PREPARATION AND QUALITY EVALUATION OF *BHAKKA* PREPARED BY INCORPORATION OF SPROUTED CHICKPEA FLOUR AND SPROUTED SOYBEAN FLOUR

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Preparation And Quality Evaluation of *Bhakka* Prepared By Incorporation of Sprouted Chickpea Flour and Sprouted Soybean Flour

A dissertation submitted to the ***Department of Food Technology, Central Campus of Technology, Tribhuvan University****, in partial fulfillment of the requirement for the degree of* ***B. Tech. in Food Technology***

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Approval Letter

This ***dissertation*** entitled ***Preparation and Quality Evaluation of Bhakka Prepared by Incorporation of Sprouted Chickpea Flour and Sprouted Soybean Flour*** presented by ***Anul Bastola*** has been accepted as the partial fulfillment of the requirement for the ***B. Tech. degree in Food Technology.***

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November 11, 2024

(Anul Bastola)

Abstract

The main aim of this study was to prepare *bhakka* incorporated with sprouted chickpea flour and sprouted soybean flour and to evaluate sensory properties, physicochemical properties and shelf life. Chickpea flour and soybean flour each were incorporated at different proportion with rice flour separately: 0:100, 5:95, 10:90, 15:85, 20:80 to prepare nine formulations. The prepared samples were subjected to sensory evaluation using a 9-point hedonic rating to evaluate the best product in terms of appearance, taste, texture, smell and overall acceptance. The formulation with 15% chickpea flour and 85% rice flour and 10% soybean flour and 90% rice flour was selected as the best product. Proximate analysis of rice flour, sprouted chickpea and soybean flour, control and best product were done as well as weight, diameter and thickness of control and best product was measured. The storage stability of the best product was studied under room and refrigerated conditions at every 2 days interval. During the storage period, changes in TPC of the product were evaluated.

The moisture content, crude fat, crude protein, crude fiber, ash and carbohydrate of best formulation of control *bhakka,* chickpea *bhakka* and best soybean *bhakka* was determined and the best products were significantly different with control in terms of all the parameters as determined at 5% level of significant. TPC of best *bhakka* was found to be 1.32 x 10^3 cfu/g for best chickpea *bhakka* and 1.21 x 10^3 cfu/g for best soybean *bhakka* at day 0 which increased faster in room temperature than in refrigerated temperature with the number of days of storage. The storage stability of the best product was estimated to be 5 days under room temperature and 8 days under refrigerated temperature. The price per piece *Bhakka* for chickpea incorporated *Bhakka* was calculated to be Rs. 12.221 and that for soybean incorporated *Bhakka* was Rs. 11.737.

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List of Abbreviations

Abbreviations	Full Form
ANOVA	Analysis of Variance
AOAC	Association of Analytical Communities
CFU	Colony Forming Unit
etc.	et cetera
fig	Figure
LSD	Least Significant Difference Figure
Ref (CP)	Refrigerated temperature of Chickpea *Bhakka*
Ref (SB)	Refrigerated temperature of Soybean *Bhakka*
RT(CP)	Room temperature of Chickpea *Bhakka*
RT(SB)	Room temperature of Soybean *Bhakka*
TPC	Total Plate Count
°C	Degree Centigrade

Part I

Introduction

1.1 General Introduction

Traditional foods are foods and dishes that are passed through generations (Kristbergsson and Oliveira, 2016) or which have been consumed for many generation (Saunders, 2010). Traditional foods and dishes are traditional in nature, and may have a historic precedent in a national dish, regional cuisine (Kristbergsson and Oliveira, 2016) or local cuisine.

In context of Nepal, there are different traditional foods such as *Bhakka, Gundruk, Sinki, Jand, Raksi, Nigar, Maseura, Selroti, Anarsha, Bagiya, Yomari, Chatamari, Chhoyla, Kachila* etc.

Bhakka is a traditional and indigenous food of Nepal. *Bhakka*, simple fluffy rice flour steamed cake, is a traditional delicacy of *Tharu* community living in eastern plains of Nepal especially of *Rajbansi* community, especially of Morang district. Nowadays, it is increasingly popular in other regions and in cultures. *Bhakka* has been a seasonal income source for people of *Tharu, Rajbanshi* and *Dhimal* community. They are sold in chowks, haat bazaar and are even been started to be sold in some restaurants of Kathmandu. There has not been found such legend of naming of *Bhakka* but they said that it was named because it is steam cooked product. In *Tharu* language, vapor means *Bhaff* and eat means *khabbe*. Therefore, it is said that *Bhakha* later turned into *Bhakka* (Kharel *et al.*, 2010).

Selling *Bhakka* is a seasonal business of winter season usually starting from Kartik upto *Magh Falgun*. It is prepared from rice flour esp. *Kanchhi* which is made traditionally by soaking cleaned whole rice in water and hand pounded (in *Okhli* or *dhiki*) it upto fine flour mass to get rice flour after complete draining of water for about 10 minutes. The flour obtained is used to make dough of desired property. Dough such obtained is press sieved through the wire screens of small mess sizes or through the mosquito curtain to obtain small granules, and this process is referred as agglomeration. Small wet granules thus obtained are loosely filled into moulds (small plate, bowl, bicycle bell) and atmospheric steam cooking is done for about 2-3 minutes after wrapping of shaped mass by muslin cloth. *Bhakka* is served hot as breakfast, lunch, dinner as staple food (replacement of *Bhaat*) generally with chutney of tomato and coriander. They can also be served with other pickles, vegetable curries, meat curries, fish curries, tea, milk etc. Different types of spices such as cardamom, cinnamon and other hot spices, coconut, cashew nut etc. can be used to prepare *bhakka (Dahal et al., 2022)*.

Chickpea (*Cicer arietinum L.*) is grown worldwide and is best adapted to cool, dry climates. Thus, it is a winter crop in some regions of the world(Aisa *et al.*, 2019). Chickpeas are high in vitamins, minerals, fiber and protein. The high fiber in chickpea benefits your digestion by increasing the number of healthy bacteria in your gut and helping waste flow efficiently through your digestive tract. These characteristics are responsible for most of their health benefits, which range from weight management to blood sugar control. Including chickpeas in your diet regularly will support your health and may reduce your risk of developing chronic diseases, such as heart disease and cancer (Elliott, 2018).

Soybean (*Glycine max*), a species of legume, a miracle bean, is an excellent health food as it contains good quality protein but only minimal saturated fat and sufficient amounts of minerals and vitamins(Gopalan *et al.*, 1989). Soy protein directly lowers serum cholesterol levels(Jenkins *et al.*, 2010). Soy foods are quite important to us as they reduce the risk of heart disease. Regular consumption of soy food delays the process of aging and also improves mental and physical abilities, memory power, and hemoglobin levels of children (Rizzo and Baroni, 2018).

1.2 Statement of the problem

Legumes are rich sources of protein throughout the world and contain approximately three times more protein than cereals. The potential for increased use of chickpea and soybean is related to its relatively low cost, relatively high protein content (18–26.8% for chickpea and 30-40% for soybean), high protein digestibility (76–78%) and other desirable functionalities (Alvarez *et al.*, 2017). They are considered rich source of vitamins, proteins, minerals and fibers and may offer a variety of health benefits, such as improving digestion, aiding weight management and reducing the risk of several diseases. Not only this, they are a great source of plant-based protein, making them an appropriate food choice for those who do not eat animal products. When you sprout chickpeas and soybean, the anti-nutrients get removed which make them better digestible and improves the absorption of other vitamins.

Normally, *bhakkas* are based on rice flour alone. Hence, through this dissertation work incorporation of sprouted chickpea and soybean flour in *bhakka* is attempted to prepare where nutritional benefits of them is more conveniently interlinked with the delightful taste of the *bhakkas*.

1.3 Objectives

1.3.1 General Objectives

The main objective of this work is to incorporate sprouted chickpea flour and sprouted soybean flour prepared after various processing methods, with rice flour to prepare *Bhakka*.

1.3.2 Specific Objectives

The specific objectives of this study are:

1. To study the physiochemical properties of rice flour, sprouted chickpea flour and sprouted soybean flour.
2. To prepare *bhakkas* incorporated with sprouted chickpea flour and sprouted soybean flour at different proportion with rice flour.
3. To carry out sensory evaluation to select best formulation.
4. To determine the physicochemical properties and physical parameters of control and best product.
5. To determine storage stability of the best product.
6. To evaluate the cost of best formulation.

1.4 Significance of work

Bhakka is indigenous food of Nepal which is cheap and affordable by almost every group of peoples. Hence, such foods should be nutritionally as rich as possible. So, the need of this study has been considered in order to fulfill the shortcomings in rice flour *bhakka* by partial incorporation of chickpea and soy flour which is richer in protein, mineral and vitamin content in comparison to normal rice flour. Hence, it serves as a small effort to solve malnutritional problem by providing high quality and complete protein and other nutrients to economically weak community.

On the other hand, a new taste is introduced to consumers. Hence, in context of Nepal, production of chickpea and soy flour incorporated *bhakka* will be beneficial not only for sellers but consumers as well.

1.5 Limitations of the work

1) Micro-nutrients of *bhakka* were not studied.
2) Suitable packaging material for the handling, transportation and storage were not studied.
3) Comparison between different varieties of rice were not studied.
4) Instrumental textural analysis was not carried out.

Part II

Literature review

2.1 Bhakka

Bhakka is a traditional and indigenous food of Nepal. *Bhakka*, simple fluffy rice flour steamed cake, is a traditional delicacy of *Tharu* and *Koch* community living in eastern plains of Nepal especially of *Rajbansi* community, especially of Morang district. Nowadays, it is increasingly popular in other regions and in cultures. *Bhakka* has been a seasonal income source for people of *Tharu*, *Rajbanshi* and *Dhimal* community. They are sold in chowks, haat bazaar and are even been started to be sold in some restaurants of Kathmandu. There has not been found such legend of naming of *Bhakka* but they said that it was named because it is steam cooked product. In *Koch* community commonly the name *Bhakka* came from the *Bhafa pitha* where the *Bhafa* means vapor and *pitha* means rice flour which later on turned into name *Bhakka*. But also in some people of *Tharu* community says that name *Bhakka* came from *Bhaff khabe* where *bhaff* is vapor and *khabe* means to eat. Therefore, it is said that Bhakha later turned into *Bhakka* (Kharel *et al.*, 2010).

Selling *Bhakka* is a seasonal business of winter season usually starting from Kartik upto *Magh Falgun*. It is prepared from rice flour esp. *Kanchhi* which is made traditionally by soaking cleaned whole rice in water and hand pounded (in *Okhli* or *dhiki*) it upto fine flour mass to get rice flour after complete draining of water for about 10 minutes. Nowadays soaked rice flour is milled to obtain fine rice flour. The flour obtained is used to make dough of desired property. Dough such obtained is press sieved through the wire screens of small mess sizes or through the mosquito curtain to obtain small granules, and this process is referred as agglomeration. Small wet granules thus obtained are loosely filled into moulds (small plate, bowl, bicycle bell) and atmospheric steam cooking is done for about 2-3 minutes after wrapping of shaped mass by muslin cloth. *Bhakka* is served hot as breakfast, lunch, dinner as staple food (replacement of *Bhaat*) generally with chutney of tomato and coriander. They can also be served with other pickles, vegetable curries, meat curries, fish curries, tea, milk etc (Dangal *et al.*, 2021).

Bhakka can be prepared from all kinds and varieties of rice like whole, broken, fines, brown, polished, new or old, high or low starchy, aromatic and non-aromatic except parboiled but the quality of *Bhakka* may differ according of variety, type, kind of rice. The best variety for *Bhakka* making is aromatic and starchy like Basmati and polished rice. But 6 generally *Kanchhi* variety of rice is used to prepare *Bhakka* as it is cheap and produces good quality *Bhakka* in terms of taste and texture compared to other common and cheap varieties of rice. Despite broken rice is cheaper compared to whole rice, generally whole rice is used to prepare *Bhakka* as broken rice may contains more impurities, and are inferior in taste compared to whole rice (Dahal *et al.*, 2022).

Bhakka can be made with both old and new varieties of rice but generally new varieties if taken produces firm and spongy texture *Bhakka* with good taste compared to aged or old rice. The aroma of the *Bhakka* prepared from the aromatic variety of rice increases the acceptability of *Bhakka* as well as it's cost. Although, the brown rice is nutritive, the color of the prepared *Bhakka* will be downgraded and reduces it's acceptability. Different types of spices such as cardamom, cinnamon and other hot spices, coconut, cashew nut etc. can be used to prepare *Bhakka* (Kharel *et al.*, 2010).

2.2 Types of *Bhakka*

Two types of *Bhakka* are being prepared namely Plain or normal *Bhakka* and Sweet *Bhakka*.

