PREPARATION AND QUALITY EVALUATION OF CHICKPEA FLOUR INCORPORATED MUFFIN AND ITS STORAGE STABILITY

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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

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Approval Letter

This *dissertation* entitled *Preparation and Quality Evaluation of Chickpea Flour Incorporated Muffin and its Storage Stability* presented *by* Archana Shrestha has been accepted as a partial fulfillment of the requirement for the B. Tech. degree in Food Technology.

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Abstract

The main aim of this study was to prepare chickpea flour incorporated muffin and to evaluate sensory properties, physicochemical properties and shelf life. Chickpea flour was incorporated with wheat flour as 0CF:100WF, 25CF:75WF, 33CF:67WF, 50CF:50WF, 67CF:33WF, 75CF:25WF and 100CF:0WF to prepare seven 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, aroma and overall acceptance. The formulation with 67CF:33WF was selected as the best product. Proximate analysis of chickpea flour, wheat flour, control and best product were done. Saponin content of chickpea flour and best product was calculated. 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 acid value, peroxide value, coliform and TPC of the product were evaluated.

The moisture, protein, fat, crude fiber, total ash, carbohydrate were found to be 24.30%, 27.37%, 26.29%, 2.85%, 2.66% and 40.83% respectively for best product. Saponin content was found to be 3906.67 mg/100g for chickpea flour and 906.67 mg/100g for best product. Acid value and peroxide value were found to be 1.12 mg KOH/g and 0.75 meq/kg respectively at day 0 which was later found to be increasing with the number of days of storage. TPC of best muffin was found to be 1.22 x 10^3 cfu/g at day 0 which increased faster in room temperature than in refrigerated temperature with the number of days of storage. There were no colonies of coliform detected throughout the storage. The storage stability of the best product was estimated to be 6 days under room temperature and 12 days under refrigerated temperature.

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List of Abbreviations

Abbreviations	Full form
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
AV	Acid Value
CD	Celiac Disease
CF	Chickpea Flour
CHD	Coronary Heart Disease
CVD	Cardiovascular Disease
FAO	Food and Agricultural Organization
LDL	Low Density Lipoprotein
PV	Peroxide Value
SD	Standard Deviation
TPC	Total Plate Count
WF	Wheat Flour
CFIM	Chickpea Flour Incorporated Muffin

Part I

Introduction

1.1 General Introduction

Muffin is one of the popular bakery product which is any quick bread without yeast, having the shape of a cup cake (cupcakes have frosting on top, while muffins have no frosting, but muffins can have glaze on top) (Garwadhiremath, 2011). Traditionally, a muffin batter recipe is mainly composed of wheat flour, sucrose, vegetable oil, egg and milk. For this reason, people with celiac disease are unable to consume this type of product. However, there has been extensive research for the development of gluten-free bakery products (Alvarez *et al.*, 2016).

Muffin formulations consist of a complex mix of interacting ingredients, essentially sugar and varying proportions of fat, flour, eggs, and baking powder, which create the typical high-volume, porous structure. Consumers need a muffin that is soft, fluffy, tender to the crumb, and has some resistance to falling apart. Stable dough placement with lots of small air bubbles and a muffin with the right textural properties like hardness, cohesion and chewiness is required (Öztürk and Mutlu, 2018). A high quality muffin is described by Halliday and Noble (1946) as follows: To be good, muffins should be very light, so light in fact that when one picks them up, one is surprised that anything of their size should weigh so little. The outside should be baked to a golden-brown shade; should be symmetrical in shape, with no tendency to form peaks or knobs at the top; and should have a somewhat pebbled, rather than a smooth and even surface. The inside should show round holes of fairly uniform size but should have none of the long, narrow ones sometimes called “tunnels” (Lamsal, 2018).

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. Two seed types are recognized: the large-seeded kabuli type, characterized by its beige-colored seed coat and ram's head shape, the desi type, with its smaller size and dark-colored irregularly shaped seeds. Kabuli varieties are preferred for consumption as whole seeds, whereas desi types are typically processed into flour (Allen, 2005). Chickpea may be considered as one of the functional foods needed to combat obesity prevalence in populations. Phytochemicals such as saponins and isoflavones are main secondary metabolites from chickpea, in which saponins been showed cause an increase in the fecal excretion of bile acids and isoflavones are critical for mediating the effects on β-cell proliferation, especially its structure has a hydroxyl group at C_5 position. Chickpea protein hydrolysates may be potential free radical scavenger which could be useful for improving immunity food products (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).

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 is related to its relatively low cost, relatively high protein content (18–26.8%), high protein digestibility (76–78%) and other desirable functionalities (Alvarez *et al.*, 2016). There is a good number of people dealing with celiac disease (CD), which is a gluten sensitive inflammatory disorder of the small intestine, also known as gluten intolerance. CD results due to an intolerance to gliadin and glutenin proteins. The only effective treatment for celiac disease is a life-long gluten-free diet. But gluten-free breads and cookies are principally based on flour from rice or maize with low content and poor-quality proteins (Lamsal, 2018). Chickpeas 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, chickpeas are a great source of plant-based protein, making them an appropriate food choice for those who do not eat animal products.

Normally, muffins are based on wheat flour alone. Hence, through this dissertation work incorporation of chickpea flour in muffin is attempted to prepare where nutritional benefits of chickpea is more conveniently interlinked with the delightful taste of the muffins.

1.3 Objectives

1.3.1 General objectives

The general objective of this study is the preparation and quality evaluation of chickpea flour incorporated muffin and its storage stability.

1.3.2 Specific objectives

1. To study the physiochemical properties of raw materials i.e. wheat and chickpea flour.
2. To prepare muffins using chickpea flour and wheat flour at different proportion and selection of best formulation through sensory evaluation.
3. To study anti-nutritional factor (saponin content) in chickpea flour and best product.
4. To analyze physicochemical and sensory properties of best product.
5. To estimate storage stability of the best product.

1.4 Significance of the study

This study can be beneficial in the possible utilization of chickpea in production of gluten free baked goods targeting celiac disease sufferers. Chickpeas are a great source of plant-based protein, making them an appropriate food choice for those who do not eat animal products and cannot afford meat. Chickpeas are high in vitamins, minerals, fiber and may be considered as one of the functional foods needed to combat obesity prevalence in population. In the current context of world, people are being health conscious so production of this muffin at commercial level might support the economy of the nation. Hence, this work might provide enthusiastic market for chickpea which would also help the economy of people involved in its cultivation, production and marketing, ultimately uplifting their living standards.

1.5 Limitations of the study

Following were the limitations of the present study:

1. Instrumental textural analysis was not carried out.
2. Alcohol acidity during storage period was not analyzed.

Part II

Literature review

2.1 Chickpea

Chickpea (*Cicer arietinum L.)* is the second most important pulse crop in the world, grown in at least 33 countries in South Asia, West Asia, North Africa, East Africa, Southern Europe, North and South America, and Australia. It covers 15% (10.2 million hectares) of the area and accounts for 14% (7.9 million ton) (FAO, 1994) of the production of pulses in the world. In the cereal dominated diets of South-, West- and East-Asia and North Africa, chickpea provides high-quality protein, particularly for vegetarians and those who cannot afford meat. It is also used as feed for livestock and has a significant role in farming systems as a substitute for fallow in cereal rotations (Singh, 1997). Chickpea has been a traditional low-input crop in the farming systems of the Indian subcontinent and the Near-East where it is an integral part of the daily diet of the people. The crop is also popular in the Ethiopian Highlands and in Central and South America. Because of its adaptability to a wide range of environments, it is being promoted even in countries such as Australia, Canada and the USA (Saxena and Singh, 1987).

Chickpea is an important source of protein for millions of people in the developing countries, particularly in South Asia, who are largely vegetarian either by choice or because of economic reasons. In addition to having high protein content (20-22%), chickpea is rich in fiber, minerals (phosphorus, calcium, magnesium, iron and zinc) and β-carotene. Its lipid fraction is high in unsaturated fatty acids (Gaur *et al.*, 2010).

2.1.1 Taxonomic description of chickpea plant

Chickpea is the only domesticated species under the genus *Cicer*, which was originally classified in the tribe *vicieae* of the family Leguminosae and sub family, papilionoideae. Based on the pollen morphology and vascular anatomy, *Cicer* is now set aside from the members of *Vicieae* and is classified in its own monogeneric tribe, *Cicereae Alef*. The genus *Cicer* comprises 43 species and is divided into two subgenera. The subgenus, *Pseudononis* is characterized by small flowers (normally 5-10 mm), sub regular calyx, with hardly gibbous base, with sub linear nearly equal teeth. The subgenus, *Viciastrum* (perennials) is characterized by medium large flowers, calyx strongly gibbous at the base, with unequal teeth (Reddy).

2.1.2 Taxonomic classification of chickpea

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Fabales

Family: Fabaceae (Leguminosae)

Subfamily: Faboideae(Papilionaceae)

Genus: *Cicer*

Species: *arietinum*

(Anonymous)

2.1.3 General Botany

The seedling of chickpea is hypogeal. The growth of the plumule produces an erect shoot. The first true leaf has two or three pairs of leaflets plus a terminal one. The primary root is long and produces lateral roots. Leaves are born singly at each node arranged in alternate phyllotaxy and are generally unipinnate compound. There are usually 11 to 13 leaflets in each leaf which are arranged on a rachis with a small petiole. Stipules are generally 3-5 nun long and 2-4 mm wide. All external surfaces of the plant, with the exception of corolla, are covered by glandular and aglandular hairs. The plant has a deep tap root with a few lateral roots. In deep vertisols, roots have penetrated deeper than 120 cm. In general, plants attain a height of 20 to 100 cm, although tall cultivars under favorable conditions can grow up to 130 cm.

Flowers are typically papilionaceous. The corolla is generally purple in the desi type and white in the kabuli type, and is rarely blue. Plants in the genus Cicer have only one carpel per flower. The chickpea has inflated pods, the number of which varies from a very few to over 1000 pods per plant. The seed is characteristically beaked, often angular and wrinkled. It is rarely round like pea. Three shapes are recognized: angular (beaked or rams-head shaped), owl (owl's-head shaped) and pea (near round shape). The seed surface may be wrinkled, smooth or tuberculated. Seed colour is an important distinguishing character in chickpea; with different colors and shades recognized (Singh, 1997).

