# PREPARATION AND QUALITY EVALUATION OF *THEKUA* INCORPORATED WITH BUCKWHEAT FLOUR

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# Preparation and Quality Evaluation of *Thekua* Incorporated With Buckwheat Flour

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

by

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## Approval Letter

**This *dissertation* entitled *Preparation and Quality Evaluation of Thekua Incorporated with Buckwheat Flour* presented by Purushotam Kumar Ray has been accepted as the partial fulfillment of the requirement for the B. Tech. degree in Food Technology.**

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(Purushotam Kumar Ray)

# Abstract

The aim of this research was to optimize buckwheat flour content and evaluation of effect on quality of *Thekua*. Different formulations were made by using DOE (Design of Expert) v 7.1.5. D- optimal design is used to formulate the recipe. Buckwheat flour incorporated *Thekua* was prepared with the incorporation of buckwheat flour in 0 parts, 6.25 parts, 8.33 parts,12.5 parts, 16.67 parts, 18.75 parts, and 25 parts concentration with whole wheat flour. The proximate analysis of prepared buckwheat flour and whole wheat flour were carried out in the lab. The sensory analysis of buckwheat flour incorporated *Thekua* of different concentration was carried out and analyzed statistically to obtain best formulation using Genstat Release 12.1 at 5% level of significance.

The malted buckwheat flour of 8.33 % incorporated *Thekua* was found to be superior than other formulation based on sensory quality. The final product was packed in LDPE pouches and were sealed and stored. For the shelf-life evaluation of *Thekua*, the oil used for the preparation of *Thekua* was analysed. The Acid Value (AV) and Peroxide Value (PV) of the oil was calculated in 7 days interval. Chemical analysis showed that the moisture content, crude protein, fat, ash content, fiber, carbohydrates of best *Thekua* were found to be 5.16 %, 9.45 %, 26.09 %, 0.50 %, 0.24 %, 58.56 % respectively. On the basis of AV and PV of oil used for preparation of *Thekua*, the shelf life of *Thekua* was found to be best before 28 days. Finally, the cost evaluation of *Thekua* was done and the price of a *Thekua* (weight=20g) was found to be Nrs. 4.

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# List of abbreviations

| Abbreviation | Full form |
|---|---|
| ANOVA | Analysis of variance |
| AOAC | Association of Official Analytical Chemists |
| LSD | Least significant difference |
| WWF | Whole wheat flour |
| BF | Buckwheat flour |
| ℃ | Degree centigrade |
| g | Gram |
| mg | Milligram |
| ml | Millilitre |
| LDPE | Low density poly ethylene |
| AV | Acid Value |
| PV | Peroxide Value |
| Meq/ kg | Milliequivalents/ kilogram |
| OA | Overall acceptability |

# Part I
# Introduction

## 1.1 General introduction

Around the world, traditional meals have been made for a very long time in a variety of societies. These goods recipes have been passed down from generation to generation. Nepal is a multicultural, multi religious, and multiracial nation. The many ethnic and racial groups have their own culture and unique eating habits, which have been influenced by their predecessors since time immemorial. Numerous traditional cuisine items can be found throughout the nation.Some of them are healthy, some are appetizers, some have therapeutic properties, and some are snacks. A few food stalls are available for particular events, including *sel-roti* during Tihar and *Furoula* is a staple of Tharu culture during *Maghe Sankranti*, *Holi*, and *Siruwa*. Although these goods have been created across the nation, there are small differences as we move from location to location (Mainali, 2003). Some of the native meals are region-specific, such as chhurpi in mountainous or hilly places, while others are community-specific, such as *chhoyala* and *kachila* in Newar, *kinema* in Limbu, but others like *gundruk*, *sinki*, *sel roti* etc., are eaten by all tribes, all geographic regions, and all cultures. These native cuisines have been cooked using customary techniques unique to the ingredients (Subba and Katawal, 2013).

*Thekua*, also known as *Thekari Pua* or *Khajuria,* is a traditional sweet delicacy that holds a significant place in the cuisine of Bihar, Jharkhand, and parts of Uttar Pradesh in India. It is particularly associated with the Chhath Puja, a popular Hindu festival dedicated to the Sun God. *Thekua* is a deep-fried cookie-like sweet made from wheat flour, sugar or jaggery, ghee (clarified butter), and a variety of aromatic spices such as cardamom and fennel seeds. The dough is shaped into small discs or flatbreads, which are then deep-fried until golden brown. *Thekua* is known for its rich flavor, crunchy texture, and long shelf life, making it an ideal festive treat and a favorite among locals. Its preparation and consumption during Chhath Puja hold religious and cultural significance, as it is offered as prasad (blessed food) to the deity and shared among devotees. *Thekua*'s unique taste and cultural significance make it a cherished part of the culinary heritage of the region (Badikilaya, 2019).

Buckwheat is a key food crop grown in Nepal's upper and mid-hilly regions. Aside from its use in *dhindo*, *roti*, *khole*, and *malpuwa*, no other notable product has been developed. Buckwheat, in addition to being nutritionally dense, Rutin is a very significant antioxidant. As a result, buckwheat can be utilized as a medically beneficial diet for people with high blood pressure and heart disease. In Japan, Korea, America, and many other nations, whole and composite buckwheat flour is used to make a variety of items such as noodles, cake, and bread. Buckwheat's health benefits are attributable in part to its high concentration of flavonoids, particularly rutin. Flavonoids are phytonutrients that function as antioxidants and extend the action of vitamin C to protect against disease (Poudel, 2019).

Rutin and other flavonoid components are mostly responsible for buckwheat's lipid- lowering effect. These chemicals aid in the maintenance of blood flow and the prevention of excessive platelet clotting. Platelets are blood components that cluster together when activated. Preventing excessive blood loss and protecting LDL from free radical oxidation into potentially hazardous cholesterol oxides. All of these acts contribute to a lower risk of heart disease. Buckwheat is an excellent source of manganese, as well as magnesium and dietary fiber. Buckwheat includes two flavonoids with important health benefits: rutin and quercitin. Buckwheat protein is of good quality, having all eight necessary amino acids, including lysine. Buckwheat is gluten-free, Buckwheat's natural antioxidants may reduce lipid peroxidation in food, improving food quality and safety. Buckwheat seed includes antioxidants like rutin and can be stored for a long time without undergoing noticeable chemical changes (Dietrych-Szostak and Oleszek, 1999).

There have been no previous studies in the context of Nepal on the formulation of buckwheat flour mixed *Thekua*. As a result, the importance of this study project has been determined (Anon, 2023).

The nutritional contribution of buckwheat flour and products to the seven essential elements, namely iron, zinc, copper, manganese, calcium, magnesium, potassium, and phosphorus, has been assessed from data from experiments (Poudel, 2019). Recommended dietary allowances for these minerals have been established in several countries.The experimental estimation has shown that one hundred grams of buckwheat flour can provide approximately 10 to 100 percent of the RDA for zinc. Copper, manganese, calcium, magnesium, potassium and phosphorus but can provide only a few percent of RDA for calcium. Therefore, we conclude that buckwheat flour and its resultant products can be a good source of zinc, copper, manganese, magnesium, potassium and phosphorus (Mamat *et al.*, 2010).

Therefore, identification and use of such under-utilized food crop in development of a combat pack of vitamins, minerals, antioxidants, amino acids etc. in food and drug could be best solution to fortification, enrichment, food security, high food cost, and malnutrition. Further it can be developed as functional food it could promote the nutritional status of the people in long-term saving huge amount of national capitals (Anon, 2023)

## 1.2 Statement of the problem

Development of nutritious and organoleptically acceptable recipes with locally available foods is a challenge for the food scientist. However, the benefits of such food-based strategies to prevent micronutrient malnutrition are manifold. They are preventive, cost-effective, sustainable, income-generating, culturally acceptable and feasible to implement, promote self- reliance and community participation, and foster the development of environmentally sound food production systems. At the same time, traditional and indigenous food are getting less concern might be due to less or peculiar nutrients supply. Few ethnic communities of Nepal have pretty much well diet diversity fulfilling from their traditional and indigenous food such as *Khajuri, Thekuwa, Bhagiya, Khurma, Bhusuwa, Yamari, Bhaka* etc. (Suman, 2012) which has not been yet scheduled on our food chart domestically or economically. Most of traditionaland indigenous food are only concerned with certain nutrients having greater energy value but lacks significant amount of nutrients (Suman, 2012). These conditions demand for the research and promotion of fortified and enriched indigenous products.

Only few researches have been in place for indigenous product *Thekua*. However, researches on *Thekua* are limited only to recipe and process optimization. The product is almost nutrient less except energy, but it can be nutritionally enriched by incorporating nutrient rich natural ingredients. This situation calls the need for finding effective and complete chain of nutrients and food supply.

## 1.3 Objectives

### 1.3.1 General objective

The general objective of this work was to incorporate parts of buckwheat flour for the preparation of indigenous food *Thekua*, and its shelf life evaluation.

### 1.3.2 Specific objectives

The specific objectives of the study were:

- To determine and compare the proximate composition of the wheat flour *Thekua* and buckwheat flour incorporated *Thekua.*
- To determine the iron content, shelf life and acceptability of the formulated buckwheat flour *Thekua* and compare it with whole wheat flour *Thekua*.

