken. It was then molded in a cup shape with a tail in it. Appropriate amount of khoa was added in the dimple of the cup. Then the opening was sealed with hand.

3.3.4 Steam cooking

Aluminum vessel was used for steaming. During steaming, the bottom aluminum pot was filled with 3 L of water to produce steam. On the top of the base pot, the aluminum pot with small hole should be present for entry of steam to cook food material. The diameter of the hole is much smaller than the diameter of the shape through which vapor passes to cause steam cooking of *Yamari*. Covered steam cooking is done. So, there is a lid on the top of the aluminum pot with small hole. The product was steamed (100°C) for approximately 15 to 20 min.

After steaming, *Yamari* was packed in polyethylene bag of 25 μm thickness and stored under refrigeration for consumption after re-steaming or it may be hot serve after cooking (Shrestha, 2012).

3.4 Experimental plan

Five samples were prepared coded as A, B, C, D and E as shown in Table 3.1. Each samples had different formulations based on results shown by DOE.

Table 3.1 Sample formulation in coded form on the basis of DOE

Samples	Brown rice (%)	White rice (%)	*Khoa* (g)
A	0	100	8
B	12.5	87.5	8
C	25	75	8
D	37.5	62.5	8
E	50	50	8

3.5 Method of preparation

The laboratory preparation of Yamari is shown in Fig. 3.1.

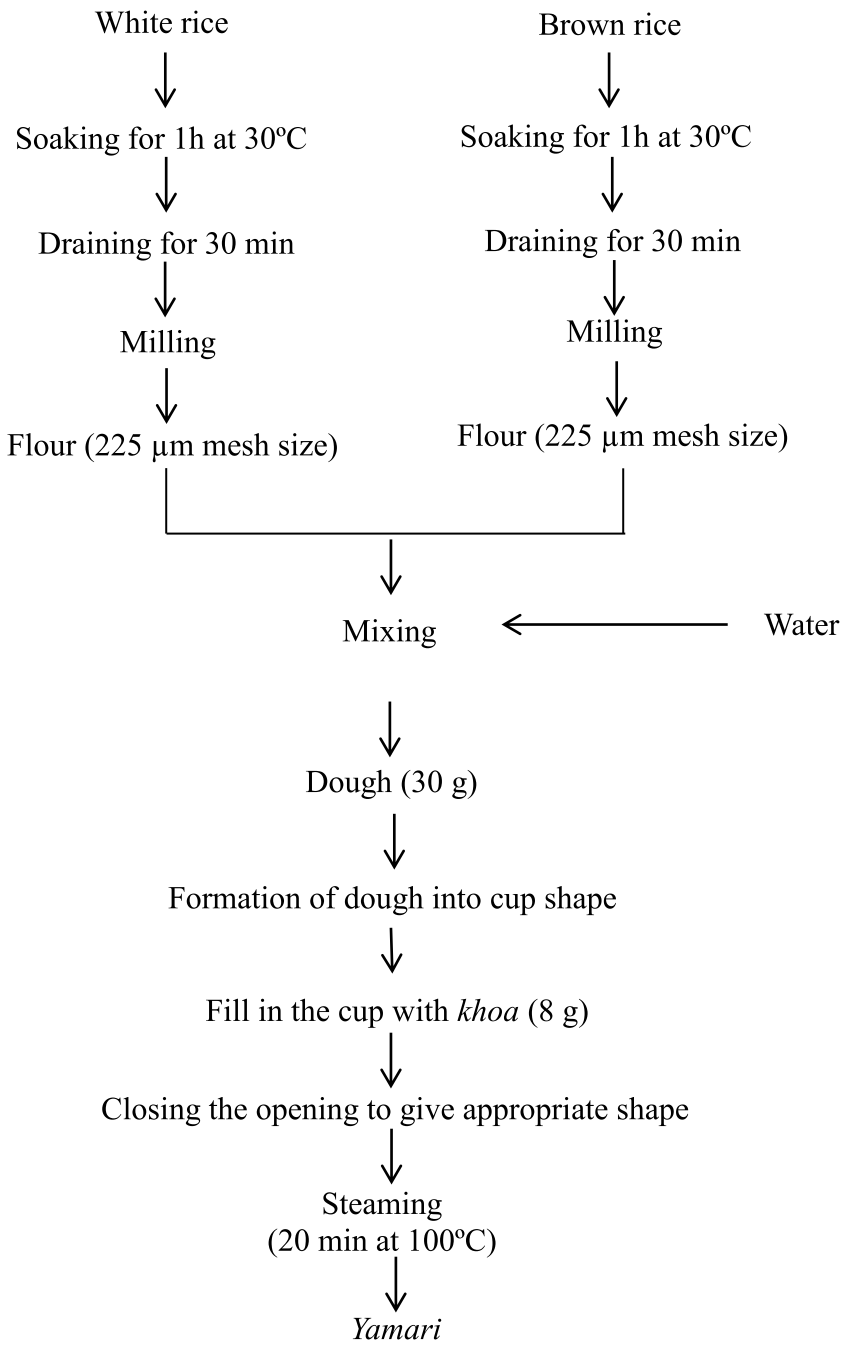

Fig. 3.1 Laboratory preparation of *Yamari*

Source: Bhadel (2015)

3.6 Chemical analysis

3.6.1 Moisture content

The moisture content was determined by using hot air oven method (Ranganna, 2000).

3.6.2 Crude fat

The fat content was determined by Soxhlet extraction method (Ranganna, 2000).

3.6.3 Crude protein

The crude protein was determined by using Kjeldahl's method (Ranganna, 2000).

3.6.4 Crude fibre

Crude fiber was determined by using chemical process, the sample was treated with boiling dilute sulphuric acid, boiling sodium hydroxide and then with alcohol, under standardized condition (Ranganna, 2000).

3.6.5 Total ash

Ash content was determined according to Ranganna (2000).

3.6.6 Reducing sugar determination

Reducing sugar was determination by the method mentioned by Ranganna (2000).

3.6.7 Total sugar determination

Total sugar was determined by the method mentioned by Ranganna (2000).

3.6.8 Determination of iron

Iron content was determined by the method mentioned by Ranganna (2000).