2.1.4 Types of chickpea

Two distinct types of chickpea are recognized.

1. Desi chickpea: Chickpeas with thick, colored seeds are called Desi type. Common seed colors include various shades and combinations of brown, yellow, green, and black. The seeds are generally small and angular with a rough surface. The flowers are usually pink and the plants show varying degrees of anthocyanin pigmentation, although some Desi species have white flowers and no anthocyanin pigmentation on the stem. The Desi species constitutes 80-85% of the chickpea area. The splits (dal) and the flour (besan) are all made of Desi types.

2. Kabuli chickpea: Kabuli-type chickpeas are characterized by white or beige seeds shaped like a ram's head, a thin seed coat, a smooth seed surface, white flowers, and a lack of anthocyanin pigmentation on the stem. Compared to Desi types, Kabuli types have higher sucrose content and lower fiber content. Kabuli types mostly have large seeds and receive a higher market price than Desi types. The markup for Kabuli species generally increases with increasing seed size.

Source: Gaur *et al.* (2010)

2.1.5 Chemical composition of chickpea

The biochemical composition of chickpea seed (g/100 g dry weight basis) is shown in Table 2.1.

Table 2.1 Biochemical composition of chickpea seed (Value ±SD)

Constituents	Value (%)
Moisture	7.01±0.4
Crude protein	19.5± 0.7
Crude fat	6.0±0.9
Crude fiber	2.88± 0.8
Total ash	2.64 ±0.2
Carbohydrate	62.0±1.4

Source: Patane (2006)

Chickpea seed has 40–60% carbohydrate, 1–5% crude fiber, 5–8% crude fat and 2–4% ash. Protein content in chickpea ranges from 19 to 24%, similar to the protein content of meat and contrasting with the 7–13% of cereals. In recent years there has been increasing utilization of chickpea grain in composite flours for various formulations, driven by the interest toward the functional properties of its proteins. The carbohydrate content decreases as the proportion of chickpea flour is increased in cereal based products (Khouryieh *et al.*, 2005). Legumes, in general, and chickpea, in particular, enhance the protein content and may improve the nutritional status of cereal-based diets (Patane, 2006).

2.1.6 Health benefits of chickpea

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 fibre. 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 (Jukanti *et al.*, 2012).

In general, increased consumption of soluble fibre from foods results in reduced serum total cholesterol and LDL-cholesterol (LDL-C) and has an inverse correlation with CHD mortality. Chickpea seeds are a relatively cheap source of DF and bioactive compounds coupled with its low glycemic index (GI) which may be useful for lowering the risk of CVD. A fibre-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 fibre 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 β-carotene, 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 (Jukanti *et al.*, 2012).

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).

2.2 Wheat flour

Wheat is botanically named as *Triticum vulgare*. Wheat flour for muffin making is obtained from the endosperm in the form of particle size enough to pass through a flour sieve usually 100 mesh per linear inch (Lamsal, 2018). Wheat flour is unique among all the cereal flours in that it forms an elastic mass when mixed with correct proportion of water. This unique property is due to the presence of insoluble proteins, collectively called gluten. The gluten forming proteins (glutenin and gliadin) constitute about 75-80% of the total flour proteins (Mukhopadhyay, 1990).

Wheat flour used for making muffin should be the product obtained by milling cleaned hard or soft wheat or a combination of both types. Flour strength is usually defined by the percentage of protein present in the flour. Weak flour is casually accepted as the flour with low percentage of protein. Usually this protein is inferred to be gluten, which when the flour is made into a dough with water, will become very extensible under stress, yet when the stress is removed it will not fully return to its original dimensions. Further, the amount of stress required to facture the dough piece is less than that required under identical conditions when strong flour is used (Smith, 1972). The flour should be free flowing, dry to touch, should be creamy in color and free from any visible bran particles. It should also have a characteristic taste and should be free from musty flavor and rancid taste (Cauvain and Young, 2006).

Sarwar (2010) reported respective proximate values of moisture content, crude protein, crude fat, crude fiber, total ash and carbohydrate were 13, 11.3, 0.90, 0.30, 0.60, 8.9 and 73.9% respectively and Khanal (1997) found that of 13.6, 10.32, 1.02, 0.56, 0.83, 9.2 and 73.67% respectively.

Bulk density of flour gives the indication of the relative volume and type of packaging material required (Udensi and Okoronkwo, 2006). Oil absorption capacity is of high importance as fat is a flavor retainer and increase the mouth feel of foods (Aremo *et al.*, 2007). Adeleke and Odedeji (2010) observed that oil absorption and water absorption of wheat flour was 2.15 g/g and 2.45 g/g respectively.

2.3 Muffins

Muffins are a kind of quick bread that is baked in suitable portions. They are similar to cupcakes, but they are usually less sweet and without frosting. There are also savory varieties like cornbread muffins or cheese muffins. The term also refers to the disc shaped muffin bread known as English muffin outside the UK. There are many varieties such as low fat and muffin flavored with specific ingredients such as blueberry, chocolate chip, raspberry, cinnamon, pumpkin, date, walnut, orange, peach, strawberry, almond and carrot. Muffins are also eaten for breakfast, alternatively they can be served with tea or other meals (Limbachiya and Amin, 2015).

Muffin formulations consist of a complex mix of interacting ingredients, essentially sugar and varying proportions of fat, flour, eggs, and baking powder, which create the typical high-volume, porous structure. Consumers need a muffin that is soft, fluffy, tender to the crumb, and has some resistance to falling apart. Stable dough placement with lots of small air bubbles and a muffin with the right textural properties like hardness, cohesion and chewiness is required (Öztürk and Mutlu, 2018).

2.3.1 The creaming method of mixing

In the creaming method, the fat (butter or shortening) is first creamed with the sugar until light and fluffy. Eggs are beaten separately until leathery consistency. All other ingredients (flour, leavening agent and water or milk) are thoroughly mixed. Later, the beaten eggs and butter creamed with sugar will be combined to it to obtain mixed muffin batter. The batter is then placed into prepared pan or muffin cups to bake in a preheated oven (Pradhananga, 2021).

2.3.2 Preparation of muffin

First butter and sugar were whipped for creaming. Eggs were beaten separately until leathery consistency. In a different bowl, flour and baking powder were mixed together, water was added slowly and thoroughly mixed. Later, the beaten eggs and butter creamed with sugar were combined to it to obtain mixed muffin batter. The flowchart for the preparation of muffin is shown in Fig. 2.1.

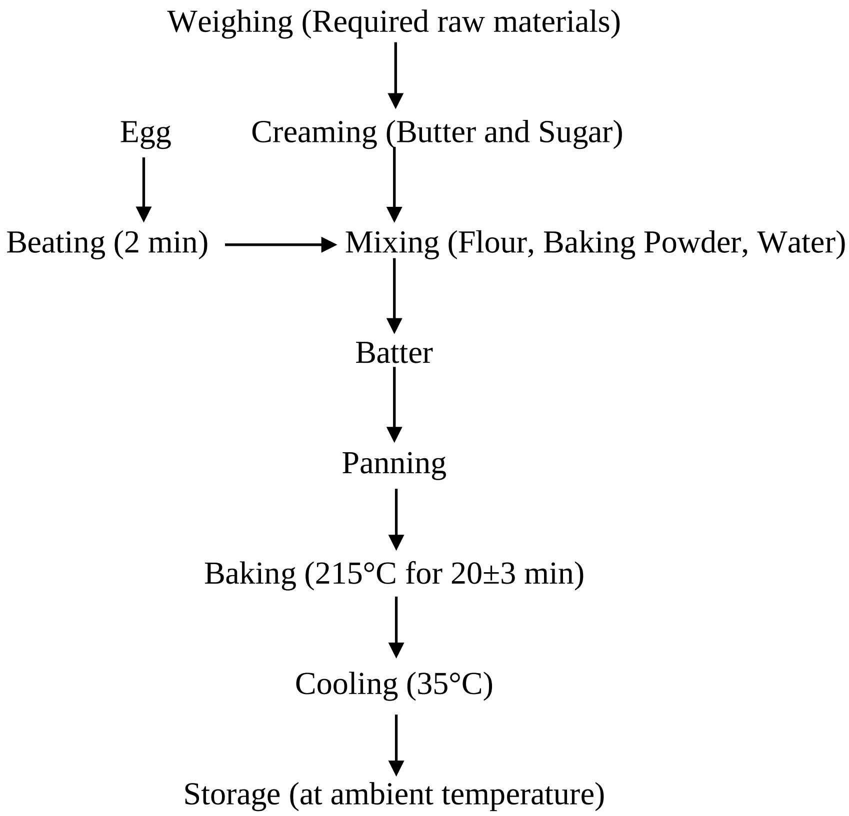

Fig. 2.1 Flow chart for the preparation of muffin

Source: Pradhananga (2021)

2.3.3 Objective of mixing

The primary objective in mixing is to achieve a homogenous mixture; generally, this means, attaining a nearly uniform distribution of the ingredient. A distinction may be drawn between batch and continuous process. Overall, the concentration of the ingredient should uniformly distributed in the output stream, should not vary with time and the processing of each part of the mixture should be same (Lamsal, 2018).

2.3.4 Chemical composition of muffin

Chemical composition of muffin is shown in Table 2.2.

Table 2.2 Chemical Composition of muffin

Constituents	Values
Moisture, %	20.33
Protein, %	14.37
Fat, %	17.60
Carbohydrate, %	44.28
Total dietary fiber, %	2.22
Ash, %	1.21

Source: Rahman *et al.* (2015)

2.4 Ingredients and their role in muffin making

2.4.1 Flour

Wheat is botanically named as *Triticum vulgare.* Wheat flour for muffin making is obtained from the endosperm in the form of particle size enough to pass through a flour sieve usually 100 mesh per linear inch (Kent and Amos, 1983). Wheat flour is unique among all the cereal flours in that it forms an elastic mass when mixed with correct proportion of water. This unique property is due to the presence of insoluble proteins, 19 collectively called gluten. The gluten forming proteins (glutenin and gliadin) constitute about 75-80% of the total flour proteins (Mukhopadhyay, 1990).