## 1.4 Significance of the work

Nepal is a multicultural, multilingual and multi-religious and agriculture based under developing country where varieties of indigenous and traditional food culture are still consumed locally (Kharel *et al.*, 2010). The ethnic groups are rich in indigenous knowledge and it is deeply rooted in their tradition and culture (Acharya and Pokhrel, 2006). Their encouragement towards traditional and indigenous food culture at their own native communities is highly appreciable, which is actually pretty impressive economical diet diversification and helps to increase meal frequency and nutrient requirements among all group of people. Such traditional and indigenous foods that suits Nepalese food habit, would be exclusively fortified or enriched to fulfill the nutrient deficiencies as well as requirements and could replace imported snack foods.

Identification and use of such under-utilized food crop in development of a combat pack of vitamins, minerals, antioxidants, amino acids etc. in food and drug could be best solution to fortification, enrichment, food security, high food cost, and malnutrition. Further it can be developed as functional food it could promote the nutritional status of the people in long-term saving huge amount of national capitals (Anon, 2023).

## 1.5 Limitations of the study

- The specific variety of buckwheat and wheat used couldn't be determined due to time and technical constraints.

- Only iron content of the product was studied, although other minerals like zinc and magnesium are also present in abundance according to the former literatures.

- The shelf life of the product could only be studied for 1.5 months due to time constraint.

- The packaging of the *Thekua* was done in simple LDPE bags rather than laminates due to technical constraints.

# Part II

# Literature review

## 2.1 Introduction of Thekua

*Thekua* is a Maithali sweetmeat which is prepared on the auspicious occasion of Chhath (a religious festival) in the month of Karthik (November). Especially it is prepared by the people of Terai belt of Nepal. *Thekua* sometimes is called by the name of Khajur. It is very nutritious. Normally there are two variants, the people in central Nepal and Bihar prefer the ones which are harder and have longer shelf life, where people in eastern Nepal and Uttar Pradesh prefer is softer (*Thekua*). The soft type *Thekua* are specially made by white wheat flour (Maida) and hard type *Thekua* are specially made from whole wheat flour (Atta). It is very popular in Nepal, Bihar, Jharkhand and eastern Uttar Pradesh (Basak *et al.*, 2023). The preparation of *Thekua* is relatively simple (Kharel *et al.*, 2010).

*Thekua* is essentially traditional Nepali cookies. *Thekua* is often given as an offering during Chhath and is a popular dish especially in the Terai region of Nepal. *Thekua* is made by deep frying a mixture of sugar syrup, ghee, and flour. Most *Thekuas* have pretty looking patterns on them that are made with the help of a special dough shaper. Moreover, *Thekua* can be enjoyed with both sweet and savory dips as well as served over afternoon tea. *Thekua* is also called "khajur", though typically *Thekua* is bit softer than khajur. *Thekua* is easy to make at home and can be a quick snack that you can store for a long time, coming in handy when you are too tired to cook something for yourself (Personal Communication, 2023).

### 2.1.1 Historical background

*Thekua* originated in Bihar and was eaten as a dessert. It was also eaten during long distance journeys since it has a long shelf life. It was prepared in a wooden handcrafted mould (Saancha). *Thekua* would get the design on its surface due to the embroidered wooden mould. *Thekua* dough is pressed into the mould for deep-frying and this gives the dish its unique design. *Thekua* is an honored Prasad (offering to god) in the chhath puja and is widely produced in chhath puja. People believe that *Thekua* has a long history with chhath puja and believe that it has been used as a Prasad in chhath puja from centuries (Personal communication, 2023).

### 2.1.2 Occurrence in market

*Thekua* is generally produced in chhath puja as an honored Prasad. It is sometimes produced by Maithali communities on special occasion like marriage ceremony as a sweet dessert. *Thekua* has not been commercialized as is not found in the local market. *Thekua* has special importance in Maithali community and is produced only on special occasions like marriage ceremony and festivals like chhath puja (Personal communication, 2023).

## 2.2 Ingredients

Although *Thekua* is well-known to all Terai residents in Nepal, the ingredients used to prepare it vary depending on culture and religion. Whole wheat flour, ghee, sugar, water, and frying fats and oils are the main ingredients used in its creation. Minor additions could also include spices or coconut bits or powder. Some people, notably in the western and eastern parts of theTerai region, utilize semolina in a specific ratio (even up to 50 g per 100 g refined wheat flour) (Suman, 2012).

### 2.2.1 Whole wheat flour

Whole wheat flour is a powdery product made from grinding or mashing the whole grain of wheat, commonly known as the wheat berry. Bread and other baked items are made with wholewheat flour. It is also commonly blended with other lighter "white" unbleached or bleached flours to restore nutrients (particularly fiber, protein, and vitamins), texture, and body to white flours that are lost in milling and other processing to the completed baked goods or other foods.Whole wheat flour is manufactured from the whole grain, which includes the bran, endosperm,and germ. It contains the same amount of bran, endosperm and germ as a wheat berry. Wholewheat flour has a low saturated fat, cholesterol, and salt content. It is also high in dietary fiber and an excellent source of manganese and selenium.

The main ingredient in *Thekua* is whole wheat flour, commonly known as Atta in Nepal and India. Some people make *Thekua* with white wheat flour (Maida), but the taste and texture suffer as a result (Personal Communication, 2023). Whole wheat flour is composed of Moisture(14%), Protein (9-14 %), Fat (1-2 %), Carbohydrates (54-62 %), Fiber (1.7-2.6%), and Ash (1.2-1.7%) (Anon, 2010). The chemical composition of whole wheat flour is given in Table 2.1.

**Table 2.1** Chemical composition of whole wheat flour

| Constituents | Nutritional value per 100 g |
|---|---|
| Energy | 1418 KJ (339 kcal) |
| Carbohydrates | 72.57 g |
| Sugars | 0.41 g |
| Dietary Fiber | 12.2 g |
| Thiamine (B1) | 0.447 mg |
| Riboflavin (B2) | 0.215 mg |
| Niacin (B3) | 6.365 mg |
| Pantothenic acid (B5) | 1.008 mg |
| Folate (B6) | 44 µg |
| Calcium | 34 mg |
| Iron | 3.88 mg |
| Magnesium | 138 mg |
| Manganese | 3.8 mg |
| Phosphorous | 346 mg |
| Potassium | 405 mg |
| Sodium | 5 mg |
| Zinc | 2.93 mg |

Source: USDA Nutrient Database, 2009

### 2.2.2 Semolina

Semolina is also used in the recipe for the preparation of *Thekua* in most parts of the country, Nepal and India. The proportion of semolina being used is in the range of 20-50 g per 100 g whole wheat flour. Semolina provides gritty texture which is liked by most of the people. Also semolina plays important role for the texture in final product. The use of Semolina has beneficial effect on the shelf-life of the product (Personal communication, 2023).

### 2.2.3 Sugar

Refined sugar (sucrose) is used as sweetening agent in *Thekua* and hence provide calories. Sugar helps to develop the characteristic color which is due to the caramelization of sugar. Sugar is used in syrup form in the dough preparation. For this, sugar is melted in water to make sweet syrup and is then added to the dough. Sugar syrup plays important role for the dough preparation. Jaggery or Shakkhar can be used as alternatives for sugar but addition of only Shakkhar gives more intense dark color. So, sugar and jaggery are used in combined form to make sugar syrup (Personal communication, 2023). Sugar helps in imparting sweetness, increasing tenderness, maintaining volume, crust color development, flavor development, moisture retention, and proper spread of the *Thekua* (C. H. Smith, 1972).

### 2.2.4 Fats and oils

Humans have used fats and oils for food and a variety of other applications since prehistoric times, as they were easily isolated from their source. Fats and oils found utility because of their unique properties. These ingredients were found to add flavor, lubricity, texture and satiety to foods. They have also been found to have a major role in human nutrition. Fats and oils are the highest energy source of the three basic food components (carbohydrates, proteins and fats), and many contain fatty acids essential for health that are not manufactured by the human body (OYEWOLE).

Refined sunflower oil is almost used by all for *Thekua* preparation during dough preparationas well as frying. Ghee is also used by some during dough preparation but it may be replaced partially or fully with other fats such as vegetable oil. Nowadays some use ghee for dough preparation while many use the same refined oil used for frying for dough preparation (Personal communication, 2023).

### 2.2.5 Other ingredients

#### 2.2.5.1 Dry fruits

Coconut, dried dates, almond, pistachio, cashew-nut, raisin, and walnut etc. can be used in the*Thekua* preparation. Among these, coconut and dried dates are exclusively used in *Thekua* (Personal communication, 2023).

#### 2.2.5.2 Jaggery

Jaggery can be used as alternatives for sugar. Jaggery is produced from cane sugar and traditionally used for sweetening. Generally jaggery is used in combination with sugar for *Thekua* preparation as addition of only jaggery gives more intense dark color (Personal communication, 2023).

#### 2.2.5.3 Milk

Milk instead of water is used in certain occasions. The product obtained surely has better sensory appeal than the usual ones, but the products should be consumed shortly as it has short shelf-life (Personal communication, 2023).

#### 2.2.5.4 Butter

When butter is used in adequate amount, it can replace both water and oil used for dough preparation. As in case of milk used this product also has short shelf-life even less than that obtained by using milk (Personal communication, 2023).

#### 2.2.5.5 Honey

Honey can be taken as optional ingredient and can be used for sweetening purpose as an alternative for sugar and jaggery (Personal communication, 2023).

