PREPARATION AND QUALITY EVALUATION OF OATS FLOUR INCORPORATED MUFFIN

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A dissertation submitted to the Department of Food Technology, Central Campus of technology, Tribhuvan University, in partial fulfilment 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 Oats Flour Incorporated Muffin* presented by Anusmriti Lamsal has been accepted as the partial fulfilment of the requirement for the B. Tech. degree in Food Technology.

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Abstract

The present work was carried out to prepare oats incorporated muffin and evaluate its sensory and physicochemical properties. Raw material (wheat flour, oats flakes) were collected from the local market of Dharan. Oats flour was prepared by grinding oats flakes in mixer grinder. The oats flour was incorporated at the level of 50, 75, 0, 25 and 100% with wheat flour and named as sample A, B, C, D and E which was prepared by muffin mixing process with incorporation of butter 65%, sugar 60%, egg 57%, baking powder 1.42% per 100 parts of flour mixture. Proximate analysis of oats flour and wheat flour were carried out and superior product obtained through sensory evaluation were determined.

Moisture content, crude protein, crude fat, crude fiber, total ash and carbohydrate content of wheat flour was found to be 13.07%, 9.17%, 1.07%, 0.45%, 0.44% and 75.82% respectively and 13.07%, 11.94%, 8.3%, 1.04%, 1.6% and 64.07% respectively for oats flour. And superior product obtained through sensory evaluation were determined. Through sensory evaluation, muffin incorporated with 75% oats flour was superior in comparison to all other muffin formulation in terms of appearance, color, flavour, and overall acceptability. So, product B was selected as the best product. Statistical analysis for the proximate composition of muffin samples showed that substitution of oats flour significantly improved all the nutritional attributes, except carbohydrate compared to whole-wheat flour muffin whereas significantly decreases the specific loaf volume of muffin. The free fatty acid as oleic acid and peroxide value of sample B at day 0 was found to be 0.41 mg KOH/g oil and 1.34 Meq O_2/kg fat respectively. The product was further analyzed for prediction of shelf life based on yeast and mold. No colony of yeast and mold were found from day 0 to day 4.

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List of Abbreviations

Abbreviations	Full form
AACCI	American Association Of Cereal Chemists International
ANOVA	Analysis Of Variance
CD	Celiac Disease
CHD	Coronary Heart Disease
CVD	Cardiovascular Disease
LDL	Low Density Lipoprotein
LDPE	Low Density Polyethylene
LSD	Least Significant Difference
OF	Oats Flour
TPC	Total Plate Count
WF	Wheat Flour
OFIM	Oats flour Incorporated Muffin

Part I

Introduction

1.1 General introduction

The preparation of quick breads is more of an art than a science because less research has been done on them than on yeast breads or cake (Griswold, 1962). Muffin a cereal based snacks, has been considered as the most popular breakfast cereals by average Americans now a days, because of their unique pleasant taste and easily consumable characteristics. Flour is the main ingredient to prepare muffins and gluten is the major protein constituent of wheat flour, which is considered to be responsible for celiac disease. Life-long gluten-free diet has been considered as the only effective treatment for celiac disease (Bhaduri, 2013). For this study, muffins, a form of quick bread, were selected. Muffins are comparatively inexpensive and popular in certain geographical areas. Some institutions have capitalized on this and built for themselves enviable reputations (Walman, 1972). A good muffin has a uniform shape, slightly rounded top, good color, a tender crust, an even tender crust and good flavor. They should break easily without crumbling (Miller, 1971).

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” (Halliday and Noble, 1946).

The oats belong to the family of poaceae and is commonly known as *Avena Sativa*. Oats are generally regarded as a minor cereal crop when considered in terms of grain produced annually, or areas sown for production. Traditionally, most of the crop has been used as animal feed. Oats has been recognized as a healthful and nutritious cereal containing high concentration of soluble fiber and dense nutrients. Oats have been linked to the health claims attributed to the use of β-glucans and are valuable sources of β-glucans. As harvested; oats retain their hull, which accounts about 25-30% of the seed. Oats for food use are first dehulled, because hulls are not suitable for humans without processing although readily digested by ruminants. However, properly processed makes it useful fiber ingredient for the food industry. Oat has recently attracted its research and commercial attention mainly due to its high nutritional value. Oats is a good source of antioxidant vitamin E (tocols), phytic acid, phenolic acid and avenantramides (Ahmed *et al.*, 2014).

Oats is well accepted in human nutrition and it is an excellent source of different β-glucan, arabinoxylans and cellulose. It contains relatively high levels of protein, lipids (unsaturated fatty acids), vitamins, antioxidants, phenolic compounds and minerals. The main part of the physiological effects of oats soluble fiber is due to the elevation of viscosity. Thus, it is of key importance to ensure a sufficient dose and a good extractability, and minimize the effect of factors reducing the molecular weight of β -glucan. β-Glucan has been shown to have effects on the glycaemic, insulin, and cholesterol responses to foods. Oats are good sources for these functional ingredients like β- glucan, with studies clearly demonstrating their potential health benefits. Irrespective of nutritionally rich cereal, it has physiological benefits like positive effect on reducing hyperglycaemia, hyperinsulinaemia, hypercholesterolemia and several other benefits (Ahmed *et al.*, 2014).

1.2 Statement of problem

Oats is a fruit with abundant food uses and nutritive value but study and production on it is very less in context of Nepal and world as a whole. Study on oats muffin may help to know its proximate composition and health benefit and may be marketed. Various research work by Acosta and Cavender (2011), Khoueyieh *et al.* (2005), (Rahman *et al.*, 2015) and many more are done regarding muffin as it is one of the healthy quick bread that is baked in appropriate portion. And oats has been recognized as a healthful and nutritious cereal containing high concentration of soluble fiber and dense nutrient. Many research and study are done regarding oats by Ahmed *et al.* (2014), (Prasad *et al.*, 2015b), Lapvetelainen (1994) and many others. Various research on product using oats by Mickee (2015) and many other are done and made available in market but the oats muffin are not practiced in general daily productions yet. Therefore, through this dissertation work nutritional benefits of oats is more conveniently synapsed with the delightful taste of the muffins.

Thus the present work is solely concerned with the study of preparation and quality evaluation of oats flour incorporated muffin.

1.3 Objectives

The objectives of this study are as follows:

1.3.1 General objectives

The main objective of this study is the preparation and quality evaluation of muffin using different proportion of oats flour.

1.3.2 Specific objectives

1. To carry out the chemical analysis of raw material i.e. wheat and oats flour.
2. To prepare muffins using oats flour and wheat flour at different proportion and selection of best formulation.
3. To analyze physicochemical and sensory properties of prepared muffins.
4. To estimate acceptability period of the muffin.
5. To perform cost evaluation of the product.

1.4 Significance of the study

Celiac disease (CD) which is a gluten sensitive inflammatory disorder of the small intestine, also known as gluten intolerance, affects genetically predisposed individuals when they ingest gluten proteins from wheat, barley and rye. CD results due to an intolerance to gliadin and glutenin proteins. In 2006, the American Dietetic Association updated its recommendations for a gluten-free diet. The only effective treatment for celiac disease is a life-long gluten-free diet. Gluten-free breads and cookies are principally based on flour from rice or maize with low content and poor-quality proteins. CD patients, especially children on a strict gluten-free diet, are undernourished because of the reduced intake of energy which is largely taken from wheat based food stuffs in a current western diet (Bhaduri, 2013).

According to the University of Chicago Celiac Disease Center, oats are technically gluten-free since they are not a type of wheat, barley or rye grain, the three groups of whole grains that naturally contain the protein gluten. Instead of containing gluten, oats actually have a protein called avenins. Oats are considered safe for those with a gluten allergy, easier for most people to digest, much less likely to cause negative reactions and are “nontoxic.” Reports show that perhaps less than 1% of celiac patients show a reaction to a large amount of oats in their diets (Axe, 2018).

1.5 Limitations of study

1. Size of oats flour was not maintained as per the standard due to the use of mixture grinder.

2. Instrumental textural analysis was not carried out.

Part II

Literature review

2.1 Muffins

Muffins are a type of semi-sweet cake or quick bread that is baked in appropriate portion. They are similar to cupcakes, although they are usually less sweet and lack in icing. Savory varieties, such cornbread muffins or cheese muffins also exist. The term also refers to disk shaped muffin bread, called an English muffin outside the United Kingdom. There are many varieties such as low- fat and flavors of muffin mace with a specific ingredient such as blueberries, chocolate chips, raspberry, cinnamon, pumpkin, date, nut, lemon, banana, orange, peach, strawberry, almond, and carrot, baked into the muffin. Muffins are also eaten for breakfast alternatively they may be served for tea or at other meals (Limbachiya and Amin, 2015).

Savory varieties such as cornbread muffin or cheese muffin also exists. The term also refers to disk shaped muffin bread, called an English muffin outside the United Kingdom. As American style muffin are also available in commonwealth countries, the term muffins either refer to product, with the context usually making clear which is meant (Arora, 1980). There are many varieties such as low-fat and flavors of muffin mace with a specific ingredient such as blueberries, chocolate chips, raspberry, cinnamon pumpkin, nut baked into muffin. Muffin are also eaten for breakfast alternatively they may be served for tea or at other meals (Walman, 1972).

2.2 The muffin method of mixing

The muffin method is a technique whereby two mixes are created: a mix of wet ingredients (eggs, soft or liquid fat, milk and sugar) and a mix of dry ingredients (flour, leavening and flavorings like cocoa powder). Once they are prepared, and the oven is preheated, the two are combined and stirred together very briefly before the finished batter is panned and baked (Miller, 1971).

2.3 Preparation of muffin

. First ingredients were divided into dry and wet ingredients. The dry ingredients included wheat flour, oats flour, baking powder and sugar. The wet ingredients were egg, water and butter. The egg was beaten for 2 min prior to addition of milk and oil. In a separate bowl, all dry ingredients were thoroughly mixed. Later, both dry and wet ingredients were combined to obtain mixed muffin batter (Rahman *et al.*, 2015) as shown in Fig 2.1.

Egg
↓
Beating (2 min)
↓
Melted butter, water → Creaming
↓
Cream
↓
Flour, Sugar, Baking powder → Mixing
↓
Batter
↓
Molding
↓
Baking (215ºC for 20±3 min)
↓
Cooling (35ºC)
↓
Storage (At ambient temperature)

Fig. 2.1 Flow chart for the preparation of muffin

Source: Rahman *et al.* (2015)

2.4 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 (Ashokan *et al.*, 2013).