2.2.1 Plain *Bhakka*

Plain *Bhakka* is just an steamed rice cake which is served with chutney made with tomato and coriander.

2.2.2 Sweet *Bhakka*

Sweet *Bhakka* contains some added sugar for enhancing it's taste and usually is not served with chutney like Plain *Bhakka* (Dangal *et al.*, 2021).

2.3 Rice

2.3.1 Introduction

Rice (*Oryza sativa*) is the most important staple food for human consumption. More than 90% of it is grown and consumed in South, East, and Southeast Asia, where ~60% of the earth's population lives (Bhattacharya, 2009). With the high levels of economic growth in Asia over the past thirty years lifting millions of people out of poverty, producing a higher proportion of middleclass people, the demand for higher quality rice is rapidly increasing (Lee and Hong, 2012). However, rice consumers, particularly from countries for which rice is the staple, have strong preferences for the sensory properties of rice. Different countries have different requirements for quality, and within countries, a range of preferences can be found (E.T. Champagne *et al*., 2010). Thus, one of emerging challenges facing the rice industry and breeders is to control the eating quality of rice for specific end-use markets. Cooked rice texture has been shown to govern the acceptance of rice by consumers (Okabe, 1979).

Taxonomic classification of rice is given below:

Kingdom: Plantae
Subkingdom: Viridiplantae
Infrakingdom: Streptophyta
Superdivision: Embryophyta
Division: Tracheophyta
Subdivision: Spermatophytina
Class: Magnoliopsida
Superorder: Lilianae
Order: Poales
Family: Poaceae
Genus: Oryza L.
Species: Oryza *sativa L.*

Source: ITIS (2022)

2.3.2 Rice production

In 2017, world production of paddy rice was 769.7 million tonnes, led by China and India with a combined 49% of this total (Prasad *et al.*, 2017). Other major producers were Indonesia, Bangladesh and Vietnam. The five major producers accounted for 72% of total production, while the top fifteen producers accounted for 91% of total world production in 2017. Developing countries account for 95% of the total production.

Rice is a major food staple and a mainstay for the rural population and their food security. It is mainly cultivated by small farmers in holdings of less than one hectare. Rice is also a wage commodity for workers in the cash crop or non-agricultural sectors. Rice is vital for the nutrition of much of the population in Asia, as well as in Latin America and the Caribbean and in Africa; it is central to the food security of over half the world population (Basavaraja *et al*., 2007).

Table 2.1 Rice production in 2017 (millions of tons)

Country	Millions of tons
China	214.4
India	168.5
Indonesia	111.5
Bangladesh	49.0
Vietnam	42.8
Thailand	42.8
Myanmar	33.4
Philippines	25.6
Pakistan	11.2
World	**670.2**

Source: Redfern *et al.* (2012)

2.3.3 Rice in Nepal

Nepal is one of the important centers of rice genetic resources. More than 1700 rice landraces are reported in Nepal growing from 60 to 3050 m altitude (Mallick, 1981). Rice samples of 500 years ago are found at Simraungadh, Bara. This shows that commercial production of rice in Nepal started some five hundred years ago.

Food grains (rice, maize, wheat, millet and barley) dominate the country's crop sector accounting for over three-fourth of the gross cultivated area in Nepal (total cultivated area-3,091,000 ha). Rice ranks the first among cereal crops in terms of area, production and livelihood of the people. As the most important staple food of Nepalese people, rice supplies about 40% of the food calorie intake and contributes nearly 20% to the agricultural gross domestic product (AGDP) and almost 7% to GDP. Rice in Nepal carries special cultural, religious and traditional values in the society (Upadhyaya, 1996).

In Nepalese society, rice forms and integral part of one's life right from the birth rites to the death rites. Annaprasana - the first rice feeding ceremony is observed on or after fifth or sixth month of a child's birth. This ritualistic ceremony initiates the formal introduction of solid food for the baby. Dashain, the biggest Hindu festival in Nepal is celebrated right after the rice harvesting season. During Dashain, Elders put tika (a mixture of rice, yoghurt and vermilion powder) and Jamara (rice sprouts or rice seedlings) on the forehead of younger relatives to bless them with abundance in the upcoming years. Pindas are balls of cooked rice offered to ancestors during Hindu funeral rites (Shraaddha). Rice is one of the key ingredients in worshipping gods and goddesses across all religions in Nepal (Pandey, 2018).

Nepal is one of the centers of origin and diversity for Asian rice. The rice cultivated in Chhumjul of Jumla (Chhumchour VDC), at an elevation of 3,050 m is the highest place in the world to produce rice (Bhujel et al., 2011). Jumli Marshi/Kali Marshi, a temperate Javanica variety of indigenous rice, having cold tolerant gene, has been cultivated probably since 1300 A.D., and is believed to have been brought by Saint Chandannath Baba, all the way from India. The Terai region, considered the granary of the country, accounts for about 70 percent of the country's rice output, while the hills produce 26 percent and the mountain about 4 percent (Tripathi, 2023). However, despite its importance in national food security and the economy, still rice crop is grown under rain fed conditions in more than 35 percent of the total rice area. Drought, flooding and insect pests and diseases are major biotic and abiotic constraints to increasing rice yield and production in Nepal. Some general features of rice supply affecting the market are that its production fluctuates over years depending on the weather conditions and production of rice is seasonal. Besides, rice is produced in different qualities which have varying market values. Rice is transplanted between June and August and harvested from September to November. The monsoon rain first arrives in the eastern part of the country and gradually advances to the west. The planting and production of the crop is very much dependent on timing and intensity of the monsoon rain, which is normally active during mid-June until mid-September. In fully irrigated areas, farmers produce two rice crops in a year (Kandel and Shrestha, 2018).

Until early 1980s, Nepal used to export rice to India. Rice used to be exported from Terai region to the nearby Indian markets thanks to easy transportation access whereas supplying rice to the food deficit hills of the country was hampered by the lack of road infrastructure. However, in recent years, rice produced in the Terai is being transported to the hills due to improved road infrastructures and market facilities. Likewise, demand for rice in the hills and mountains are sharply augmented due to increased rice consumption behavior. Furthermore, Nepal has lagged behind in increasing productivity to fulfill the rice demand of the increasing population (Gadal *et al.*, 2019). As a result, Nepal gradually turned into a net importer of rice. In 2012/13, Nepal imported rice amounting Rs 9.23 billion or 259,045 tons. Imports of rice from India alone amounted to Rs 8.94 billion (MoAD, 2013). At the present context in Nepal, import tariff for processed rice is 8% and unprocessed rice is of 5%.

2.3.4 Chemical Composition of Rice

The removal off husk, results in the brown rice. The brown rice can be looked into many layers, pericarp, seed coat, germ and endosperm. The brown rice consists about 8% protein, 75% starch and small amount of fat, fiber, ash (at 14% moisture content) but the milled rice contains 7% protein, 78% starch (Carbohydrate) (Kent, 1983).

Chemical composition of milled and brown rice is shown in table below:

Table 2.2 Chemical composition of brown and milled rice (wet basis)

Constituents (%wb)	Brown rice (%)	Milled rice (%)
Carbohydrates	80.83	86.33
Protein	6.78	5.64
Ash(minerals)	1.09	0.45
Crude fiber	1.10	0.23
Fat	1.20	0.34
Moisture	14.00	14.00

Source: Rosniyana *et al.* (2006)

2.3.5 Cooking Quality of Rice

Stickiness or cohesiveness of the cooked grain is generally expected as the most important characteristics determining cooking quality. Absence of stickiness is desired in Thailand, India, Nepal, Pakistan, Sri Lanka and western countries, while in Japan, Korea and Vietnam, the stickiness in cooked rice is preferred criterion. Due to the differences in cooking behavior, varieties of rice also differ in their processing such as suitability by canning for making rice products and conditions for parboiling etc.

Several physic-chemical quality parameters have been used to determine the cooking quality of rice. For example, water uptake ratio, alkali scores, gruel loss, kernel elongation ratio, starch iodine blue value and hardness etc. None of these parameters gives an unfailing indication of the cooking quality of rice as a subjective criterion. The ultimate test of cooking of rice is it's sensory evaluation by a panel (Bhattacharya, 2009).

The cooking quality of rice can be examined under the following headings: Amylose content (AC), gelatinization temperature (GT), gel consistency (GC).

2.3.5.1 Gelatinization Temperature

Gelatinization temperature of the rice grain is recognized as one of the most important determinants of cooking quality (Rao *et al.*, 1952). The time required for cooking milled rice is determined by gelatinization temperature. In many rice growing countries, there is a distinct preference for rice with intermediate gelatinization temperature (IRRI, 2004).

2.3.5.2 Gel Consistency

Gel consistency measures the tendency of the cooked rice to harden after cooling. Within the same amylose group, varieties with a softer gel consistency are preferred and the cooked rice has a higher degree of tenderness. Hard cooked rice tends to be less sticky. Gel consistency is determined by heating a small quantity of rice in a dilute alkali (IRRI, 2004).

2.3.5.3 Amylose

The amylose content of starches usually ranges from 15 to 35%. Cooking and eating qualities of rice have long been associated with amylose content (Hamaker and Griffin, 1990). Rice low in amylose is generally known to be sticky and moist, where as those high in amylose are non-sticky, flaky and dry (B. O. Juliano *et al.*, 1965). However, deviations from this correlation exist, such as low - amylose rice that are non-sticky vice versa. Also, rice containing the same amylose content may differ substantially in hardness (firmness) and stickiness (Perez and Juliano, 1993).

2.3.6 Some Nepalese traditional foods from rice

2.3.6.1 *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).

2.3.6.2 *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).

2.3.6.3 *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 25gm to 50gm (Pokhrel, 2008).

2.3.6.4 *Chuira*

Chuira 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, Chaudhary*, etc. Special course variety of rice is suitable for chuira production. Researchers shows that *chuira* making incurs loss of minerals like calcium and iron (Kharel *et al.*, 2010).

2.3.6.5 *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* ethnic 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).

2.3.6.6 *Anarasa*

The term *Anarsa* or *Anarasa* may be originated from "Anna" means grains and "Rasa" means juiciness in Nepali dialect. *Anarasa* is fried, sweet, chapatti like product prepared from rice flour, sugar and ghee, indigenous to Nepal. It is popular specially among *Brahmin* and *Chettry* communities of Nepal. It is normally prepared in festivals, occasions and rituals like Tihar, wedding ceremony, Puja etc. *Anarasa* roti are old fashioned sweet rice patties (resembling large cookies). Rice flour gives this bread a crisp texture. The dough is hand stretched into circles and deep fried from one side only (Kharel *et al.*, 2010).

2.3.6.7 *Bagiya*

Bagiya is a healthy and delicious dish to celebrate Deepawali in Nepal's eastern terai region. *Bagiya* is served at the morning breakfast. It is oblong in shape, has a tail, and resembles a squirrel, but the tail is much shorter. They eat *bagiya* most frequently with pickles or vegetable curry. While Tharu prefers flat *bagiya* with lentils in eastern Nepal, westerners prepare *bagiya* in a tubular shape without lentils (Pradhan, 2005).

2.3.7 Nutritional benefits of rice

Rice is an excellent food to help in keeping our body healthy. Rice has the following nutritional benefits:

2.3.7.1 Excellent source of carbohydrate and energy

Good nutrition is vital to everyday performance, and eating more carbohydrate rich foods means having more energy. Rice is an excellent source of carbohydrates. Carbohydrates provide energy to fuel working muscles and feed the brain to enhance concentration. Carbohydrates are not normally converted to body fat, as they are the body's preferred source of energy. Carbohydrates are broken down to glucose, most of which is used as energy for exercise and as essential fuel for the brain (Kondidin, 2005).

2.3.7.2 Low in fat, salt and has no cholesterol

Rice is an excellent food to include in a balanced diet. It is low in total fat and saturated fat, is cholesterol free, and contains negligible amounts of sodium. Rice is therefore an excellent food to include in a cholesterol lowering diet. Brown rice contains a small amount of rice bran oil (Jacobs, 1958).

2.3.7.3 Gluten free

Some people are unable to tolerate the proteins found in wheat, barley, rye and oats. People choose foods that are gluten free. All rice is gluten free, making rice the essential choice for people with gluten free dietary requirements (Kondidin, 2005).

2.3.7.4 Low glycemic Index

Worldwide research has shown that different carbohydrate foods have dramatically different effects on blood sugar levels. The glycemic index was developed as a means of ranking foods based on their immediate effect on blood sugar levels. Carbohydrates which break down quickly during digestion have the highest GI factors and carbohydrates which break down slowly, have low GI factors. Health benefits of low GI foods result in lower insulin levels which makes fat easier to burn and less likely to be stored, and reduce appetite and help to sustain endurance exercise for longer (Kondidin, 2005).