## 2.3 Method of preparation

For the preparation of *Thekua*, whole wheat flour, semolina, coconut and dried dates pieces are mixed together and kneaded well for some time into coarse textured dough except the sugar.Sugar is then melted in water and is then added in the dough and is kneaded well for some time. After the dough is ready, a small piece or lump of dough is taken and is pressed in the embroidered mould (Saancha) for shaping purpose. After shaping, the shaped dough is then fried in refined sunflower oil. After frying, the fried product is taken out and allowed to cool for some time and is then packed and stored. A general flow chart for the preparation of *Thekua* is given in Fig.2.1.

Whole wheat flour + Semolina + Oil

↓

Mix well and Knead for about 2-3 min.

Sugar ⟶ ↓

Continue kneading and left for sometime

↓

Take small pieces or lump of dough and press on embroidered mould (Saancha).

↓

Deep frying at 140 - 180°C in suitable oil

↓

Cooling and Packaging

**Fig. 2.1** General flow chart for the preparation of *Thekua*

## 2.4 Frying

Frying is the cooking of food in oil or another fat. Foods can be fried in a variety of fats. including lard, vegetable oil, rapeseed oil and olive oil (Balbino *et al.*, 2020). Fried foods have continued to be popular from long time. Frying can be distinctly divided into three types viz, pan, shallow and deep frying. Pan frying is a form of frying characterized by the use of minimal cooking oil or fat (compared to shallow frying or deep frying): typically using just enough oil to lubricate the pan (although, in the case of a greasy food such as bacon, no oil or fats may beneeded). As a form of frying, pan frying relies on oil as the heat transfer medium and on correct temperature to retain the moisture in the food. The exposed top side allows, unlike deep frying,some moisture loss and contact with the pan bottom creates greater browning on the contact surface. Because of the partial coverage, the food must be flipped at least once to cook both sides. Shallow frying is a type of pan frying using only enough fat to immerse approximately one-third to one-half of each piece of food. During deep frying of food the oil used come under a heavy temperature region of 150-200 °C and a heavy three-prong attack, namely, hydrolysis, oxidation, thermal polymerization (Nayak *et al.*, 2016).

### 2.4.1 The chemistry of frying

Glycerol is a chemical that is found in all lipids. Fatty acids are another type of chemical found in nature. Through esterification, glycerol can mix with these fatty acids to generate mono, di, and triglycerides. Triglycerides are the building blocks of all fats and oils. Some fatty acids have double bonds, and their existence makes these fatty acids more sensitive and unstable. Many chemical interactions occur during frying, affecting the oil's quality and storage time. Several of these variables contribute to oil spoiling (Nayak *et al.*, 2016).

#### 2.4.1.1 Hydrolysis

Moisture from the food being fried vaporizes and hydrolyses triglycerides in the frying oil to glycerol, free fatty acids, mono glycerides and diglycerides (Dana and SAGUY, 2001). It is the major chemical reaction taking place during frying caused by the water in the food. It results in the formation of free fatty acids. The smoke point is reduced and the oil and food develop off-flavors. Baking powder and moisture in the food promote hydrolysis (Nayak *et al.*, 2016)

#### 2.4.1.2 Oxidation

Triglyceride molecules in the frying oil undergo primary oxidation to unstable lipid species called "hydroperoxides" which cleave to form secondary oxidation products which comprise non-volatile and volatile compounds. Some of these secondary products polymerize (tertiary oxidation), increasing the oil viscosity, cause browning on the surface and darken the oil (Dana and SAGUY, 2001). It results in the extensive breakdown of the chemical structure of the fat resulting in the formation of lower molecular weight compounds (Nayak *et al.*, 2016)

#### 2.4.1.3 Thermal polymerization

High temperatures of the frying operation produce high molecular cyclic fatty acid monomers, triglycerides dimers and oligomers (Alconada and Moure, 2022). This reaction occurs rapidly during standby and frying periods. The molecule is rearranged and the double bonds can often end up closer together making the fat more unstable and more sensitive to oxidation (Nayak *et al.*, 2016).

The volatile secondary oxidation products, acrolein formed from the glycerol and short chain fatty acids move to the surface, aided by steam formed from moisture in the food being fried. Both pleasant fried flavors and obnoxious odours are formed. Several physical and chemical processes follow, namely: i) the food being fried absorbs oil as well as releases some of its own lipid content into the frying medium, ii) charring of food particles and lipid browning darkens the oil. The immediate environment of the kitchen area gets unpleasant, especially when the smoke point of the frying medium is exceeded, as often happens when animal fat such as lard is used as the frying medium (Henry and Chapman, 2002).

### 2.4.2 Physical and chemical changes in the oil during frying

Heat is transported from the oil to the food during deep frying, while water evaporates from the food and oil is absorbed by the food. Oil is also absorbed onto the fried food's surface. These processes are greatly influenced by factors such as food shape and size, as well as oil temperature. Understanding the physical processes that occur during the frying process will aid in improving the frying process to produce high-quality food and oil with a longer fry life. The amount of oil lost depends on the type of fried food; for example, potatoes absorb more oil than meat. The oil stability is also affected by the type of frying vat used. Oil heated in a pressure deep-fat fryer, for example, degrades less than oil heated in an open vat. As the frying time progresses, physical changes in the oil include increased viscosity, color darkening, greater foaming, and decreased smoke point. These impacts may not be noticed by the frying operation until the oil has been utilized for an extended period of time. Although many frying operations rely solely on visual inspection of the oil to determine whether or not these negative effects are occurring, specific methods exist to measure degradation processes and product fractures and even product may not take shape and high water yields quite dense product with uncooked remains (Personal communication, 2023).

## 2.5 Physical and chemical characteristics (Quality parameters) of *Thekua*

### 2.5.1 Texture

It is *Thekua's* most crucial sensory characteristic. The texture of the product determines its final quality. High moisture content in the product, which results in a soft feel, is undesirable. Further, the tougher the goods, the longer its shelf life. A small amount of water is employed and left for a while to achieve the desired texture. However, a product that is too hard is not preferred. With age, the texture grows tougher (Personal communication, 2023).

### 2.5.2 Bulk density

A unit volume is occupied by the product's mass. Unlike density, bulk density includes the air space trapped between the gaps. Low bulk density items are popular among both producers and consumers. Low bulk density adds bulkiness to a product while maintaining the same weight, which benefits the producer while also providing a more crispy texture for customers (Personal communication, 2023).

### 2.5.3 Fat uptake

Because the food is deep fried, one of the most essential parameters is fat uptake. Fat has both positive and negative effects on the product. Fat has a high calorific value, but it also has a high satiety value. It adds flavor to the product but decreases its shelf life. Products with a high fat content are prone to oxidative rancidity. The growing urge to reduce the fat content of fried foods has substantially increased the amount of study devoted on the issue of fat uptake during deep-fat frying. In *Thekua*, fat uptake might range between 20 and 30% (Mellema, 2003).

## 2.6 Physical, chemical and biological changes on heating

### 2.6.1 Physical changes oh heating

The hydrogen-bond network is altered and reformed throughout the cooking process with heat and water. In the presence of starch, the starch granules enlarge and eventually rupture, releasing the polysaccharide component. This 'gelatinization' event is extremely important because it is the essence of the conversion of raw starch to carbohydrate metabolism. The starch granule is not chemically homogeneous, and at least two different components, amylose and amylopectin, can be separated. These two components are released during the cooking of rice (Priestley and Leopold, 1979).

### 2.6.2 Chemical changes on heating

Heating causes numerous chemical changes. The first is the chemical change caused by interactions with lipids. Then there's the chemical change caused by the contact with enzymes. There is also an increase in browning. Finally, there occurs chemical change caused by mineral contact (Buckle *et al.*, 1975).

### 2.6.3 Biological changes on heating

The most fundamental biological change in starch caused by heating is that it becomes available to enzymes in the digestive tract. Another significant biological change caused by heating is the loss of nutritional value of food (Springer *et al.*, 1999).

## 2.7 Frying time and temperature

Frying time and temperature are important factors in the final product's quality. For frying, *Thekua* oil is heated almost to smoking temperature and then cooled somewhat to remove the raw flavor. *Thekua* fry temperatures range from 150 to 180 °C. The cooking time is primarily determined by the temperature and can range from 5 to 15 minutes. Better quality *Thekua* should be fried on a low flame (about 150 °C) for 7-8 minutes (Personal communication, 2023).

## 2.8 Buckwheat (Fagopyrum esculentum)

Buckwheat (Fagopyrum esculentum), a dicotyledonous plant in the Polygonaceae family, is a moisture-loving, cool-weather annual grain with significant potential for application in sustainable tropical cropping systems. Buckwheat has been farmed in China as a grain crop for over 1000 years. The two most prevalent buckwheat species are prevalent buckwheat (F. esculentum) and Tartary buckwheat (F. tartaricum), the former known as mithe phapar and the latter as tite phapar in local language. It is one of the quickest growing green manure crops, blossoming in only 4-5 weeks following seeding. Buckwheat is a broad leaf annual crop that grows to a height of 2-5 feet (60-150 cm). It bears multiple branches on a single succulent stalk.Its flowers range in color from white to pale green to pink to red. Its root structure is dense andfibrous, with a deep taproot. The majority of its roots are focused in the top ten inches of soil. Buckwheat cultivation is not only limited to a specific type of soil or fertilization requirement,but it is also grown at greater altitudes above 3,000 meters in Nepal and Bhutan (J. Smith and Valenzuela, 2002).