2.5 Chemical composition of muffins

Chemical composition of muffin is shown in Table 2.1

Table 2.1 Chemical Composition of muffin

Constituents	
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)

2.6 Oats

Cereal grains feed a large population around the world. They constitute a significant part of daily diet of the consumers. Wheat, rice and maize are the leading grains in terms of consumption. These grains are consumed as whole or in fractionated forms. Oats remains an important cereal crop in the developing world and the most popularly cultivated species is *Avena sativa* and is trivially known as common covered white oats. Oats requires lesser nutrients (sodium, phosphorus and potassium) to cultivate than that required for wheat or maize. Since oats requires more moisture to produce a given unit of dry matter than all other cereals except rice, it grows well in cool and moist climate (Prasad *et al.*, 2015a). Oats is predominantly grown in American and European countries, mainly Russia, Canada and United States of America. It is used mostly for animal feeding and to some extent as human food. The use of oats as animal feed has declined steadily owing to emerging use and interest in oats as human health food (Ahmad *et al.*, 2010).

2.7 Morphology of oats plant

Oats are annual grasses with flat leaf blades; inflorescences open, effuse, or contracted or one-sided panicles with peduncles of pedicellate spikelets. Peduncles at the lower part of the panicle are usually longer bearing several spikelets. Spikelets are large, one to several flowered, and hermaphrodite. The rachilla is fragile, at least below the lowest floret in the wild species but tough in cultivated oats. Glumes, lower and upper, equal to one another or markedly unequal, chaffy, and remain attached to the panicle after seed dispersal. Lemmas are coriaceous to crustaceous, hairy or naked, seven-nerved, two-lobed, or entire with a stout geniculate awn issuing from the dorsal surface. The callous of the disarticulated florets have vertical or oblique scars. The palea is two-keeled, bearing hairs on the keels. There are three stamens, ovary is villous, and there are two lodicules, ovate to lanceolate, acuminate, fleshy. Grains are oblong, hairy, adherent to the lemma and palea, or free in some cultivated oats. Embryos are about one-eighth the length of the grain with basal hillum. Of the oat morphological characters, those of the spikelet have been mainly used or species delimitation and classification and can be regarded as diagnostic characters. They are as follows:

- Glumes shape.
- The structure of the lemma tips.
- Size and shape of the disarticulation scar.
- Shape of the callus at the bottom of the dispersal unit.
- Point of insertion of the awn into the lemma.
- The mode of the spikelet disarticulation at maturity (Ladizinsky, 2012).

2.7.1 Cultivation and production of oats plant

Oats are best grown in temperate regions. They have a lower summer heat requirement and greater tolerance of rain than other cereals, such as wheat, rye or barley, so are particularly important in areas with cool, wet summers, such as Northwest Europe and even Iceland. Oats are an annual plants and can be planted either in Autumn (for late summer harvest) or in the spring (for early autumn harvest) (Beloshapka *et al.*, 2016).

In 2016, global production of oats was 23 million tons, led by Russia with 21% of the world total, followed by Canada with 13% of the total (Table 2.1). Other substantial producers were Poland, Australia, and Finland, each with over one million tons (Bhaduri, 2013). The production of oats in world is shown in Table 2.2 the structure of oats plant is shown in Fig 2.2.

Table 2.2 Oats production in 2016

Country	Tons
Russia	4,761,365
Canada	3,018,100
Poland	1,358,079
Australia	1,299,680
Finland	1,037,400
United states	940,130
World	22,991,780

Source: Chan (2017)

2.3.2 Structure of Oats

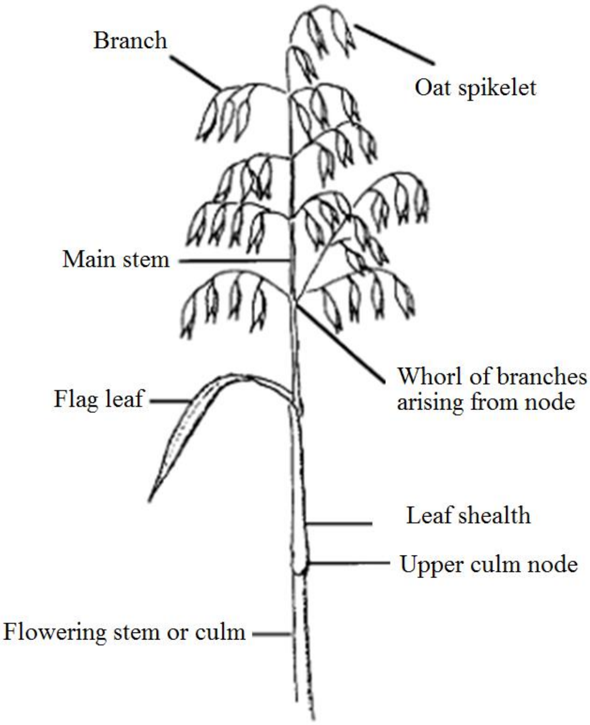

Fig. 2.2 Mature oats (*Avena sativa*)

2.3.3 Grain structure of oats

Grain structure is an expression of grain composition as it reflects properties from the standpoint of plant physiology. The plant does not synthesize or incorporate component into structures unless they have a specific function in preservation or propogation of the species. Cereal chemist and technologist, on the other hand are interested in another set of properties the function the grain or its fractions can perform in the production of nutritious foods, that have good shelf life, and are acceptable to the consumer (Pomeranz, 2005).

Thus, in a way, grain structure forms the link between composition that is the source of our basic knowledge of biological systems and utilization of those components in food production (Kent and Amos, 1983). The grain structure of oats is shown in Fig. 2.3.

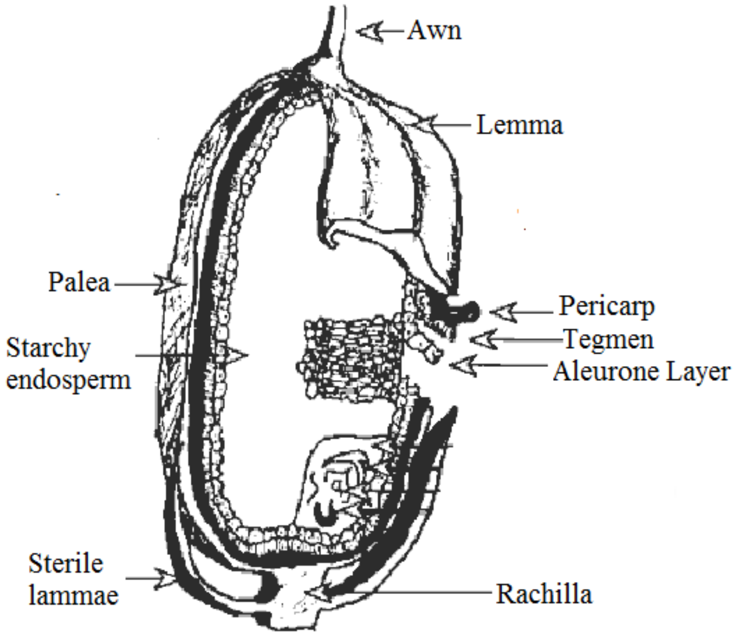

Fig. 2.3 Oats grain

Source: Kent and Amos (1983)

The structure and adherence of the hull may contribute to protection of grain during germination or malting and protection against insect infestations. Germ retention during threshing and separation during processing depend on the germ structure and location in the kernel. The subaleurone and central endosperm layers differ in cell size, shape, and structure and in composition, especially with regard to protein contents and quality. The main factor in grain hardness of the main components, the strength of interaction within the cell, and the interaction of individual cells to produce overall grain structure (Pomeranz, 2005).

Endosperm structure and hardness is related to oats conditioning, to breakage in milling, and to the structure and composition of the milled flour particles. Milling quality is governed by morphological characteristics of oats kernel and it mechano-physical properties and by the methods of grinding and separation. Reducing changes in texture and structure during drying of maize and rice are important in minimizing breakage during handling, storage, and transportation, dust formation, and infestation. Difference in grain structure are expressed in difference in composition, gradient of components in grain tissues, and the end-use properties. Those differences have important nutritional implications. New microscopic methods to determine grain structure, composition, and end-use properties have the potential of contributing to improved nutritional quality and utilization of cereals by modifying restructuring grain morphology through classical plant breeding and genetic engineering (Pomeranz, 2005).

2.8 Chemical composition and nutritive value of oats

The biochemical composition of oats grain is shown in Table 2.3.

Table 2.3 Biochemical composition of oats grain (Value ±SD)

Parameters	Husked oats	Naked oats
Protein content, %	10.58±0.67	15.71±1.10
Fat content, %	5.15±0.19	9.66±1.87
Starch, %	48.08±0.29	31.55±3.72
Total dietary fiber, %	17.63±1.52	22.97±1.89
β-glucan, %	3.15±0.19	3.29±0.26

Source: Zhao *et al.* (2014)

2.9 Nutritional component of oats

2.9.1 Oats starch

Starch constitutes about 60% of oat grain. It is mainly a constituent of endosperm. There is considerable difference observed between the physicochemical properties of oats starch and other cereal starches. Differences in physicochemical properties are also observed in different cultivars of oats. These differences are probably due to differences in the magnitude of interaction between and among starch chains within the amorphous and crystalline regions of the native granules and by the chain length of amylose and amylopectin fractions of oats starch. Oats starch offers untypical properties such as small size of granules, well developed granule surface and high lipid content (Berski and Ptaszek, 2011).

2.9.2 Oats protein

Oats is consider as potential source of low cost protein with good nutritional value. Oats has a unique protein composition along with high protein content of 11–15%. Cereal proteins have been classified into four types according to their solubility as follows: albumins (water-soluble), globulins (salt water-soluble), prolamins (soluble in dilute alcohol solution) and glutelins (soluble in acids or bases). Oat protein not only differs in the structural properties but also differs in distribution of protein fraction in comparison to other cereal grains. Other cereals such as wheat and barley have characteristic protein matrix which lacks in oat. In wheat and some other cereals, the storage protein is insoluble in salt solutions, while in oats, a large portion of salt water soluble globulins also belong to the storage proteins of the endosperm (Klose *et al.*, 2009).