3.6.9 Determination of calcium

Calcium content was determined by the method mentioned by (Ranganna, 2000)

3.6.10 Carbohydrate determination

Carbohydrate content was determined by difference method.

3.7 Sensory evaluation

Yamari of uniform shape and size were evaluated through hedonic rating test. The sensory evaluation of *Yamari* was performed in the laboratory of Central Campus of Technology (CCT), TU by 10 panelists. The panelists were research students and teaching staffs of Central Campus of Technology (CCT), TU who had some knowledge about the characteristics of *Yamari*, thus considered to be semi-trained panelists. Sensory evaluation of the product was performed by hedonic rating test Ranganna (2000).

The parameters for sensory evaluation were taken to be color, flavor, texture, appearance and overall acceptability. Panelist was requested to give the points from 1 to 9, 1 for extremely disliked and 9 for extremely liked sample. Sensory evaluation was carried out in individual booth with adequate light and free from obnoxious odors. Each panelist was provided with coded samples with random numbers and evaluation card (Appendix A).

3.8 Data analysis

The analyses were carried out in triplicate. Statistical calculations were performed in Microsoft office Excel (2010). All the data obtained in this experiment were analyzed for significance by Analysis of Variance (ANOVA) using the statistical program known as Genstat Release 12.1 (2009). From this, means were compared using Fisher’s protected LSD (Least Significance Difference) at 5% level of significance (Payne, 2007).

Part IV

Results and discussion

Yamari was made by using white rice of Taichin variety incorporating brown rice of that same variety and *khoa*. Altogether, 5 samples of *Yamari* with 0%, 12.5%, 25%, 37.5% and 50% brown rice incorporation were prepared taking constant amount of *khoa* in each and every sample. Proximate analysis of both white rice flour and brown rice flour along with *khoa* were done. The best product among the five variations was determined by carrying out sensory evaluation and the nutritional value of the best product was analyzed. The results showing the effect of incorporation of brown rice and *khoa* on chemical and sensory characteristics of *Yamari* are presented.

4.1 Chemical properties of brown rice and white rice

The chemical components of rice as obtained in the variety used for *Yamari* are tabulated in Table 4.1.

Table 4.1 Chemical properties of brown rice and white rice

Parameters	White rice (%)	Brown rice (%)
Moisture content	12.25 (0.18)	11.48 (0.32)
Crude protein	7.13 (0.35)	7.96 (0.1)
Total ash	0.41 (0.2)	1.1 (0.26)
Fat	0.55 (0.62)	1.8 (0.3)
Total carbohydrate	79.08 (0.25)	77.76 (0.3)
Crude fiber	0.83 (0.33)	2.9 (0.11)

Above all the values were expressed in db% except moisture content. The values are the means of triplicate samples and the values in the parenthesis are Standard deviation.

The moisture content of *Taichin* variety for white rice was found to be 12.25% while 11.48% for brown rice. The moisture content in white rice was found to be slightly higher than that of brown rice. The maximum tolerable limit for moisture content in case of rice is 14 % (NFC, 2062). The growth of microorganism gets retarded, thus spoilage is minimized at low moisture. The lower the moisture, the better will be the storability of rice (Pillaiyar, 1988). Fungi need oxygen for their respiration, and die or at least cease to grow in condition of low oxygen. Water activity ranges from 0 to 1. Water activity below 0.60 is adequate to prevent microbial growth but chemical and enzymatic reaction may continue at an unacceptable rate. Lower limit of aw for bacterial growth is 0.90, for yeasts 0.86, for molds 0.72 and lower limit for bacterial growth is 0.60. Here, the moisture content of white rice as well as that of brown rice was found within the standard as described by Karna and Upadhyay (2017).

The moisture content, crude protein, total ash, fat, total carbohydrate and crude fiber of white rice were found out to be 12.25%, 7.13%, 0.41%, 0.55%, 79.08% and 0.83% respectively on dry basis while it were observed to be 11.48%, 7.96%, 1.1%, 1.8%, 77.76% and 2.9% in brown rice respectively. Karna and Upadhyay (2017) reported that the moisture content, crude protein, fat, total carbohydrate and crude fiber of white rice to be 11.62%, 7.13%, 0.66%, 79.95% and 1.3% respectively on dry basis while in case of brown rice, it were observed to be 10.37%, 7.94%, 2.92%, 77.24% and 3.5% respectively (Appendix A.1).

4.2 Chemical composition of *khoa*

The chemical analysis of *khoa* was carried out. The result obtained is shown in Table 4.2.

Table 4.2 Chemical composition of *khoa*

Parameters	Value %
Moisture content	26.25 (0.50)
Fat	36.05 (0.28)
Protein	27.36 (0.39)
Total ash	4.4 (0.19)
Total carbohydrate	30.28 (0.72)

Above all the values were expressed in db except moisture content. The values are the means of triplicate samples and the values in the parenthesis are standard deviation.

As compared with the composition as given by Gopalan *et al.* (2012), the proximate composition was found similar. The variation in the composition of *khoa* depends on the initial composition of milk, the degree of concentration of milk solids and the losses or gains in handling (Gopalan *et al.*, 2012). The proximate composition of *khoa* may also depend upon type of milch animal. Proximate composition of *khoa* made from cow's milk differ from buffalo's milk (FAO, 2013). Rajorhia (2002) have reported that *Khoa* manufactured from buffalo milk yielded more free fat than obtained from cow milk.

4.3 Sensory analysis of *Yamari*

Sensory analysis of *Yamari* was performed with the aid of ten semi- trained panelists evaluating appearance, color, flavor, texture and overall acceptance of prepared *Yamari.* From the statistical analysis ($p< 0.05$), products were found significantly different in terms of all sensory parameters.