Buckwheat is primarily a human food crop, utilized in the same way that wheat and oats are. Buckwheat is occasionally referred to as a "pseudo cereal" despite the fact that it is not a true cereal. Buckwheat seeds are dehulled, and the leftover seed material, known as groats, is crushed into flour. To make breads, breakfast cereals, and other multi-grain items, the flour is frequently combined with flour from other cereal grains. Buckwheat and wheat flour are used to manufacture the popular "soba" noodles in Japan. Buckwheat is native to Russia, where it isused in a number of food dishes, including roasting whole groats to make "kasha." Buckwheat contains more lysine than wheat or corn. The protein content of dehulled buckwheat is about 12%, with only 2% fat (Myers, 2002). Taxonomically, buckwheat can be classified as:

| | |
|---|---|
| Kingdom: | Plantae |
| Division: | Magnoliophyta |
| Class: | Magnoliopsida |
| Order: | Caryophyllales |
| Family: | Polygonaceae |
| Genus: | Fagopyrum |
| Species: | esculentum |

Source: (Ahmed *et al.*, 2014)

### 2.8.1 Nutritional composition of buckwheat

Chemical components of buckwheat include protein/ amino acids, starch, lipids, fiber, minerals, vitamins, and other functional components (e.g., flavonoids, phytosterols, and fagopyrins). These are distributed in different parts of the buckwheat grain, e.g., protein mainlyoccurs in the aleurone layer and embryo, starch in the endosperm, and fiber, ash, and flavonoids are normally in testa and pericarp. The chemical composition of buckwheat is as shown in Table 2.2.

**Table. 2.2** Nutritional composition of buckwheat

| **Components** | **Buckwheat seeds** | **Buckwheat groats** |
|---|---|---|

| | | |
|---|---|---|
| Moisture | 12-14 | 12.3 |
| Carbohydrate | 58.5-73.5 | 70.9 |
| Protein | 10-14.5 | 9.7 |
| Fat | 2.0-2.6 | 1.8 |
| Fiber | 9.3-10.9 | 3.7 |
| Ash | 2.0-2.5 | 1.7 |

Source: Baltensperger and Cai (2004)

### 2.8.2 Nutritional value of buckwheat

Buckwheat seed provides a variety of nutrients, including protein and carbohydrates. Thus, buckwheat seed products are rich providers of these nutrients. Buckwheat seed includes a variety of minerals in quite high concentrations. Therefore, Buckwheat products appear to be an important source of nutrients for those who eat them. Despite its importance as a food, minerals in buckwheat and its products have yet to be adequately described in terms of nutrition and functionality (Poudel, 2019).

Zinc is one of the minerals that humans require. Zinc may be extremely beneficial to human health. In terms of zinc, buckwheat is thought to contain a comparatively high level of zinc when compared to other grains (Ikeda, 1991). Furthermore, studies have shown that a relatively-high level of zinc in buckwheat flour is released after pepsin pancreatic digestion. Recent studies clarify changes in various minerals, besides zinc, in buckwheat flour after enzymatic digestion. Analysis has shown that high levels of zinc, copper and potassium in buckwheat flour are released on enzymatic digestion; moderate levels of magnesium and phosphorus are released; and low levels of calcium and manganese are released. Studies have also shown that 100 gm of buckwheat flour can fulfill 10 to 100% of RDA of minerals namely, Zinc, Copper, Iron and Potassium (Suzuki *et al.*, 2005). The amino acid composition in buckwheat flour is richer than the whole wheat flour which is as described in Table 2.3.

**Table 2.3** Amino acid composition (g/100g of protein) of groats of buckwheat samples

| **Amino acids** | **Sample** |
|---|---|
| Aspartic acid | 10.38 |
| Threonine | 3.93 |
| Serine | 5.07 |
| Glutamic acid | 18.73 |
| Proline | 3.01 |
| Glycine | 6.33 |
| Alanine | 4.72 |
| Cystine | 2.67 |
| Valine | 5.7 |
| Methionine | 2.15 |
| Isoleucine | 4.09 |
| Leucine | 7.01 |
| Tyrosine | 2.98 |
| Phenylalanine | 4.79 |
| Lysine | 6.07 |
| Histidine | 2.56 |
| Arginine | 9.84 |

Source: (Bonafaccia *et al.*, 2003)

Buckwheat can be justified in composite flour-based biscuits because it has excellent neutraceutical characteristics and its gluten-free nature can play a significant role in celiac disease prevention. Buckwheat flour has been included to noodle recipes. Significant influences on cooking quality, chemical and sensory qualities, and color values of noodles have been reported (Bilgicli, 2008). Cereal grains, notably soft wheat, are low in protein (7–14%) and weak in certain amino acids, including lysine. Buckwheat, on the other hand, has a higher protein content than other cereal grains and might be used to make bread. Certain amino acids,such as lysine, histidine, valine, and leucine, are supported. Given the neutraceutical and other functional features of buckwheat, the current study was designed to compare the functional properties of buckwheat flour with whole wheat flour and mix it into *Thekua* to evaluate the quality and acceptance of *Thekua* (Baljeet *et al.*, 2010).The amino acid composition in buckwheat flour is richer than the whole wheat flour which is as described in Table 2.3.

### 2.8.3 Health benefits of buckwheat

Buckwheat is both a good medicinal herb and a nutrient-dense crop. Its flour and leaves are high in flavonoid chemicals. Rutin content ranges between 0.8 and 1.5%, with auto tetraploid tartary buckwheat containing as much as 2.41%. Rutin contributes to a wide range of physiological tasks, including maintaining blood capillary resistance and promoting cell proliferation. It can also be used as an anti-inflammatory and anti-allergic agent, as a diuretic and spasmolytic, and for cough suppression, lipemia reduction, and heart stimulation (Gang *et al.*, 2001).

Buckwheat contains plentiful vitamins. Vitamin B1 can help to enhance digestive functionto resist neuritis and to prevent beriberi. Vitamin B2 can enhance human body's development and is a vital element for protection against perleche, glossitis and eyeliditis. Tartary buckwheat contains fairly rich common elements and microelements (Mg, Ca, Se, Mo, Zn, Cr, etc.) which serve protection against coronary heart disease. The microelement selenium (Se) contained in tartary buckwheat could combine with minerals into an unstable 'mineral selenium-protein' compound which helps to decompose and excrete toxins (eg, Pb, Hg, Cd, etc.) in human body.Tartary buckwheat food possesses apparent functions of three reductions, namely the reductions of lipemia, blood sugar and Glucosuria. It still possesses certain radiation-resistant property, hence an extremely curative food for radiation sufferes (Gang *et al.*, 2001).

### 2.8.4 Storage and shelf life of *Thekua*

*Thekua* is a consistent product. It can be kept for up to a month, and even longer. However, after two weeks, the product turns brittle. The storage life is primarily determined by the ingredients used in the recipe. Typically, there are two variants: some prefer firmer (*Thekua*) and have a longer shelf-life, while others prefer softer (*Thekua*). The use of correct packaging material may extend *Thekua*'s shelf life (Personal communication, 2023).

*Thekua*'s shelf life can be evaluated by the oil's AV and PV values, which provide the first indication of rancidity in unsaturated fats and oils. PV quantifies the degree to which an oil sample has experienced primary oxidation. Oils with a high degree of unsaturation are the mostsensitive to autoxidation (oxidative rancidity), which causes fats and oils to deteriorate and produce off-flavors and off-odors. The assessment of the PV is the best test for autoxidation. Peroxides are autoxidation intermediates. PV, or peroxide concentration in an oil or fat, is useful for determining the level of deterioration (Lin *et al.*, 2009).

## Part III

# Materials and methods

## 3.1 Raw materials required

Raw materials required for the preparation of the *Thekua* was purchased from local market of Dharan, Sunsari. 'Whole Wheat Flour' was taken for the preparation of *Thekua*. The frying oil used was Cello brand refined sunflower oil, available in the local market of Dharan. The common buckwheat (Fagopyrum esculentum) flour was bought from the local market of Dharan.

## 3.2 Equipments, chemicals and utensils

Equipments and other required materials were taken from laboratory of Central Campus of Technology, Dharan, Nepal. *Thekua* was prepared and all the analysis were done in the laboratory of Central Campus of Technology. The main utensil for frying of *Thekua* is called 'Karahi'. It is a pan of iron with holding ring in either sides.

Other utensils used for different purposes in *Thekua* preparation are:

'Aari' or 'dekchi': It is made up of stainless steel or aluminum and used for mixing of Whole wheat flour and buckwheat flour with sugar, ghee or other ingredients; rubbing or kneading and preparing batter.

A Flat dish: It is made up of stainless steel and used for keeping the fried or prepared *Thekua* just after removing from Karahi.

Jhir: A pointed stick made up of iron. It is used to turn the *Thekua* upside down and to removefrom hot oil of frying pan.

Nanglo: Winnowing tray made up of bamboo hands. It is used to get the flour of varied particlesize.

Weighing Machine: Used to measure the weight of whole wheat flour, sugar, buckwheat flour. Vernier Caliper: Used to measure the diameters of *Thekua.*

Timer/ Clock: Used to measure time interval of frying.

### 3.3 Preparation of *Thekua*

*Thekua* was prepared as that of (Suman, 2012) with slight modifications Figure 2.2. Buckwheat flour was used with whole wheat flour to make *Thekua*. Semolina (25 g), sugar (30 g), oil (20g) and water (25 g) were kept constant for every formulation Table 2.4.