2.4 Role of ingredient in quality of *bhakka*

Good *bhakka* is made from good ingredient. Therefore, the selection of raw materials in making of *bhakka* is very important to achieve expected quality of the final product.

2.4.1 Flour

The main ingredient in making of *bhakka* is rice flour. Flour used for preparation of sel-roti must be of better quality. Also, the preparation of *bhakka* was not technically feasible from the flour having mean particle size smaller than 120 µ and greater than 890 µ. The flour comprised of more coarse particles produced dense product with very less or no puffiness. Likewise, the batter made from the flour of finer particle size puffed excessively during steaming but collapsed instantaneously upon cooling. So, the flour used must contain (coarse: medium: fine=30:50:20 part) for the *bhakka* preparation (Subba and Katawal, 2013).

2.4.2 Sugar

Sugar is a optional ingredient of *bhakka* since there are two types of *bhakka* i.e. plain and sweet *bhakka.* Sugar is used to provide sweetness in *bhakka* and adds the calories value. Sugar dissolves at the time of kneading. Sugar develops the characteristic color and also improves the flavor. Sugar contributes structure, bulk and texture to the most baked and fried products (Lawson, 1995).

2.4.3 Water

Water is one of the most important ingredients during *bhakka* making. Quality of water used has a great effect on the product. Dissolved minerals and organic matters present in water can affect the flavor, color and physical attributes of the finished product (Smith, 1972). The water used in the making product should be potable and odorless if required, although no significant effect has been noticed due to the hardness, but demineralization is recommended if the mineral content is too higher which might cause an adverse in product color (Arora, 1980).

2.5 Technology involved in *bhakka* making

Method of preparation of Bhakka is shown in fig 2.1.

Rice

↓

Soaking (2 hours, Rice: Water = 1:2)

↓

Draining off water (leave 15 minutes)

↓

Grinding (Burr mill, hand pounding, electrical grinder)

↓

Sieving (sieve of 500 μm)

↓

Fine flour

↓

Water ⟶ Mixing (till 29% mc of dough)

↓

Dough

↓

Shaping and moulding (putting in bowl loosely)

↓

Excess amount is cut out by knife without pressing

↓

Wrapping with muslin cloth

↓

Steam cooking with bowl in inverted position at normal pressure (3-5 minutes)

↓

Bhakka

Fig 2.1 Flowsheet for preparation of *Bhakka*

Source: Pokhrel (2008)

2.6 Nutritive Value of *Bhakka*

Bhakka is rich in carbohydrates. Fat and mineral content is low and contains moderate amount of protein. It is high in calorific value and relatively low in nutritive value. Nutritive value of *bhakka* is given in table 2.5.

Table 2.3 Nutritive value of *Bhakka*

Parameter (%wb)	Percentage (%)
Moisture content	43
Protein	4.3
Fat	0.4
Ash	0.2
Crude fibers	0.16
Carbohydrate	51.94

Source: Rai (2004)

2.7 Chickpea (Cicer arietinum)

2.7.1 Introduction to Chickpea

Chickpea (*Cicer arietinum*) is a member of the legume, pea, or pulse family, "Fabaceae". Also called Leguminosae, this family of flowering plants is one of the largest plant families and includes such important plants as beans, peas, peanuts, lupines, alfalfa, clover, and acacia, and many others. Chickpea is considered the third most important pulse in the world, being widely grown in many subtropical and warm-temperate regions. Other common names for this seed are garbanzo bean, Indian pea, ceci bean, bengal gram, chana, kadale kaalu, sanaga pappu, and shimbra. It is the only cultivated crop within the Cicer. This light brown colored pulse is considered to be a good source of protein. It is used as an edible seed and is also used for making flour throughout the globe. Having a capacity to stand in drought conditions, this crop does not have the requirement being fed with nitrogen fertilizers.

2.7.2 Scientific classification of Chickpea

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Fabales

Family: Fabaceae (Leguminosae)

Subfamily: Faboideae (Papilionaceae)

Genus: Cicer

Species: *arietinum*

Source: Shrestha (2022)

2.7.3 Nutritional Value of Chickpea

Table 2.4 Nutrient Values of Chickpeas per 100g:

Constituents (db)	Amount
Calories	164kcal
Energy value	686kj
Total Fat	2.59g
Carbohydrate	27.42g
Dietary Fiber	7.6g
Protein	8.86g
Sodium	7mg
Zinc	1.53mg
Potassium	291mg
Iron	2.89mg
Magnesium	1.030mg
Calcium	49mg
Vitamin C	1.3mg
Vitamin B3(Niacin)	0.526mg
Vitamin B6	0.139mg
Vitamin B1(Thiamin)	0.116mg
Vitamin B2(Riboflavin)	0.063mg

Source: Patane (2006)

2..7.4 Health Benefits of Chickpeas

Chickpea consumption has been reported to have some physiological benefits that may reduce the risk of chronic diseases and optimize health. Therefore, chickpeas could potentially be considered as a 'functional food' in addition to their accepted role of providing proteins and fiber. Chickpea is a relatively inexpensive source of different vitamins, minerals and several bioactive compounds that could aid in potentially lowering the risk of chronic diseases. Due to its potential nutritional value, chickpea is gaining consumer acceptance as a functional food. A fiber-rich chickpea-based pulse (non-soybean) diet has been shown to reduce the total plasma cholesterol levels in obese subjects. Chickpea when incorporated as part of a regular diet may help to reduce blood pressure and the incidence as well as severity of type 2 diabetes. Butyrate is a principal short chain fatty acid produced from the consumption of a chickpea diet (200 g/d) in healthy adults which has been reported to suppress cell proliferation and induce apoptosis, which may reduce the risk of colorectal cancer (Jukanti *et al.*, 2012).

Diets with low-GI foods resulted in reduced insulin levels and higher weight loss compared with those with higher-GI foods. Since chickpea is considered to be a low-GI food, it may help in weight-loss and obesity reduction. There is a significant increase in dietary fiber with the intake of chickpea and chickpea flour that promotes laxation/bowel function by aiding in the movement of material through the digestive system. Chickpea seed oil contains different sterols, tocopherols and tocotrienols. These phytosterols have been reported to exhibit anti-ulcerative, anti-bacterial, anti-fungal, anti-tumor and anti-inflammatory properties coupled with a lowering effect on cholesterol levels. Carotenoids have been reported to increase natural killer cell activity. Vitamin A, a derivative of βcarotene, is important in several developmental processes in humans such as bone growth, cell division/differentiation and, most importantly, vision. Chickpea has been reported to have higher levels of it and could be potentially used as a source of dietary carotenoids (Shrestha, 2022).

Chickpea seeds have been used in traditional medicine as tonics, stimulants and aphrodisiacs. Further, they are used to expel parasitic worms from the body (anthelmintic property), as appetizers, for thirst quenching and reducing burning sensation in the stomach. In the Ayurvedic system of medicine, chickpea preparations are used to treat a variety of ailments such as throat problems, blood disorders, bronchitis, skin diseases and liver- or gall bladder-related problems (biliousness). In addition to these applications, chickpea seeds are also used for blood enrichment, treating skin ailments, ear infections, and liver and spleen disorders (Jukanti *et al.*, 2012).

2.8 Soybean (Glycine Max)

2.8.1 Introduction to Soybean

Soybeans or soya beans (*Glycine max*) are a type of legume native to eastern Asia. They are an important component of Asian diets and have been consumed for thousands of years. Today, they are mainly grown in Asia and South and North America. In Asia, soybeans are often eaten whole, but heavily processed soy products are much more common in Western countries. Various soy products are available, including soy flour, soy protein, tofu, soy milk, soy sauce, and soybean oil. Soybeans contain antioxidants and phytonutrients that are linked to various health benefits.

2.8.2 Scientific classification of Soybean

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Fabales

Family: Fabaceae

Genus: Glycine

Species: Glycine *max*

Source: Garcia *et al.* (1997)

2.8.3 Nutritional Value of Soybean

Table 2.5 Nutrient Values of soybean per 100g

Constituents	Amount (in %wb)
Calories	172kcal
Water	62
Protein	18.2
Carbohydrate	8.4
Sugar	3
Fiber	6
Fat	9

Source: Murugkar (2014)

2.8.4 Health Benefits of Soybean

According to Nguyen and Nguyen (2020), the essential amino acids that the body cannot produce are found in soybeans. The nutritional value of the soybean is not the only factor enhancing its consumption, as it plays an important role in health. Many clinical studies have demonstrated the associated advantages of the use of soy products in preventing heart disease, obesity, blood cholesterol, cancer, diabetes, kidney disease, and osteoporosis. Most observational studies indicate that consumption of soy products may reduce breast cancer risk. Studies also indicate a protective effect against prostate cancer in men (Garcia *et al.*, 1997).

A number of soybean compounds including isoflavones and lunasin may be responsible for the potential cancer-preventive effects. Consumption of soy products may reduce the risk of osteoporosis (reduced bone density and an increased risk of fractures) in women who have undergone menopause. Additionally, the inhibitory activity of an angiotensin converting enzyme (ACE) detected in soybean has been found to play an important role in regulating blood pressure and salt and water balance (Dukariya *et al.*, 2020).

2.9 Sprouting

According to Welle (2020), because of the harsh conditions found in nature, many nuts, grains and seeds also contain enzyme inhibitors that protect them from damage during their initial stage of growth. The problem is that when ingested, the enzyme inhibitors also slow down the absorption of nutrients that we ingest with food. By sprouting we can break down these enzyme inhibitors and let them release their full nutritional potential. Germinated grains are good sources of ascorbic acid, riboflavin, choline, thiamine, tocopherols and pantothenic acid and also have increased availability of minerals such as copper, sodium, potassium, iron, phosphorus, calcium, manganese and magnesium (Kayembe, 2011). Germination of soybeans has been known to be beneficial for the reduction of anti-nutrients like trypsin inhibitor, phytic acid, flatulent, etc (Murugkar, 2014).

Part III

Materials and methods

3.1 Materials

3.1.1 Raw materials

New variety Rice (*Oryzae sativa,* variety: Ranjeet), Chickpea (*Cicer arietinum*) and white color Soybean (*Glycine Max*) were bought from local market of Dharan, Sunsari. Potable water available at Central Campus of Technology was used. LDPE (50 µm) ziplock bag used for packing of *bhakka* was brought from local market of Dharan.

3.1.2 Equipment and chemicals

Equipment and chemicals used were available in Central Campus of Technology.

3.2 Methods

3.2.1 Method of preparation of rice flour

Required amount of new variety of rice (*Oryzae sativa,* variety: Ranjeet) was weighed and cleaned in a running water. Then the cleaned rice was soaked for 2 hours at room temperature (28 ± 5°C). Then the water was drained off in a container having holes in the base. After draining of water rice was grinded in an electric grinder for the milling purpose and the rice flour obtained was sieved in a sieve of 500 µm to separate broken rice and fine flour was obtained. The method of preparation is shown in figure 3.1.

New Variety of Rice (Oryzae sativa var. Ranjeet)

↓

Cleaning

↓

Soaking for 2 hours (at 28 ± 5°C)

↓

Drain off water (leave for 15 minutes)

↓

Grinding (electrical grinder)

↓

Sieving (sieve of 500 µm)

↓

Fine rice flour

Fig 3.1 Flowchart for the preparation of Rice flour

Source: Lee and Shin (2009)

3.2.2 Method of preparation of chickpea flour

Chickpea was weighed and cleaned in a running water and placed in a large jar. The jar was covered and soaked overnight. After soaking, it was rinsed and drained well. The soaked soybean seeds were germinated at room temperature (28 ± 5°C) for 48hr following the method of Kaur and Kapoor (1990). After two days, the tail's length was equal to the bean's length. After this, a final rinse was done and drained well.

Sprouted chickpeas were sundried at 32 ± 5°C for a whole day and then spread onto a drier tray at 30 °C for 6 hours. After cooling to room temperature, the dried chickpeas were grinded in an electric grinder for the milling purpose and then, the flour obtained was sieved in a sieve of 500 µm to separate coarse and fine flour.

3.2.3 Method of preparation of Soybean flour

Soybean was weighed and cleaned in a running water and placed in a large jar. The jar was covered and soaked overnight. After soaking, it was rinsed and drained well. The soaked soybean seeds were germinated at room temperature (28 ± 5°C) for 48hr following the method of Kaur and Kapoor (1990). After two days, the tail's length was equal to the bean's length. After this, a final rinse is done and drained well.

Sprouted soybeans were sundried at 32 ± 5°C for a whole day and then spread onto a drier tray at 30 °C for 6 hours. After cooling to room temperature, the dried chickpeas were grinded in an electric grinder for the milling purpose and then, the flour obtained was sieved in a sieve of 500 µm to separate coarse and fine flour.