4.3.1 Effect of formulation on appearance

The mean sensory scores for appearance of samples A, B, C, D and E were found to be 6.8±0.62, 6.3±0.49, 6.5±0.67, 8.3±0.45 and 7.1±0.79 respectively which is shown in Fig. 4.1

The mean score was found to be highest for sample D which was preferred by the most of the panelist based on its appearance. Sample D was found to be significantly different in appearance from samples A, B and E. However, Samples B and C had no significant difference between them at 5% level of significance. It was indicated that the given panelist couldn't find out the significance difference with the increase in the concentration of brown rice up to 25% while the *Yamari* incorporated with 37.5% was found to be more preferred than other samples. On other hand, The concentration of brown rice increased up to 50% was less preferred which may be due to the presence of dark appearance with some extent of breakage on the surface.

Alice and Wan Rosli (2015) reported that the incorporation of increasing levels of brown rice into the rice based traditional local *Kuih* decreased the degree of preference on the basis of appearance. So, the addition of 30% of brown rice in local *Khuih* could be recommended as the ideal formulation of its preparation which is comparable to the concentration of brown rice used in *Yamari*.

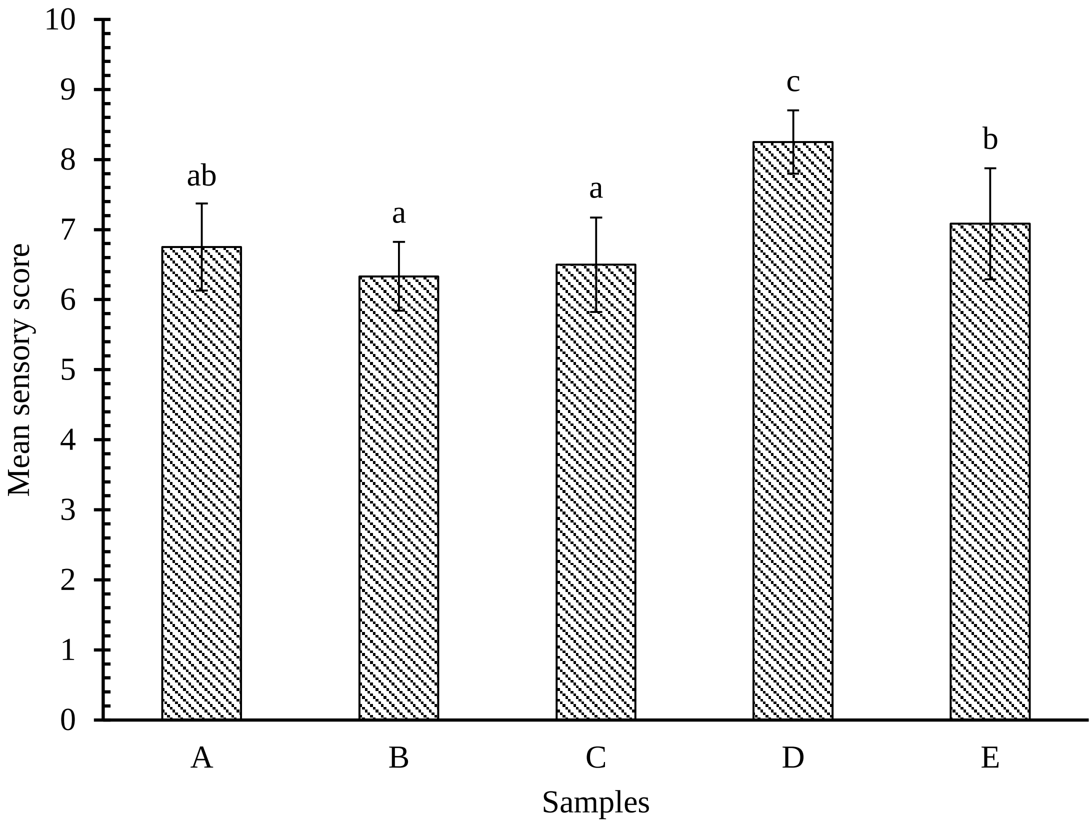

Fig. 4.1 Mean sensory score for appearance of *Yamari*

Fig. 4.1 represents the mean sensory scores for appearance of *Yamari*. Values on top of the bars bearing similar superscript were not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by panelists. Samples A, B, C, D and E represent sample formulations as given in Table 3.1

4.3.2 Effect of formulation on color

The mean sensory scores for color of samples A, B, C, D and E were found to be 6.4±0.51, 6.3±0.78, 6.4±0.51, 7.9±0.67 and 6.9±0.67 respectively which is shown in Fig 4.2.

The mean score was found to be highest for sample D which was preferred by the most of the panelist based on its color. Sample D was found to be significantly different in color from samples A, B and E. However, Samples A & C had no significant difference between them at 5% level of significance. It was indicated that the given panelist couldn't find out the significance different among samples with respect to color with the increase in the concentration of brown rice up to 25% while the *Yamari* incorporated with 37.5% was found to be more preferred than other samples on the basis of color. On other hand, The concentration of brown rice increased up to 50% was less preferred which showed that panelists preferred the presence of light brown color over white color of *Yamari* due to the incorporation of brown rice of 37.5% concentration while not preferred exceeding up to 50% concentration thus making color more darker. Similar results were obtained by Alice and Wan Rosli (2015)

Bunde *et al.* (2010) reported that panelist couldn't find the significant difference on the basis of color in the biscuits with the increase in the concentration of brown rice up to 40% which falls in the same range of incorporation of brown rice found in this study.