Whole wheat flour + Buckwheat flour (100g) + Oil (20g) + Semolina(20g)

↓

Sugar (30g) → Mixing

↓ ← Water spraying (25ml)

Kneading (12-15 min.)

↓

Tough dough

↓

Moulding (desired mould )

↓

Frying in oil with mild heating (145°C, 15 min.)

↓

Cooling at room

↓

Thekua

**Fig 2.2**. Preparation process of *Thekua*

(Anon, 2023)

**Table 2.4** Mixture design of the samples with different proportions of whole wheat flour and buckwheat flour.

| **Sample** | **Whole wheat flour (g)** | **Buckwheat flour (g)** |
|---|---|---|
| A | 100 | 0 |
| B | 81.25 | 18.75 |

| | | |
|---|---|---|
| C | 87.5 | 12.5 |
| D | 75 | 25 |
| E | 93.75 | 6.25 |
| F | 91.67 | 8.33 |
| G | 83.33 | 16.67 |

### 3.3.1 Preparation of dough

For preparation of dough, whole wheat flour, buckwheat flour and semolina was mixed together by rubbing with hands for 2-3 min. sugar was added to the mixture and was kneaded well with hands. Also, little refined oil or ghee can be added.

### 3.3.2 Shaping and dieing

A lump of dough was taken and made round like done while making chapatti with hand. Then it is placed on a special die (Saancha). Saancha has a great role in the preparation of *Thekua*. Saancha consists of special designs which makes *Thekua* attractive in appearance and is mostly used for shaping purpose. Small amount of oil was applied to the surface of Saancha which helps in shaping and easy removal after required shaping. Same design was used for the shaping purpose.

### 3.3.3 Deep frying

The shaped products were fried in refined sunflower oil. Frying was conducted in kitchen Karahi on LPG gas. 500 ml oil was taken in the utensil, heated to specified temperature and theproduct was fried. The products were fried at 155°C for 7 min. Product was turned upside downjust after 2$^{nd}$ min and again after 4th min and product was taken out at 7 min and allowed to cool on a vessel. The cooled product was packed in LDPE pouches.

## 3.4 Analytical procedures

### 3.4.1 Moisture content

Moisure content was determined using IR-Moisture Meter as described in Ranganna (2008). The products were finely ground in mortar and pestle before quartering and the necessary stepsas described in Ranganna (2008) was followed to calculate the moisture content.

### 3.4.2 Fat

Fat was determined by solvent extraction method using Soxhlet apparatus as described in Ranganna (2008). The finely ground sample was extracted using petroleum ether. The solvent was removed and extracted fat was accurately determined.

### 3.4.3 Protein

Protein of the product was determined by micro-Kjeldahl method as described in Ranganna (2008). Total nitrogen content is obtained from Kjeldahl method from which protein was calculated by using the factor 5.70 used for wheat protein.

### 3.4.4 Ash content

Ash content was determined by dry ashing as described in AOAC (2005). Finely ground sample in silica dish was ashed in Muffle furnace at 550±10 °C until constant weight was obtained.

### 3.4.5 Crude fiber

Crude fiber of the samples was determined gravimetrically by acid and alkali treatment as described in AOAC (2005).

### 3.4.6 Carbohydrates

Carbohydrate content in the sample was calculated by difference method as described in AOAC (2005).

### 3.4.7 Energy value

The energy value of the sample was determined by multiplying the physiological energy value for carbohydrates, protein and fat AOAC (2005).

### 3.4.8 Iron

The iron content of the *Thekua* was determined by colorimetric method as described by Ranganna (2000).

### 3.4.9 AV and PV of oil

The AV and PV of oil extracted from the sample were determined as described in K.C. and Rai (2007). Following formula were used for the determination of AV and PV.

$$AV = \frac{ml\ of\ alkali \times N\ of\ alkali \times 56.1}{Weight\ of\ sample\ (g)}$$

$$PV = \frac{N \times (Vs - Vb) \times 1000}{Weight\ of\ sample\ (g)}$$

Where. N= Normality of sodium-thiosulfate, Vs = sodium thiosulfate consumed by sample (ml) and $V_b$ = sodium-thiosulfate consumed by blank (ml).

## 3.5 Sensory analysis

Acceptance of products prepared was determined by sensory evaluation using a semi-trained panel of 10 students and faculties of Central Campus of Technology. The panelists were asked to evaluate the appearance, texture, taste and overall acceptability. Hedonic rating test was adopted as a method of sensory evaluation on scale as follows: like extremely (9), like very much (8), like moderately (7), like slightly (6), neither like nor dislike (5), dislike slightly (4), dislike moderately (3), dislike very much (2), dislike extremely (1). Score card used for sensory evaluation of *Thekua* is given in Appendix A. The samples were presented to the panelists in random order to omit the biasness. Three samples at a time for the first step experiment and 4 samples at a time for second step experiments were presented to the panelists in well-ventilated and good light conditioned room. The samples were tasted within 2 days after frying and presented to the panelists in between 9 am and 11 am. Panelists were provided warm water for rinsing mouth between the tasting samples.

## 3.6 Statistical analysis

All the data obtained in this research work were analyzed by the statistical program known as Genstat which was developed by Lawes Agricultural Trust (1995). From this mean ANOVA (No blocking at 5% Level of significance), LSD and interaction effects were obtained to determine whether the sample were significantly different from each other and also to determine which one is superior among them. The specimen evaluation card used for the sensory test appears in the appendix.

### 3.7 Determination of shelf life

Shelf life of the product was determined by studying the acid value (AV), Peroxide value (PV) of the extracted fat and the moisture content of the *Thekua*. The analysis was carried out once in a week basis.

# Part IV

## Results and discussion

The whole wheat flour and the buckwheat flour were collected and mixed with other ingredients to formulate buckwheat flour incorporated *Thekua*. Proximate composition of the flour as well as *Thekua* was carried out. The best product among the seven variations was determined by carrying out sensory evaluation and the detailed nutritional value of the best product was analyzed. The proximate composition of buckwheat flour as well as whole wheat flour was obtained as given in Table 2.5.

**Table 2.5** Proximate composition of whole wheat flour, buckwheat flour and semolina

| Parameters in % | Whole wheat flour | Buckwheat flour | Semolina |
|---|---|---|---|
| Moisture | 12.30±0.35 | 11.50±0.45 | 12.85±0.08 |
| Crude Protein (db) | 11.90±0.25 | 13.69±0.67 | 12.01±0.00 |
| Crude fat (db) | 1.85±0.73 | 2.10±0.43 | 1.67±0.02 |
| Crude fibre (db) | 1.45±0.46 | 0.70±0.67 | 2.50±0.11 |
| Total ash (db) | 0.56±1.23 | 1.71±0.69 | 1.00±0.01 |
| Carbohydrate (db) | 71.94±0.45 | 70.30±1.1 | 72.47±0.85 |
| Gluten content (db) | 7.10±0.89 | 0 | 6.25±0.35 |

* The values are the means of triplicate samples and the values in the parenthesis are standard deviation.

The moisture content of both the wheat and buckwheat flour was in normal range as described by Arora (1980). The protein content of the whole wheat flour taken for *Thekua* making seemed to be slightly higher than the standard range for *Thekua*. The gluten content of the whole wheat flour was found to be 7.10%, while in case of buckwheat flour gluten was not observed which resembles the gluten less explanation of buckwheat flour as explained by (Dietrych-Szostak and Oleszek, 1999). The fat content of whole wheat flour was found to be 1.85% while it was observed to be 2.10% in buckwheat flour.

## 4.1 Physical properties of *Thekua*

In order to characterize *Thekua*, different physical parameters viz. color, shape, thickness, diameter, weight etc. were investigated and data on these physical properties are presented in Table 2.5.

**Table 2.5** Physical attributes of *Thekua*

| Physical Attribute | *Thekua* |
|---|---|
| Color | Dark brown |
| Shape | Circular |
| Thickness (mm) | 12.7±0.60 |
| Diameter (mm) | 38.2±2.81 |
| Weight (gm) | 20.45±0.50 |

Values are the mean of triplicates and the values in parenthesis indicates standard deviation.

## 4.2 Effect of buckwheat flour content on sensory attributes of *Thekua*

*Thekua* is an important cereal-based food in the local diet of Nepali of the Terai. In present investigation, efforts were made to utilize buckwheat flour in *Thekua* to evaluate the influence of buckwheat flour on quality of *Thekua* and contents of functional 68 components as a result of supplementation. The consumer acceptability of *Thekua* may be assessed with the help of sensorial evaluation of the products. In order to study the effect of buckwheat fortification on sensorial quality characteristics, different random trials with wide range of fortification levels have been undertaken following the sensorial evaluation using 9 point hedonic scale for the organoleptic characteristics like appearance, taste, texture, and overall acceptability.