Oats contains lower quantity of prolamins (15%) relative to the high amount of globulins (80%) of the total oats protein. Prolamins (avenins) are low molecular weight fractions of oats proteins. These prolamins are soluble in 50–70% ethyl alcohol or 40% 2-propyl alcohol. Prolamins have high percentage of glutamine and proline and are low in lysine as compared to the other protein fractions (Robert and Nozzolillo, 1985). Avenins, a type of prolamins, have storage function similar to that of other cereal prolamins. Glutelin values are reported to be varying from 5 to 66% of the total protein as they are difficult to be completely solubilised and are dependent on the extraction solvent and solvent concentration. Of the total metabolically active proteins of oats, water soluble albumin accounts for most of the fraction. Albumins account for about 1–12% of the total oats protein. In general, albumin and globulin have higher lysine content. Thus oats are rich in lysine content compared to other cereals while they have rather lower content of glutamic acid and prolamin (Lapvetelainen, 1994).

Celiac disease is triggered by the ingestion of gluten in gluten intolerant persons. Gluten is an alcohol soluble complex protein present mostly in wheat and other related cereals such as barley and rye. In individuals who are genetically susceptible, the ingestion of gluten causes an inappropriate small intestinal immune response characterized by villous atrophy and crypt hyperplasia (Fasano and Catassi, 2001), resulting in malabsorption of protein, fats, carbohydrates, soluble vitamins, folate and minerals especially, iron and calcium. The only therapy available at present is to completely exclude gluten from the diet of the individual. Oat contains comparatively more favourable and nutritionally more valuable composition of protein fractions (Capouchova, 2004). However, it has long been debated, whether oats can be considered safe for celiac patients. Dicke *et al.* (1953) and Baker and Ream (1976) recommended complete elimination of oats; while, Ripsin *et al.* (1992) and Janatinen *et al.* (2006) advocated the use of oats in celiac diet. The use of oats in gluten free diet depends on the composition of the protein fractions; albumins, globulins, prolamins (avenins) and glutelins.

Prolamins together with glutelins forms the reserve protein located in the grain endosperm, which forms about 60–70% of the grain proteins of cereals. The prolamin fractions are less susceptible to hydrolysis and hence are also difficult to digest. The prolamins content in oats (10–15% of the total protein) is rather low as compared to wheat (40–50%), rye (30–50%) and barley (35–45%). Kumar and Farthing (1995) stated that avenins (oats prolamins) could be responsible for toxicity in the celiac patients only if oats is consumed in high amounts, as compared to rye and barley. Amount of prolamins in oats varies with species, variety and time of cultivation. However, recently European commission regulation No. 41/2009 has included oats amongst permitted ingredients, if the gluten content does not exceed 20 ppm (mg/kg) (Henkey, 2009).

2.9.3 Dietary fibers

Dietary fibers are an essential part of the human diet. They consist of many substances of plant origin that are not digested in the human upper gastrointestinal tract. They include polysaccharides such as cereal β-glucan, arabinoxylans and cellulose. Dietary fibers are located in the cell walls of the grain. The outer layers, the seed coat and the pericarp contribute significantly to the insoluble dietary fiber content of the grain. According to American Association of Cereal Chemists (AACC), a dietary fiber is defined as "the edible part of plant or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. It includes polysaccharides, oligosaccharides, lignin and associated plant substances. Dietary fibers promote beneficial physiological effects including laxation and/or blood cholesterol attenuation and/or blood glucose attenuation (AACC, 2016).

2.9.4 Lipids

Oat has been widely shown to provide a vast range of human health benefits such as reduced symptoms of diabetes and obesity. The primary component of oats responsible for these health benefits is considered β-glucan, however phenolic compounds of oats and other antioxidant compounds also provide health benefits. Oats possess antioxidant capacity mainly due to presence of tocopherols, tocotrienols, phytic acid, flavanoids and non flavanoid phenoilc compounds such as avenaantramides (Tapola *et al.*, 2005).

2.10 Oats: as a functional food

Oats has been recognised as a healthful and nutritious cereal containing high concentration of soluble fiber and dense nutrients. Irrespective of nutritionally rich cereal, it has physiological benefits like positive effects on reducing hyperglycaemia, hyperinsulinaemia, hypercholesterolemia and several other benefits are discussed in this review. The main part of the physiological effects of oats soluble fiber is due to the elevation of viscosity and that is due to soluble fiber such as (1→3, 1→4) - β -D-glucan or β-glucan. β-glucan has been shown to have effects on the glycaemic, insulin, and cholesterol responses to foods. Oats are good sources for these functional ingredients like β-glucan, with studies clearly demonstrating their potential health benefits (Ahmed *et al.*, 2014).

Oats are source of different dietary fiber components of mixed-linkage (1→3), (1→4)-β-D-glucan arabinoxylans and cellulose. The neutral cell wall of polysaccharide β-glucan has outstanding functional and nutritional properties. It achieves high viscosities at relatively low concentrations and is of particular importance in human nutrition. Soluble fiber of oats has been reported to reduce elevated blood cholesterol, triglyceride, and glucose levels. Oats also good sources of insoluble fiber functions as a water-holding-capacity agent and can reduce intestinal transit time when present in adequate amounts in food (Paton *et al.*, 1995).

2.11 Oats flour

Oats flour may be milled directly from grinding rolled oats. The fines streams from groat cutting and flaking typically end up in the oat flour stream. Grinding is usually accomplished by hammer mills, but pin mills and other types of size reduction equipment are also used alone or in sequence. Corrugated rolls, commonly used for wheat milling, are unsuitable for oats milling because the grooves tend to plug due to the high fat content of oat groats (Menon and Watson, 2016). Prasad *et al.* (2015b) reported proximate values of moisture content, crude protein, crude fat, crude fiber, total ash and carbohydrate 12, 13.1, 9.2, 1, 1.8 and 62.8% respectively.

In 2004 the AACCI (American Association of Cereal Chemists International) provided a definition for whole oats flour as: “whole oats flour is produced from clean, 100% groats, or from products derived without material loss from whole groats, by stabilizing and size reduction” (Bhaduri, 2013).

2.11.1 Benefits of oats flour

a. Reduces heart disease risk

An epidemiologic study published in the *Archives of Internal Medicine* looked at the relationship between dietary fiber intake and the risk of coronary heart disease (CHD) and cardiovascular disease (CVD) in 9,776 adults. The researchers found that subjects consuming the most fiber, 20.7 g per day, had 12% less CHD and 11% less CVD compared to those eating the least amount (five grams per day) of fiber (Khanal, 1997)

b. Lowers cholesterol

Another reason that oats flour is so great for the heart is that it has been shown to lower LDL (“bad”) cholesterol. Specifically, it’s the beta-glucan (β-glucan) found mainly in the endosperm cell wall of oats that’s believed to be responsible for decreasing total serum cholesterol and LDL cholesterol. How does it work? Well β-glucan is a highly glutinous soluble fiber so as it travels through the small intestine, it actually limits the absorption of dietary cholesterol (Mickee, 2015).

c. Helps diabetics

Research shows that, in moderation, oats can be a healthy and helpful food for diabetics and others struggling with blood sugar issues. The aim of a 2015 scientific review was to figure out if oats intake is beneficial for diabetic patients. The researchers looked at 14 controlled trials and two uncontrolled observational studies, and the findings are quite impressive (Prasad *et al.*, 2015a).

Compared with the controls, “oats intake significantly reduced” the concentrations of A1c and fasting blood glucose as well as total cholesterol and LDL cholesterol. The conclusion of the review is that oats intake can benefit both blood sugar control and lipid profiles in type 2 diabetics, making it a great addition to any diabetic diet plan (Prasad *et al.*, 2015a).

d. Satiety star

If you have ever eaten a bowl of oatmeal for breakfast, you are familiar with how oats can hold you over really well until your next meal. Since oats flour is really just ground-up whole oats, adding it to your meals and recipes can also help you feel more satisfied after consuming it (Barro and Real, 2017)

Scientific research published in the *European Journal of Clinical Nutrition* aimed to produce a validated satiety index of common foods. Many different foods were tested, and oatmeal ended up being rated No. 1 among breakfast foods and No. 3 overall. A scientific review published in 2016 suggests that it’s likely the beta-glucan content of oats that has such a positive effect on perceptions of satiety (Barro and Real, 2017).

2.12 Wheat

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, collectively called gluten. The gluten forming proteins (glutenin and gliadin) constitute about 75-80% of the total flour proteins (Mukhopadhyay, 1990).

Glutenin gives solidity to the product whilst gliadin is the binding agent imparting the soft sticky character to the gluten. Gliadin is soluble in 70% alcohol and may be extracted from flour whereas glutenin is soluble in alcohol and water (Gorinstein *et al.*, 2002).Gluten is elastic, cohesive and rubbery and holds together and holds together the various ingredients of the dough. It has the property of holding the gases given off during fermentation and during baking. It sets in oven to form the firm, porous, open texture during baking which are necessary in the production of biscuits and crackers. Thus gluten is the necessary framework, forming the sustaining wall of the whole structure of baked products (Bohn, 1956).

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 strong flour protein has long links with few bonds while weak flour protein has short links with many bonds. During cake making weak and easy to stretch, soft wheat flour is found to be better (Kim and Kim, 1999).Beside the natural quality of flour, the modifications in the flour strength can be done by various treatments. Treatment of the flour with sulphur dioxide reduces the flour strength. Heat treated flour added to untreated flour is claimed to strengthen the flour. According to Kent and Amos (1983), improvers have some effect upon the nature and character of the gluten and cause it to behave, during fermentation, like the gluten of the stronger flour.

The flour should be free flowing, dry to touch, should be creamy in colour and free from any visible bran particles. It should also have a characteristic taste and should be free from musty flavour and rancid taste (Young and Cauvain, 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.

2.13 Ingredient and their role in muffin making

2.13.1 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, 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).

2.13.1.1 Requirement of flour characteristics

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. The characteristics as required in flour is shown in Table 2.4.

Table 2.4 Requirements for flour characteristics

S. No	Characteristics	Requirements
1	Moisture content	13.0% max.
2	Gluten content on dry basis	7.5% min.
3	Total ash on dry basis	0.5% max.
4	Acid insoluble ash on dry basis	0.05% max.
5	Protein (N×7.5) on dry basis	9.0%
6	Alcohol acidity as H_2SO_4 in 90% alcohol	0.1%
7	Water absorption	55%
8	Sedimentation value	22%
9	Uric acid (mg/100 g)	10% max.
10	Granularity	To satisfy the taste

Source: Arora (1980)

2.13.2 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).