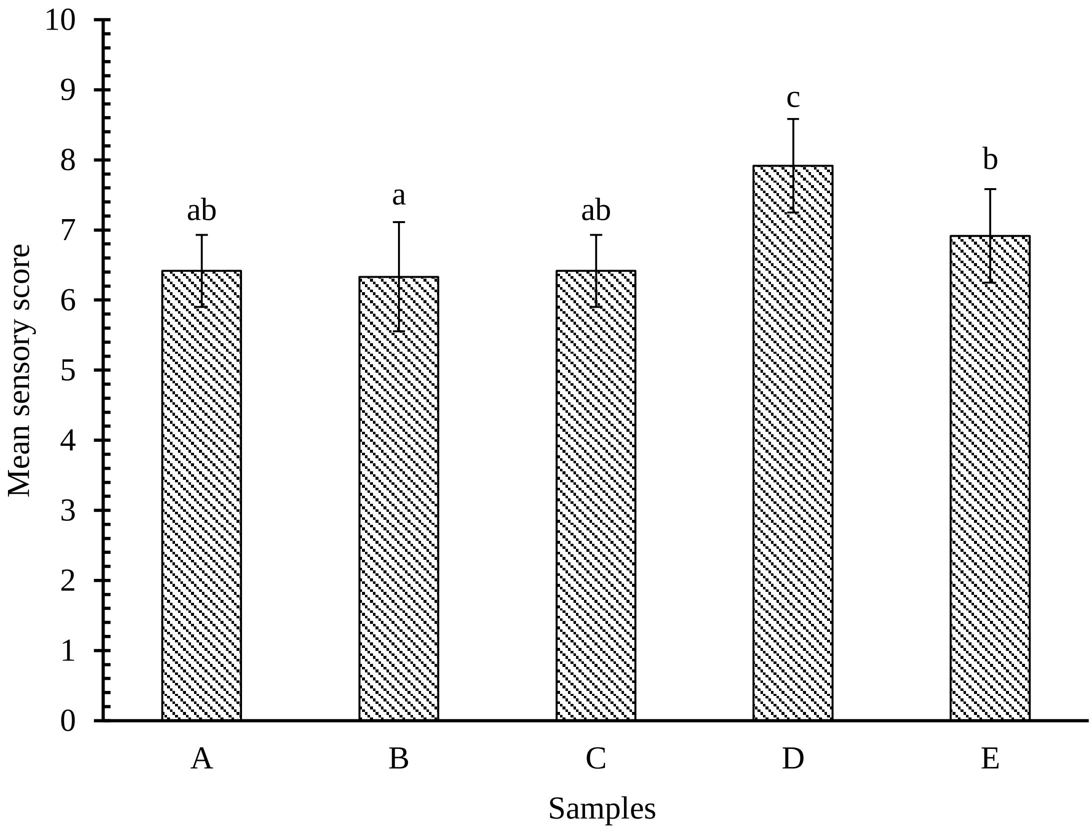

Fig. 4.2 Mean sensory score for color of *Yamari*

Fig. 4.2 represents the mean sensory scores for color of *Yamari*. Values on top of the bars bearing similar superscript were not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by panelists. Samples A, B, C, D and E represent sample formulations as given in Table 3.1

4.3.3 Effect of formulation on flavor

The mean sensory scores for flavor of samples A, B, C, D and E were found to be 6.5±0.67, 6.3±0.49, 6.4±0.51, 7.8±0.97 and 7.0±0.74 respectively which is shown in Fig. 4.3. The mean score was found to be highest for sample D which was preferred by the most of the panelist based on its flavor. Sample D was found to be significantly different from samples A, C and E in terms of flavor. However, Samples B and C had no significant difference between them at 5% level of significance which was almost nearly similar to the control sample A.

It was found that the incorporation of brown rice at 37.5% had flavor difference significantly ($p \leq 0.05$) than others incorporating with brown rice less than 37.5% which was mostly preferred by the panelist. Further increase in the proportion of brown rice lowered the mean sensory score for flavor.

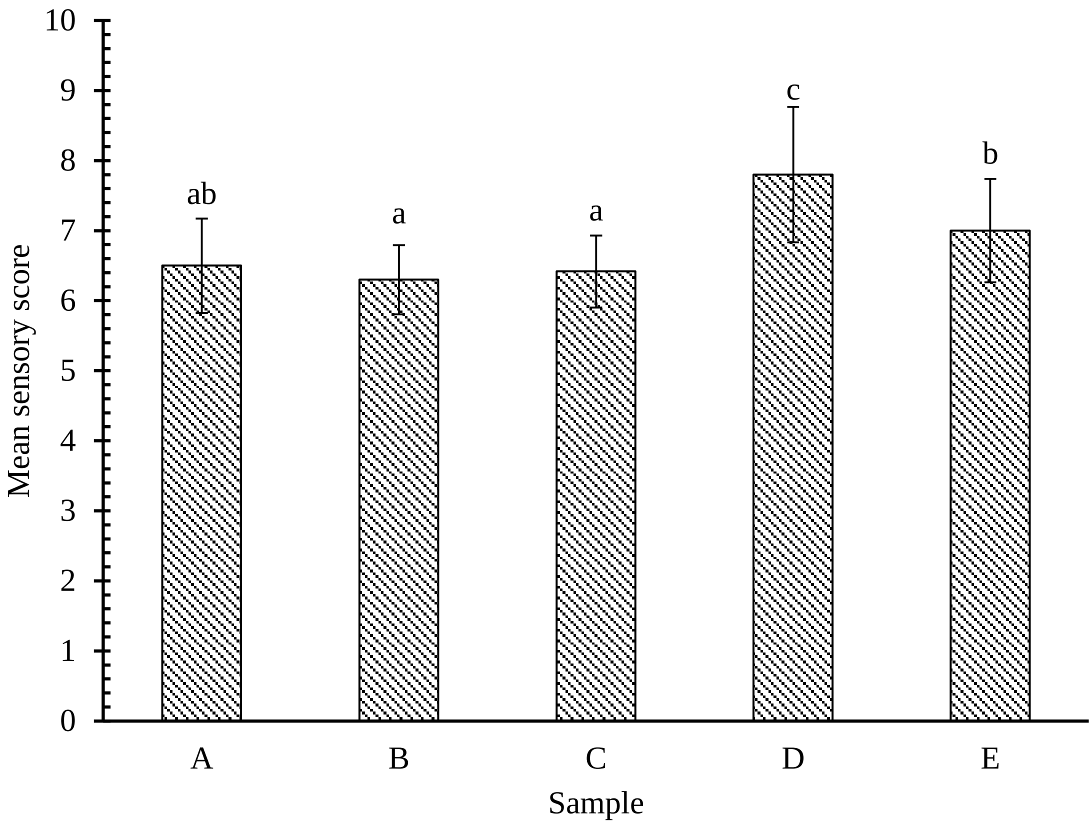

Fig. 4.3 Mean sensory score for flavor of *Yamari*

Fig. 4.3 represents the mean sensory scores for flavor of *Yamari*. Values on top of the bars bearing similar superscript were not significantly different at 5% level of significance.