This provides most of the bulk of the baked item. For bread baking the flour should be a wheat flour which is high in gluten content (protein) as this is the substance that gives bread its fine texture and supports the ingredients during rising (Khanal, 1997).

2.4.2 Fat or shortening

Fat is one of the main ingredient in muffin making. Fat gives a softer texture and helps prevent the CO_2 bubbles from escaping from the mixture too soon. The greatest attribute a shortening can possess is that it should have a plastic nature over a wide range of temperatures as it is likely to be encountered in its use for cake making (Smith, 1972). The main action of the fat or shortening during mixing is to avoid the gluten forming proteins to come in contact with water by insulating the gluten forming protein molecules due to its hydrophobic nature. Hence, less tough dough with desired amount of gluten formation can be obtained. Thus shortened baked products possess less hard, crispier nature and can easily melt in mouth (Mukhopadhyay, 1990).

2.4.3 Sweetening agent

Sugar is another major ingredient in muffin making. Sugar generally used in muffin making is obtained from sugarcane and sugar beet. The sugarcane consists of 16-22% of sucrose while sugar beet consists of 8-9% of sucrose. During muffin making various forms of sugar namely crystalline, pulverized, liquid, brown or soft sugar are used as per product requirement. Generally most commonly used form of sugar in muffin making is pulverized sugar. The reason behind this may be due to its readily soluble characteristic which causes the palate to be deceived in sweetness. The crystalline size also has effect on sweetness, shortness and better spread capacity of muffin (Lamsal, 2018).

2.4.4 Leavening agent

Chemical leavening involves the action of an acid on bicarbonate to release CO_2 for aeration of a dough or batter during mixing and baking. The aeration provides a light, porous cell structure, fine grain, and a texture with desirable appearance along with palatability to baked goods. There are essentially two components in a chemical leavening system: bicarbonate that supplies carbon dioxide gas, and an acid that triggers the liberation of CO_2 from bicarbonate upon contact with moisture. Sodium bicarbonate (baking soda) is the primary source of CO_2 in practically all chemical leavening systems. This compound is stable and is obtainable as a highly purified dry powder at relatively low cost. Modern baking powder consists of a mixture of baking soda, one or more acid components, and an inert ingredient that serves to keep the reactive components physically separated and thus minimizes premature reaction in dry mixtures (Brodie and Godber, 2007).

2.4.5 Whole egg

Beaten egg white, like fat, helps to retain gas bubbles, while egg alone acts as a binder (Bhaduri, 2013).

2.4.6 Water

Water is one of the most important ingredients during muffin 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 baked product (Smith, 1972).

The water used in the baking 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 Baking profile

Baking is the major step of muffin production without which the product loses its eating quality. During baking, the product is cooked, flavor and color is developed and the raw dough is converted into an edible snack named muffin. The main objective of baking is to remove the excess moisture present in the dough by gradual heating (Bloksma, 1990).

Every baking process depends upon the heat transfer from a hot source to the product being baked. Method of heat transfer during baking is mainly by three methods namely, conduction, convection and radiation. During baking a major part of heat transfer to the dough pieces is by radiation while the heat transfer by convection is very low as long as the air velocity in the tunnel is not higher than 5 feet per second, after which the heat transfer by convection tends to be higher. Apart from these three modes of heat transfer, high frequency heating is also used which has a higher rate of moisture removal (Smith, 1972).

Every oven used till date consists of four basic parts.

1. A heat source
2. A base (sole or hearth), capable of being heated, on which the dough piece is placed.
3. A cover over the base, making up a chamber in which to retain the heat.
4. A closable opening through which the dough piece can be put into and taken from the baking chamber.

During baking the dough undergoes gradual changes physically and chemically.

Physical changes include:

- Formation of a film crust on the dough.
- Melting of the fat in the dough.
- Gas release and volume expansion.
- Conversion of water into steam.
- Escape of carbon dioxide, other gases and steam.

Chemical changes include:

- Gas formation
- Starch gelatinization
- Protein changes
- Caramelization of sugar
- Dextrinization

Temperature in the baking oven has different effect on the raw dough, which is shown in Table 2.3.

Table 2.3 Temperature related changes in muffin during baking

Temperature (˚F)	Changes occurred
90-100	Top crust skin formation (Evaporation of surface moisture)
90-120	Evolution of CO_2 within crumb (Less solubility of CO_2)
90-150	Increase in volume due to CO_2
90-210	Gas expansion (CO_2 and steam)
125-210	Starch gelatinization (Muffin structure)
170-250	Coagulation of protein (Irreversible)
370-400	Dextrinization (surface gloss)

Source: Mukhopadhyay (1990)

During baking it is necessary to have more steam in the oven than that derived from the moisture from the dough and the combustion of the fuel. Introducing steam into the baking chamber, either immediately at the entry of the dough pieces or at a point very early in their passage through the oven, helps to create a shiny crust formation, prevention of cracked crusts, increased volume and to some degree agitation of the oven atmosphere. The need of steam injection can be removed by using fast moving fans recirculating air at speeds of 2000 cu ft. per min. The dampers present at the ovens play a vital role in releasing the high positive pressure within the oven created due to high heat evaporation, similarly if high moisture cookies or biscuits are desired than the dampers at the last zone must be closed (Smith, 1972).

2.6 Sensory parameter of muffin

Sensory evaluation is a scientific discipline used to evoke, measure, analyze, and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch and hearing. Sensory evaluation is a technique where food scientists use the human body and its perception of the five basic senses as a tool to measure differences and intensities of food characteristics (Gao, 2018). Sensory testing was performed to determine consumer likeability of the muffin formulations. Muffins from each formulation were quartered and placed into individual serving containers. Panelists were given one sample from each formulation at a given sitting, and were directed to rate each sample on a 9- point hedonic scale, ranging from 1 (dislike extremely) to 9 (like extremely) for appearance, aroma, taste, texture and overall acceptability. A balanced order of presentation was used and panelists were given distilled water in between the analysis (Acosta *et al.*, 2011).

Muffin with the increment in level of chickpea flour becomes darker as increased protein content accelerates Maillard reactions by providing amino acids to react with sugars to produce dark brown substances (Shevkani and Singh, 2014). Chickpea flour helps to incorporate air into the batter, which is essential for achieving appropriate final volume and spongy texture (Alvarez *et al.*, 2016). The likeness of muffin increases up to certain level of incorporation of chickpea flour. Further increment in chickpea flour resulted in chickpea-like taste, despite which it was not a driver of disliking for the panelists (Herranz *et al.*, 2016).

2.7 Saponin

Saponins are widely distributed secondary metabolites in the plant kingdom. They act as a chemical barrier or shielding compounds against pathogens and herbivores in the plant defense system. The name of these compounds derives from the ability to form stable, soap-like foams in aqueous solutions (Barakat *et al.*, 2015). Food legumes are known to contain substantial amount of saponins. Chickpea and black gram are two important pulses consumed by a large stratum of the Indian population. Legume grains are processed and consumed in a variety of forms. The application of heat treatment was observed to lower the saponin content in chickpea (Jood *et al.*, 1986).

2.8 Storage stability

2.8.1 Oxidative rancidity

While many bakery products contain high levels of fats, including dairy products, relatively few problems occur with oxidative rancidity. One reason being that the microbial shelf life of bakery products (exception is low ERH products such as biscuits) is too short for the effects of oxidative rancidity to become apparent (Cauvain and Young, 2011).

Acid value should not exceed 6 mg KOH/g according to Nepal mandatory standard (Upadhyay *et al.*, 2021). The acid value increases more rapidly in room temperature than in refrigerated temperature. Increase in AV is due to the hydrolysis of the oil to free fatty acids which will lead to further formation of aldehydes and ketones (Noorolahi *et al.*, 2013). Peroxide value exceeding 10 meq/kg is considered rancid (Pearson, 1976). The peroxide value increases significantly with the increase in storage time that may be due to a high decomposition of peroxide as a result of the oxidation of polyunsaturated fatty acid present in muffin over storage period (Shrestha, 2018).

2.8.2 Microbial shelf life

The concept of water activity was first used by Scott (1957) to show that a_w rather than moisture content determined the microbial safety of food. Hence knowledge of a product's a_w or ERH is useful in identifying and understanding potential microbial issues. When all baked products are out of the oven, their surfaces are sterile and so it is microbial contamination of the surface during cooling that leads to product spoilage. This also applies for bakery products that are sliced like cakes and bread, since the exposed surfaces tend to have higher ERHs than the product crust (Cauvain and Young, 2011).

Total Plate Count (TPC) of muffin should not exceed the maximum limit (2.0×10^5 cfu/g) for baked products according to (WHO, 1994) (Saddozai and Samina, 2009). This increase in TPC may be due to the availability of favorable environment for the growth of microorganisms i.e. PH between 2-9, moisture, water activity 0.85, elevated temperature 10-35 °C and so on (Shrestha, 2018).

Part III

Materials and methods

3.1 Materials

3.1.1 Raw materials

Kabuli type chickpea, wheat flour, sugar, eggs, muffin liner and butter named 'Safal butter' manufactured by Sujal Dairy Pvt. Ltd., Pokhara were bought from the local market of Dharan. Baking powder named as 'Foodchem' manufactured and packed by Foodchem Nepal Pvt. Ltd., Birgunj was used which was made available in the laboratory of Central Campus of Technology. Potable water available at Central Campus of Technology was used.

3.1.2 Equipment and chemicals

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

3.2 Method of experiment

3.2.1 Methodology

Design expert v7.1.5 was used to create the recipe. Mixture D-optimal was used to formulate the recipe. The independent variable for the experiment is concentration of chickpea flour used to prepare muffin.