3.2.4 Preparation of rice flour-chickpea flour mixes

Different combination of rice flour and chickpea flour was carried out as in table 3.1.

Table 3.1 Preparation of rice flour- chickpea flour mixes (parts by weight)

Product	Rice flour	Chickpea flour
A(control)	100	0
B	95	5
C	90	10
D	85	15
E	80	20

The *bhakka* was made as per the recipe formulation done and coded name A, B, C, D and E were given to each recipe.

3.2.5 Preparation of rice flour-soybean flour mixes

Different combination of rice flour and soybean flour was carried out as in table 3.1.

Table 3.2 Preparation of rice flour- soybean flour mixes (parts by weight)

Product	Rice flour	Soybean flour
F(control)	100	0
G	95	5
H	90	10
I	85	15
J	80	20

The *bhakka* was made as per the recipe formulation done and coded name F, G, H, I and J were given to each recipe.

3.2.6 Preparation of *Bhakka* with chickpea flour

Bhakka was prepared at laboratory of Central Campus of Technology, Dharan using method described by Pokhrel (2008).

Rice

↓

Soaking (2 hours, Rice: Water = 1:2)

↓

Draining off water (leave 15 minutes)

↓

Grinding (Electrical grinder)

↓

Sieving (sieve of 500 μm)

↓

Fine flour

↓

Water ⟶ Mixing (till mc was 29%) ⟵ Sprouted chickpea flour

↓

Dough

↓

Shaping and moulding (putting in bowl loosely)

↓

Excess amount is cut out by knife without pressing

↓

Wrapping with muslin cloth

↓

Steam cooking with bowl in inverted position at normal pressure

↓

Bhakka

Fig 3.2 Flowsheet for preparation of chickpea flour incorporated *Bhakka*

Source: Pokhrel (2008)

3.2.7 Preparation of *Bhakka* with Soybean flour

Bhakka was prepared at laboratory of Central Campus of Technology, Dharan using method described by Pokhrel (2008).

Rice

↓

Soaking (2 hours, Rice: Water = 1:2)

↓

Draining off water (leave 15 minutes)

↓

Grinding (Electrical grinder)

↓

Sieving (sieve of 500 μm)

↓

Fine flour

↓

Water ⟶ Mixing (till mc was 29%) ⟵ Sprouted soybean flour

↓

Dough

↓

Shaping and moulding (putting in bowl loosely)

↓

Excess amount is cut out by knife without pressing

↓

Wrapping with muslin cloth

↓

Steam cooking with bowl in inverted position at normal pressure

↓

Bhakka

Fig 3.3 Flowsheet for preparation of soybean flour incorporated *Bhakka*

Source: Pokhrel (2008)

3.2.8 Analytical procedure

3.2.8.1 Proximate analysis of rice flour, sprouted chickpea flour, sprouted soybean flour and *bhakka*

3.2.8.1.1 Moisture content

Moisture content of samples was determined by using a hot air oven as per described by Ranganna (1986).

3.2.8.1.2 Crude fat

Crude fat in samples was determined by Soxhlet extraction method as per described by Ranganna (1986).

3.2.8.1.3 Crude protein

Crude protein of samples was determined by Kjeldhal method as per described by Ranganna (1986).

3.2.8.1.4 Crude fiber

Crude fiber in samples was determined by method described in Ranganna (1986).

3.2.8.1.5 Ash

Ash content in samples was determined by method described in Ranganna (1986).

3.2.8.1.6 Carbohydrate

Total carbohydrate content was determined by difference method as per Ranganna (1986).

3.2.8.2 Weight of *Bhakka*

Weight of *Bhakka* was taken by electronic weighing balance available in campus.

3.2.8.3 Diameter of *Bhakka*

Diameter of *Bhakka* was measured by laying three *Bhakka* edge to edge with the help of a scale rotating them 90° and again measuring diameter of three *Bhakkas* (cm) and then taking average value (Baljeet *et al*., 2010).

3.2.8.4 Thickness of *Bhakka*

Thickness was measured by stacking three *Bhakka* on top of each other and taking average thickness (Baljeet *et al*., 2010).

3.2.9 Storage stability and microbiological analysis

Bhakkas were stored at normal room temperature (25±3°C) and refrigerated condition (4±1°C) in LDPE (50 µm) ziplock bag. Total Plate Count (TPC) was determined by pour plate technique on Plate Count Agar (PCA) medium (incubated at 30°C/48 h) (AOAC, 2005).

3.2.10 Sensory analysis of *Bhakka*

The sensory evaluation for overall quality was carried out with 10 semi-trained panelists (teachers and students of CDFT). The parameters for sensory evaluation are appearance, taste, texture, smell and overall acceptability. Sensory evaluation was performed by 9 points hedonic rating (1= dislike extremely, 9= like extremely) as described by Ranganna (1986).

3.2.11 Statistical method

All the data obtained in this experiment were analyzed by using a statistical package Genstat 12th edition, version 12.1.0, 2009. Sample means were compared by two-way ANOVA (No blocking) followed by LSD method at 5% level of significance. All the referencing of citations were done using Endnote X9.

3.2.12 Cost calculation of *bhakka*

The total cost associated with the best product will be calculated including overhead cost (processing and labor cost) and profit of 10%.

Part IV

Results and Discussion

The rice, chickpea and soybean were bought from local market and rice flour was prepared and incorporated with sprouted chickpea flour and sprouted soybean flour to formulate the sprouted chickpea flour incorporated *Bhakka* and sprouted soybean flour incorporated *Bhakka* by using different proportion to make 100 parts of flour i.e. A(100:0), B(95:5), C(90:10), D(85:15) and E(80:20) for sprouted chickpea flour incorporated *Bhakka* and F(100:0), G(95:5), H(90:10), I(85:15) and J(80:20) for sprouted soybean flour incorporated *Bhakka* respectively. Proximate composition of flours of rice, chickpea and soybean as well as of *Bhakka* was carried out.

The best product among the five variations was determined by carrying out sensory evaluation and the detailed nutritional value of the best sample and control sample was analyzed.

4.1 Proximate composition of raw materials

The proximate compositions of rice flour, sprouted chickpea flour and sprouted soybean flour were analyzed. The proximate composition is presented in Table 4.1.

Table 4.1 Proximate composition of rice flour, chickpea flour and soybean flour

Parameter	**Rice flour (%)**	**Sprouted Chickpea flour (%)**	**Sprouted Soybean flour (%)**
Moisture (%wb)	12.10±0.417	7.74±0.25	7.16±0.09
Crude protein (%db)	8.25±0.206	21.68±0.13	39.1±0.29
Crude fat (%db)	0.227±0.014	5.62±0.11	17.8±0.27
Crude fiber (%db)	0.28±0.018	3.17±0.07	8.1±0.33 8.1
Total ash (%db)	0.51±0.013	3.01±0.09	5.09±0.24
Carbohydrate (%db)	90.68±1.12	66.52±0.28	29.91±0.33

* Data are presented as the mean of triplicate analysis ± standard deviation.

The moisture, crude protein, crude fat, crude fiber and total ash content and carbohydrate of the rice flour were determined 12.1, 8.25, 0.227, 0.28, 0.51 and 90.68 respectively. The values fall in the range as described by Arora (1980). Also, chickpea flour and soybean flour were analyzed for it's proximate composition. The obtained values are in table 4.1. The moisture, crude protein, crude fat, crude fiber and total ash content and carbohydrate of the chickpea flour was found to be 7.74, 21.68, 5.62, 3.17, 3.01 and 66.52 respectively which was similar to the results observed by Patane (2006) and that of soybean flour was 7.16, 39.1, 17.8, 8.1, 5.09 and 29.91 respectively which was similar to the results observed by Gopalan *et al.* (1989).

4.2 Sensory analysis of *Bhakka*

4.2.1 Sensory analysis of chickpea flour incorporated *bhakkas*

Sensory evaluation of *bhakkas* made with various levels of chickpea flour incorporation according to recipes was done. Appearance, taste, texture, smell and overall acceptability of the samples were assessed using the hedonic rating system (1 = dislike extremely, 9 = like extremely) (Rangana, 1986). Ten panelists were presented the samples. It was suggested that the panelist give scores based on their perception.

Here, A is 100% rice flour containing *bhakka*, B is *bhakka* with 5% chickpea flour and 95% rice flour, C is *bhakka* with 10% chickpea flour and 90% rice flour, D is *bhakka* with 15% chickpea flour and 85% rice flour and E is *bhakka* with 20% chickpea flour and 80% rice flour. The Analysis of Variance (ANOVA) was carried out using least significant difference (LSD) at 5 % level of significance.

4.2.1.1 Appearance

The mean sensory score for appearance were found to be 7.05, 5.95, 7, 8 and 6 on 9-point hedonic rating scale for the *bhakka* formulation A, B, C, D and E respectively. ANOVA at 5% level of significance showed that the partial substitution of chickpea flour had significant effect ($p<0.05$) on the color of the different *bhakka* formulations which are represented in fig 4.1.

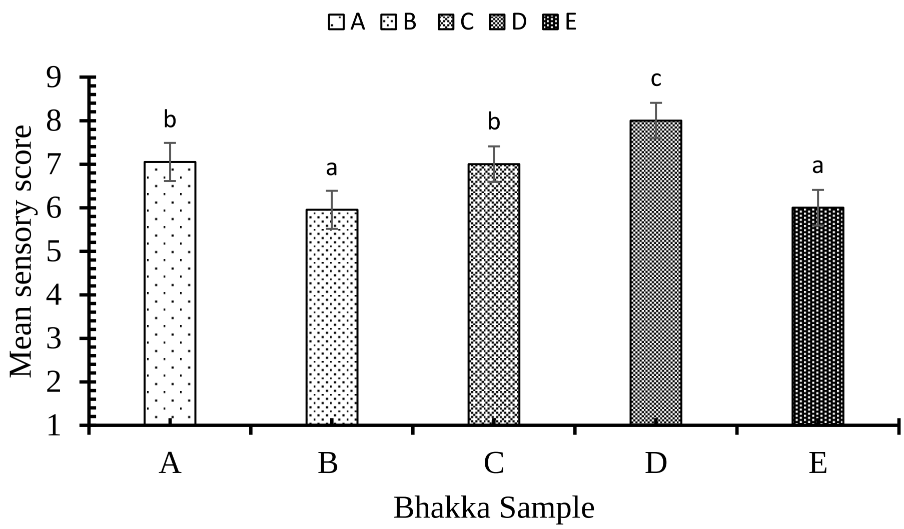

Fig 4.1 Mean scores for appearance of *bhakka* of different formulations**.**

Vertical error bars represent the value of standard deviation. Values of same subscript represents that the samples were similar in terms of appearance.

Sample D has highest mean sensory score for appearance and sample B has the lowest score. The mean score for sample A and sample C was not significantly different but they were significantly different from other samples. Also, the mean score for sample B and sample E was not significantly different but they were significantly different from other samples.

Sample B was of very light color which was not so attractive. Sample C got better and sample D had the perfect appealing color. However, sample E was of dark brown color which was not liked by panelists.

4.2.1.2 Taste

The mean sensory score for taste were found to be 7, 8, 7.6, 8.75 and 6 on 9-point hedonic rating scale for the *bhakka* formulation A, B, C, D and E respectively. ANOVA at 5% level of significance showed that the partial substitution of chickpea flour had significant effect ($p<0.05$) on the taste of the different *bhakka* formulations which are represented in fig 4.2.

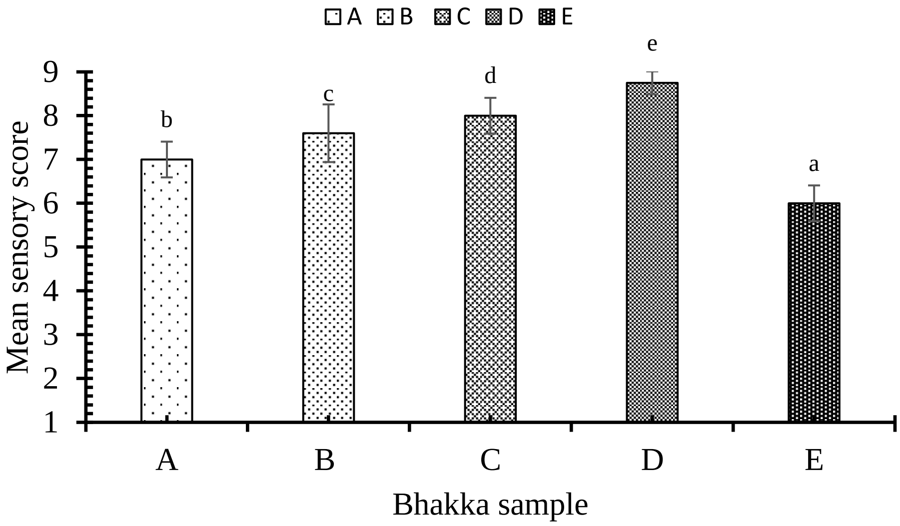

Fig 4.2 Mean scores for taste of *bhakka* of different formulations**.**

Vertical error bars represent the value of standard deviation. Values of same subscript represents that the samples were similar in terms of taste.