Vertical error bars represent ± standard deviation of scores given by panelists. Samples A, B, C, D and E represent sample formulations as given in Table 3.1

Alice and Wan Rosli (2015) found the almost similar results where the panelist may not favor the flavor caused by the rice bran in the brown rice flour when it is added more than 30% in the rice based traditional local *Kuih*. It was found that the rice bran present in the brown rice flour was described as having a slightly toasted and nutty flavor (Babu *et al.*, 2009).

4.3.4 Effect of formulation on texture

The mean sensory scores for texture of samples A, B, C, D and E were found to be 6.8±0.94, 6.5±0.90, 6.9±1.24, 7.8±0.83 and 7.5±0.67 respectively which is shown in Fig. 4.4.

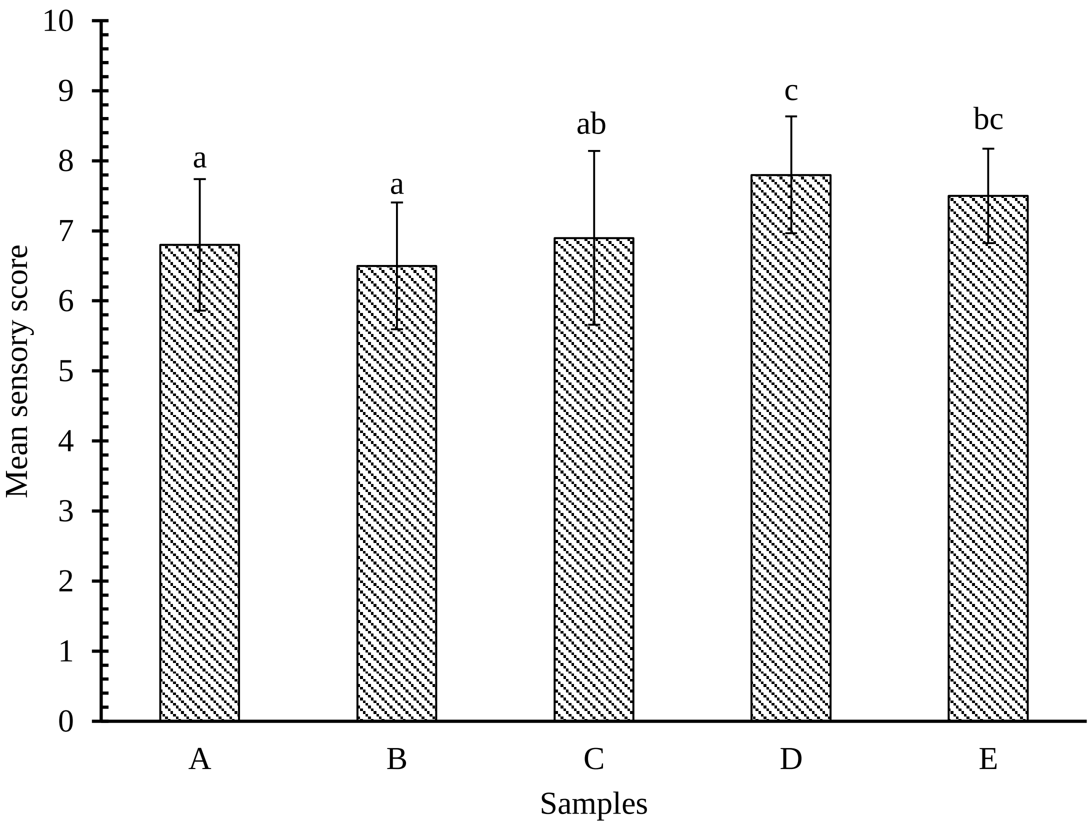

Fig. 4.4 Mean sensory score for texture of *Yamari*

Fig. 4.4 represents the mean sensory scores for texture of *Yamari*. Values on top of the bars bearing similar superscript were not significantly different at 5% level of significance.

Vertical error bars represent ± standard deviation of scores given by panelists. Samples A, B, C, D and E represent sample formulations as given in Table 3.1

The mean score was found to be highest for sample D which was preferred by the most of the panelist based on its texture. Sample D was found to be significantly different from samples B, C and E in terms of texture. However, Samples A and B had no significant difference between them at 5% level of significance which was almost nearly similar to the sample C. It was indicated that the incorporation of brown rice at 37.5% had texture difference significantly ($p \leq 0.05$) than others incorporating with brown rice less than 37.5% which was mostly preferred by the panelist. Further increase in the proportion of brown rice negatively impact the textural property of the product thus resulting lowered the mean sensory score for texture. Similar results were obtained by Alice and Wan Rosli (2015).

4.3.5 Effect of formulation on overall acceptability

The mean sensory scores for overall acceptability of samples A, B, C, D and E were found to be 6.3±0.65, 6.0±0.85, 6.5±0.67, 8.1±0.51 and 7.3±0.45 respectively which is shown in Fig 4.5. The mean sensory score was found to be highest for sample D which was preferred by the most of the panelist followed by sample E. Sample D was found to be significantly different from samples A and E in terms of overall acceptability of *Yamari*. However, Samples A, B and C had no significant difference between them at 5% level of significance.

No significant different among the samples A, B and C in terms of overall acceptability indicates that panelist couldn't find out the significant different among the samples A, B and C with the increasing order in concentration of brown rice at 0%, 12.5% and 25%. Further incorporation of brown rice up to 37.5% in *Yamari* was preferred by almost all the panelist in term of its acceptability while the sensory mean score started to drop with the further increase in the proportion of brown rice to 50%. Similar results were obtained by Alice and Wan Rosli (2015)