3.2.2 Formulation of recipe

The recipe formulation for the chickpea flour incorporated muffin was carried out as per design expert v7.1.5 which is given in Table 3.1. The amount given is on parts basis.

Table 3.1 Recipe formulation for muffin (on parts basis)

Ingredients	A	B	C	D	E	F	G
Wheat flour	0	25	33	50	67	75	100
Chickpea flour	100	75	67	50	33	25	0
Sugar	60	60	60	60	60	60	60
Fat	65	65	65	65	65	65	65
Baking powder	1.42	1.42	1.42	1.42	1.42	1.42	1.42
Egg	57	57	57	57	57	57	57
Water	31	31	31	31	31	31	31

Source: Lamsal (2018)

The muffin was made as per the recipe formulation and coded named A, B, C, D, E, F and G were given to each recipe.

3.3 Preparation of chickpea flour

Chickpeas were first grinded with the help of mortar and pestle. They were further grinded in mixture grinder and pulverized to a fineness that 90% of the powder passed through 400 µ sieve. The flour obtained were sealed in a plastic container and stored at ambient condition for further processing.

3.4 Preparation of chickpea flour incorporated muffin

In this study, different formulations of muffin were prepared. One formulation was prepared without chickpea flour (control) and others were formulated with chickpea flour at different levels. First butter and sugar were whipped for creaming. Eggs were beaten separately until leathery consistency. In a different bowl, wheat flour, chickpea flour, baking powder and water were thoroughly mixed. Later, the beaten eggs and butter creamed with sugar were combined to it to obtain mixed muffin batter. The flowchart for the preparation of chickpea flour incorporated muffin is shown in Fig. 3.1.

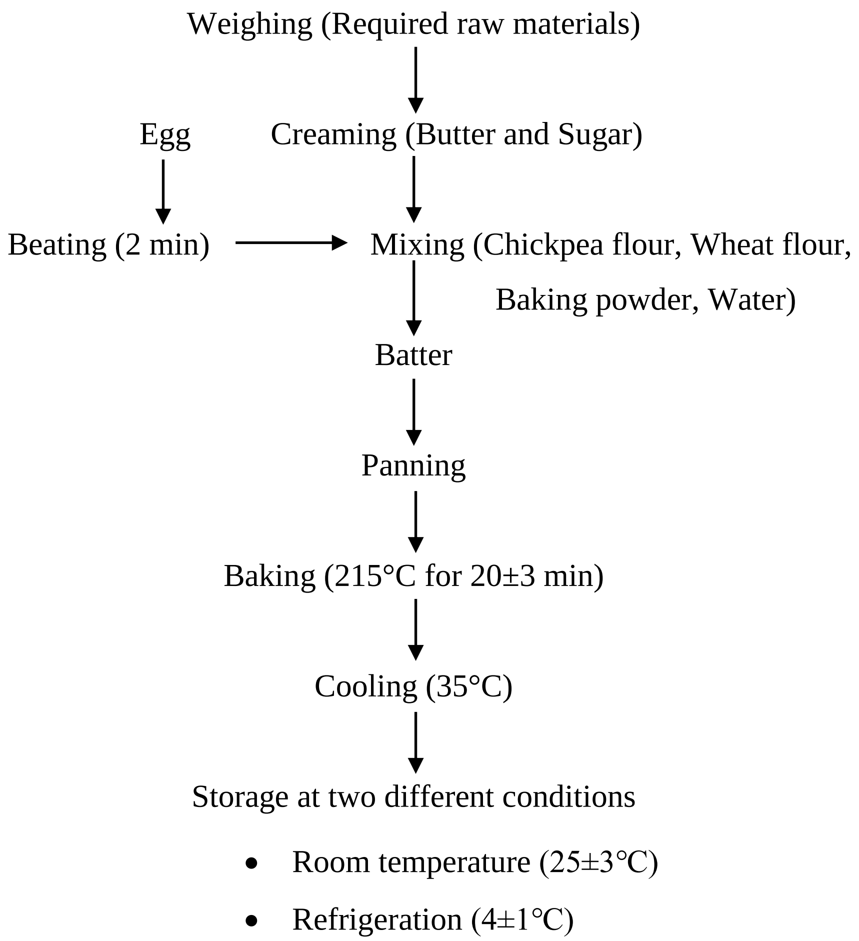

Fig. 3.1 Flow chart for the preparation of chickpea flour incorporated muffin

Source: Pradhananga (2021)

The batter were filled in paper muffin cup. The muffins were baked at 215ºC in oven for 20±3 min (Khoueyieh *et al.*, 2005).

3.5 Analysis of raw materials and product

3.5.1 Physical properties of flour

3.5.1.1 Bulk density

Bulk density of chickpea flour and wheat flour were determined using Onwuka (2005) method.

3.5.1.2 Foaming capacity

Foaming capacity of chickpea flour and wheat flour were determined using a method as described by Narayana and Narasinga Rao (1982).

3.5.1.3 Water and oil absorption capacity

Water and oil absorption capacities were determined according to the method described by Okezie and Bello (1988).

3.5.1.4 Emulsion capacity

Emulsion capacity was determined using the procedure of Abbey and Ibeh (1988) with slight modification.

3.5.2 Physicochemical analysis of flour

3.5.2.1 Moisture content

Moisture content of the sample was determined by heating in an oven at 100 ± 5°C to get constant weight (Rai, 2007).

3.5.2.2 Crude fat

Crude fat content of the samples was determined by solvent extraction method using Soxhlet apparatus and solvent petroleum ether as per Rai (2007).

3.5.2.3 Crude protein

Crude protein content of the samples was determined indirectly by measuring total nitrogen content by micro Kjeldahl method. Factor 5.7 was used to convert the nitrogen content to crude protein as per AOAC (2005).

3.5.2.4 Crude fiber

Crude fiber content of the samples was determined by gravimetric method as given by Rai (2007).

3.5.2.5 Total ash

Total ash content of the samples was determined by following the method given by Rai (2007) using muffle furnace.

3.5.2.6 Carbohydrate

The carbohydrate content of the sample was determined by difference method as given by Pearson (1976).

Carbohydrate (%) = 100 - (protein + fat + ash + crude fiber)

3.5.2.7 Gluten

25g flour was weighed into a plastic bowl. 15 ml water was added and mixed to get a dough ball. The dough ball was immersed in water for one hour to ensure proper hydration. The starch was washed out by kneading gently in a gentle stream of water over a fine sieve. Washing was continued till the washed out liquid was clear. The washed water was squeezed into clean water. If water seemed turbid, washing was continued. The cohesive mass obtained was wet gluten which was pressed as dry as possible and placed in a petri dish containing a small piece of aluminum foil. The wet gluten so obtained was dried in a hot air oven at 100°C for 24 h. The gluten was weighed to constant weight and the dry gluten was calculated as given by AACC (2000).

$$\%\text{ dry gluten} = \frac{\text{wt. of dry gluten}}{\text{wt. of flour}} \text{ x } 100$$

3.5.3 Anti-nutritional factor of chickpea flour

3.5.3.1 Saponin content

The spectrophotometric method of Brunner (1984) was used for saponin analysis. 1 g of the finely ground sample was weighed into a 250 ml beaker and 100 ml of isobutyl alcohol was added. The mixture was shaken for 2 h to ensure uniform mixing. Thereafter the mixture was filtered through a Whatman No. 1 filter paper into a 100 ml beaker, 20 ml of 40% saturated solution of magnesium carbonate was added and the mixture made up to 250 ml in a 250 ml standard flask. The mixture obtained with saturated $MgCO_3$ was again filtered through a Whatman No. 1 filter paper to obtain a clear colourless solution. One milliliters of the colourless solution was pipette into a 50 ml volumetric flask and 2 ml of 5% $FeCl_3$

solution was added and made up to mark with distilled water. It was allowed to stand for 30 min for blood red colour to develop. 0–10 ppm standard saponin was prepared from saponin stock solution. The standard solutions were treated similarly with 2 ml of 5% $FeCl_3$. The absorbance of the sample, as well as standard saponin solution, was read after colour development on a spectrophotometer at a wavelength of 380 nm (Olawoye and Gbadamosi, 2017).

$$\text{Saponin} = \frac{\text{Absorbance of sample x dil. factor x gradient of standard graph}}{\text{sample weight x 100}} \ (\text{mg/g})$$

3.5.4 Physiochemical analysis of muffin

Moisture content, crude protein, crude fat, total ash, crude fiber and total carbohydrate of muffin were determined same as in the flour.

3.5.5 Color and surface analysis

Color and surface were determined by visual inspection method. The chickpea flour and wheat flour were spread on separate tray and color and surface were meticulously examined.

3.5.6 Anti nutritional factor in chickpea flour incorporated muffin

3.5.6.1 Saponin content

Saponin content was determined by the same method as described in flour.

3.5.7 Sensory analysis

The sensory analysis for overall quality was carried out by semi-trained panelists, which consisted of teachers and students of Central Campus of Technology. The parameters for sensory evaluation were texture, appearance, taste, aroma and overall acceptability. Sensory evaluation was performed according to the 9- Point Hedonic Scale as in appendix A.

3.5.8 Statistical analysis

The obtained data was analyzed statistically by Genstat for Analysis of Variance (ANOVA) at 1% level of significance. The data obtained from proximate analysis and sensory evaluations were subjected to one and two way Analysis of Variance. Design expert v7.1.5 was used to create the recipe. Mixture D-optimal was used to formulate the recipe.

3.5.9 Storage stability of muffin

Muffins were stored at normal room temperature (25±3°C) and refrigerated condition (4±1°C). The storage stability of muffins were studied by noting the change in acid value, peroxide value, coliform and total plate count (TPC) in every two days until acceptability period was determined.

3.5.9.1 Chemical analysis

3.5.9.1.1 Acid value

Acid value was determined by titrimetric method of the extracted fat from the sample as described in Rai (2007).

3.5.9.1.2 Peroxide value

Peroxide value was determined by titrimetric method of the extracted fat from the sample as described in Rai (2007).