Sample D has scored highest sensory mean value for taste and sample E has the lowest score. All samples were found to be significantly different with each other.

The likeness of *bhakka* increased up to a certain level i.e. 15% of incorporation of chickpea flour. Further increment in chickpea flour resulted in slightly chickpea-like taste, which was not liked by panelists. Similar result was observed by Herranz *et al.* (2016).

4.2.1.3 Texture

The mean sensory score for texture were found to be 6, 6.95, 7.45, 8.25 and 6.9 on 9-point hedonic rating scale for the *bhakka* formulation A, B, C, D and E respectively. ANOVA at 5% level of significance showed that the partial substitution of chickpea flour had significant effect ($p<0.05$) on the texture of the different *bhakka* formulations which are represented in fig 4.3.

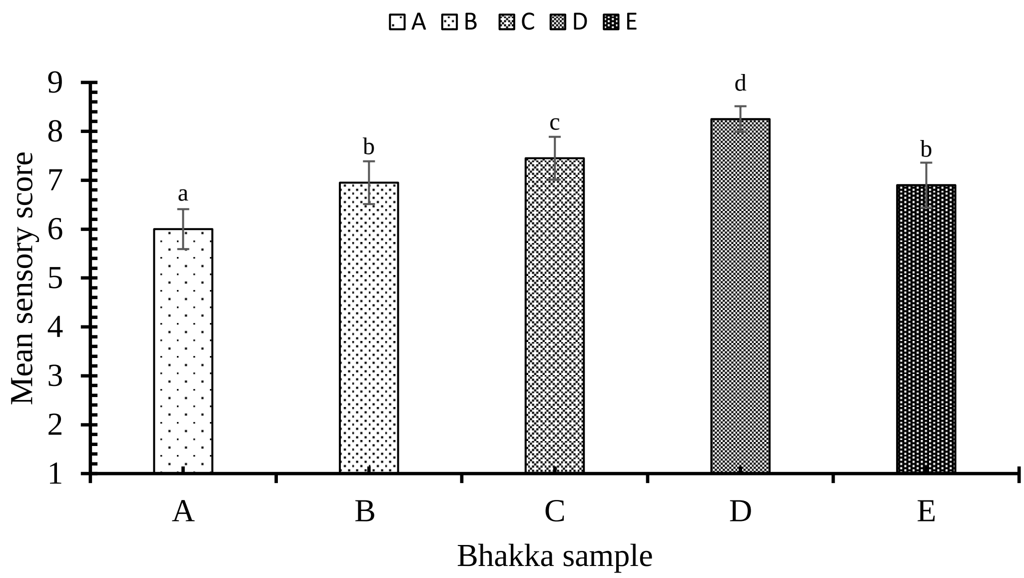

Fig 4.3 Mean scores for texture of *bhakka* of different formulations**.**

Vertical error bars represent the value of standard deviation. Values of same subscript represents that the samples were similar in terms of texture.

Sample D has scored highest sensory mean value for texture and sample A has the lowest score. Sample B and sample E were not significantly different from each other but were significantly different from other samples. All other samples were found to be significantly different with each other.

Scores from sensory analysis showed sample D as the best. This might be due to balancing of decreasing proportion of amylose by increasing proportion of protein. Amylose was found to positively correlate well with rice texture(Williams *et al.*, 1958).

4.2.1.4 Smell

The mean sensory score for smell were found to be 6.95, 5.95, 6.55, 8.45 and 7 on 9-point hedonic rating scale for the *bhakka* formulation A, B, C, D and E respectively. ANOVA at 5% level of significance showed that the partial substitution of chickpea flour had significant effect ($p<0.05$) on the smell of the different *bhakka* formulations which are represented in fig 4.4.

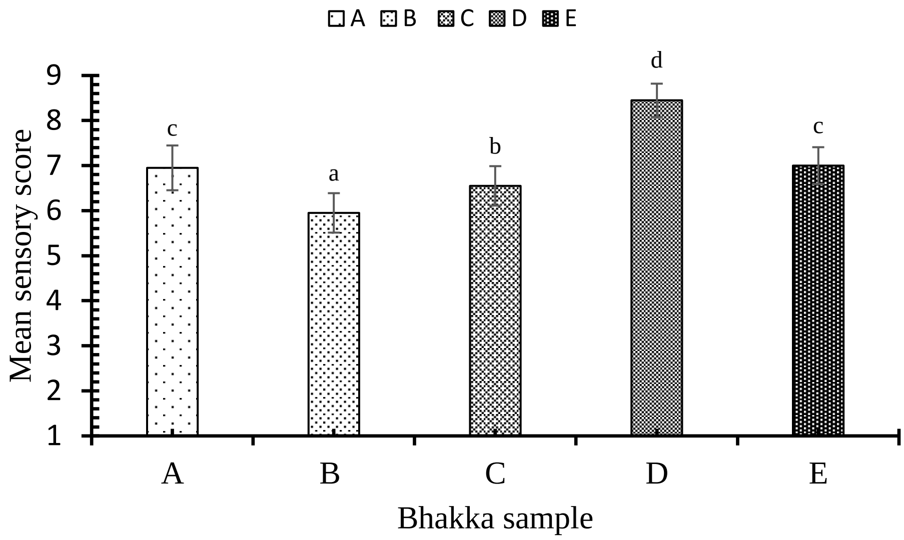

Fig 4.4 Mean scores for smell of *bhakka* of different formulations.

Vertical error bars represent the value of standard deviation. Values of same subscript represents that the samples were similar in terms of smell.

Sample D has scored highest sensory mean value for smell and sample B has the lowest score. Sample A and sample E were not significantly different from each other but were significantly different from other samples. All other samples were found to be significantly different with each other.

The likeness of smell of *bhakka* increased up to a certain level i.e. 15% of incorporation of chickpea flour. Further increment in chickpea flour resulted in strong chickpea-like scent, which was not liked by panelists. Similar result was observed by Herranz *et al.* (2016).

4.2.1.5 Overall acceptance

The mean sensory score for overall acceptance were found to be 6.75, 6.71, 7.15, 8.36 and 6.48 on 9-point hedonic rating scale for the *bhakka* formulation A, B, C, D and E respectively. ANOVA at 5% level of significance showed that the partial substitution of chickpea flour had significant effect (p<0.05) on the overall acceptance of the different *bhakka* formulations which are represented in fig 4.5.

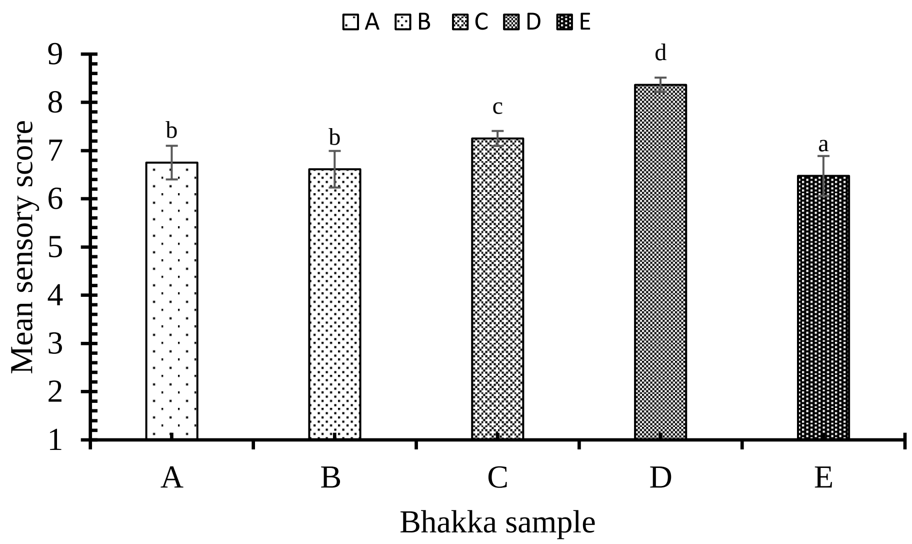

Fig 4.5 Mean scores for overall acceptance of *bhakka* of different formulations**.**

Vertical error bars represent the value of standard deviation. Values of same subscript represents that the samples were similar in terms of overall acceptance.

Sample D has scored highest sensory mean value for overall acceptance and sample E has the lowest score. Sample A and sample B were not found to be significantly different with each other but were different from all other samples. All other samples were found to be significantly different with each other.

On the basis of mean score with respect to overall acceptance, the superiority(p<0.05) of the *bhakka* samples was found to rank as follows:

[D] > [C] > [A] > [B] > [E]

All the factors, appearance, taste, texture and smell of product D was favored. Therefore, product D got high score in terms of overall acceptability as shown in Fig. 4.5. The overall acceptability of the 15% chickpea flour and 85% rice flour incorporated *bhakka* was found to be significantly superior and was selected as best product.

4.2.2 Sensory analysis of soybean flour incorporated *bhakkas*

4.2.2.1 Appearance

The mean sensory score for appearance were found to be 6.75, 6.05, 7.95, 7.05 and 5.95 on 9-point hedonic rating scale for the *bhakka* formulation A, B, C, D and E respectively. ANOVA at 5% level of significance showed that the partial substitution of soybean flour had significant effect ($p<0.05$) on the color of the different *bhakka* formulations which are represented in fig 4.6.

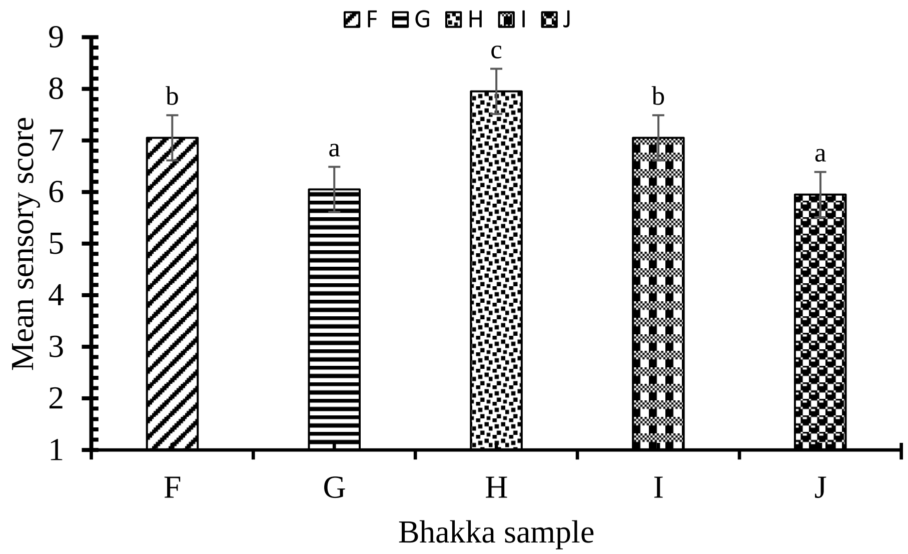

Fig 4.6 Mean scores for appearance of *bhakka* of different formulations**.**

Vertical error bars represent the value of standard deviation. Values of same subscript represents that the samples were similar in terms of appearance.

Sample H has scored highest sensory mean value appearance and sample J has the lowest score. The mean score for sample F and sample I was not significantly different but they were significantly different from other samples. Also, the mean score for sample G and sample J was not significantly different but they were significantly different from other samples.

Sample G was of very light color which was not so attractive. Sample H had the perfect appealing color. Sample I was a little darker and sample J was of dark yellow color which was not liked by panelists.

4.2.2.2 Taste

The mean sensory score for taste were found to be 7, 8, 8.65, 7.4 and 6.05 on 9-point hedonic rating scale for the *bhakka* formulation F, G, H, I and J respectively. ANOVA at 5% level of significance showed that the partial substitution of soybean flour had significant effect ($p<0.05$) on the taste of the different *bhakka* formulations which are represented in fig 4.7.