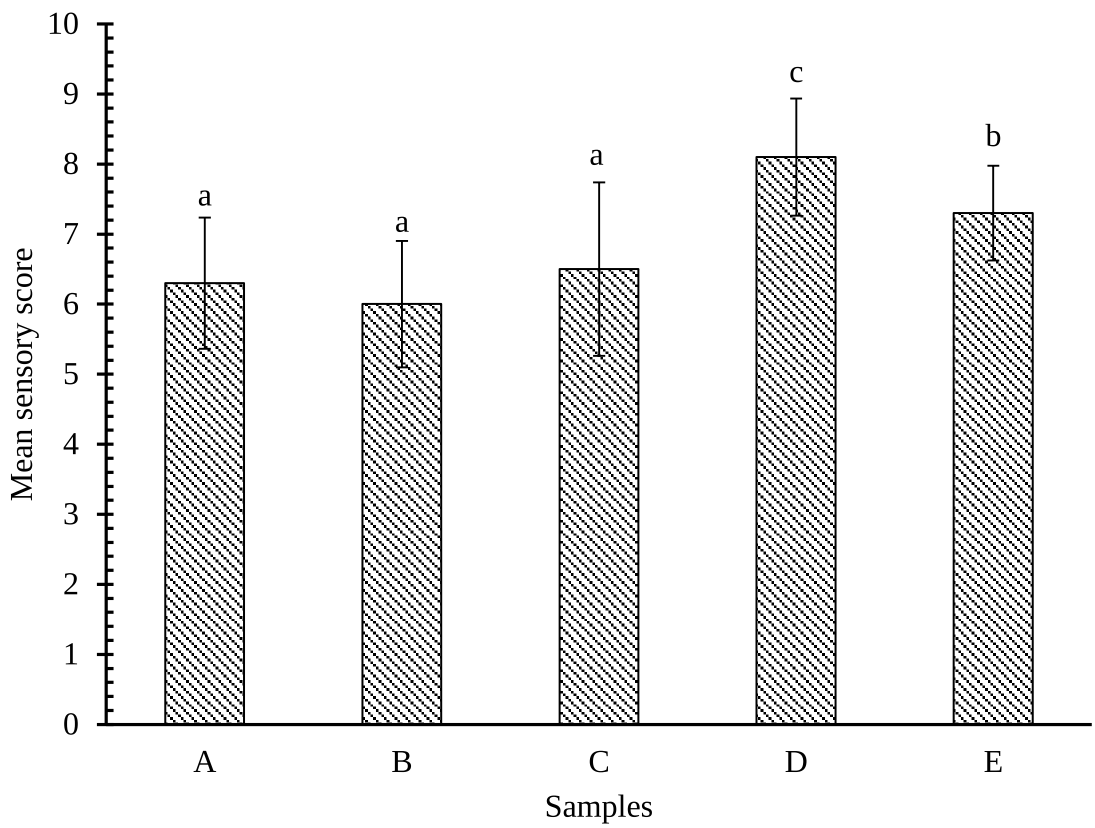

Fig. 4.5 Mean sensory score for overall acceptability of *Yamari*

Fig. 4.5 represents the mean sensory scores for acceptability of *Yamari*. Values on top of the bars bearing similar superscript were not significantly different at 5% level of significance. Vertical error bars represent ± standard deviation of scores given by panelists. Samples A, B, C, D and E represent sample formulations as given in Table 3.1

Therefore, sample D was found to be the best in most of the parameters and overall acceptability as well. The formulation with 37.5% brown rice and 62.5% white rice was chosen to be the best product by sensory evaluation and obtained data interpretation. This conclusion was derived based on sensory analysis of limited number of panelists and so the experimental results should be taken with some reservations as it may differ when subjected to other populations.

4.4 Determination of chemical properties of *Yamari*

The Table 4.3 shows the proximate composition of *Yamari.* The moisture content of *Yamari* was found out to be 44.20%. This is due to the steam cooking of the product. The crude protein and crude fat content of *Yamari* was found to be 14.15% and 12.80%

respectively. The protein content is due to the protein present in both brown rice & white rice and *khoa* while the fat content is mainly due to the fat present in *khoa*.

Table 4.3 Chemical composition of *Yamari*

Parameters	Values (%)
Moisture content %	44.20±1.30
Crude protein %	14.15±0.39
Total ash %	1.97±0.09
Fat %	12.80±0.20
Crude fiber %	1.86±0.01
Total carbohydrate %	69.37±1.02
Total sugar %	5.55±0.38
Reducing sugar %	1.10±0.24
Energy/ 100 g	449.28 Kcal
Calcium mg/100 g	280±3.95
Iron mg/100 g	4.1±0.43

Above all the values were expressed in db% except moisture content. The figures are the mean ± SD of triplicate results.

The ash content and crude fiber content was found to be 1.97 % and 1.86 % respectively. The carbohydrate content of *Yamari* was found to 69.37 %. This was due to the rice flour being major ingredient of the product. The calcium content was found out to be 280 mg/100 g. The iron content of *Yamari* was found out to be 4.1 mg/100 g. According to (Shrestha 2012), the moisture content of *Yamari* incorporating sesame and jaggery *was* found out to be 45.5%. The crude protein and crude fat content of *Yamari* was found to be 6.49% and 1.6% respectfully. The ash content and crude fiber content was found to be 0.83

and 0.75 respectively. The carbohydrate content of *Yamari* was found to 44.81%. The calcium content was found out to be 274.3 mg/100 g. The iron content of *Yamari* was found out to be 2.14 mg/100 g. (Appendix A.3)

As according to (Shrestha, 2012), the calorific value of the product was found to be 226.768 Kcal/100g of *Yamari*. After the incorporation of brown rice and *khoa* in to the *Yamari*, the calorific value of the resulting product increased to 449.28 Kcal/100 g.

4.5 Physical analysis of *Yamari*

The Table 4.4 given below shows the weight and volume of the *Yamari*.

Table 4.4 Physical analysis of *Yamari*

Parameter	Value
Weight (g)	67.5±0.82
Volume (cm^3)	116.52±0.73

The values obtained are mean of three determinations.

The weight and volume of *Yamari* was found to be 67.5 g and 116.52 cm^3 respectively. According to (Shrestha, 2012), the weight and volume of *Yamari* was found to be 70.32 g and 121.39 cm^3 respectively. The value obtained may vary according to the size of the *Yamari*.

4.6 Cost evaluation

The total cost associated with the best product was calculated and the cost of *Yamari* per 67.5 g was NRs.7.11, excluding labor cost, packaging cost and tax. Mass production further reduces this cost. From the cost calculation given in Appendix C, it can be seen that due to the partial replacement of white rice with the brown rice, the total cost has been reduced to some extent.