3.5.9.2 Microbial analysis (TPC and coliform count)

Total Plate Count (TPC) was determined by pour plate technique on Plate Count Agar (PCA) medium (incubated at 30°C/48 h). Coliform count was determined by pour plate technique on MacConkey medium (incubated at 37°C/48 h) (AOAC, 2005).

Part IV

Results and discussion

This work was carried out for the preparation of standard quantity of muffin with different proportion of chickpea flour with wheat flour and to study its storage stability. Chickpea flour and wheat flour was blended into 7 different proportion given by design of expert.

4.1 Proximate composition of wheat flour and chickpea flour

The proximate composition of wheat flour and chickpea flour were determined. Determined results are presented in Table 4.1.

Table 4.1 Proximate composition (dry basis) of wheat flour and chickpea flour

Parameters (% db)	Wheat flour (%)	Chickpea flour (%)
Moisture	11.53±0.04	7.87±0.16
Crude protein	9.13±0.03	18.12±0.10
Gluten	7.88±0.04	-
Crude fat	1.05±0.10	5.90±0.09
Crude fiber	0.58±0.02	2.91±0.07
Total ash	0.56±0.03	2.77±0.06
Carbohydrate	88.68±0.15	70.3±0.10

*Values are the means of triplicates and figures in the parenthesis are standard deviation of the triplicates.

The moisture content, protein, fat, crude fiber, ash, gluten and carbohydrate of wheat flour were found to be 11.53%, 9.13%, 1.05%, 0.58%, 0.56%, 7.88% and 88.68% respectively. Similar results were observed by Sarwar (2010) and Khanal (1997). The moisture content, protein, fat, crude fiber, ash and carbohydrate of chickpea flour were found to be 7.87%, 18.12%, 5.90%, 2.91%, 2.77% and 70.3% respectively which was similar to the results observed by Patane (2006). Here, the level of available carbohydrates in wheat flour (88.68%) was higher than that of chickpea flour studied (70.30%). On the other hand, crude fiber content of chickpea flour (2.91%) was appreciably higher than that of wheat flour (0.58%). The total ash content of chickpea flour (2.77%) was also higher than that of wheat flour (0.56%). The gluten content of wheat flour was found to be 7.88% whereas chickpea flour was found to be naturally gluten free. On a comparative basis, level of crude protein in chickpea flour (18.12%) was significantly higher than that of wheat flour (9.13%). This shows that one of the major compositional differences between wheat flour and chickpea flour lies in their levels of proteins.

4.2 Functional properties

The functional properties of flour are as shown in Table 4.2.

Table 4.2 Functional properties of flour

Properties	100% WF (For control)	33% WF: 67% CF (For best product)
Water Absorption Capacity (g/g)	2.88±0.025	1.44±0.040
Oil Absorption Capacity (g/g)	2.76±0.020	1.28±0.077
Emulsion Capacity (g/g)	12.88±0.105	25±0.190
Foaming Capacity (%)	18.22±0.138	16.42±0.13
Bulk Density (g/cm^3)	0.73±0.015	0.71±0.005

WF means wheat flour, CF means chickpea flour

The bulk density of flour blends ranges from 0.61-0.942 g/cm^3. Sample from 100% WF had greater value (0.73 g/cm^3) than that of 33% WF: 67% CF (0.71 g/cm^3). Bulk density gives the indication of the relative volume and type of packaging material required (Udensi and Okoronkwo, 2006). Oil absorption capacity of 100% WF was also higher than that of 33% WF: 67% CF. Adeleke and Odedeji (2010) observed that oil absorption of wheat flour was 2.15 g/g. Oil absorption capacity is of high importance as fat is a flavor retainer and increase the mouth feel of foods (Aremo *et al.*, 2007). Water absorption capacity of 100% WF was also higher than that of 33% WF: 67% CF. Adeleke and Odedeji (2010) reported that the water absorption of wheat flour was 2.45 g/g. The value of wheat flour in this work existed between the reported values. The high values obtained in this work for flour mixtures suggest that the flours would be useful functional ingredients in bakery products.

4.3 Sensory properties of different treatments

The muffin prepared from using different proportions of wheat flour and chickpea flour was subjected to sensory evaluation. The muffin with different proportions were coded as A, B, C, D, E, F and G. The coded samples were provided to 11 semi trained panelists using 9-point hedonic rating scale (9= like extremely, 1= dislike extremely). They were asked to score the experimental muffin for appearance, aroma, taste, texture and overall acceptability as in the score sheet given in appendix A. Best muffin was selected statistically at 1% level of significance.

4.3.1 Appearance

The mean sensory score for appearance were found to be 6.75, 7.08, 7.83, 7.91, 8, 8 and 8 for the muffin formulation A, B, C, D, E, F and G respectively. Statistical analysis showed that partial substitution of wheat flour with chickpea flour had significant effect ($p<0.01$) on the appearance of the different muffin formulations. Sample A was significantly different to all other samples except sample B which is shown graphically in Fig. 4.1.

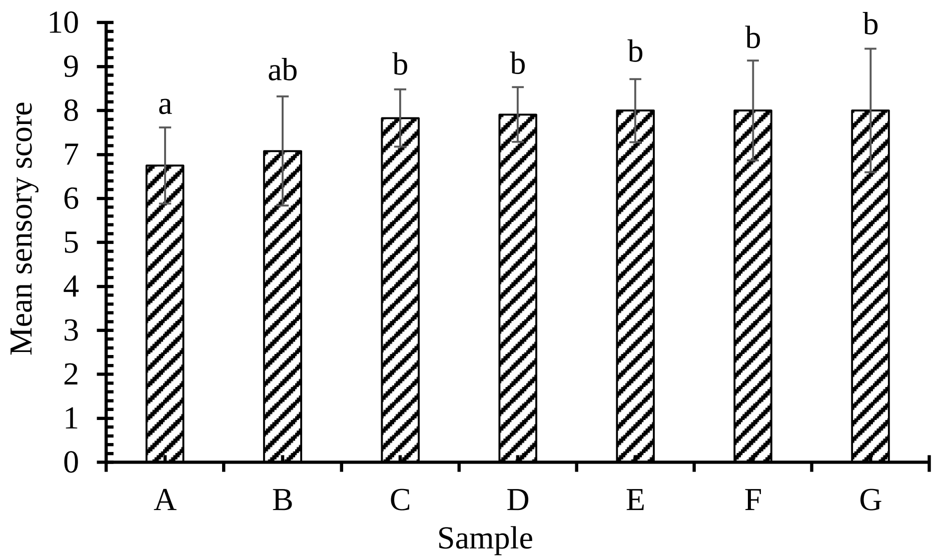

Fig. 4.1 Mean sensory scores for appearance of muffins of different formulations

Muffin with the increment in level of chickpea flour became darker than control as increased protein content accelerated Maillard reactions by providing amino acids to react with sugars to produce dark brown substances (Shevkani and Singh, 2014).

4.3.2 Aroma

The mean sensory score for aroma were found to be 7.08, 7.16, 7.08, 7.33, 6.91, 6.67 and 6.5 for the muffin formulation A, B, C, D, E, F and G respectively. Statistical analysis showed that the partial substitution of wheat flour with chickpea flour had no significant effect ($p<0.01$) on the aroma of the different muffin formulations. None of the sample were significantly different from each other which is shown graphically in Fig. 4.2.

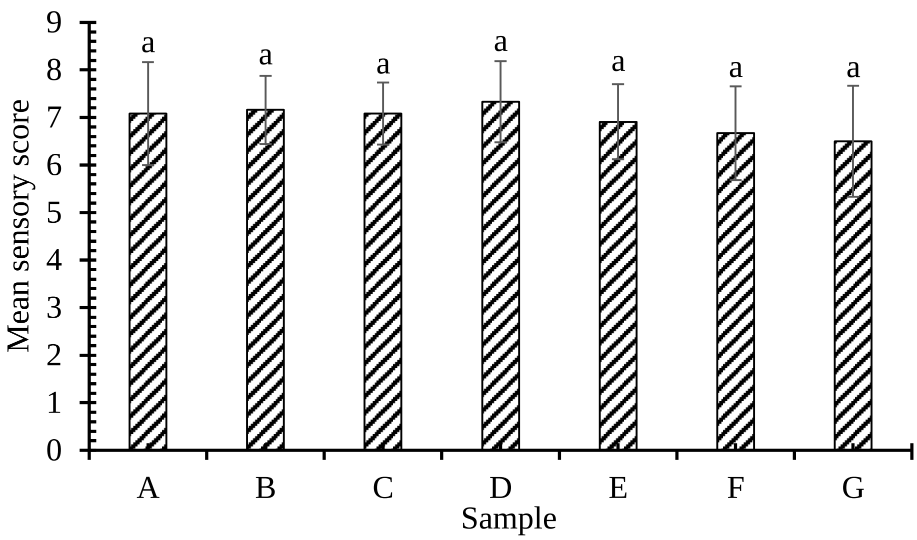

Fig. 4.2 Mean sensory scores for aroma of muffins of different formulations

4.3.3 Taste

The mean sensory score for taste were found to be 6.83, 7.58, 7.83, 7.58, 6.91, 6.67 and 6.67 for muffin formulation A, B, C, D, E, F and G respectively. Statistical analysis showed that the partial substitution of wheat flour with chickpea flour had no significant effect ($p<0.01$) on the taste of the different muffin formulations. None of the sample were significantly different from each other as sweetener, shortening agent and leaving agent used were same for all formulations and taste from these ingredient overcome the taste of chickpea and wheat flour which is shown graphically in Fig. 4.3.