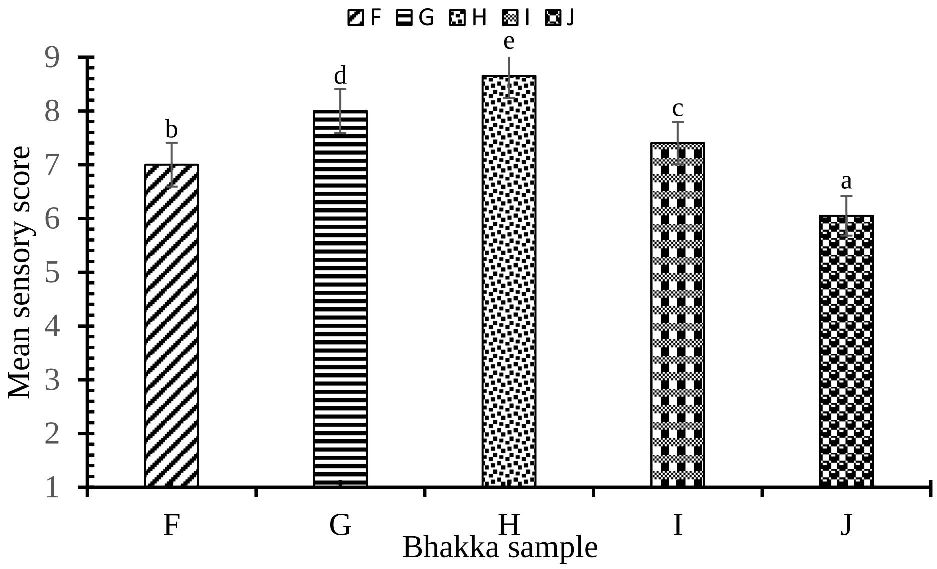

Fig 4.7 Mean scores for taste of *bhakka* of different formulations.

Vertical error bars represent the value of standard deviation. Values of same subscript represents that the samples were similar in terms of taste.

Sample H has scored highest sensory mean value for taste and sample J has the lowest score. All samples were found to be significantly different with each other.

The likeness of *bhakka* increased up to 10% incorporation of soybean flour. Further increment in soybean flour resulted in slightly soybean-like taste, which was not liked by panelists. Similar result was observed by Farzana and Mohajan (2015).

4.2.2.3 Texture

The mean sensory score for texture were found to be 6, 6.9, 8.35, 7.15 and 6.95 on 9-point hedonic rating scale for the *bhakka* formulation F, G, H, I and J respectively. ANOVA at 5% level of significance showed that the partial substitution of soybean flour had significant effect ($p<0.05$) on the texture of the different *bhakka* formulations which are represented in fig 4.8.

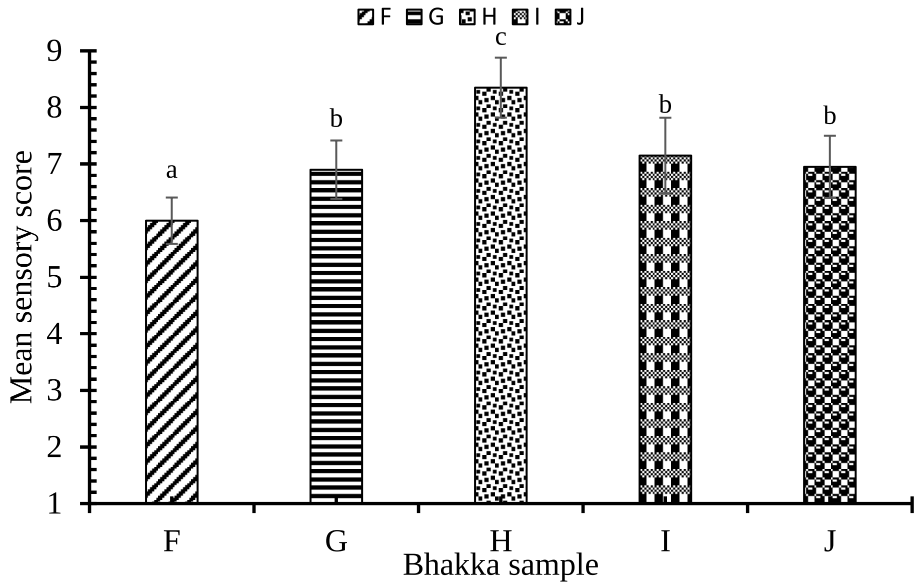

Fig 4.8 Mean scores for texture of *bhakka* of different formulations**.**

Vertical error bars represent the value of standard deviation. Values of same subscript represents that the samples were similar in terms of texture.

Sample H has scored highest sensory mean value for texture and sample F has the lowest score. Sample G, I and J were not significantly different from each other but were significantly different from other samples. All other samples were found to be significantly different with each other.

Scores from sensory analysis showed sample H as the best. This might be due to balancing of decreasing proportion of amylose by increasing proportion of protein. Amylose was found to positively correlate well with rice texture(Williams *et al.*, 1958).

4.2.2.4 Smell

The mean sensory score for smell were found to be 6.95, 6.65, 8, 6.4 and 6.2 on 9-point hedonic rating scale for the *bhakka* formulation F, G, H, I and J respectively. ANOVA at 5% level of significance showed that the partial substitution of soybean flour had significant effect ($p<0.05$) on the smell of the different *bhakka* formulations which are represented in fig 4.9.

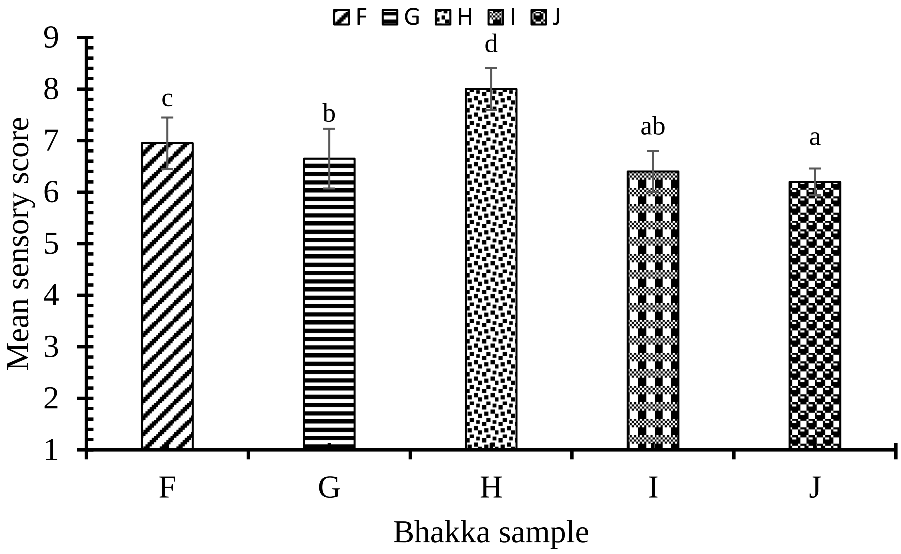

Fig 4.9 Mean scores for smell of *bhakka* of different formulations.

Vertical error bars represent the value of standard deviation. Values of same subscript represents that the samples were similar in terms of smell.

Sample H has scored highest sensory mean value for smell and sample J has the lowest score. Sample I was not significantly different from sample G and sample J but was significantly different from other samples. All other samples were found to be significantly different with each other.

The likeness of smell of *bhakka* increased up to 10% incorporation of soybean flour. Further increment in soybean flour resulted in strong soybean-like scent, which was not liked by panelists. Similar result was observed by Banureka and Mahendran (2009).

4.2.2.5 Overall Acceptance

The mean sensory score for overall acceptance were found to be 6.75, 6.9, 8.24, 7 and 6.29 on 9-point hedonic rating scale for the *bhakka* formulation F, G, H, I and J respectively. ANOVA at 5% level of significance showed that the partial substitution of soybean flour had significant effect ($p<0.05$) on the overall acceptance of the different *bhakka* formulations which are represented in fig 4.10.

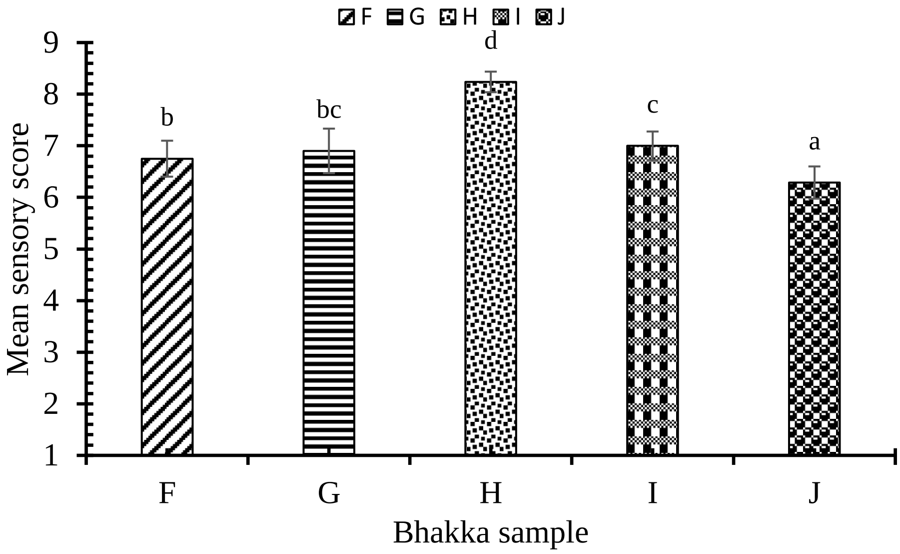

Fig 4.10 Mean scores for overall acceptance of *bhakka* of different formulations.

Vertical error bars represent the value of standard deviation. Values of same subscript represents that the samples were similar in terms of overall acceptance.

Sample H had scored highest sensory mean value for overall acceptance and sample J had the lowest score. Sample G was not found to be significantly different with sample F and sample I but was different from all other samples. All other samples were found to be significantly different with each other.

On the basis of mean score with respect to overall acceptance, the superiority($p<0.05$) of the *bhakka* samples was found to rank as follows:

[H] > [I] > [G] > [F] > [J]

All the factors, appearance, taste, texture and smell of product H was favored. Therefore, product H got high score in terms of overall acceptability as shown in Fig. 4.10. The overall acceptability of the 10% soybean flour and 90% rice flour incorporated *bhakka* was found to be significantly superior and was selected as best product.

4.3 Changes in physical characteristics

From statistical sensory analysis, for chickpea flour incorporated *bhakka,* the best product was found to be sample D *bhakka* containing 85% rice flour and 15% chickpea flour, whereas for soybean flour incorporated *bhakka*, the best product was found to be sample H *bhakka* containing 90% rice flour and 10% soybean flour. The physical characteristics of control *bhakka*(100% rice flour), sample D of chickpea *bhakka* and sample H of soybean *bhakka* and were presented in Table 4.3.

Table 4.2 Physical parameters of control and best product

Parameters	Control sample	Best sample (chickpea)	Best sample (soybean)
Weight(g)	$28.84^{a}\pm0.03$	$31.33^{b}\pm0.006$	$30.18^{b}\pm0.01$
Diameter(cm)	$9.28^{a}\pm0.02$	$8.85^{b}\pm0$	$8.81^{b}\pm0.006$
Thickness(cm)	$1.67^{a}\pm0.006$	$1.44^{b}\pm0.06$	$1.48^{b}\pm0.006$

*Data are presented as the mean of triplicate analysis ± standard deviation. Values in the column having different superscripts are significantly different at 5% level of significance.

The weight(g), diameter(cm) and thickness(cm) for control sample was found to be 28.84, 9.28 and 1.67 respectively. Whereas for best chickpea sample, the weight(g), diameter(cm) and thickness(cm) was found to be 31.33, 8.85 and 1.44 respectively and that for best soybean sample was 30.18, 8.81 and 1.48 respectively. The best product was significantly different with control in terms of all the parameters as determined at 5% level of significant (Table 4.2).

Weight of best *bhakkas* were higher than the control bhakka. Chickpea and soybean flour are denser than rice flour(Altaf *et al.*, 2020; Sabanis and Tzia, 2009). This means that, for the same volume of batter, chickpea and soybean flour contributes more mass compared to rice flour. When some of the rice flour was replaced with those flours, the overall density of the batter increased, which led to a slight increase in the weight of the cooked *bhakka*.

The diameter and thickness of best *bhakkas* were less than the control bhakkas. Rice flour contributes to a lighter and fluffier texture due to its ability to create air pockets during cooking. Chickpea and soybean flour, being more protein-rich and less airy, does not contribute as much to this expansion(Gadallah, 2017). Thus, the *bhakkas* made with soybean flour had a reduced diameter and is thinner.

4.4 Proximate composition of control and best product

From statistical sensory analysis, for chickpea flour incorporated *bhakka*, the best product was found to be sample D *bhakka* containing 85% rice flour and 15% chickpea flour, whereas for soybean flour incorporated *bhakka*, the best product was found to be sample H *bhakka* containing 90% rice flour and 10% soybean flour. The proximate composition of sample D of chickpea *bhakka*, sample H of soybean *bhakka* and control *bhakka*(100% rice flour) were presented in Table 4.2.