### 4.2.1 Appearance

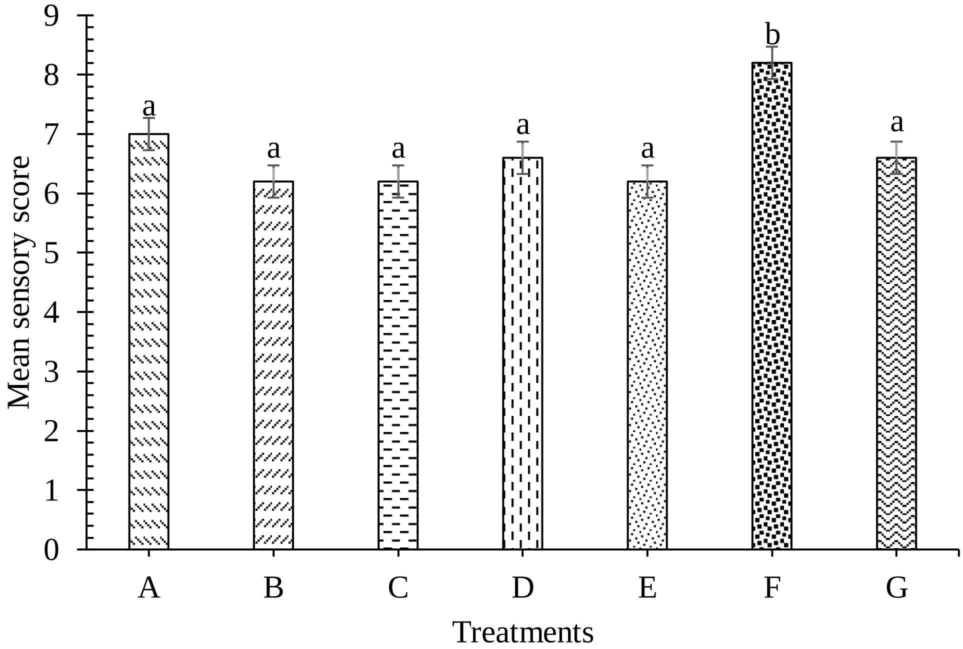


**Fig 2.3** Characteristics of product with respect to appearance

The mean score for the appearance were 7, 6.2, 6.2, 6.6, 6.2, 8.2 and 6.6 respectively for sampleA, B, C, D, E, F and G. The obtained mean values are represented as bar diagram in Fig. 2.3. There is a significant difference in appearance within the sample ($p \leq 0.05$), according to the ANOVA table (Table B.1, Appendix C).

On the basis of mean score with respect to appearance, the superiority/inferiority ($p \leq 0.05$) of the *Thekua* samples was found to rank as follows:

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

Similarly, the alphabet above the bar graph denotes a significant difference. Sample F received the highest score for appearance, followed by the other product formulations. Statistical analysis showed that partial substitution of whole wheat flour with buckwheat flour had significant effect ($p<0.05$) on the appearance of different *Thekua* formulations.

### 4.2.2 Taste

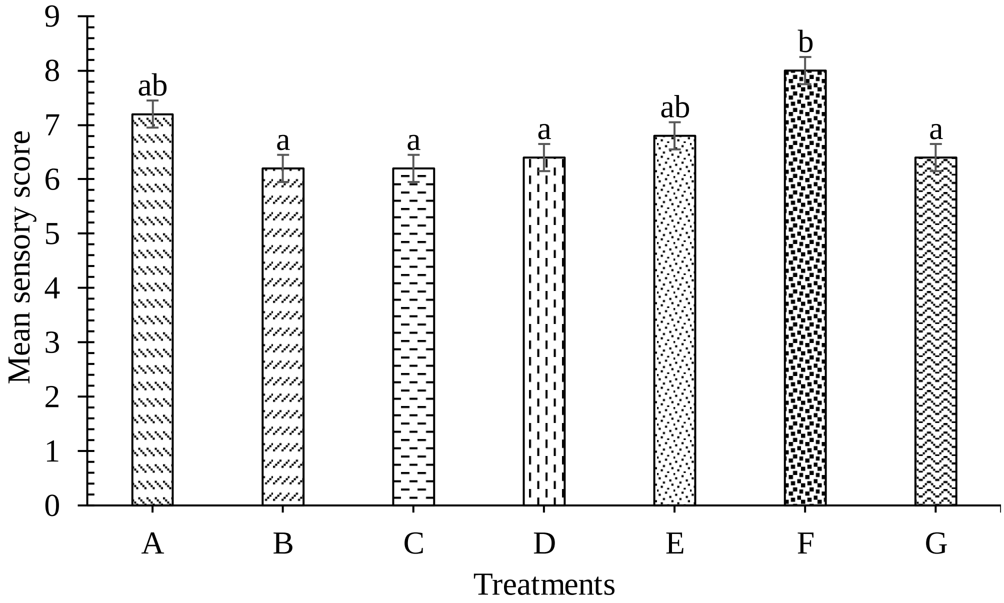


**Fig. 2.4** Characteristics of product with respect to taste

The mean score for the taste were 7.4, 6.4, 6.2, 6.4, 6.6, 7.8 and 6.4 respectively for sample A,B, C, D, E, F and G. The obtained mean values are represented as bar diagram in Fig. 2.4. There is a significant difference in taste within the sample ($p \le 0.05$), according to the ANOVA table (Table B.3, Appendix C).

On the basis of mean score with respect to taste, the superiority/inferiority ($p \le 0.05$) of the *Thekua* samples was found to rank as follows:

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

Similarly, the alphabet above the bar graph denotes a significant difference. Sample F received the highest score for taste, followed by the other product formulations. Statistical analysis showed that partial substitution of whole wheat flour with buckwheat flour had significant effect ($p<0.05$) on the appearance of different *Thekua* formulations.

### 4.2.3 Texture

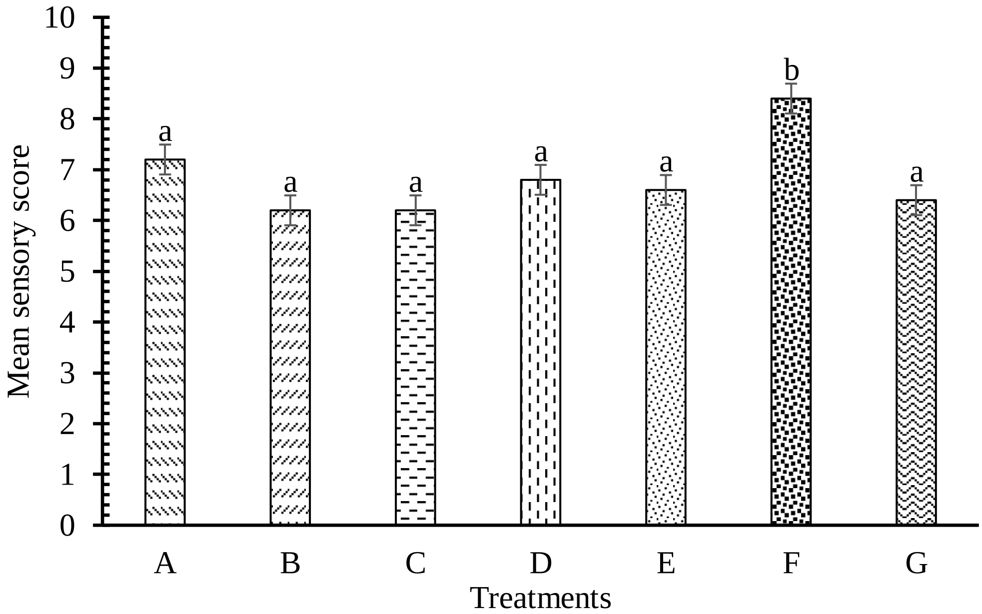


**Fig. 2.5** Characteristics of product with respect to texture

The mean score for the texture were 7.2, 6.2, 6.2, 6.8, 6.6, 8.4 and 6.4 respectively for sample A, B, C, D, E, F and G. The obtained mean values are represented as bar diagram in Fig. 2.5. There is a significant difference in texture within the sample ($p \leq 0.05$), according to the ANOVA table (Table B.5, Appendix C).

On the basis of mean score with respect to texture, the superiority/inferiority ($p \leq 0.05$) of the *Thekua* samples was found to rank as follows:

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

Similarly, the alphabet above the bar graph denotes a significant difference. Sample F received the highest score for texture, followed by the other product formulations. Statistical analysis showed that partial substitution of whole wheat flour with buckwheat flour had significant effect ($p<0.05$) on the texture of the different *Thekua* formulations.

### 4.2.4 Overall acceptability

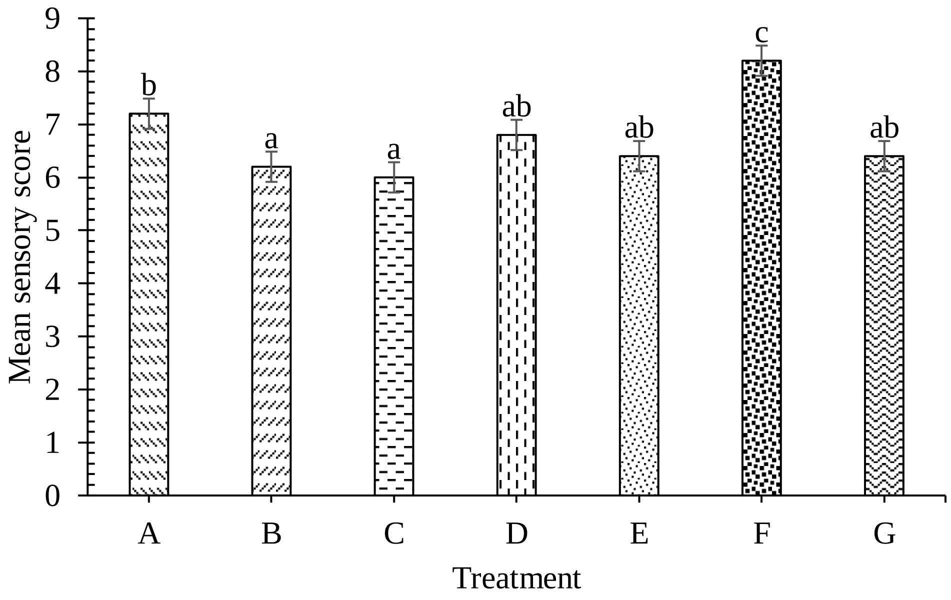


**Fig. 2.6** Characteristics of product with respect to overall acceptability

The mean score for the overall acceptability were 7.9, 8.2, 6.5, 6.7 and 6.6 respectively for sample A, B, C, D and E. The obtained mean values are represented as bar diagram in Fig.2.6. There is a significant difference in overall acceptability within the sample ($p \leq 0.05$), accordingto the ANOVA table (Table B.7, Appendix C).