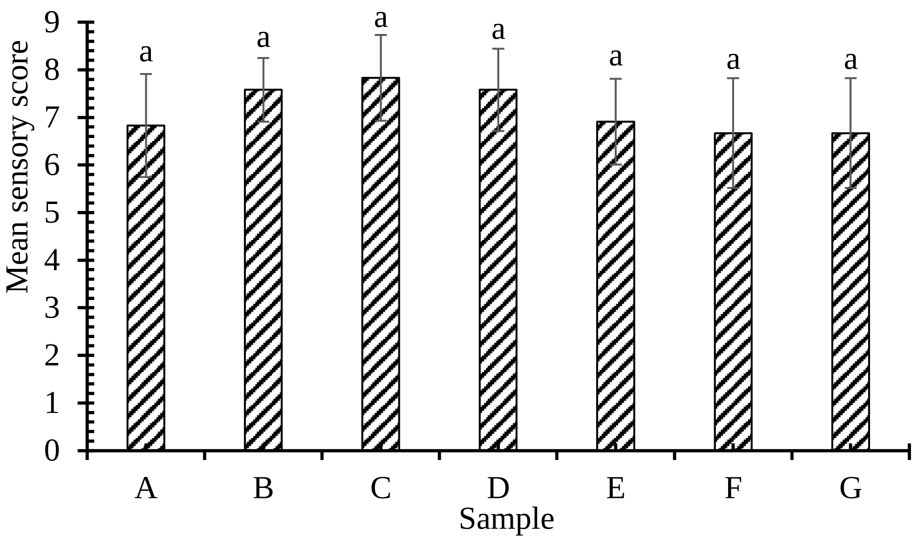

Fig. 4.3 Mean sensory scores for taste of muffins of different formulations

The likeness of muffin increased up to a certain level i.e. 67% of incorporation of chickpea flour. Further increment in chickpea flour resulted in slightly chickpea-like taste, despite which it was not a driver of disliking for the panelists. Similar result was observed by Herranz *et al.* (2016).

4.3.4 Texture

The mean sensory score for texture were found to be 6.08, 7.16, 8.66, 7.08, 6.91, 6.83 and 7 for muffin formulation A, B, C, D, E, F and G respectively. Statistical analysis showed that the partial substitution of wheat flour with chickpea flour had no significant effect ($p<0.01$) on the texture of the different muffin formulations. Sample C got the highest score. None of the samples were significantly different to each other except sample C which is shown graphically in Fig. 4.4. Chickpea flour helped to incorporate air into the batter, which is essential for achieving appropriate final volume and spongy texture (Alvarez *et al.*, 2016).

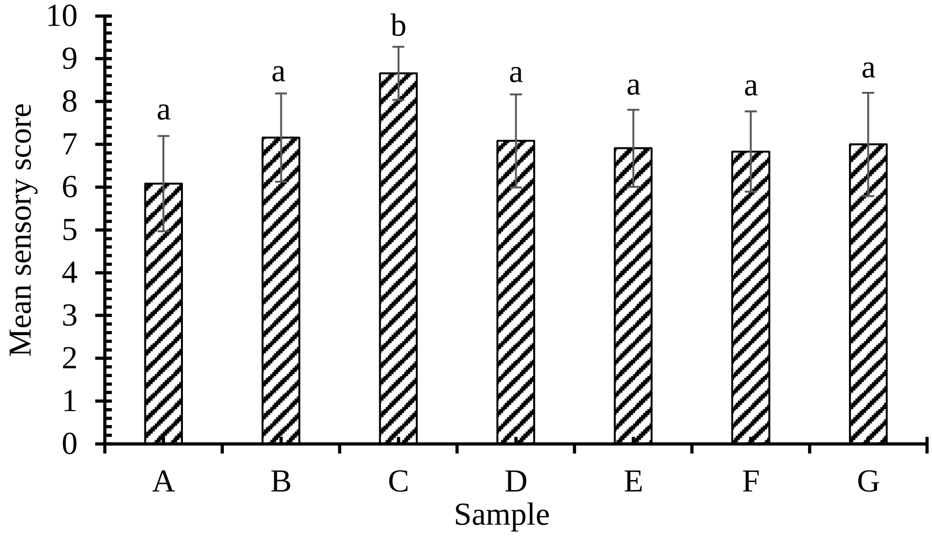

Fig. 4.4 Mean sensory scores for texture of muffins of different formulations

4.3.5 Overall acceptability

The mean sensory score for overall acceptability were found to be 6.41, 7.16, 8.2, 7.5, 7, 6.58 and 6.5 for the muffin formulation A, B, C, D, E, F and G respectively. Statistical analysis showed that partial substitution of wheat flour with chickpea flour had significant effect ($p<0.01$) on the overall acceptability of the different muffin formulations. Sample C got the highest score which was significantly different to samples A, F and G which is shown graphically in Fig. 4.5.

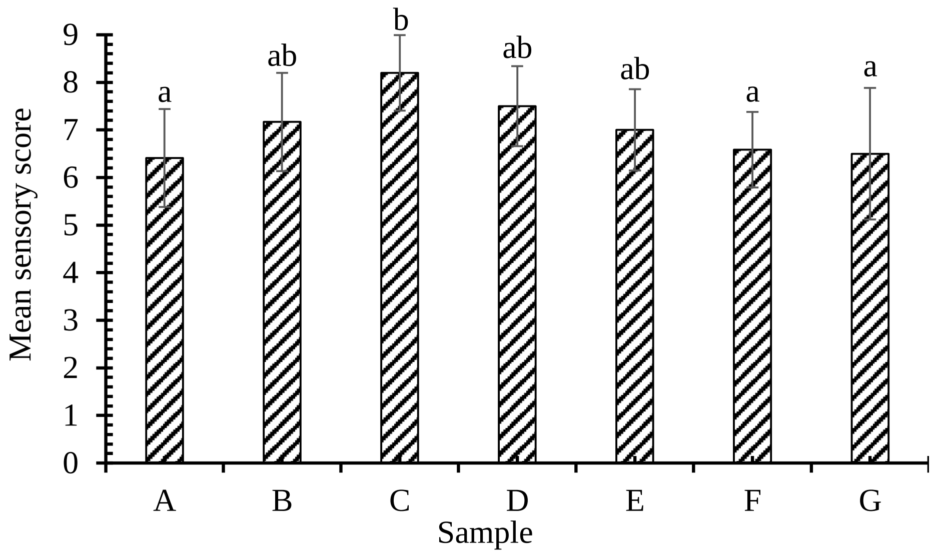

Fig. 4.5 Mean sensory scores for overall acceptability of muffins of different formulations.

Texture and taste of product C was favored. Therefore product C got high score in terms of overall acceptability as shown in Fig. 4.5. The overall acceptability of the 33 % wheat flour and 67% chickpea flour incorporated muffin was found to be significantly superior and was selected as best product.

4.4 Proximate composition of control and best product

Thus from statistical sensory analysis, the best product was found to be sample C muffin containing 67% of chickpea flour and 33% of wheat flour. The proximate composition of sample C and control muffin (100% wheat flour) were presented in Table 4.3.

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

Parameters (% db)	Product G (Control)	Product C (Best)
Moisture	29.01 ± 0.27	24.30 ± 1.16
Crude Protein	15.39 ± 0.20	27.37 ± 0.45
Crude Fat	25.18 ± 0.70	26.29 ± 0.54
Crude Fiber	0.58 ± 0.03	2.85 ± 0.18
Total Ash	0.55 ± 0.05	2.66 ± 0.41
Carbohydrate	58.3± 0.36	40.83 ± 0.75

*Values are the means of triplicates and figures in the parenthesis are standard deviation of the triplicates.

The moisture content, protein, fat, crude fiber, ash and carbohydrate of product G were found to be 29.01, 15.39, 25.18, 0.58, 0.55 and 58.3 respectively. Similar results were observed by Rahman *et al.* (2015). The moisture content, protein, fat, crude fiber, ash and carbohydrate of product C were found to be 24.30, 27.37, 26.29, 2.85, 2.66 and 40.83 respectively.

Moisture content of product C was 24.30 % while that of product G was 29.01 %. The lower moisture content of chickpea incorporated product may be due to low water holding capacity of chickpea. The lower moisture content makes it less prone to microbial attack.

The protein content of product C (27.37%) is higher than product G (15.39%) which may be due to the 18.12 % protein content in chickpea flour which contribute to more protein. The increase in crude fiber content of product C may be due to the incorporation of chickpea flour in muffins. The crude fat and total ash of product C was 26.29 and 2.66 % respectively while for product G 25.18 % and 0.55 % respectively were obtained.

The carbohydrate content decreases as the proportion of chickpea flour in muffins increases, supporting the claim of Khouryieh *et al.* (2005).

4.5 Anti - nutritional composition of flour and muffin

4.5.1 Saponin content

The saponin content of chickpea flour was found to be 3906.67 mg/100g and saponin content of best product was found to be 906.67 mg/100g which is shown graphically in Fig. 4.6. This value was obtained from the standard curve of saponin which is shown in appendix C.

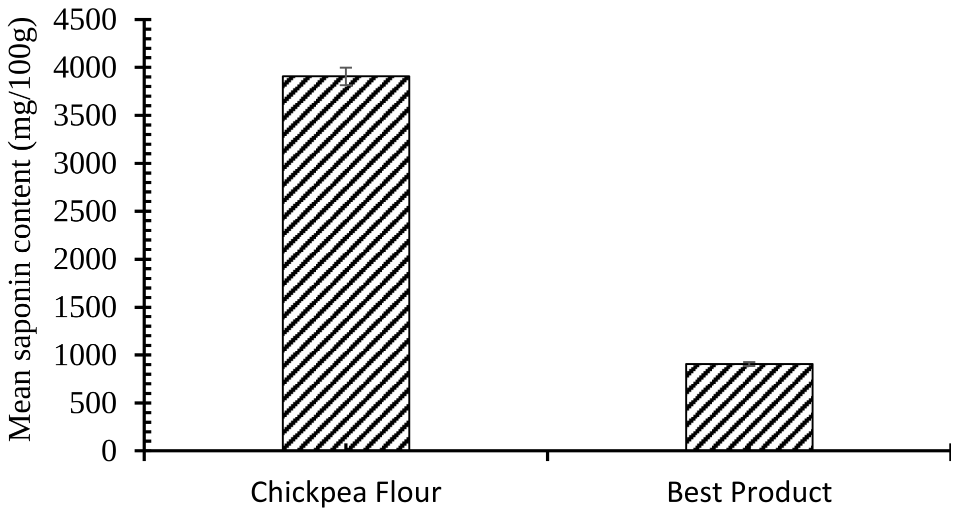

Fig. 4.6 Comparison of saponin content between chickpea flour and best product

From the Fig. 4.6 decrease in saponin content was observed when processed into muffin, which is due to the heat treatment during baking. The application of heat treatment was observed to lower the saponin content in chickpea. Similar result was observed by Jood *et al.* (1986).