Table 4.3 Proximate composition (dry basis) of control and best product

Parameters	Control Sample	Best Sample(chickpea)	Best Sample(soybean)
Moisture (%wb)	$36.92^{a}\pm0.3$	$35.67^{b}\pm0.54$	$35.63^{b}\pm0.11$
Crude fat (% db)	$0.22^{a}\pm0.005$	$2.03^{b}\pm0.005$	$2.98^{b}\pm0.04$
Crude protein (% db)	$8.21^{a}\pm0.27$	$10.56^{b}\pm0.36$	$11.8^{b}\pm0.3$
Crude fiber (% db)	$0.29^{a}\pm0.005$	$4.05^{b}\pm0.24$	$4.11^{b}\pm0.08$
Ash (% db)	$0.34^{a}\pm0.002$	$2.65^{b}\pm0.0$	$2.74^{b}\pm0.06$
Carbohydrate (% db)	$90.94^{a}\pm0.5$	$80.71^{b}\pm0.28$	$78.37^{b}\pm0.36$

*Data are presented as the mean of triplicate analysis (dry basis) ± standard deviation. Values in the column having different superscripts are significantly different at 5% level of significance.

The moisture, crude fat, crude protein, crude fiber, ash and carbohydrate for control sample was found to be 36.92, 0.22, 8.21, 0.18, 0.29, 0.34 and 90.94 respectively. Whereas for best chickpea sample, the moisture, crude fat, crude protein, crude fiber, ash and carbohydrate was found to be 35.67, 2.03, 10.56, 4.05, 2.65 and 80.71 respectively and that for best soybean sample was 35.63, 2.98, 11.8, 4.11, 2.74 and 78.37 respectively. The best product was significantly different with control in terms of all the parameters as determined at 5% level of significant (Table 4.2).

The moisture content of best samples decreased from control sample. The lower moisture content of chickpea and soybean incorporated product may be due to low water holding capacity of chickpea and soybean. Shrestha (2022) stated same in case of chickpea flour incorporated muffin. The fat content of best samples *bhakka* was higher than that of rice *bhakka*. The reason could be the higher amount of fat of chickpea and soybean flour than that of rice flour. The *bhakka* showed an increase in protein content when chickpea and soya flour was increased which might be due to the use of higher protein content flours. Similar results was obtained by Siddiqui *et al.* (2003) in case of soybean flour incorporated biscuit.

The increase in crude fiber content in product may be due to the incorporation of chickpea and soya flour in *bhakkas* as chickpeas and soybean themselves are known for their high fiber content, and this characteristic is retained in their flour(Shrestha, 2022). Chickpea and soybean flour has a higher mineral content compared to rice flour. Minerals, including calcium, potassium, magnesium, and others, contribute to the ash content(Ayo and Olawale, 2003). Since chickpea and soybean flour has more minerals, the overall ash content of the *bhakka* increases when chickpea flour is added. The carbohydrate content decreases as the proportion of chickpea and soybean flour increases, supporting the claim of Gopalan *et al.* (1989).

4.5 Storage stability and microbiological analysis of product

After preparation of *bhakkas*, they were stored at room and refrigerated conditions in LDPE (50 µm) ziplock bag. In the room temperature (25±3°C), TPC of sample D of sprouted chickpea incorporated *bhakkas* was found to increase from 1.32 x 10^3 cfu/g to 1.9 x 10^5 cfu/g at 5 days interval of storage and in the refrigeration temperature (4±1°C), TPC of *bhakka* was found to increase from 1.32 x 10^3 cfu/g to 1.8 x 10^5 cfu/g at 8 days interval of storage which exceed the maximum limit (10^5 cfu/g) for steamed rice products according to Xiao *et al.* (2022). This is shown in Fig. 4.11.

In the room temperature (25±3°C), TPC of sample H of sprouted soybean incorporated *bhakkas* was found to increase from 1.21 x 10^3 cfu/g to 1.87 x 10^5 cfu/g at 5 days interval of storage and in the refrigeration temperature (4±1°C), TPC of *bhakka* was found to increase from 1.21 x 10^3 cfu/g to 1.76 x 10^5 cfu/g at 8 days interval of storage which exceed the maximum limit (10^5 cfu/g) for steamed rice products according to Xiao *et al.* (2022). This is shown in Fig. 4.11.

Bhakkas stored under refrigerated conditions were sound compared to *bhakkas* under room temperature.

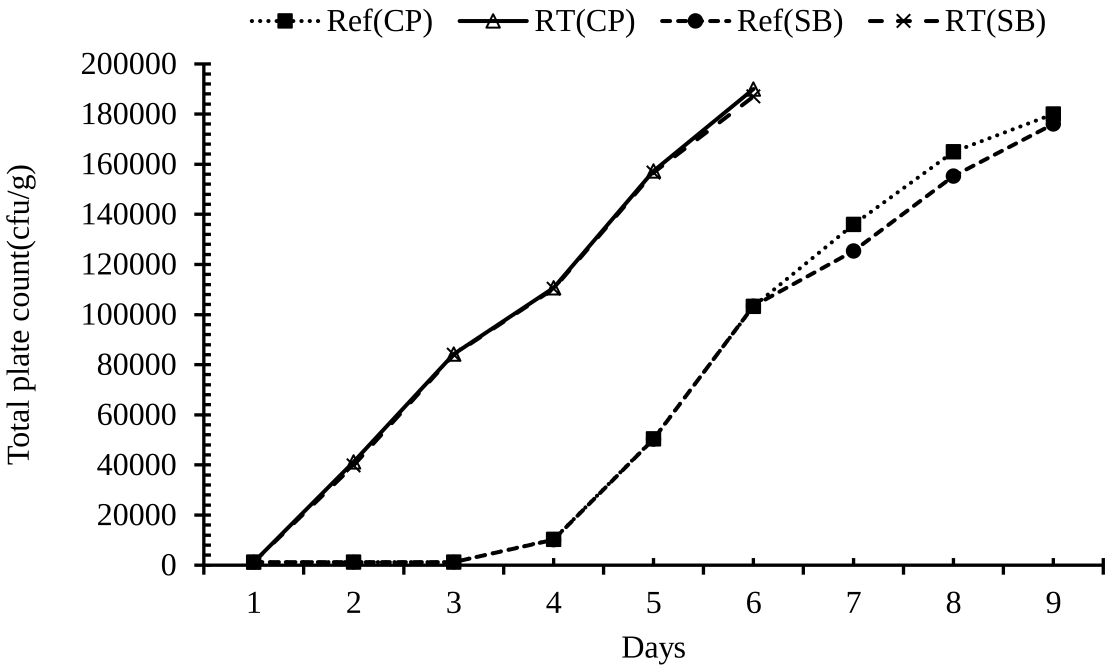

Fig 4.11 Changes in TPC in refrigerated and room conditions with respect to number of days of storage

4.6 Cost evaluation of chickpea flour incorporated *bhakka*

The total cost of best product was calculated and the cost of chickpea flour incorporated *bhakka* was Rs. 12.221 per piece including overhead cost and profit of 10%. (Appendix D)

4.7 Cost evaluation of soybean flour incorporated *bhakka*

The total cost of best product was calculated and the cost of soybean flour incorporated *bhakka* was Rs. 11.737 per piece including overhead cost and profit of 10%. (Appendix D)

Part V

Conclusions and recommendations

5.1 Conclusions

On the basis of the study carried out, the following conclusions were drawn:

1. *Bhakka* prepared by using rice flour and sprouted chickpea flour in the ratio 85:15 while *Bhakka* prepared by using rice flour and sprouted soybean flour in the ratio 90:10 was found to be the best in terms of sensory analysis with no adverse effect on the acceptable quality.
2. Sprouted chickpea and sprouted soybean flour are superior to rice flour in terms of crude protein, crude fat, crude fiber and total ash.
3. The incorporation of sprouted chickpea flour and sprouted soybean flour in *bhakka* seemed to enhance protein and fiber content.
4. The TPC count showed that the acceptability of *bhakkas* was up to 5 days at room temperature and up to 8 days at refrigerated temperature without any artificial preservatives used.
5. The price per piece of *Bhakka* for chickpea incorporated *Bhakka* was Rs. 12.221 and that for soybean incorporated *Bhakka* was Rs. 11.737.

5.2 Recommendations

1. Texture of the prepared *bhakka* can be analyzed using texture meter.
2. Further analysis of mineral content can be done.

Part VI

Summary

Bhakka are very popular seasonal food in Terai region which is generally consumed from *Kartik* to *Magh*. It is served hot with tomato and coriander chutney and is one of the seasonal morning-evening business of Tharu and Rajbanshi women. Chickpea flour and soybean flour was obtained by soaking, rinsing, draining, sprouting, drying, grinding and sieving the chickpea and soybean respectively.

Bhakka were prepared by incorporating rice flour and sprouted chickpea flour and also rice flour and sprouted soybean flour in the ratio of 95%:5%, 90%:10%, 85%:15% and 80%:20%of which the best formulation by sensory analysis was found to be 85%:15% in ratio of rice flour and sprouted chickpea flour respectively whereas, so was found to be 90%:10% in the ratio of rice flour and sprouted soybean flour. Superior *bhakka* obtained from sensory and statistical analysis was analyzed for the proximate constituents like moisture content, crude fat, crude protein, crude fiber, ash and carbohydrate. The values obtained were 35.67%, 2.03%, 10.56%, 4.05%, 2.65% and 80.71% respectively for of best formulation of chickpea *bhakka* and that for best soybean *bhakka* was 35.63%, 2.98%, 11.8%, 4.11%, 2.74% and 78.37% respectively whereas for control sample it was found to be 36.92%, 0.22%, 8.21%, 0.29%, 0.34% and 90.94% respectively.

The weight(g), diameter(cm) and thickness(cm) for control sample was found to be 28.84, 9.28 and 1.67 respectively. Whereas that for best chickpea sample, it was found to be 31.33, 8.85 and 1.44 respectively and 30.18, 8.81 and 1.48 respectively for best soybean sample. The best product was significantly different with control in terms of all the parameters as determined at 5% level of significant.

Storage stability of best sample was studied by total plate count at both room and refrigerated conditions at every 2 days interval. From the TPC study, the best product was acceptable only up to 5 days at room temperature and up to 8 days at refrigerated temperature. The price per piece of *Bhakka* for chickpea incorporated *Bhakka* was calculated to be Rs. 12.221 and that for soybean incorporated *Bhakka* was Rs. 11.737.

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Appendices

Appendix-A

<u>SENSORY ANALYSIS SCORE CARD</u>

Name: ....   Date: ....

Name of the product: *Bhakka*

Dear panelist, you are provided with five samples of *bhakka* prepared from the variation of

1. Rice flour and sprouted chickpea flour
2. Rice flour and sprouted soybean flour

Please test the following samples of *bhakka* and check how much you prefer for each of the samples. Give the points for your degree of preferences for each parameter for each sample as shown below:

Judge the characteristics on the 1-9 scale as below:

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

1. For Rice flour and sprouted chickpea flour

Sample code	Appearance	Taste	Texture	Smell	Overall Acceptance
A					
B					
C					
D					
E					

Comments if any:

2. For Rice flour and sprouted soybean flour.

Sample code	Appearance	Taste	Texture	Smell	Overall Acceptance
F					
G					
H					
I					
J					

Comments if any:

Signature: ....