Hydrogenated Vegetable fat are superior to the lards recently used in various aspects. Furthermore in order to obtain the best product the hydrogenated vegetable oil to be used for biscuit making should possess the following properties:

1. It should possess good white to creamy color.
2. After keeping the fat at 50ºC for 24 h and filtering, its color should be comparable with the control sample of oil.
3. The fat should have a smooth, uniform texture, free from any oil separation and large grains.
4. The fat should have a bland ‘clear’ odor and taste.
5. The fat should have a wide plastic range to suit particular production techniques and the product.
6. The crystalline structure of fat should be stable during mixing and after baking.
7. The fat should possess reasonable shelf life on its own without the addition of antioxidants. The acid value and peroxide value of the extracted fat should not exceed 0.5 mg KOH/g oil and 10 meqv peroxide/kg fat respectively (Mukhopadhyay, 1990)

2.13.3 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 pulverised 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 (Whitely, 1971).

2.13.4 Leavening agent

Leavening are the gassing agents which causes the dough to spring off or puff up to give a porous open texture to the final product. Ammonium and sodium bicarbonate are the major chemical leaveners, while yeasts are the biological leaveners. Similarly, mechanical leavening can be done by incorporating the air within the dough matrix by mechanical agitation. Reaction of two or more chemicals also leads to production and incorporation of gas, mainly the reaction takes place between bicarbonates of ammonia as well as sodium with acidulants. To discuss about the major and most common leavening agent the baking powder, it should possess the following properties (Smith, 1972)

1. Maximum gas strength-greatest volume of gas for least weight of the product.
2. Proper balance of ingredients to prevent any impairment of the taste or appearance of the biscuit.
3. Innocuous ingredients and residues.
4. Optimum velocity of reaction to be susceptible to control.
5. Keeping quality under diverse and extreme conditions to remain unimpaired over reasonable periods of time.
6. Minimum cost of production, economical in use Smith (1972).

The chemical reaction during use of chemical leaveners and acidulants is as given in this section.

$$\underset{\text{Ammonium bicarbonate}}{NH_4HCO_3} \xrightarrow{\text{Heat}} \underset{\text{Ammonia}}{NH_3} + \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{H_2O}$$

$$(NH_4)_2CO_3 \xrightarrow{\text{Heat}} 2NH_3 + CO_2 + H_2O$$

Ammonium carbonate Ammonia Carbon dioxide Water

The chemical equations for the reaction of soda and the commonly used acidulants are as follows:

$$NaHCO_3 + HX \longrightarrow NaX + CO_2 + H_2O$$

Sodium bicarbonate Acid Carbon dioxide Water

$$NaHCO_3 + C_4H_5O_6K \longrightarrow C_4H_4O_6NaK + CO_2 + H_2O$$

Cream of tartar Sod. Pot. Tartrate

Both sodium and ammonium bicarbonate react with acidic ingredients if any, in the dough. Use of an excess ammonium bicarbonate makes the dough more alkaline and thereby may affect the protein structure of the dough. Use of an excess sodium bicarbonate will affect the crumb and crust color often with an accompanying unpleasant or soapy taste, unless any acidic material is used to neutralize the residual sodium carbonate (Bohn, 1956).

2.13.5 Whole egg

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

2.13.6 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).

2.14 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 as well as chemically. Physical changes include:

1. Formation of a film crust on the dough.
2. Melting of the fat in the dough.
3. Gas release and volume expansion.
4. Conversion of water into steam.
5. Escape of carbon dioxide, other gases and steam.
6. Chemical changes include:
7. Gas formation
8. Starch gelatinization
9. Protein changes

10. Caramelization of sugar
11. Dextrinization

Temperature in the baking oven has different effect on the raw dough, which is shown in Table 2.5.

Table 2.5 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).

Part III

Materials and methods

3.1 Raw material

3.1.1 Oats

Rolled oats named ‘D lite’ was brought from the local store of Dharan at the rate of Rs. 289 per kg.

3.1.2 Wheat flour

Wheat flour named ‘fortune maida’ produced by Nutri Food Pvt. Ltd., Sonapur, Sunsari, Nepal was used for muffin making. The maida was purchased from the local market of Dharan.

3.1.3 Sugar

Sugar in the form of pulverized sugar was used and brought from the local market of Dharan.

3.1.4 Shortening

Vegetable ghee named ‘Delicious Fat Spread’ manufactured by Kaira District Co-operative milk producer’s Union Ltd. Anand, India was used which was also brought from the local stores of Dharan.

3.1.5 Egg

Eggs were bought from the local market of Dharan.

3.1.6 Baking powder

Baking powder named as ‘Weikfied baking powder double action’ manufactured and packed by Weikfied food Pvt. Ltd., Pune, India was used which was made available in the laboratory of Central Campus of Technology.

3.1.7 Packaging material

Paper muffin cup available in the local market of Dharan was used.

3.1.8 Water

Drinking water available at Central Campus of Technology was used.

3.1.9 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. Rotatable composite design was used to formulate the recipe. The independent variable for the experiment is concentration of oats flour used to prepare muffin.

3.2.2 Formulation of recipe

The recipe formulation for the oats incorporated muffin was carried out as given in Table 3.1. The amount given is on parts basis.

Table 3.1 Recipe formulation for muffin

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

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

3.3 Preparation of oats flour

Oats flakes were grinded with the help of grinder. The oats were powdered in the laboratory pulverized to a fineness that 90% of the powder passed through 400 µ sieve. The flour obtained was shield in a plastic container and stored at ambient condition for further processing.

3.4 Preparation of oats flour incorporated muffin

In present study, five different formulations of muffin were prepared. One formulation was prepared without oats flour (control) and another four were formulated with oats flour at different levels as shown in Table 3.1. First ingredients were divided into dry and wet ingredients. The dry ingredients included wheat flour, oats flour, baking powder and sugar. The wet ingredients were egg, water and butter. The egg was beaten for 2 min prior to addition of milk and oil. In a separate bowl, all dry ingredients were thoroughly mixed. Later, both dry and wet ingredients were combined to obtain mixed muffin batter.

Egg
↓
Beating (2 min)
↓
Melted butter, water → Creaming
↓
Cream
↓
Flour (75% oats flour and 25% wheat flour), Sugar, Baking powder → Mixing
↓
Batter
↓
Molding
↓
Baking (215ºC for 20±3 min)
↓
Cooling (35ºC)
↓
Storage (At ambient temperature)

Fig. 3.1 Flow chart for the preparation of oats muffin

Source: Rahman *et al.* (2015)

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 parameter analysis

3.5.1.1 Color and surface

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

3.5.1.2 Specific loaf volume of the muffin

First volume and weight of the muffin was determined. Volume was determined by rapeseed displacement method as mentioned in AACC (2016) for muffin and weight by physical balance. In this case seeds, usually rape or canola seeds or pearled barley, take the place of a liquid. The process is quite straightforward. A box of known volume will be filled with seed and the weight of seed required to just fill the box is noted. The sample is introduced and the seed poured back into the box. The volume of seed displaced is equal to the volume of the product. The more seed that is displaced the larger the product volume (Stauffer, 2001).

$$\text{Specific loaf volume} = \frac{\text{volume of the muffin}}{\text{weight of the muffin}}$$

3.5.2 Physicochemical analysis

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 Ranganna (1986).

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 Ranganna (1986).

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 Ranganna (1986).

3.5.2.4 Crude fiber

Crude fiber content of the samples was determined by the method given by Ranganna (1986).

3.5.2.5 Total ash

Total ash content of the samples was determined by following the method given by Ranganna (1986) using muffle furnace.

3.5.2.6 Carbohydrate

The carbohydrate content of the sample was determined by difference method as by Ranganna (1986).

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

3.5.3 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, crispiness, color, taste, flavour and overall acceptability. Sensory evaluation was performed according to the 9- Point Hedonic Scale as in appendix A.

3.5.4 Statistical analysis

The obtained data was analyzed statistically by Genstat Discovery Edition 3, for Analysis of Variance (ANOVA) at 5% level of significance. The data obtained from proximate analysis and sensory evaluations were subjected to one and two way Analysis of Variance.

3.5.5 Microbiological analysis

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 hr) (AOAC, 2005).

3.5.6 Acceptability period of muffin

Acceptability period of the product was determined by acid value, peroxide value of the extracted fat and moisture content of the muffin. The analysis was carried out for 4 days.

Part IV

Results and discussion

This work was carried out for the preparation of standard quantity of different muffin formulation with different proportion of oats flour with wheat flour. As muffin is, a product widely flavored and consumed by general population as a healthy breakfast food. At first, the major raw materials were subjected for proximate analysis.

4.1 Proximate composition of wheat flour and oats flour

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

Table 4.1 Proximate composition of wheat flour and oats flour

Parameters	Wheat flour (%)	Oats flour (%)
Moisture	13.07±0.116	13.07±0.120
Crude protein	9.17±0.152	11.94±0.050
Crude fat	1.07±0.060	8.3±0.100
Crude fiber	0.45±0.012	1.04±0.006
Total ash	0.44±0.036	1.6±0.006
Carbohydrate	75.82±0.079	64.07±0.274

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

4.1.1 Chemical composition of wheat flour

The moisture content, protein, fat, crude fiber, ash, gluten and carbohydrate of wheat flour were found to be 13.07, 9.17, 1.07, 0.45, 0.44, 9.1 and 75.82% respectively. Sarwar (2010) reported respective proximate values 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. The crude protein content in wheat flour 9.17 was lower than that obtained by

Sarwar (2010) and Khanal (1997). The crude fiber and ash content were higher than obtained by Khanal (1997) and Sarwar (2010). However, wheat flour fulfills requirement for bread making as described by Nepal Rajpatra Standards (Adhikari *et al.*, 2057). The difference in proximate composition may be due to factors like varieties, climatic conditions, soil type, maturity, fertility and others.

4.1.2 Chemical composition of oats flakes

The moisture content, protein, fat, crude fiber, ash and carbohydrate of oats flakes were found to be 12.5, 11.9, 8.9, 1.04, 1.6 and 64.06% respectively. Zhao *et al.* (2014) reported respective proximate values were 8.3, 14.2, 7.4, 1.2, 1.9 and 67% respectively and Beloshapka *et al.* (2016) found out that of 8, 14.1, 6.9, 1.6, 1.4 and 68% respectively. The crude protein content of oats flakes was lower than that obtained by Zhao *et al.* (2014) and Beloshapka *et al.* (2016). The crude fat content was however higher that that obtained by Beloshapka *et al.* (2016) and Zhao *et al.* (2014). The difference in proximate composition may be due to the factors like varieties, climatic conditions, soil type, maturity, fertility geographical conditions and others.