Part V

Conclusions and recommendations

5.1 Conclusions

The present work was carried out to study the acceptability of *Yamari* incorporated with brown rice and khoa and to observe the effect of incorporation of brown rice in the sensory attributes of *Yamari*. On the basis of survey and sensory evaluation, the following conclusions can be drawn:

1. The brown rice flour could be successfully incorporated up to 37.5%, with no adverse effect on the acceptable quality.
2. The brown rice flour had significant effect on appearance, color, flavor and texture of the *Yamari*.
3. The incorporation of increasing level of brown rice flour decreased the sensory acceptability of the *Yamari*.
4. Chemical analysis showed that, the crude protein, crude fat and crude fiber of *Yamari* was 14.15%, 12.80% and 1.86% respectively.
5. The calorific value of *Yamari* was found out to be 449.28 Kcal per 100 g of the product.
6. The cost of 100 g *Yamari* was found to be Rs. 10.54 while the cost of 1 piece *Yamari* (67.5 g) was found to be Rs.7.11.

5.2 Recommendations

Based on the present study, the following recommendations have been made:

1. The effects of adding different ingredients like nuts and spices and nutritional quality of *Yamari* can be studied.
2. The shelf life of the product can be studied in different storage conditions using different packaging materials such as aluminum foil, BOPP.
3. Growth of specific micro-organism like coliform, S. thermophiles etc. can be studied during storage.
4. Broken rice flour can be used instead of whole grain *taichin* flour to minimize the cost of the product.

Part VI

Summary

Yamari is one such delicacy that has close ties with different festivals especially of the Newar community. It is one of the cultural and traditional steamed dumpling food with an external shell made out of the flour of freshly harvested rice shaped like a fish with its insides filled with either *Chaku* (molasses) and sesame paste or *Khoa*. Brown rice being a source of all round nutrition having nutraceutical properties can be used as an ideal replacement of white rice in a desired proportion to yield brown rice incorporated *Yamari*. This study was mainly focused on the nutritional value addition of normal *Yamari* by incorporating brown rice flour at various levels of incorporation.

For this dissertation *Taichin* variety of white rice & brown rice and market *Khoa* were used to prepare *Yamari*. The rice was soaked in water for 1 h and then water was drained completely and then ground to flour. The white rice flour and brown rice flour were mixed as according to the formulation obtained from DOE. The mixed rice flour dough was prepared with the addition of water. 30g of dough was taken and then molded in a cup shape with a tail. The calculated amount of Khoa was added in the dimple of the cup. Then the opening was sealed with hand. After that steam cooking was done.

The flour obtained from brown rice and white rice of *Taichin* variety along with *Khoa* was analyzed for the determination of its chemical composition. The chemical composition of Khoa was found to be 26.25 % moisture, 36.05 % crude fat, 27.36 % protein, 4.4 % ash and 36.05% carbohydrate. Furthermore, chemical composition of white rice flour and brown rice flour were found to be 12.25% and 11.48% moisture, 7.13% and 7.96% crude protein, 0.41% and 1.1% total ash, 0.55% and 1.8% fat, 0.83% and 2.9% crude fiber while 79.08% and 77.76% total carbohydrate respectively.

The incorporation of brown rice was carried out as 0%, 12.5%, 25%, 37.5% and 50%. From sensory analysis, the *Yamari* incorporated with 37.5% brown rice was found to be the best. It was found that the incorporation of brown rice had a significant effect on appearance, color, flavor, texture and overall acceptability of *Yamari*. The physical and chemical analysis of best *Yamari* was carried out. The weight and volume of *Yamari* was found to be 67.5g and 116.52 cm^3 respectively. Moisture content, crude protein, total ash,

crude fat, total carbohydrate and crude fiber of optimized product were found to be 44.20%, 14.15%, 1.97%, 12.80%, 69.37% and 1.86% respectively while its calcium content and iron content were found to be 280 mg/100g and 4 mg/100g respectively.

Similarly, the calorific value of the final product was found to be 449.28 Kcal/ 100g which was increased by nearly about two times of normally prepared *Yamari* due to the incorporation of brown rice and *Khoa*. The cost of optimized 100g of *Yamari* was found to be NRs. 10.54. The overall study showed that brown rice incorporated *Yamari* at 37.5% incorporation would give a nutritionally enriched product with best acceptability.

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Appendices

Appendix A

Table A.1 Proximate composition of brown rice and white rice (g/100 g wt)

Nutrient	Brown Rice	White Rice
Moisture (%)	10.37	11.62
Protein (%)	7.94	7.13
Total lipid (fat) (%)	2.92	0.66
Carbohydrate (%)	77.24	79.95
Fiber (total dietary) (%)	3.5	1.3
Total sugar (%)	0.85	0.12
Calcium, Ca (mg/100 g)	23	28
Iron, Fe (mg/100 g)	1.47	0.8
Magnesium, Mg (mg/100 g)	143	25
Phosphorus, P (mg/100 g)	333	115
Potassium, K (mg/100 g)	223	115
Sodium, Na (mg/100 g)	7	5
Zinc, Zn (mg/100 g)	2.02	1.09
Thiamine (mg/100 g)	0.401	0.07
Riboflavin (mg/100 g)	0.093	0.049
Niacin (mg/100 g)	5.091	1.6
Vitamin B6 (mg/100 g)	0.509	0.164
Folate (mg/100 g)	20	8
Vitamin E (mg/100 g)	1.2	0.11

Source: Karna and Upadhyay (2017)

Table A.2 Proximate composition of brown rice and white rice

Parameters	Brown rice	White rice
Moisture (%)	12	12
Energy, Kcal/100 g	360	363
Protein (%)	7.5	6.7
Total lipid (fat) (%)	1.9	0.4
Carbohydrate (%)	77.4	80.4
Fiber (total dietary) (%)	0.9	0.3
Ash (%)	1.2	0.5
Calcium, Ca (mg/100 g)	32	24
Iron, Fe (mg/100 g)	1.6	0.8
Phosphorus, P (mg/100 g)	221	94
Potassium, K (mg/100 g)	214	92
Sodium, Na (mg/100 g)	9	5
Thiamine (mg/100 g)	0.34	0.07
Riboflavin (mg/100 g)	0.05	0.03
Niacin (mg/100 g)	4.7	1.6