On the basis of mean score with respect to overall acceptability, the superiority/inferiority ($p \leq 0.05$) of the *Thekua* samples was found to rank as follows:

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

Similarly, the alphabet above the bar graph denotes a significant difference. Sample F received the highest score for overall acceptability, followed by the other product formulations. Statistical analysis showed that partial substitution of whole wheat flour with buckwheat flour had significant effect ($p<0.05$) on the overall acceptability of the different *Thekua* formulations. The product B and C were not significantly different to each other but were significantly different to others while product D, E and G were not significantly different to each other but were from A, B which is shown graphically in Fig 2.6.

On the basis of overall acceptability sample F was found to be best. It was found that increasing the amount of buckwheat flour beyond 8.33% reduced the acceptability of the *Thekua*.The highest overall sensory score was obtained when buckwheat flour was used at 8.33% addition level. This *Thekua* had desirable appearance, texture and taste. While, increasing amount of buckwheat flour reduced texture, appearance and taste of *Thekua* so, they have low acceptability.

## 4.3 Chemical composition of *Thekua*

The proximate compositions of control *Thekua* and best sample (8.33% buckwheat flour) incorporation were analyzed and obtained results are given in Table 2.6.

**Table 2.6** Proximate composition of control and best *Thekua*.

| Parameters | Control sample (A) | Best sample (F) |
|---|---|---|
| Moisture content | 5.12±0.01 | 5.16±0.01 |
| Crude protein | 8.12±0.02 | 9.45±0.01 |
| Crude fat | 27.05±0.01 | 26.09±0.03 |
| Crude fiber | 0.15±0.01 | 0.24±0.01 |
| Total ash content | 0.39±0.01 | 0.50±0.02 |
| Total carbohydrate | 59.17±0.04 | 58.56±0.04 |
| Total energy (Kcal) | 512.61±0.01 | 506.85±0.07 |

Note: Values are means of triplicate ± standard deviations.

## 4.4 Effect of incorporation of buckwheat flour on nutritional quality of *Thekua* onthe basis of iron content

*Thekua* prepared from the incorporation of buckwheat flour at different level were analyzed for the best acceptability and the best sample was further analyzed for the iron content and was compared with the control sample, whole wheat flour *Thekua*. The amount of iron content determined is given in Table 2.7.

**Table 2.7** Iron content in whole wheat flour *Thekua* and buckwheat flour incorporated *Thekua*.

| Sample | Iron Content (%) | |
|---|---|---|
| | BFT | WWFT |
| 1 | 0.034 | 0.017 |
| 2 | 0.031 | 0.019 |
| 3 | 0.03 | 0.016 |
| 4 | 0.036 | 0.016 |
| 5 | 0.029 | 0.018 |
| Average | 0.032 | 0.0172 |

*BFT = Buckwheat flour thekua *WWFT = Wholewheat flour thekua

The results obtained were subjected for further statistical analysis. From ANOVA the grand mean of iron content in buckwheat flour incorporated *Thekua* was observed to be 0.03200 mg/10gm and the grand mean of iron in whole wheat flour *Thekua* was observed to be 0.01720mg/10gm. At 5% level of significance the two samples were significantly different from each other. The comparison of mean between the two samples showed that the iron content in the buckwheat flour incorporated *Thekua* was higher than the normal whole wheat flour *Thekua*.

## 4.5 Shelf-life evaluation of buckwheat flour incorporated *Thekua*

The best product sample 'F' was packed in low density poly-ethylene (LDPE) plastic packets and stored at ambient temperature. For the shelf life evaluation of *Thekua,* the oil used for the preparation of *Thekua* was analyzed. The AV and PV of the oil was calculated in the duration of 7 days i.e. weekly. The shelf life of *Thekua* can be determined by the AV and PV value of the oil as it gives the initial evidence of rancidity in unsaturated fats and oils. PV gives a measure of the extent to which an oil sample has undergone primary oxidation. Oils with a high degree of unsaturation are most susceptible to autoxidation (oxidative rancidity) that leads to deterioration of fats and oils which form off-flavors and off-odors. The best test for autoxidation is determination of the PV. Peroxides are intermediates in the autoxidation. PV, concentration of peroxides in an oil or fat, is useful for assessing the extent to which spoilage has advanced. The AV and PV of fresh oil was 0.92 and 4 respectively. The AV and PV of oil determined or calculated weekly is shown in Fig 2.7 and 2.8 respectively.

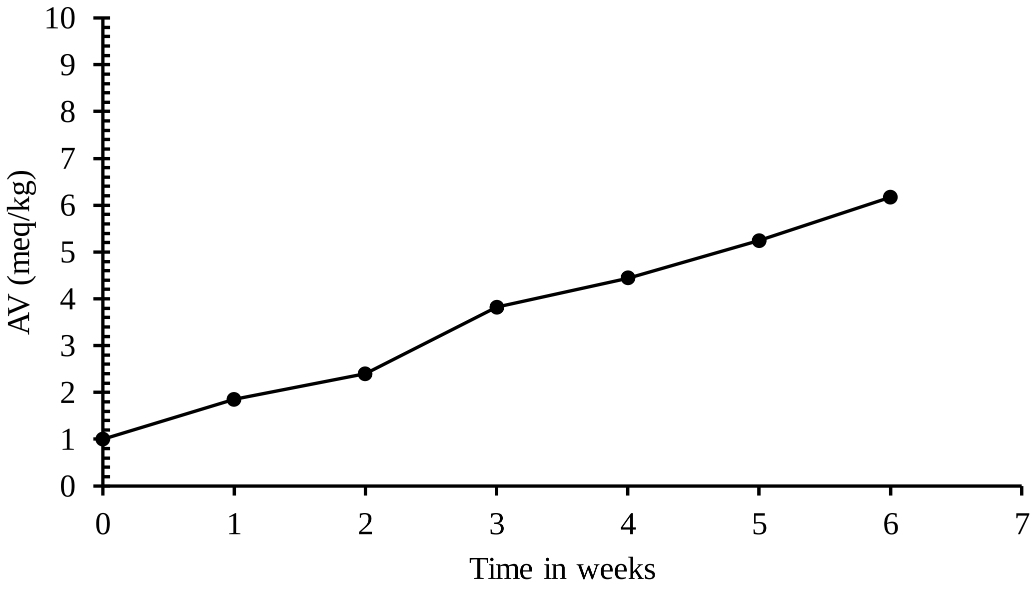


**Fig. 2.7** Change in AV with time

In the above fig. AV was found to be 1.85, 2.40, 3.82, 4.44, 5.24 and 6.17 meq/kg in 1st, 2nd,3rd, 4th, 5th, and 6th weeks respectively.

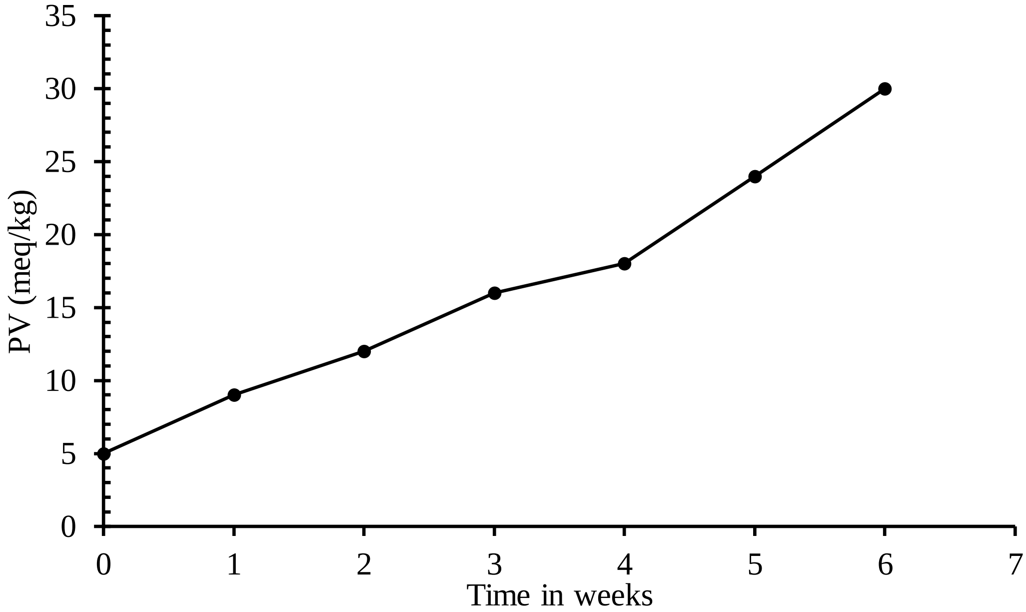


**Fig. 2.8** Change in PV with time

In the above fig. PV was found to be 9, 12, 16, 18, 24 and 30 meq/kg in 1$^{st}$, 2$^{nd}$, 3$^{rd}$, 4$^{th}$, 5$^{th}$ and6$^{th}$ weeks respectively.