4.1.3 Chemical composition of oats flour

The moisture content, protein, fat, crude fiber, ash, and carbohydrate of oats flour were found to be 13.07, 11.94, 8.3, 1.04, 1.6, and 64.07% respectively as given in Table 4.1. While Prasad *et al.* (2015b) reported 12, 13.1, 9.2, 1, 1.8 and 62.8% respectively.

There was not significant change in ash content and crude fiber of oats flakes and oats flour. The higher moisture content in oats flour than that of oats flakes is may be due to powder form of flour.

4.2 Volume of the muffins

The change in volume of muffins with incorporation of oats is shown in Fig. 4.1.

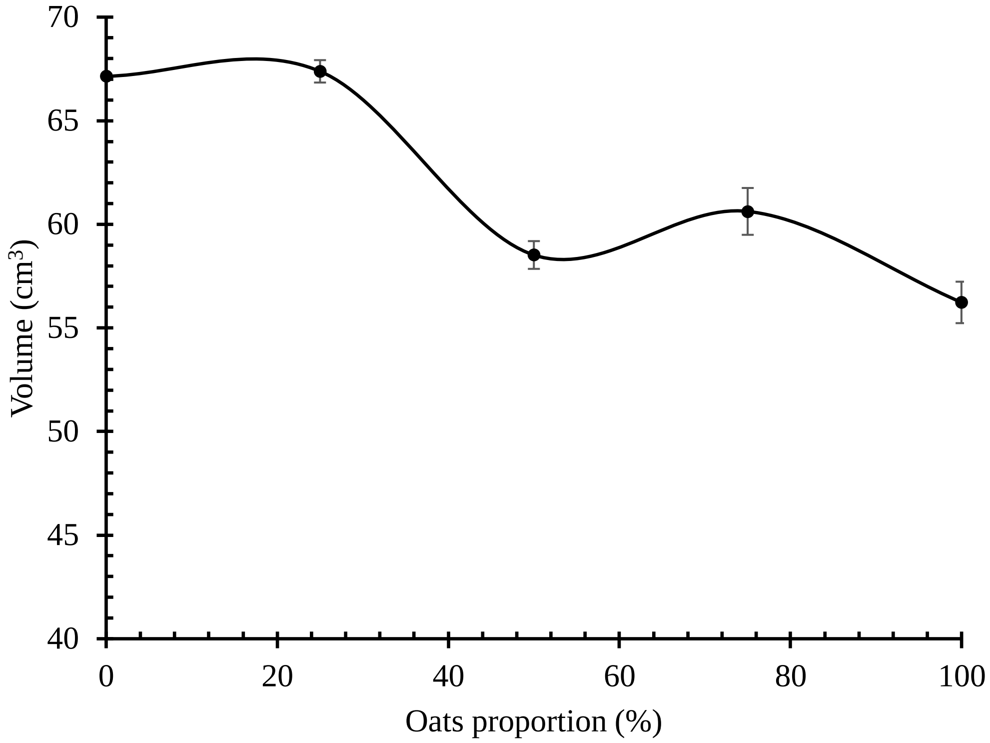

Fig. 4.1 Effect of oats flour on volume of the muffins

*Values are the means of three determinations. Vertical error bars represent standard deviation.

From the Fig.4.1 it was seen that the incorporation of oats decreases the volume of muffins. The decrease in volume of oats incorporated muffin may be justified by diluting effect of gluten caused by oats flour which led to lower loaf volume of muffin. Oats being a gluten free cereal content no gluten which directly effect the volume while baking (Mickee, 2015). A decrease in loaf volume of bread fortified with barley β-glucan was also reported by Knuckles *et al.* (1997). Oats contain very high amount of β-glucan than wheat flour which results in decrease of volume of muffin. Higher the β-glucan content lower will be the volume of the muffin. The same conclusion was drawn by Vittadini and Vodovotz (2007). As the oats flour is denser than wheat flour using same mass volume will be smaller for oats flour.

4.3 Weight of the muffins

The change in weight of muffins with incorporation of oats is shown in Fig. 4.2.

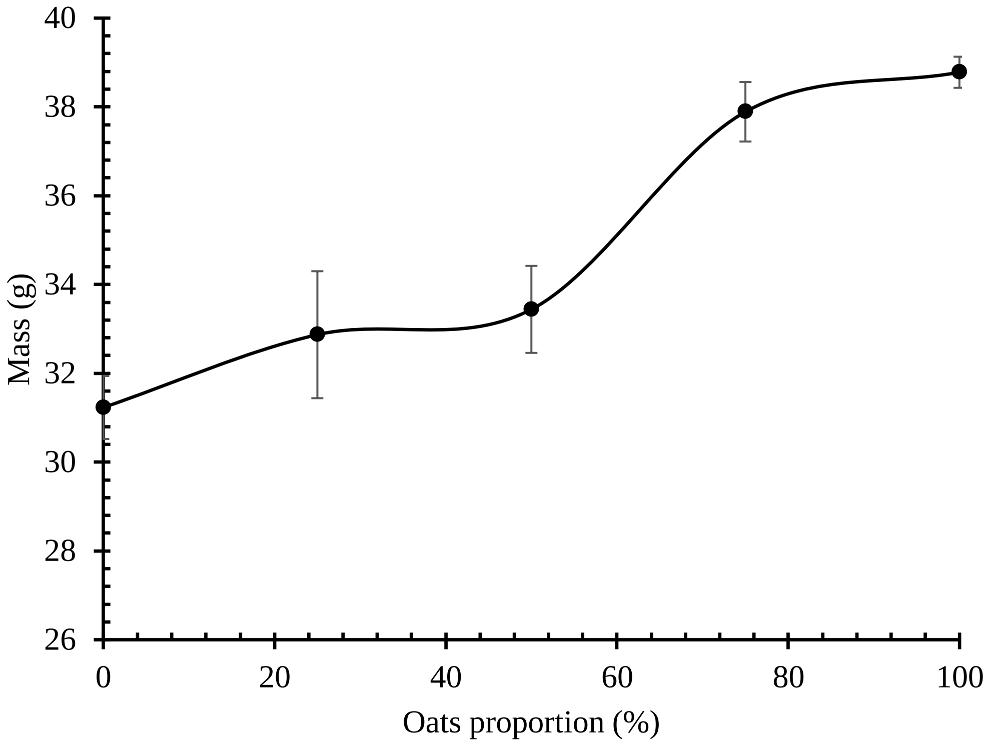

Fig. 4.2 Effect of oats flour on weight of the muffins

*Values are the means of three determinations. Vertical error bars represent standard deviation.

From the Fig. 4.2 it was seen that the incorporation of oats increases the weight of muffins. The same conclusion was drawn by Vittadini and Vodovotz (2007). As the weight of oats flour is denser than the wheat flour so the mass of oats is greater than wheat flour with the same volume. Volume of a muffin is also affected by water level and oats having higher water holding capacity entrap higher amount of water than wheat flour which causes the increase in weight of the product. This result is supported by Knuckles *et al.* (1997) and Mudgil *et al.* (2016).

4.4 Specific loaf volume

As the incorporation of oats flour in muffin increases, the specific loaf volume decreases. The LSD shows that formulations A, B, C, D and E are significant different among themselves at 5% level of significance which is clear from Fig. 4.3. Vittadini and Vodovotz (2007) found similar results when comparing the loaf volume of soy and wheat cakes.

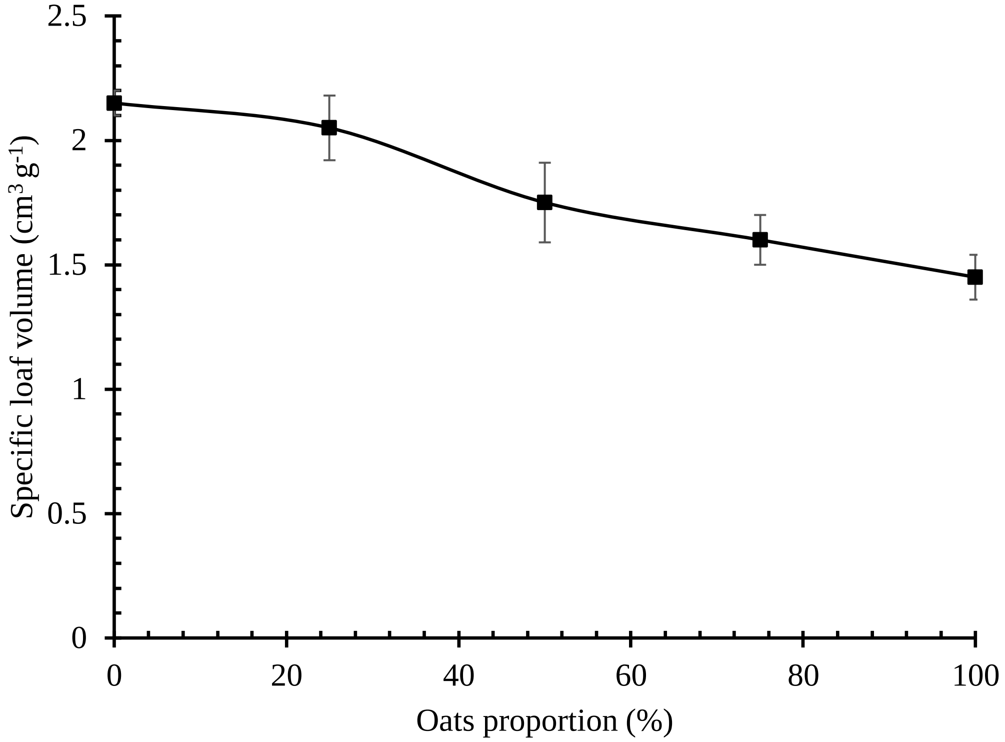

Fig. 4.3 Effect of oats flour on specific loaf volume of the muffins

*Values are the means of three determinations. Vertical error bars represent standard deviation.