Appendix B

ANOVA results of sensory analysis

Table B.1 ANOVA (no interaction) for Appearance of *Bhakka* prepared by variation in proportion of rice flour and chickpea flour.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Bhakka sample	4	28.82000	7.20500	264.67	<.001	0.1496
Panelist	9	6.74500	0.74944	27.53	<.001	0.2116
Residual	36	0.98000	0.02722			
Total	49	36.54500				

Table B.2 ANOVA (no interaction) for taste of *Bhakka* prepared by variation in proportion of rice flour and chickpea flour.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Bhakka sample	4	43.1800	10.7950	65.65	<.001	0.3678
Panelist	9	3.1050	0.3450	2.10	0.056	0.5201
Residual	36	5.9200	0.1644			
Total	49	52.2050				

Table B.3 ANOVA (no interaction) for taxture of *Bhakka* prepared by variation in proportion of rice flour and chickpea flour.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Bhakka sample	4	27.1700	6.7925	45.03	<.001	0.3523
Panelist	9	2.0450	0.2272	1.51	0.183	0.4982
Residual	36	5.4300	0.1508			
Total	49	34.6450				

Table B.4 ANOVA (no interaction) for smell of *Bhakka* prepared by variation in proportion of rice flour and chickpea flour.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Bhakka sample	4	34.0700	8.5175	70.82	<.001	0.3146
Panelist	9	3.3450	0.3717	3.09	0.008	0.4448
Residual	36	4.3300	0.1203			
Total	49	41.7450				

Table B.5 ANOVA (no interaction) for overall appearance of *Bhakka* prepared by variation in proportion of rice flour and chickpea flour.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Bhakka sample	4	22.59188	5.64797	137.67	<.001	0.1837
Panelist	9	3.30750	0.36750	8.96	<.001	0.2598
Residual	36	1.47688	0.04102			
Total	49	27.37625				

Table B.6 ANOVA (no interaction) for Appearance of *Bhakka* prepared by variation in proportion of rice flour and soybean flour.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Bhakka sample	4	27.1000	6.7750	41.34	<.001	0.3672
Panelist	9	2.5000	0.2778	1.69	0.126	0.5193
Residual	36	5.9000	0.1639			
Total	49	35.5000				

Table B.7 ANOVA (no interaction) for taste of *Bhakka* prepared by variation in proportion of rice flour and soybean flour.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Bhakka sample	4	39.0300	9.7575	67.94	<.001	0.3437
Panelist	9	1.9800	0.2200	1.53	0.174	0.4861
Residual	36	5.1700	0.1436			
Total	49	46.1800				

Table B.8 ANOVA (no interaction) for texture of *Bhakka* prepared by variation in proportion of rice flour and soybean flour.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Bhakka sample	4	28.3300	7.0825	26.37	<.001	0.4701
Panelist	9	3.5050	0.3894	1.45	0.204	0.6648
Residual	36	9.6700	0.2686			

Total	49	41.5050

Table B.9 ANOVA (no interaction) for smell of *Bhakka* prepared by variation in proportion of rice flour and soybean flour.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Bhakka sample	4	20.10000	5.02500	51.69	<.001	0.2828
Panelist	9	4.52500	0.50278	5.17	<.001	0.3999
Residual	36	3.50000	0.09722			
Total	49	28.12500				

Table B.10 ANOVA (no interaction) for overall acceptance of *Bhakka* prepared by variation in proportion of rice flour and soybean flour.

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Bhakka sample	4	21.05438	5.26359	71.62	<.001	0.2459
Panelist	9	2.45750	0.27306	3.72	0.002	0.3477
Residual	36	2.64562	0.07349			
Total	49	26.15750				

Appendix C

Table C.1 t-test two-sample assuming unequal variance) for moisture of the best sample (sample D) with control (sample A) prepared by variation in proportion of rice flour and chickpea flour.

	Sample D (Best)	Sample A(Control)
Mean	35.66333	36.92333
Variance	0.292633	0.090133
Observations	3	3
Hypothesized Mean Difference	0	
df	3	
t Stat	-3.52748	
P(T<=t) one-tail	0.019355	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.038709	
t Critical two-tail	3.182446	

Table C.2 t-test two-sample assuming unequal variance) for crude fat of the best sample (sample D) with control (sample A) prepared by variation in proportion of rice flour and chickpea flour.

	Sample D (Best)	Sample A(Control)
Mean	1.276667	0.143333
Variance	3.33E-05	3.33E-05
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	240.4163	
P(T<=t) one-tail	8.98E-10	
t Critical one-tail	2.131847	
P(T<=t) two-tail	1.8E-09	
t Critical two-tail	2.776445	

Table C.3 t-test two-sample assuming unequal variance) for crude protein of the best sample (sample D) with control (sample A) prepared by variation in proportion of rice flour and chickpea flour.

	Sample D (Best)	Sample A(Control)
Mean	6.626667	5.24
Variance	0.129033	0.0703
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	5.37951	
P(T<=t) one-tail	0.002885	
t Critical one-tail	2.131847	
P(T<=t) two-tail	0.005771	
t Critical two-tail	2.776445	

Table C.4 t-test two-sample assuming unequal variance) for crude fiber of the best sample (sample D) with control (sample A) prepared by variation in proportion of rice flour and chickpea flour.

	Sample D (Best)	Sample A(Control)
Mean	2.553333	0.183333
Variance	0.058433	3.33E-05
Observations	3	3
Hypothesized Mean Difference	0	
df	2	
t Stat	16.97676	
P(T<=t) one-tail	0.001726	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.003452	
t Critical two-tail	4.302653	

Table C.5 t-test two-sample assuming unequal variance) for ash of the best sample (sample D) with control (sample A) prepared by variation in proportion of rice flour and chickpea flour.

	Sample D (Best)	Sample A(Control)
Mean	1.666667	0.281667
Variance	0.003333	8.33E-06
Observations	3	3
Hypothesized Mean Difference	0	
df	2	
t Stat	41.49816	
P(T<=t) one-tail	0.00029	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.00058	
t Critical two-tail	4.302653	

Table C.6 t-test two-sample assuming unequal variance) for carbohydrate of the best sample (sample D) with control (sample A) prepared by variation in proportion of rice flour and chickpea flour.

	Sample D (Best)	Sample A(Control)
Mean	52.26667	57.53
Variance	0.078033	0.2527
Observations	3	3
Hypothesized Mean Difference	0	
df	3	
t Stat	-15.8519	
P(T<=t) one-tail	0.000273	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.000546	
t Critical two-tail	3.182446	

Table C.7 t-test two-sample assuming unequal variance) for moisture of the best sample (sample H) with control (sample F) prepared by variation in proportion of rice flour and soybean flour.

	Sample H (Best)	Sample F(Control)
Mean	35.63	36.92333
Variance	0.0127	0.090133
Observations	3	3
Hypothesized Mean Difference	0	
df	3	
t Stat	-6.98561	
P(T<=t) one-tail	0.003011	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.006022	
t Critical two-tail	3.182446	

Table C.8 t-test two-sample assuming unequal variance) for crude fat of the best sample (sample H) with control (sample F) prepared by variation in proportion of rice flour and soybean flour.

	Sample H (Best)	Sample F (Control)
Mean	1.876667	0.143333
Variance	0.001633	3.33E-05
Observations	3	3
Hypothesized Mean Difference	0	
df	2	
t Stat	73.53911	
P(T<=t) one-tail	9.24E-05	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.000185	
t Critical two-tail	4.302653	

Table C.9 t-test two-sample assuming unequal variance) for crude protein of the best sample (sample H) with control (sample F) prepared by variation in proportion of rice flour and soybean flour.

	Sample H (Best)	Sample F(Control)
Mean	7.48	5.24
Variance	0.1393	0.0703
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	8.474479	
P(T<=t) one-tail	0.000531	
t Critical one-tail	2.131847	
P(T<=t) two-tail	0.001063	
t Critical two-tail	2.776445	

Table C.10 t-test two-sample assuming unequal variance) for crude fiber of the best sample (sample H) with control (sample F) prepared by variation in proportion of rice flour and soybean flour.

	Sample H (Best)	Sample F(Control)
Mean	2.59	0.183333
Variance	0.0067	3.33E-05
Observations	3	3
Hypothesized Mean Difference	0	
df	2	
t Stat	50.79974	
P(T<=t) one-tail	0.000194	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.000387	
t Critical two-tail	4.302653	

Table C.11 t-test two-sample assuming unequal variance) for ash of the best sample (sample H) with control (sample F) prepared by variation in proportion of rice flour and soybean flour.

	Sample H (Best)	Sample F (Control)
Mean	1.726667	0.281667
Variance	0.004133	8.33E-06
Observations	3	3
Hypothesized Mean Difference	0	
df	2	
t Stat	38.89027	
P(T<=t) one-tail	0.00033	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.000661	
t Critical two-tail	4.302653	

Table C.12 t-test two-sample assuming unequal variance) for carbohydrate of the best sample (sample H) with control (sample F) prepared by variation in proportion of rice flour and soybean flour.

	Sample H (Best)	Sample F (Control)
Mean	50.60333	57.53
Variance	0.130433	0.2527
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	-19.3825	
P(T<=t) one-tail	2.09E-05	
t Critical one-tail	2.131847	
P(T<=t) two-tail	4.18E-05	
t Critical two-tail	2.776445	

Table C.13 t-test two-sample assuming unequal variance) for weight of the best sample (sample D) with control (sample A) prepared by variation in proportion of rice flour and chickpea flour.

	Sample A (Control)	Sample D (Best)
Mean	28.84333333	31.32667
Variance	0.001033333	3.33E-05
Observations	3	3
Hypothesized Mean Difference	0	
df	2	
t Stat	-131.698638	
P(T<=t) one-tail	2.8825E-05	
t Critical one-tail	2.91998558	
P(T<=t) two-tail	5.76501E-05	
t Critical two-tail	4.30265273	

Table C.14 t-test two-sample assuming unequal variance) for diameter of the best sample (sample D) with control (sample A) prepared by variation in proportion of rice flour and chickpea flour.

	Sample A (Control)	Sample D (Best)
Mean	9.276666667	8.85
Variance	0.000233333	0
Observations	3	3
Hypothesized Mean Difference	0	
df	2	
t Stat	48.37945255	
P(T<=t) one-tail	0.000213486	
t Critical one-tail	2.91998558	
P(T<=t) two-tail	0.000426972	
t Critical two-tail	4.30265273	

Table C.15 t-test two-sample assuming unequal variance) for thickness of the best sample (sample D) with control (sample A) prepared by variation in proportion of rice flour and chickpea flour.

	Sample A (Control)	Sample D (Best)
Mean	1.666667	1.436667
Variance	3.33E-05	3.33E-05
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	48.79037	
P(T<=t) one-tail	5.28E-07	
t Critical one-tail	2.131847	
P(T<=t) two-tail	1.06E-06	
t Critical two-tail	2.776445	

Table C.16 t-test two-sample assuming unequal variance) for weight of the best sample (sample H) with control (sample F) prepared by variation in proportion of rice flour and soybean flour.

	Sample F (Control)	Sample H (Best)
Mean	28.84333333	30.17667
Variance	0.001033333	0.000133
Observations	3	3
Hypothesized Mean Difference	0	
df	3	
t Stat	-67.61234038	
P(T<=t) one-tail	3.56468E-06	
t Critical one-tail	2.353363435	
P(T<=t) two-tail	7.12937E-06	
t Critical two-tail	3.182446305	

Table C.17 t-test two-sample assuming unequal variance) for diameter of the best sample (sample H) with control (sample F) prepared by variation in proportion of rice flour and soybean flour.

	Sample F (Control)	Sample H (Best)
Mean	9.276666667	8.813333
Variance	0.000233333	3.33E-05
Observations	3	3
Hypothesized Mean Difference	0	
df	3	
t Stat	49.14392129	
P(T<=t) one-tail	9.2765E-06	
t Critical one-tail	2.353363435	
P(T<=t) two-tail	1.8553E-05	
t Critical two-tail	3.182446305	

Table 18 t-test two-sample assuming unequal variance) for thickness of the best sample (sample H) with control (sample F) prepared by variation in proportion of rice flour and soybean flour.

	Sample F (Control)	Sample H (Best)
Mean	1.666667	1.483333
Variance	3.33E-05	3.33E-05
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	38.89087	
P(T<=t) one-tail	1.31E-06	
t Critical one-tail	2.131847	
P(T<=t) two-tail	2.61E-06	
t Critical two-tail	2.776445	

Appendix D

Table D.1 Cost calculation of chickpea flour incorporated *bhakka*

Materials	Weight(gm)	Cost per kg (Rs)	Cost (Rs)
Rice	85	80	6.8
Chickpea flour	15	220	3.3
Raw material cost			10.1
Processing and labor cost (raw 10% of material cost)			1.01
Profit (10%)			1.111
Grand total			12.221

Table D.2 Cost calculation of soybean flour incorporated *bhakka*

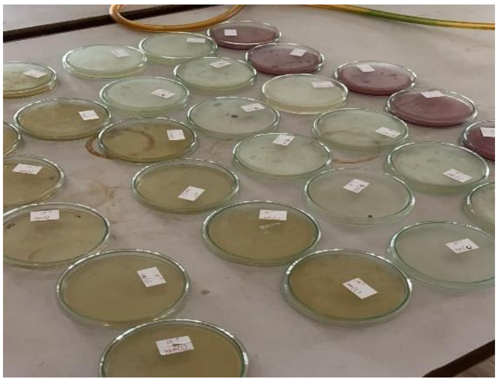
Materials	Weight(gm)	Cost per kg (Rs)	Cost (Rs)
Rice	90	80	7.2
Soybean flour	10	250	2.5
Raw material cost			9.7
Processing and labor cost (10% of raw material cost)			0.97
Profit (10%)			1.067
Grand total			11.737

Color plates

P1: Sprouting of soybean

P2: Steaming *Bhakka*

P3: Sensory evaluation



P4: Microbial analysis