4.6 Storage stability

The storage stability of chickpea flour incorporated muffin stored at room and refrigerated conditions were studied. The acid value and peroxide value of extracted fat, coliform and total plate count of the product were determined.

4.6.1 Acid value

After preparation of muffins, the muffins were stored at room and refrigerated conditions. Acid value should not exceed 6 mg KOH/g according to Nepal mandatory standard (Upadhyay *et al.*, 2021). In the room temperature (25±3℃), acid value was found to increase from 1.12 mg KOH/g to 2.64 mg KOH/g at 8 days interval of storage, while in the refrigerated temperature (4±1℃), acid value was found to increase from 1.12 mg KOH/g to 2.82 mg KOH/g at 15 days interval of storage which is shown graphically in Fig. 4.7.

The acid value was found to increase more rapidly in room temperature than in refrigerated temperature. Increase in AV is due to the hydrolysis of the oil to free fatty acids which will lead to further formation of aldehydes and ketones (Noorolahi *et al.*, 2013).

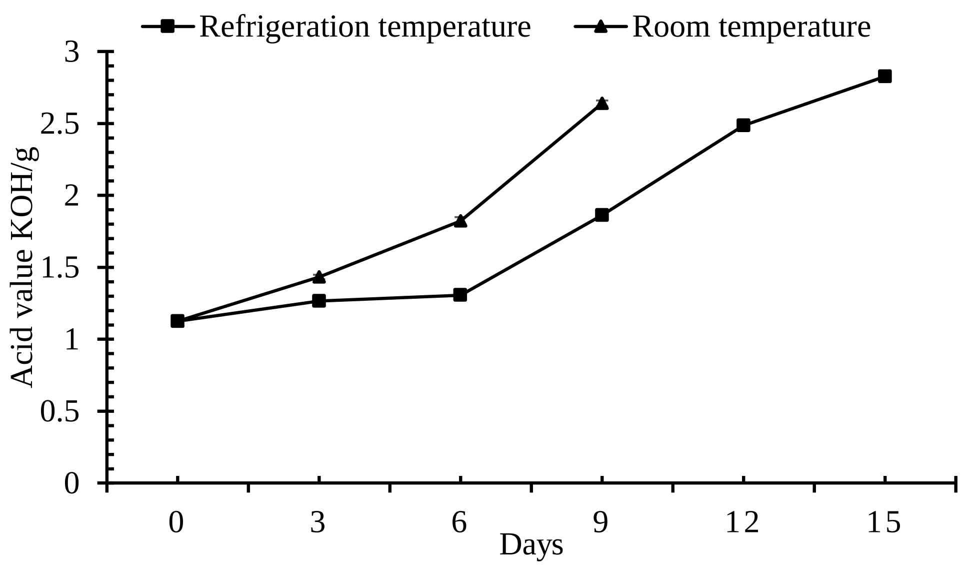

Fig. 4.7 Changes in AV in room and refrigerated conditions with respect to number of days of storage

4.6.2 Peroxide value

After preparation of muffins, they were stored at room and refrigerated conditions. Peroxide value exceeding 10 meq/kg is considered rancid (Pearson, 1976). In the room temperature

(25±3°C), peroxide value was found to increase from 0.75 meq/kg to 5.05 meq/kg at 8 days interval of storage, while in the refrigerated temperature (4±1°C), peroxide value was found to increase from 0.75 meq/kg to 3.52 meq/kg at the same interval of storage which is shown graphically in Fig. 4.8. The peroxide value was found to increase more rapidly in room temperature than in refrigerated temperature.

The peroxide value increased significantly with the increase in storage time that may be due to a high decomposition of peroxide as a result of the oxidation of polyunsaturated fatty acid present in muffin over storage period (Shrestha, 2018).

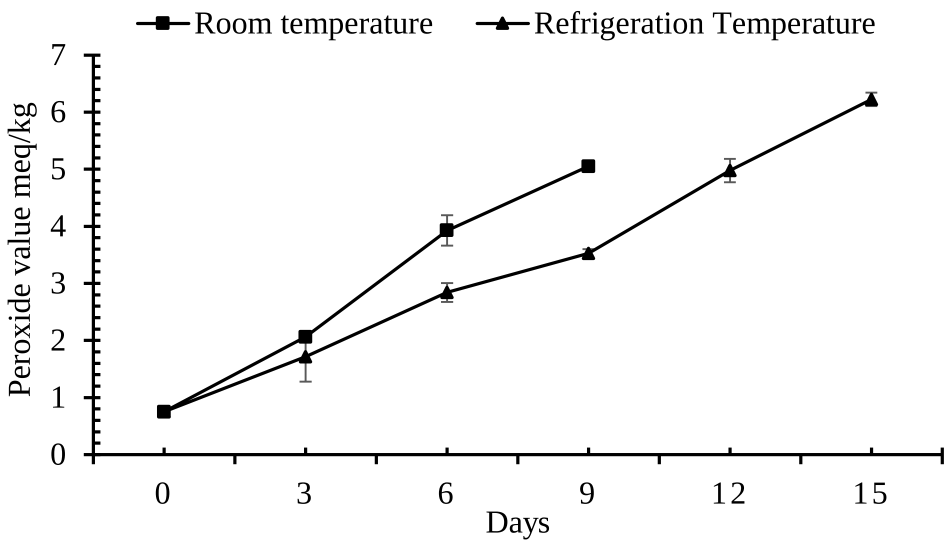

Fig. 4.8 Changes in PV in room and refrigerated conditions with respect to number of days of storage

4.6.3 Total plate count (TPC)

After preparation of muffins, they were stored at room and refrigerated conditions. In the room temperature (25±3°C), TPC of muffin was found to increase from 1.22 x 10^3 cfu/g to 3.9 x 10^5 cfu/g at 8 days interval of storage and in the refrigeration temperature (4±1°C), TPC of muffin was found to increase from 1.22 x 10^3 cfu/g to 2.4 x 10^5 cfu/g at 14 days interval of storage which exceed the maximum limit (2.0 x 10^5 cfu/g) for baked products according to (WHO, 1994) (Saddozai and Samina, 2009). This is shown in Fig. 4.9.

Muffins stored under refrigerated conditions were sound compared to muffins under room temperature. This may be due to the availability of favorable environment for the growth of microorganisms i.e. PH between 2-9, moisture, water activity 0.85, elevated temperature 10-35 °C and so on (Shrestha, 2018).

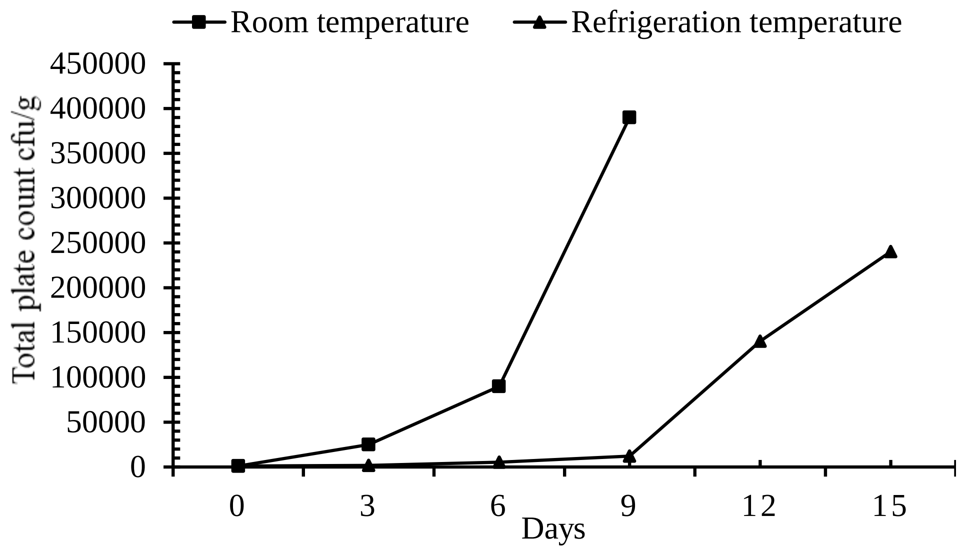

Fig. 4.9 Changes in TPC in room and refrigerated conditions with respect to number of days of storage

4.6.4 Coliform count

There were no colonies of coliform found during storage period in both room and refrigerated condition as they must have been destroyed during baking and later stored in hygienic conditions.

4.7 Cost evaluation of chickpea flour incorporated muffin

The total cost of best product was calculated and the cost of chickpea flour incorporated muffin was NRs. 58.59 per 100g including overhead cost and profit of 10%.

Part V

Conclusions and recommendations

5.1 Conclusions

On the basis of the research, following conclusions can be drawn. Since the work was done under controlled condition on a small scale, its generalization may warrant some reservations.

1. The chickpea flour can be incorporated up to 67% with 33% wheat flour, with no adverse effect on sensory quality of muffin.
2. Chickpea flour is superior to wheat flour in terms of crude protein, crude fat, crude fiber and total ash.
3. The incorporation of chickpea flour in muffin seemed to enhance protein and fiber content.
4. The TPC count shows that the acceptability of muffin was up to 6 days at room temperature and up to 12 days at refrigerated temperature without any artificial preservatives used.

5.2 Recommendations

1. The storage stability in different packaging materials can be studied.
2. Chickpea flour incorporated muffin can be commercialized by substituting wheat flour by chickpea flour up to 67% of the total mixture.
3. Alcohol acidity of the product can be determined.
4. Texture of the prepared muffin can be analyzed using texture meter.