Specific loaf volume is an important parameter to analyze the quality of the muffin which is directly affected by volume and weight of the product. Weight and volume are influenced by particles size, particle weight, amount of water, gluten content, fiber content (Mudgil *et al.*, 2016). As the incorporation of oats flour increases the specific loaf volume of the muffin decreases this is most probably due the gluten content of the product. Higher the wheat flour content high is the specific loaf volume. Because wheat content 75 to 80% of protein which comprise of glutenin and gliadin but oats being a gluten free cereal can't give rise to volume as wheat flour did. This result is also supported by Vittadini and Vodovotz (2007) and Knuckles *et al.* (1997).

4.5 Sensory properties

Statistical analysis of sensory scores obtained from 11 semi-trained panelist using 9-point hedonic rating scale (9= like extremely, 1= dislike extremely) for oats muffin formulation. Panelists are those who have tasted muffins. The ANOVA and LSD table for sensory evaluation are presented in the Appendix B.

Here A (50% oats flour 50% wheat flour), B (75% oats flour 25% wheat flour), C (100% wheat flour), D (75% wheat flour 25% oats flour), E (100% oats flour).

4.5.1 Appearance

The mean sensory score for appearance were found to be 7.000, 8.091, 7.909, 6.909, and 6.727 for the muffin formulation A, B, C, D, and E respectively. Statistical analysis showed that partial substitution of wheat flour with oats flour had significant effect ($p<0.05$) on the appearance of the different muffin formulations. The product B and C were not significantly different to each other but significantly different to other, which is shown graphically in Fig 4.4. The product B and C got highest score than product A, D and E.

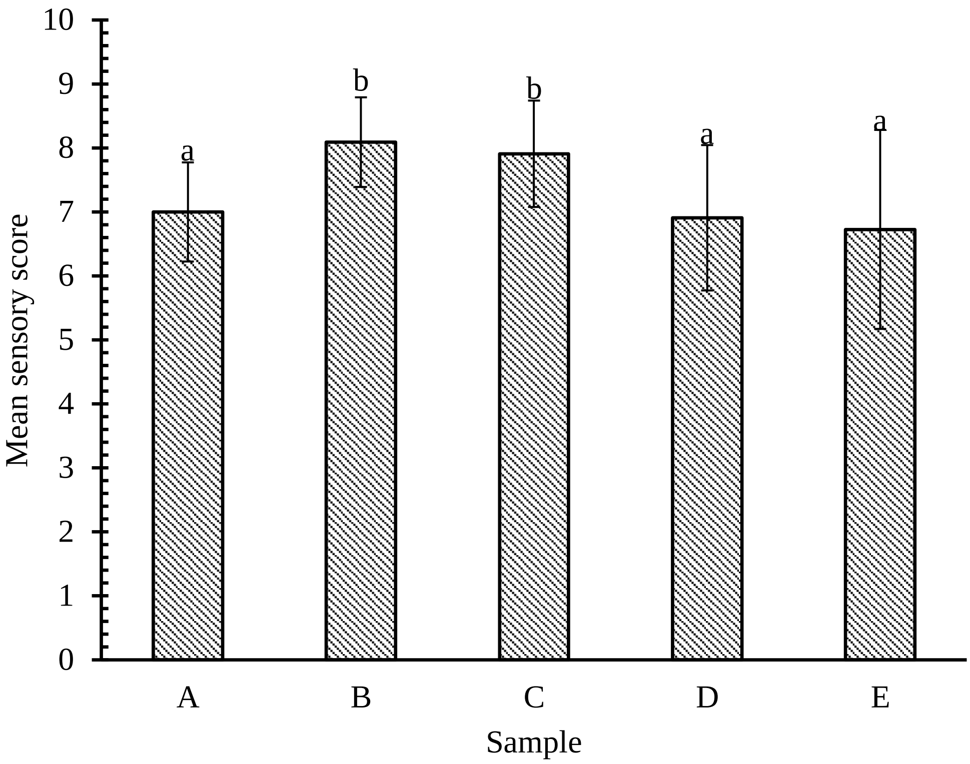

Fig. 4.4 Mean sensory scores for appearance of muffins of different formulations. Bars with similar alphabets at the top are not significantly different.

Gluten is a protein that makes dough elastic and baked goods chewy. Without gluten, oat flour can leave your baked goods heavy or the item may fall apart. Many people are attracted to oat flour for their baking because it is gluten-free, unlike wheat flour. Some people avoid gluten because of medical or dietary concerns (Zhao *et al.*, 2014).

4.5.2 Color

The mean sensory score for color were found to be 6.818, 7.909, 8.091, 6.727 and 6.636 respectively for the muffin formulation A, B, C, D and E respectively. Statistical analysis showed that the partial substitution of wheat flour with oats flour had significant effect ($p<0.05$) on the color of the different muffin formulations. Product B and C were not significantly different to each other but significantly different to other which can be seen in Fig. 4.5. Similarly, product A, D and E were also not significantly different. Product B and C had high mean score. The color of B (75% oats flour and 25% wheat flour) and C (100% wheat flour) were found to be significantly superior.

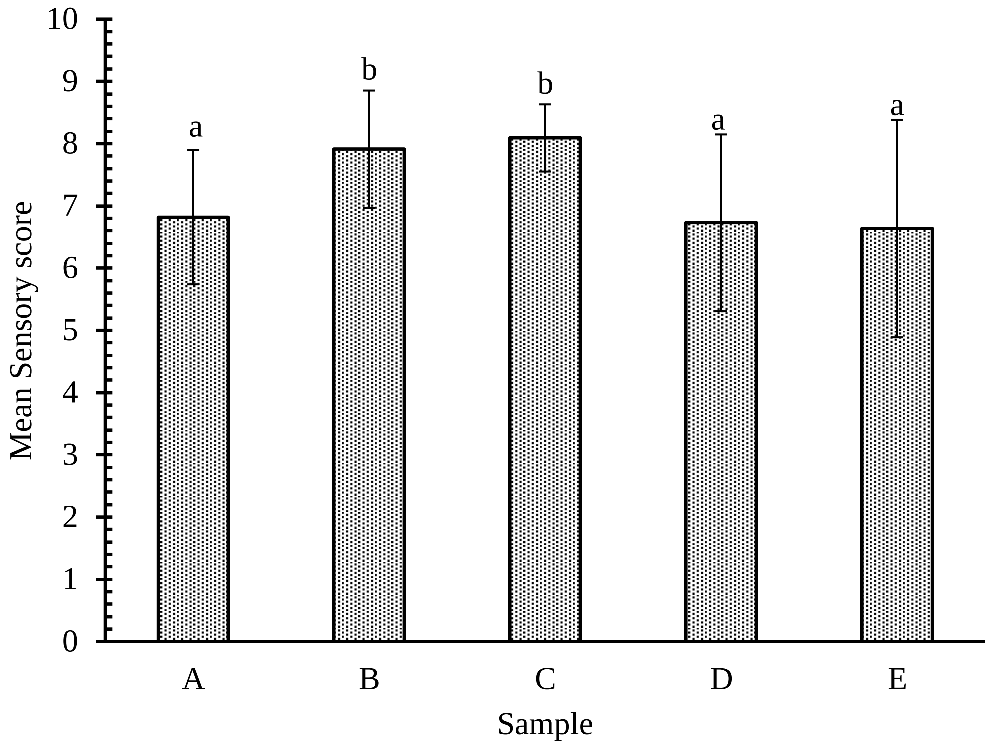

Fig. 4.5 Mean sensory scores for color of muffins of different formulations. Bars with similar alphabets at the top are not significantly different

The sample B got the higher score may be due to the appropriate amount oats flour. The result is in accordance with Masoodi and Bashir (2012) who found that the colour of the fortified bread attained more dark colour as the supplementation was increased. However, the texture was slightly decreased with supplementation but described no undesirable change. Color in baked goods comes from two sources: intrinsic color imparted by individual ingredients and developed color resulting from the interaction of ingredients (Acosta and Cavender, 2011). Millard browning results from interactions of free amino groups with reducing sugars, and when compared with amylose, amylopectin has more reducing ends (Zanoni *et al.*, 1995).

4.5.3 Texture

The mean sensory score for texture were found to be 6.73, 7, 7.36, 6.55 and 6.36 for muffin formulation A, B, C, D and E respectively and is shown in Fig 4.6. Statistical analysis showed that the partial substitution of wheat flour with Oats flour had no significant effect (p<0.05) on the texture of the different muffin formulations. None of the sample was significantly different from each other.

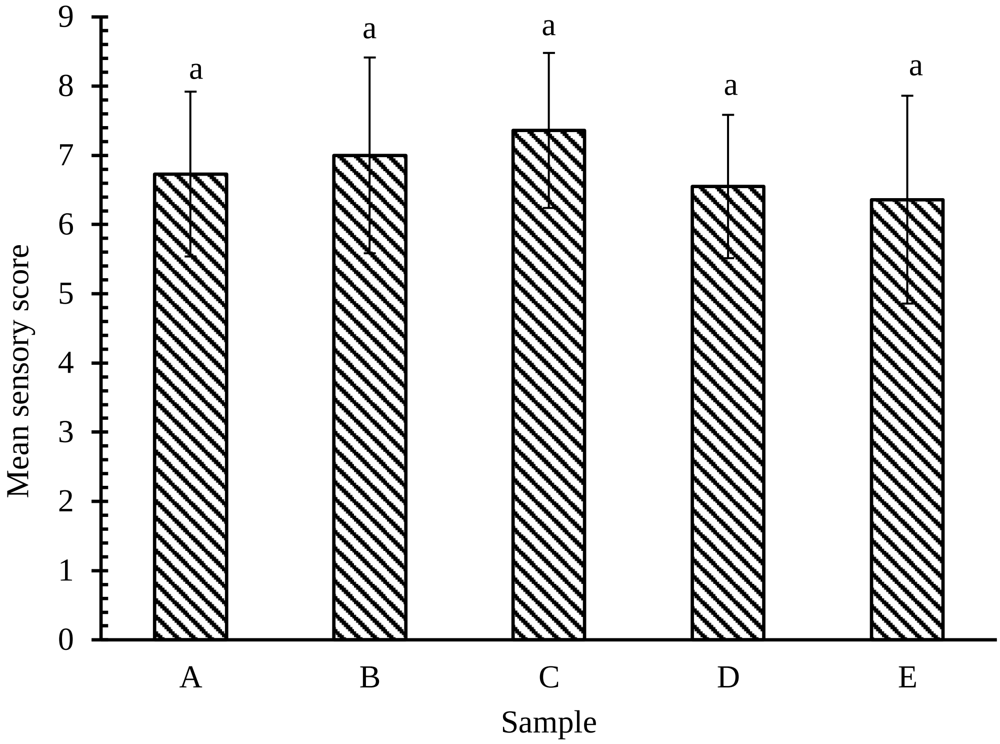

Fig. 4.6 Mean sensory scores for texture of muffins of different formulations. Bars with similar alphabets at the top are not significantly different.