The PV of fresh oils are less than 10 meq/kg and when the PV is between 20 and 40, a rancid taste is noticeable and oil becomes rancid (OJEH, 1981). In the present study, PV of fresh oil was 4 meq/kg, and PV was between 20 and 40 meq/kg after 4 weeeks i.e. 28 days and the product had rancid taste. Therefore, the shelf life of *Thekua* was found to be best before 4 weeks i.e. 28 days.

# Part V

# Conclusions and recommendations

## 5.1 Conclusions

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

- The buckwheat flour can be successfully incorporated up to 8.33%, with no adverse effecton the acceptable quality.
- The nutritional quality of the *Thekua* seemed to be enhanced in the case of mineral content mainly iron.
- This formulation could help in reducing the amount of gluten in the *Thekua* which would be beneficial for gluten intolerance people.
- Incorporation of buckwheat flour above 8.33% showed an adverse effect on the textural quality and good body formation.
- The shelf life of the buckwheat flour incorporated *Thekua* was found to be satisfactory. Further studies on formulation of *Thekua* with higher shelf-life using buckwheat flour can be done.

## 5.2 Recommendations

The following recommendations for further research work can be drawn from the work:

- Microbiological analysis of *Thekua* can be studied.
- Effect of incorporation of other flour in quality of *Thekua* can be studied.
- Development of neutraceutical food mainly targeted to iron deficient patients can be done.
- Proper production and marketing of this product will surely promote the production of this neglected but very beneficial crop.

# Part VI

## Summary

*Thekua*, a Maithili indigenous product is a deep fried product which is very tasty and delicious cultural food produced mainly in Chhath puja. *Thekua*, is an honored Prasad (offering to God) in the Chhath puja. Further value of *Thekua* can be added by incorporating buckwheat flour. Besides being nutritionally rich buckwheat also contains a very important antioxidant called rutin.

This study was mainly focused on the nutritional value addition of normal whole wheat flour *Thekua* by incorporating buckwheat flour at various levels of incorporation. Thus, formulated *Thekua* were subjected to proximate analysis, iron content and shelf life estimation.The proximate analysis of the flour used was also carried out. The incorporation was carried out as 18.75%, 12.5%, 25%, 6.25%, 8.33% and 16.67% and the best product was found out. The whole wheat flour and buckwheat flour was analysed for moisture, protein, fat, crude fibre,total ash and carbohydrates. The values were found to be 12.30, 8.90, 1.50, 0.45, 0.56 and 68.19% for wheat flour and 13.29, 10.69, 2.22, 0.70, 1.71 and 71.39% for buckwheat flour respectively.

The *Thekua* with 8.33% buckwheat flour was found to be best among the seven varieties. The overall acceptability mean showed the product F with 8.33% incorporation of buckwheat flour to be superior. This showed that buckwheat flour can be incorporated in *Thekua* up to 8.33% with good acceptability. Product F and whole wheat flour *Thekua* was further analysed for iron content. The comparison of mean between the two samples showed that the iron content in the buckwheat flour incorporated *Thekua* was higher than the normal whole wheat flour *Thekua*. The result obtained showed that intake of 100 gm of buckwheat flour incorporated *Thekua* supplemented 22% of the RDI of iron, while the iron content in whole wheat flour *Thekua* was significantly low. Sample F was further analysed for shelf life.The AVand PV of the triplicate samples were analysed on weekly basis for 1 months. The values were all within the acceptable limits. The overall study showed that buckwheat flour incorporated *Thekua* at 8.33% incorporation would give a nutritionally enriched product with best acceptability.

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# Appendices

## Appendix A

### Sensory Evaluation Card

Specimen card for sensory evaluation by hedonic rating test

Sensory evaluation of buckwheat flour incorporated *Thekua*

Name of panelist: Date:

Dear panelist, please test the given samples and score how much you prefer each one. Give points of your degree of preference of each parameter as shown below

Please rate the *Thekua* from 1 to 9

Where,

9 = like extremely

8 = like very much

7 = like moderately

6 = like slightly

5 = average

4 = dislike slightly

3 =dislike moderately

2 = dislike strongly

1 = dislike extremely

| Sample | Appearance | Taste | Texture | Overall Acceptability |
|---|---|---|---|---|
| A | | | | |
| B | | | | |
| C | | | | |
| D | | | | |
| E | | | | |
| F | | | | |
| G | | | | |

Remarks:

**Signature_____________**

**Appendix B**

## Cost evaluation

Table: Cost evaluation of *Thekua*

| Particulars | Quantity (g) | Rate (Rs.) | Price (Rs.) |
|---|---|---|---|
| Whole wheat flour (Atta) | 92 | 60 | 5 |
| Buckwheat flour | 8 | 250 | 3 |
| Semolina | 20 | 70 | 2 |
| Sugar | 20 | 90 | 2 |
| Oil | 18 | 200 | 4 |
| Overhead cost | 20% of total cost | - | 3 |
| Total | | | 19 |

Price of *Thekua*/ 100g = Nrs. 19

Price of *Thekua* (Weight = 20g) = Nrs. 4

**Appendix C**

## ANOVA Results

**Table B.1** Two way ANOVA (no blocking) for appearance

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Panelist | 4 | 2.0000 | 0.5000 | 2.14 | 0.107 |
| Sample | 6 | 15.5429 | 2.5905 | 11.10 | <.001 |
| Residual | 24 | 5.6000 | 0.2333 | | |
| Total | 34 | 23.1429 | | | |

**Table B.2** Tukey's protected least significant difference test for appearance

| Sample | Mean | |
|---|---|---|
| A | 7.00 | a |
| B | 6.20 | a |
| C | 6.20 | a |
| D | 6.60 | a |
| E | 6.20 | a |
| F | 8.20 | b |
| G | 6.60 | a |

**Table B.3** Two way ANOVA (no blocking) for taste

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Panelist | 4 | 2.6857 | 0.6714 | 1.81 | 0.160 |
| samples | 6 | 11.0857 | 1.8476 | 4.97 | 0.002 |
| Residual | 24 | 8.9143 | 0.3714 | | |
| Total | 34 | 22.6857 | | | |

**Table B.4** Tukey's protected least significant difference test for taste

| Sample | Mean |
|---|---|
| A | 7.40 ab |
| B | 6.40 a |
| C | 6.20 a |
| D | 6.40 a |
| E | 6.60 b |
| F | 7.80 ab |
| G | 6.40 a |

**Table B.5** Two way ANOVA (no blocking) for texture

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Panelist | 4 | 2.6857 | 0.6714 | 2.64 | 0.059 |
| samples | 6 | 18.1714 | 3.0286 | 11.89 | <.001 |
| Residual | 24 | 6.1143 | 0.2548 | | |
| Total | 34 | 26.9714 | | | |

**Table B.6** Tukey's protected least significant difference test for texture

| Sample | Mean |
|---|---|
| A | 7.20 a |
| B | 6.20 a |
| C | 6.20 a |
| D | 6.80 a |
| E | 6.60 a |
| F | 8.40 b |
| G | 6.40 a |

**Table B.7** Two way ANOVA (no blocking) for overall acceptability

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Panelist | 4 | 2.1143 | 0.5286 | 2.31 | 0.087 |
| samples | 6 | 17.0857 | 2.8476 | 12.46 | <.001 |
| Residual | 24 | 5.4857 | 0.2286 | | |
| Total | 34 | 24.6857 | | | |

**Table B.8** Tukey's protected least significant difference test for overall acceptability

| Sample | Mean |
|---|---|
| A | 7.20 b |
| B | 6.20 a |
| C | 6.00 a |
| D | 6.80 ab |
| E | 6.40 ab |
| F | 8.20 c |
| G | 6.40 ab |

**Table B.9** One way ANOVA (no blocking) for iron

| Source of variation | d.f. | s.s. | m.s. | v.r. | F pr. |
|---|---|---|---|---|---|
| Sample | 1 | $5.48 \times 10^{-4}$ | $5.48 \times 10^{-4}$ | 107.37 | <.001 |
| Residual | 8 | $4.08 \times 10^{-5}$ | $5.10 \times 10^{-6}$ | | |
| Total | 9 | $5.88 \times 10^{-4}$ | | | |

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

**Table B.10** LSD for iron content

| Sample code | Mean score | LSD at 0.05 | Mean difference | Remarks |
|---|---|---|---|---|
| A (Buckwheat flour) | 0.032 | 0.003294 | A-B = 0.015 | >LSD* |
| B (Whole wheat flour) | 0.017 | | | |

(* = Significantly different)

## Appendix D

## List of instruments used:

(i) Electric balance

(ii) Grinding arrangement

(iii) Hot plate

(iv) Bunsen burner

(v) Thermometer

(vi) Soxhlet apparatus

(vii) Muffle furnace

(viii) Hot air oven

(ix) Desiccator

(x) Glasswares (Beaker, Volumetric flask, Conical flask, Pipette, Burette, Petri dish, Porcelain basin, Crucible)

(xi) Kjeldahl digestion and distillation set

(xii) Utensils (Karahi, Aari, Jhir, Nanglo)

## Photo gallery

**P. 1** Sensory evaluation

**P. 2** Crude fiber determination

**P. 3** Frying of *Thekua*

**P. 4** Absorbance determination