Part VI

Summary

Muffin is one of the popular bakery product being any quick bread which has the shape of a cup cake and does not contain yeast. Chickpea (Cicer arietinum L.) is the second most important pulse crop in the world and considered very healthy food as it is rich in vitamins, proteins, minerals and fibers. Chickpea is a great source of plant-based protein which makes it a proper alternative for the people who do not eat animal products and could be used wherever plant based high protein, less carbohydrate products are required. Thus the preparation of muffin leads to higher use and commercial production of chickpea. This study mainly focuses on the nutritional value addition of wheat muffin by incorporating chickpea flour at various levels.

Chickpeas were crushed, grinded and shifted to obtain fine chickpea flour. The chickpea flour and wheat flour were analyzed for moisture, protein, fat, crude fiber, total ash and carbohydrates. The values were found to be 7.87%, 18.12%, 5.90%, 2.91%, 2.77%, 70.3% for chickpea flour and 11.53%, 9.13%, 1.05%, 0.58%, 0.56%, 88.68% for wheat flour respectively.

Chickpea flour incorporated muffins were prepared using design of expert for the formulation of recipe. Seven different muffin formulations namely A (100 parts chickpea flour), B (75 parts chickpea flour), C (67 parts chickpea flour), D (50 parts chickpea flour), E (33 parts chickpea flour), F (25 parts chickpea flour) and G (0 parts chickpea flour) were prepared by applying creaming method. Other ingredients such as fat 65 parts, pulverized sugar 60 parts, baking powder 1.42 parts, 57 parts egg and 31 parts water were taken constant. The seven different samples were prepared and then subjected to sensory evaluation. Sensory evaluation was carried out based on appearance, taste, texture, aroma and overall acceptability. The data obtained were statistically analyzed using two way ANOVA (no blocking) at 1% level of significance. Sample C (CF:WF:: 67:33) got the highest mean sensory score. The best scored muffin was chemically analyzed and moisture, protein, fat, crude fiber, total ash and carbohydrate were found to be 24.3%, 27.37%, 26.29%, 2.85%, 2.66% and 40.83% respectively.

Storage stability of best sample was studied by evaluating acid value, peroxide value, coliform and total plate count at both room and refrigerated conditions at every 2 days interval. Acid value and peroxide value were found to be 1.12 mg KOH/g and 0.75 meq/kg respectively at day 0 which was later found to be significantly increasing with the number of days of storage. From the TPC study, the best product was acceptable only up to 6 days at room temperature and up to 12 days at refrigerated temperature. There were no colonies of coliform detected. The cost of the muffin was calculated to be Rs.58.59 per 100g.

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Appendices

Appendix A

Sensory evaluation score sheet for chickpea flour incorporated muffin

Date:

Name of the panelist:

Name of the product: Chickpea flour incorporated muffin

Dear panelist, you are provided with 5 samples of chickpea flour incorporated muffin on each proportion with variation on chickpea flour content. Please test the following samples of muffin 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

Parameters	Sample Code						
	A	B	C	D	E	F	G
Appearance							
Texture							
Taste							
Aroma							
Overall acceptability							

Any comments:

Signature:

Appendix B

ANOVA results of sensory analysis

Table B.1 ANOVA (no blocking) for appearance of chickpea incorporated muffin

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	6	19.2381	3.2063	7.91	<.001
Panelist	11	4.9881	0.4535	1.12	0.362
Residual	66	26.7619	0.4055		
Total	83	50.9881			

Table B.2 ANOVA (no blocking) for aroma of chickpea incorporated muffin

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	6	6.1429	1.0238	1.51	0.188
Panelist	11	16.0357	1.4578	2.15	0.028
Residual	66	44.7143	0.6775		
Total	83	66.8929			

Table B.3 ANOVA (no blocking) for taste of chickpea incorporated muffin

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	6	17.5714	2.9286	3.59	0.004
Panelist	11	17.5595	1.5963	1.96	0.048
Residual	66	53.8571	0.8160		
Total	83	88.9881			

Table B.4 ANOVA (no blocking) for texture of chickpea incorporated muffin

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	6	43.2857	7.2143	10.58	<.001
Panelist	11	11.7500	1.0682	1.57	0.130
Residual	66	45.0000	0.6818		
Total	83	100.0357			

Table B.5 ANOVA (no blocking) for overall acceptability of chickpea incorporated muffin

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	6	29.7798	4.9633	5.85	<.001
Panelist	11	11.2232	1.0203	1.20	0.303
Residual	66	56.0060	0.8486		
Total	83	97.0089			

Appendix C

Table C.1 t-test (two-sample assuming unequal variance) for moisture of best sample with control

	Product G	Product C
Mean	29.01333	24.30333
Variance	0.076133	1.355233
Observations	3	3
Pearson Correlation	0.997881	
Hypothesized Mean Difference	0	
df	2	
t Stat	9.176679	
P(T<=t) one-tail	0.005834	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.011667	
t Critical two-tail	4.302653	

Table C.2 t-test (two-sample assuming unequal variance) for protein of best sample with control

	Product G	Product C
Mean	15.39333	27.37333
Variance	0.042133	0.206933
Observations	3	3
Pearson Correlation	0.039982	
Hypothesized Mean Difference	0	
df	2	
t Stat	-42.2152	
P(T<=t) one-tail	0.00028	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.000561	
t Critical two-tail	4.302653	

Table C.3 t-test (two-sample assuming unequal variance) for fat of best sample with control

	Product G	Product C
Mean	25.18667	26.29333
Variance	0.490133	0.298133
Observations	3	3
Pearson Correlation	-0.99129	
Hypothesized Mean Difference	0	
df	2	
t Stat	-1.54154	
P(T<=t) one-tail	0.131558	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.263117	
t Critical two-tail	4.302653	

Table C.4 t-test (two-sample assuming unequal variance) for crude fiber of best sample with control

	Product G	Product C
Mean	0.583333	2.85
Variance	0.001233	0.0349
Observations	3	3
Pearson Correlation	0.449644	
Hypothesized Mean Difference	0	
df	2	
t Stat	-22.579	
P(T<=t) one-tail	0.000978	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.001956	
t Critical two-tail	4.302653	

Table C.5 t-test (two-sample assuming unequal variance) for total ash of best sample with control

	Product G	Product C
Mean	0.556667	2.66
Variance	0.003433	0.1708
Observations	3	3
Pearson Correlation	0.995211	
Hypothesized Mean Difference	0	
df	2	
t Stat	-10.2619	
P(T<=t) one-tail	0.004681	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.009363	
t Critical two-tail	4.302653	

Table C.6 t-test (two-sample assuming unequal variance) for carbohydrate of best sample with control

	Product G	Product C
Mean	28.14667	15.80333
Variance	0.131733	0.571033
Observations	3	3
Pearson Correlation	0.284634	
Hypothesized Mean Difference	0	
df	2	
t Stat	28.91645	
P(T<=t) one-tail	0.000597	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.001194	
t Critical two-tail	4.302653	

Appendix D

Table D.1 Standard curve data for saponins

Saponin Concentration (ppm)	Absorbance
0	0
2	0.506
4	0.919
6	1.732
8	2.046
10	2.354

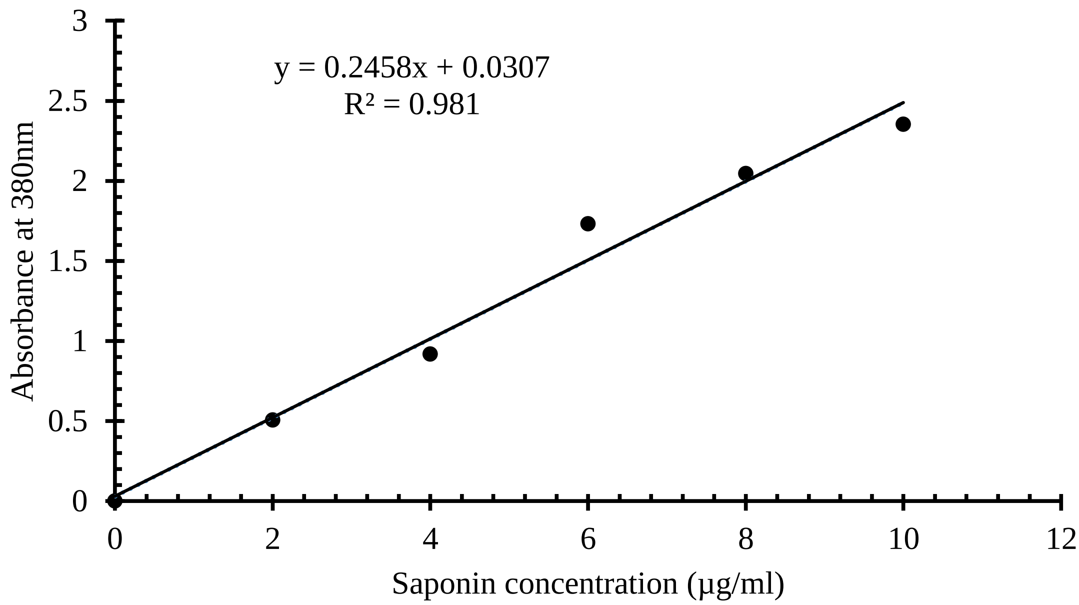

Fig. D.1 Standard curve for saponin determination

Appendix E

Table E.1 Cost calculation of the product (CFIM)

Particulars	Weight in a lot (g)	Cost (NRs/kg)	Cost (NRs)
Wheat flour	33	60	1.98
Chickpea flour	67	140	9.38
Sugar	60	90	5.4
Butter	65	900	58.5
Egg	57	526	30
Baking powder	1.42	160	0.22
Raw material cost			119.94
Processing and labor cost			11.994
(10% of raw material cost)			
Profit (10%)			13.193
Grand total cost			145.12
Average weight of CFIM (g)	283.42		
Total no. of CFIM formed	30		
Total weight of CFIM (g)	8502.6		
Total cost of CFIM (NRs/100g)			58.59

Color Plates

P1: Prepared sensory **s**amples

P2: Panelist performing sensory

P3: Saponin determination

P4: Protein determination