4.5.4 Taste

The mean sensory score for taste were found to be 7.09, 7.45, 7.64, 6.73 and 7 for muffin formulation A, B, C, D and E respectively and is plotted in Fig. 4.7. Statistical analysis showed that the partial substitution of wheat flour with oats flour had no significant effect (p<0.05) on the taste of the different muffin formulations. None of the sample was significantly different from each other as sweetener, shortening agent and leaving agent used were same for all formulation and taste from these ingredient overcome the taste of oats and wheat flour.

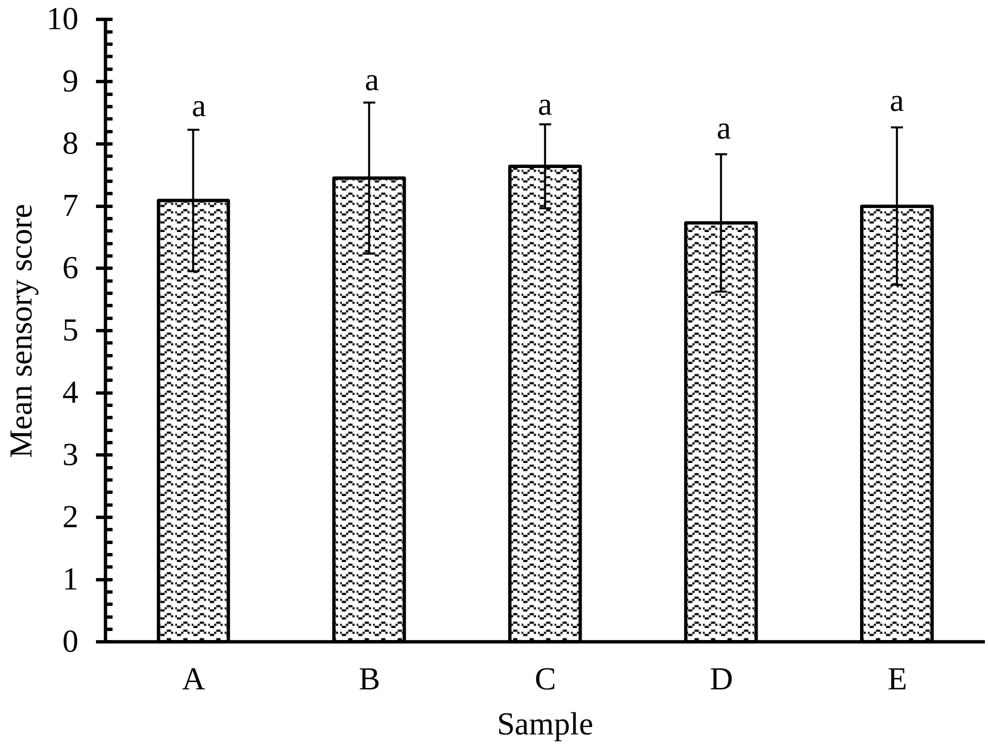

Fig. 4.7 Mean sensory scores for taste of muffins of different formulations. Bars with similar alphabets at the top are not significantly different.

4.5.5 Flavor

The mean sensory score for flavor were found to be 7.091, 7.455, 7.091, 6.545 and 6.727 for muffin formulation A, B, C, D and E respectively. Statistical analysis showed that the partial substitution of wheat flour with Oats flour had significant effect ($p<0.05$) on the color of the different muffin formulations. Product B got highest score which was significantly different from other formulation which is shown in Fig 4.8.

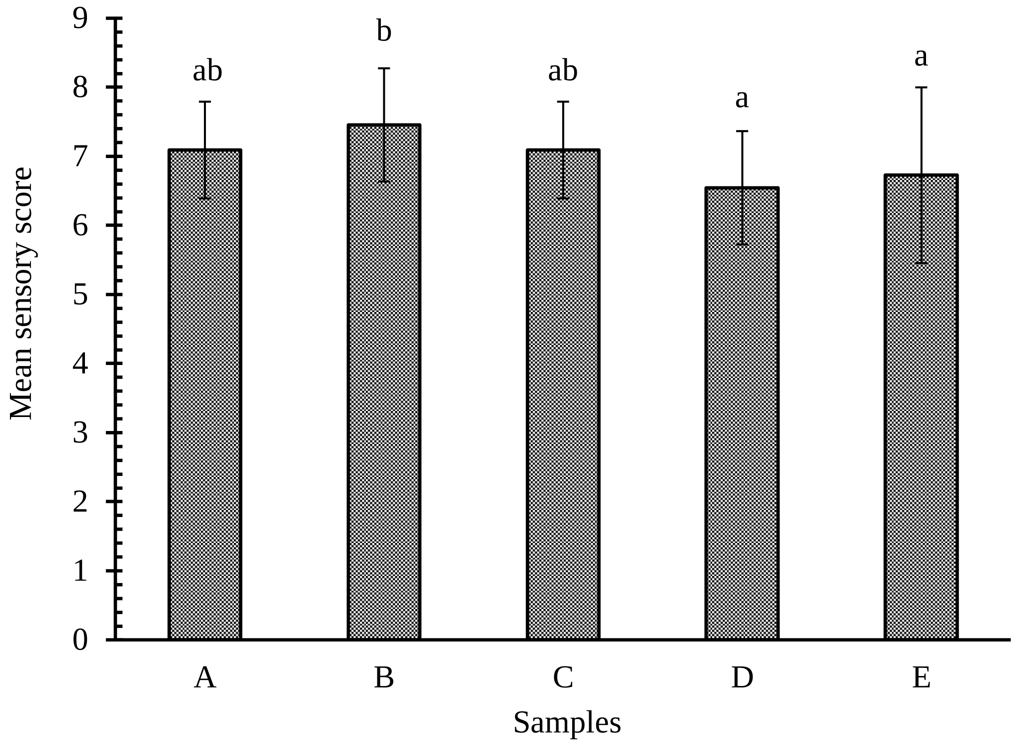

Fig. 4.8 Mean sensory scores for flavor of muffins of different formulations. Bars with similar alphabets at the top are not significantly different

The muffin with the higher amount of oats flour is preferred which could indicate that due to the more amount. The flavor of native oat is mild and during heating there arises combination of volatile and nonvolatile compound, including or produced from phenolic, amino acid and peptides, sugars and fatty acids (Welch and McConnell, 2014). The flavor of sample B was found to be of balanced flavor giving as a whole of blended flavor which was preferable to other product formulations. Oat and wheat flour have similar flavors, though many will find that an oat flour has a heartier flavor than all-purpose wheat flour. It is also somewhat sweeter than whole wheat flour, so we may consider adding less sweetener to your recipe (Mickee, 2015).

4.5.6 Overall acceptability

The mean sensory score for overall acceptability were found to be 6.909, 7.818, 7.545, 6.545 and 6.364 for the muffin formulation A, B, C, D, and E respectively, which is plotted in Fig 4.9. Statistical analysis showed that partial substitution of wheat flour with oats flour had significant effect ($p<0.05$) on the overall acceptability of the different muffin formulations. The product D and E were not significantly different to each other but significantly different to other samples. The product B got highest score than product A, D, C and E. Similarly, 75 parts of oats flour provide good flavor, color and solubility capacity might have provided good mouth feel in sample B.

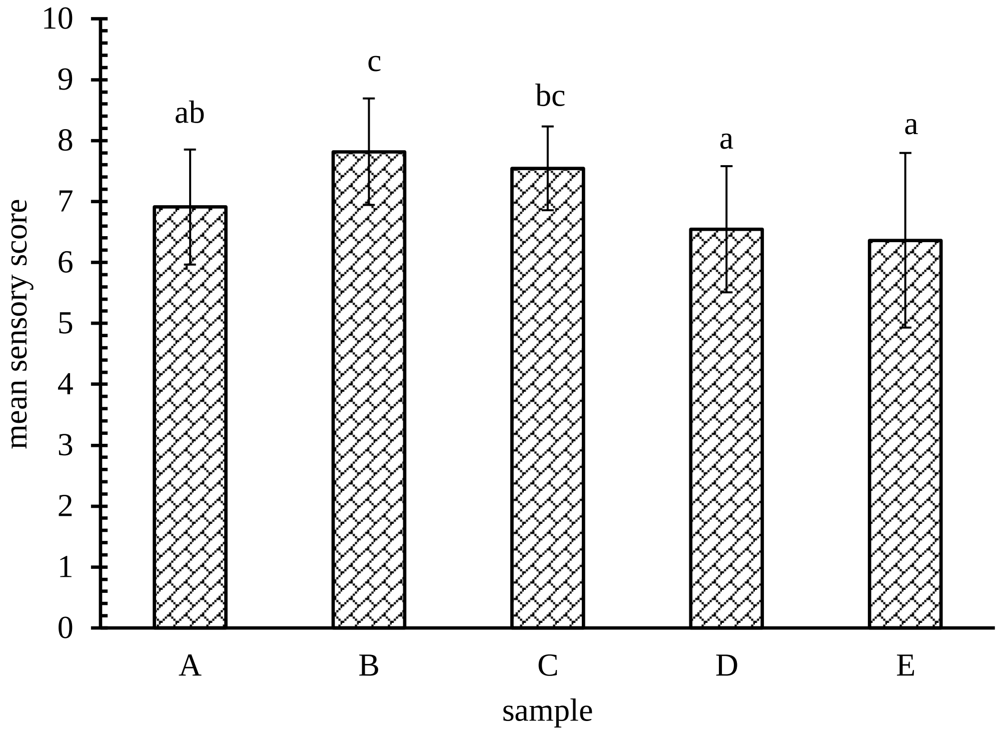

Fig. 4.9 Mean sensory scores for overall acceptability of muffins of different formulations. Bars with similar alphabets at the top are not significantly different.