Source: (Raut (2006))

Table A.3. Proximate composition of *Yamari*

Parameter	Values (%)
Moisture content, %	45.51±0.36
Crude protein, %	6.49±0.48
Total ash, %	0.83±0.10
Fat, %	1.6±0.3
Total carbohydrate, %	44.81±0.22
Crude fiber, %	0.75±0.12
Reducing sugar, %	1.14±0.2
Total sugar, %	6.03±0.29
Energy/ 100 g	226.768 Kcal
Calcium, mg/100 g	274.3±0.62
Iron, mg/100 g	2.14±0.25

Source: Shrestha (2012)

The values obtained are mean of three determinations.

Appendix B

Specimen card for sensory evaluation

Hedonic rating test

Date........................

Name of panelist...............................

Name of the product: ***Yamari***

Dear panelist, you are given 5 samples of ***Yamari*** containing different proportion of brown rice. Please taste the sample and score how much you prefer the each one. Please give points for your degree of preference for each parameter as shown below using the scale given.

Parameter	A	B	C	D	E
Appearance					
Color					
Flavour					
Texture					
Overall acceptance					

Give points as follows:

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

Comments (if any)………………………………………………………………………

Signature

Appendix C

Survey questionnaire

1. What are the different indigenous products produced on this place?
2. On what occasions do you produce *Yamari*?
3. Why *yamari* not others?
4. When was it originated (any ancient data if you know)?
5. Who taught you to produce it?
6. What are the main ingredients used for the production (with amount if possible)?
7. What are the other ingredients that can be used in the production (with amount if possible)?
8. How do you produce *yamari* (process flow chart)?
9. What are technical problems in the production (that make your product superior than others)?
10. How do you store and for how many days?
11. What are the technical problems during production?
12. When it has best religious value and when?
13. Which texture does you like (medium, or soft)?
14. What are the changes observed during storage?
15. What are the defects in it (on storage)?
16. What are the modifications in recipe and process that can be applied?
17. What should be done to obtain the best product?
18. Who likes it most (age group, community)?
19. What is its market price?
20. What is the consumption rate in the community?

Appendix D

Cost evaluation of the product

Ingredients	Quantity	Rate NRs	Quantity used	Rate NRs
White rice	1000 g	105	62.5	6.56
Brown rice	1000 g	90	37.5	3.38
Khoa	1000 g	800	8	6.4
Total Costing				16.34

Yield from 62.5 g white rice, 37.5 g brown rice and 8 g khoa is 155 g. So the price of 100 g of *Yamari* is Rs 10.54. The cost of 1 piece *Yamari* (67.5 g) is Rs 7.11.

Appendix E

ANOVA for sensory analysis of *Yamari*

Table D.1 Two way ANOVA (No blocking) for appearance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	4	27.9000	6.9750	18.16	<.001
Panelist	11	4.1833	0.3803	0.99	0.470
Residual	44	16.9000	0.3841		
Total	59	48.9833			

Since F pr. <0.05, there is significant difference between the samples so LSD testing is necessary.

Table D.2 Two way ANOVA (No blocking) for color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	4	21.2667	5.3167	13.98	<.001
Panelist	11	5.6000	0.5091	1.34	0.236
Residual	44	16.7333	0.3803		
Total	59	43.6000			

Since F pr. <0.05, there is significant difference between the samples so LSD testing is necessary.

Table D.3 Two way ANOVA (No blocking) for flavor

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	4	16.7667	4.1917	9.79	<.001
Panelist	11	8.0000	0.7273	1.70	0.105
Residual	44	18.8333	0.4280		
Total	59	43.6000			

Since F pr. <0.05, there is significant difference between the samples so LSD testing is necessary.

Table D.4 Two way ANOVA (No blocking) for texture

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	4	13.9333	3.4833	6.07	<.001
Panelist	11	22.9833	2.0894	3.64	0.001
Residual	44	25.2667	0.5742		
Total	59	62.18330			

Since F pr. <0.05, there is significant difference between the samples so LSD testing is necessary.

Table D.4 Two way ANOVA (No blocking) for overall acceptability

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	4	33.5000	8.3750	19.50	<.001
Panelist	11	3.9333	0.3576	0.83	0.609
Residual	44	18.9000	0.4295		
Total	59	56.3333			

Since F pr. <0.05, there is significant difference between the samples so LSD testing is necessary.

Appendix F

Summary of the ANOVA of sensory evaluation of *Yamari*

Sample code	Appearance	Color	Flavor	Texture	Overall
A	$6.8^{ab} \pm 0.62$	$6.4^{ab} \pm 0.51$	$6.5^{ab} \pm 0.67$	$6.8^{a} \pm 0.94$	$6.3^{a} \pm 0.65$
B	$6.3^{a} \pm 0.49$	$6.3^{a} \pm 0.78$	$6.3^{a} \pm 0.49$	$6.5^{a} \pm 0.90$	$6.0^{a} \pm 0.85$
C	$6.5^{a} \pm 0.67$	$6.4^{ab} \pm 0.51$	$6.4^{a} \pm 0.51$	$6.9^{ab} \pm 1.24$	$6.5^{a} \pm 0.67$
D	$8.3^{c} \pm 0.45$	$7.9^{c} \pm 0.67$	$7.8^{c} \pm 0.97$	$7.8^{c} \pm 0.83$	$8.1^{c} \pm 0.51$
E	$7.1^{b} \pm 0.79$	$6.9^{b} \pm 0.67$	$7.0^{b} \pm 0.74$	$7.5^{bc} \pm 0.67$	$7.3^{c} \pm 0.45$
LSD (5%)	0.5099	0.5074	0.5383	0.6235	0.5392

Appendix G

Color plates

P. 1 Performing **s**urvey

P. 2 Making dough

P. 3 Brown rice incorporated *Yamari*

P. 4 Sensory analysis of *Yamari*