Appearance, color and flavor of product B was very much liked. Therefore product B got high score in term of overall acceptability as shown in Fig. 4.9. The overall acceptability of the 75% Oats flour and 25% wheat flour incorporated muffin was found to be significantly superior.

4.6 Proximate composition of product

Thus from statistical sensory analysis, the best product was found to be sample B muffin containing 75% of oats flour and 25% of wheat flour. The proximate composition of sample B and control muffin (100% wheat flour) were presented in Table 4.2.

Table 4.2 Proximate composition of product

Parameters	Product C (Control)	Product B (Best)
Moisture	$32.183^{a} \pm 1.75$	$37.06^{b} \pm 0.93$
Crude Protein	$14.47^{a} \pm 0.35$	$18.11^{b} \pm 0.27$
Crude Fat	$26.89^{a} \pm 0.63$	$27.48^{a} \pm 0.02$
Crude Fiber	$0.51^{a} \pm 0.07$	$0.92^{a} \pm 0.23$
Total Ash	$0.48^{a} \pm 0.02$	$1.39^{b} \pm 0.31$
Carbohydrate	$25.48^{b} \pm 1.57$	$15.04^{a} \pm 1.01$

*Values are the means of triplicates and figures in the parenthesis are standard deviation of the triplicates. Values in the column having different superscripts are significantly different at 5% level of significance.

The moisture content, protein, fat, crude fiber, ash and carbohydrate of product B were found to be 37.06, 18.11, 27.48, 0.92, 1.39 and 15.04 respectively and that of product C were found to be 32.183, 14.47, 26.89, 0.51, 0.48 and 25.48 respectively. The LSD shows that these proximate values are significantly different from product B.

Moisture content of product B was 37.06% while that of product C was 32.183%. The higher moisture content of oats incorporated product may be due to high water holding capacity of oats.

The higher moisture content makes it prone to microbial attack but it also gives the characteristic firmness to the muffins.

The increase protein content of product B may be due to the incorporation of oats flour in muffins. The crude fat content of product B is higher than product C which may be due to the 8.3% fat content in oats flour contribute to more fat. The crude fiber and total ash of product B was 0.92 and 1.39% while for product C 0.51% and 0.48% were obtained.

Other research work done by Acosta and Cavender (2011) have reported similar findings. The carbohydrate content decreases with increase in proportion of oats in muffins., supporting the claims of Khoueyieh *et al.* (2005).

4.7 Chemical and microbiological analysis of product

The product B was kept in packaging material i.e. LDPE (50 µ). Then that was kept in normal atmospheric condition for microbiological and chemical analysis for 5 days. The free fatty acid (as oleic acid) of extracted fat of fresh muffin (0 day) was found to be 0.41% while that after three day was found to be 0.46% which indicates no danger of rancidity (Manly, 1996). The total plate count (TPC) of the stored muffin was analyzed. There were no colonies of coliform found. They were destroyed during the baking of muffin before packaging. Also there were no any colony of yeast and mold up to 4 days.

4.8 Cost of the oats flour incorporated muffin

The total cost associated with the best product was calculated and the cost of oats flour incorporated muffin was NRs. 47.40 including overhead cost and profit of 10%. From the cost calculation given in appendix D, it can be seen that due to the high cost of oats flour to prepare muffin, the cost of muffin has been increased.

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. Oats flour is superior to wheat flour in terms of crude protein, crude fat, crude fiber and total ash
2. The oats flour can be incorporated up to 75% with 25% wheat flour, with no adverse effect on sensory quality of muffin.
3. The nutritional quality of the oats muffin seemed to be enhanced in the case of fiber and protein content.
4. The chemical and microbiological analysis of product shows acceptability of muffin was up to four days at room temperature without any artificial preservatives used.

5.2 Recommendations

1. Oats muffin can be commercialized by substituting wheat flour by oats flour up to 75% of the total mixture.
2. Texture of the prepared muffin can be analyzed using texture meter.

Part VI

Summary

Muffin are a type of semi-sweet cake or quick bread i.e. baked in appropriate portion. Oats (*Avena Sativa*) is a minor cereal crop, which is nutritive and richest natural food known and produced annually. However, it has several uses it is not utilized in commercial way in context of Nepal. In term of nutrition value, oats cereal have relatively high content of protein, soluble fiber while it has low fat content and calories value. Thus the preparation of muffin leads to higher use and commercial production of oats. In fact, oats could be used wherever high gluten content cereals are used. The present study deals with the formulation that can add value to oats.

For the preparation of oats muffin, the oats flakes were grinded to a fine oats flour. Response surface methodology was used for the formulation of recipe and for this Design Expert v. 7.1.5 software was used. Five different muffin formulation namely A (50 parts oats flour), B (75 parts oats flour), C (0 parts oats flour), D (25 parts oats flour) and E (100 parts oats flour) were prepared by muffin mixing process. The other ingredient fat 65 parts, pulverized sugar 60 parts, baking powder 1.42 parts, 57 parts egg were taken constant. The five different muffin sample were prepared and subjected to sensory evaluation.

Sensory evaluation was carried out based on appearance, color, flavor, taste, texture and overall acceptability. The data obtained were statistically analysed using two way ANOVA (no blocking) at 5% level of significance. Sample B (OF: WF: 75:25) got the highest mean sensory score. The proximate analysis for moisture, crude protein, crude fat, crude fiber, total ash and carbohydrate were found to be 13.07%, 11.94%, 8.3%, 1.04%, 1.6% and 64.07% and 37.06%, 18.11%, 27.48%, 0.92%, 1.39%, and 15.04% of oats flour and sample B respectively. The loaf volume decreases with the increase in oats flour proportion.

The free fatty acid as oleic acid and peroxide value of sample B at day 0 was found to be 0.41 mg KOH/g oil and 1.34 meq O_2/kg fat respectively. The product was further analysed for prediction of shelf life based on yeast and mold. No colony of yeast and mold were found from day 0 to day 4.

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Appendices

Appendix A

Sensory evaluation score sheet oats flour incorporated muffin

Date:

Name of Panelist:

Name of the product: Oats flour incorporated muffin

Dear panelist, you are provided 5 samples of Oats flour incorporated muffin on each proportion with variation on Oats 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 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

Parameters	Sample Code				
	A	B	C	D	E
Appearance					
Color					
Flavor					
Taste					
Texture					
Overall acceptability					

Any Comments:

Signature:

Appendix B

ANNOVA results of sensory analysis

Table B.1 ANNOVA (no blocking) for appearance of oats incorporated muffin

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Sample	4	17.2	4.3	8.11	<.001	0.6274
Panelist	10	33.7091	3.3709	6.36	<.001	0.9306
Residual	40	21.2	0.53			
Total	54	72.1091				

Table B.2 ANNOVA (no blocking) for color of oats incorporated muffin

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Sample	4	21.7455	5.4364	7.19	<.001	0.749
Panelist	10	43.9273	4.3927	5.81	<.001	1.112
Residual	40	30.2545	0.7564			
Total	54	95.9273				

Table B.3 ANNOVA (no blocking) for flavor of oats incorporated muffin

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d.
Sample	4	5.5273	1.3818	2.87	0.035	0.5982
Panelist	10	20.1818	2.0182	4.19	<.001	0.8873
Residual	40	19.2727	0.4818			
Total	54	44.9818				

Table B.4 ANNOVA (no blocking) for taste of oats incorporated muffin

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Sample	4	5.8182	1.4545	2.04	0.108	0.728
Panelist	10	31.7818	3.1782	4.45	<.001	1.081
Residual	40	28.5818	0.7145			
Total	54	66.1818				

Table B.5 ANNOVA (no blocking) for texture of oats incorporated muffin

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Sample	4	6.8	1.7	1.83	0.142	0.831
Panelist	10	42.8	4.28	4.6	<.001	1.233
Residual	40	37.2	0.93			
Total	54	86.8				

Table B.6 ANNOVA (no blocking) for overall acceptability of oats incorporated muffin

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	l.s.d
Sample	4	17.3818	4.3455	6.63	<.001	0.698
Panelist	10	26.3273	2.6327	4.02	<.001	1.035
Residual	40	26.2182	0.6555			
Total	54	69.9273				

Appendix C

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

	Product C	Product B
Mean	32.183	37.06
Variance	3.0625	0.8649
Observations	3	3
Hypothesized Mean Difference	0	
Df	3	
t Stat	-4.26246	
P(T<=t) one-tail	0.011843	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.023686	
t Critical two-tail	3.182446	

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

	Product C	Product B
Mean	14.47	18.11
Variance	0.1225	0.0729
Observations	3	3
Hypothesized Mean Difference	0	
Df	4	
t Stat	-14.2626	
P(T<=t) one-tail	7.02E-05	
t Critical one-tail	2.131847	
P(T<=t) two-tail	0.00014	
t Critical two-tail	2.776445	

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

	Product C	Product B
Mean	26.89	27.48
Variance	0.3969	0.0004
Observations	3	3
Hypothesized Mean Difference	0	
Df	2	
t Stat	-1.62126	
P(T<=t) one-tail	0.123206	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.246413	
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 C	Product B
Mean	0.51	0.92
Variance	0.006241	0.0529
Observations	3	3
Hypothesized Mean Difference	0	
Df	2	
t Stat	-2.92012	
P(T<=t) one-tail	0.049996	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.099992	
t Critical two-tail	4.302653	

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

	Product C	Product B
Mean	25.48	15.04
Variance	2.4649	1.0201
Observations	3	3
Hypothesized Mean Difference	0	
Df	3	
t Stat	9.686341	
P(T<=t) one-tail	0.001168	
t Critical one-tail	2.353363	
P(T<=t) two-tail	0.002337	
t Critical two-tail	3.182446	

Appendix D

Table D.1 Cost calculation of the product (OFIM)

Particulars	Cost (NRs/kg)	Weight in a lot (g)	Cost (NRs)
Wheat flour	38	25	0.95
Oats flour	562	75	42.15
Sugar	65	60	3.9
Fat	310	65	20.15
Egg	380	57	21.66
Baking powder	125	1.42	0.1775
Raw material cost			88.9875
Processing and labor cost (10% of raw material cost)			8.89875
Profit (10%)			9.7886
Grand total Cost			107.67485
Average weight of OFIM (g)		283.42	
Total no. of OFIM formed		18	
Total weight of OFIM (g)		5101.56	
Total cost of OFIM (NRs/100g)			47.40

Color plates

P1: Prepared muffin samples

P2: Sensory samples

P3: Panelist performing sensory