EFFECT OF INCORPORATION OF MALTED BARLEY IN THE QUALITY OF BISCUITS

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Approval Letter

This *dissertation* entitled *Effect of Incorporation of Malted Barley in the Quality of Biscuits* presented by Sangita Sah has been accepted as the partial fulfillment of the requirement for the B. Tech. degree in the Food Technology

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Abstract

Malted barley incorporated biscuit is a thin, small, unleavened, typically crisp, flat and sweet biscuit prepared using malted barley flour and wheat flour as the major ingredients. The aim of this study was to prepare malted barley incorporated biscuit and evaluate of its effect on the biscuit quality. The recipe was formulated through the DOE software Design Expert v7.1.5 for mixture method. Malted barley incorporated biscuit was prepared by soft dough process by partially substituting wheat flour with malted barley flour in the range 0 to 50 parts. The sensory analysis of the formulated biscuits were carried out for acceptability through 9-point hedonic rating (9= like extremely, 1= extremely dislike) for color, flavor, texture, taste, overall acceptability attributes. The obtained data were statistically analyzed using two-way ANOVA (no blocking) at 5% level of significance.

Biscuit with the incorporation of 16.67 parts of malted barley flour was selected as the best formulation and subjected for further physiochemical analysis. The crude protein, fat, fiber, total ash and total carbohydrate of malted barley flour incorporated biscuit were found to be 11.21%, 20.45%, 3.14%, 1.71% and 61.08% (db) respectively whereas the same parameters for wheat flour biscuit were found to be 6.8%, 15.8%, 1.23%, 1.30%, 72% respectively. These findings suggest that malted barley flour can be successfully incorporated in refined wheat flour up to the concentration of 16.67 parts without any adverse effect on sensory attributes. The iron content and calcium content of the barley grain and malt were also calculated and found to be 5.67 mg/100 g; 8.52 mg/100 g and 140 mg/100 g; 165 mg/100 g. Malting of barley significantly increases amylase activity, increasing the level of reducing sugar. The calcium, fat, fiber and ash content were found to be higher in malted barley incorporated biscuit in comparison to normal wheat flour biscuit.

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List of Abbreviations

Abbreviation	Full form
ANOVA	Analysis of Variation
CCT	Central Campus of Technology
CFTRI	Central Food Technology Research Institute
FAO	Food and Agriculture Organization
LI-BIRD	Local Initiatives for Biodiversity, Research and Development
NARC	Nepal Agriculture Research Council
KMS	Potassium metabisulphite
SMP	Skim Milk Powder

Part I

Introduction

1.1 General introduction

Humans have consumed bakery products for hundreds of years. Among the different bakery products, biscuits constitute the most popular group. Biscuits are confectionery dried to very low moisture content. Biscuit is defined as a thin flat baked product made from flour, salt, sweetening agent, fat and preservatives. They are crisps, unleavened and sometimes sweet pastry produced by the addition of baking powder or soda, sometimes with chocolate or fruit input. Biscuit can also be defined as a baked product having not less than 8% of flour content calculated. Bohn (1956) Stated that biscuits are termed "cookies" in USA but the word biscuit means a small cake like bun.

Biscuit, this word has its origin from the Latin word Bixcuit where, Bix- means twice and – cuit means baked (Ed, 1976). Biscuit is a kind of crispy dry bread, more or less hard, variously flavored and usually unleavened, prepared usually in small, flat, thin cakes Smith (1972).

During ancient days biscuit was one of the best and most suitable foods to be carried along during long voyages especially due to its higher shelf life and nutritive value. Those biscuits were called as ship's biscuit; Walker's dictionary defines: 'Biscuit is a kind of hard, dry bread, made to be carried to sea as a substitute of bread; it is a composition of fine flour, almonds and sugar.'

Based upon these old themes, biscuits have gone through various modifications through new trials till this date. Nowadays various ranges of biscuits with distinct identical qualities and composition are found in the market.

Wheat flour is a principal raw material in biscuit production. Its superiority over other cereals is due to the presence of gluten, which inherently imparts all the essential qualities to their products. The absence of this simple protein in non-wheat flour makes them unsuitable as substitutes for wheat flour. Choice of raw materials is generally done as per the quality and organoleptic requirement of the final product (Martins *et al.*, 2017).

The Composite Flour Program was established by the Food and Agriculture Organization in 1964 to find new ways of using flours other than wheat, particularly maize, millet and sorghum, barley in bakery and pasta products, with the objective of stimulating local agricultural production, and saving foreign exchange, in those countries heavily dependent on wheat imports (Kent and Evers, 2004).

Similarly, barley (*Hordeum vulgare)* was presumably first used as human food but evolved primarily into a feed, malting and brewing grain due in part to the rise in prominence of wheat and rice, and there is renewed interest throughout the world in barley food because of its nutritional value. β-glucans (from barley, oat, and other cereals) has also been regarded as important functional ingredients for the cereal foods industry (Brennan and Cleary, 2005). Anti-nutritional factors however need to be addressed as grains have nutritional value which is of public importance. Barley is staple food in Nepal. These are oldest crop known to human beings (Paudyal, 2001)**.** 18.7% of the people of Nepal are below poverty line (Anon., 2020) and are engaged in agriculture and mainly produce rice, maize, wheat, barley etc.

Malting is the process to produce fermentable sugar and free amino acid by activity of enzymes synthesized during seed germination. The steps of malting are usually given as steeping, germination and kilning. During malting the cereal grain undergoes three main types of modification: (1) mobilization of hydrolytic enzymes; (2)a variety of chemical changes that occur in the grain and; (3) physical change that appear as softening and weakening of the grains. The modification renders the constituents of the grain more readily soluble, which is significant in different respects including that it results in less viscous food products and it enables biochemical reactions (e.g. mashing reactions in brewing) to occur (Briggs *et al.*, 2004).

1.2 Statement of the problem

Wheat flour used for the production of biscuits is deficient in several nutrients including some vitamins, mineral elements as well as dietary fiber (Awan *et al.*, 1991). Wheat flour lacks certain essential amino acids such as lysine, tryptophan and threonine (Kent and Amos, 1983); hence ,the low nutritive value of biscuits is an issue of great concern because biscuits are the most commonly eaten snacks by school children who need more protein per unit body weight than adults.

Malted barley is highly nutritious food but rarely used in making of baked products. The use of malted barley in biscuits making would greatly enhance the utilization of this crop in field other than brewing. Use of malted barley increases bio-functional substances and improve organoleptic qualities due to softening of texture and increase of flavor in grains which leads to particular flavor given to the derived products (Rimsten *et al.*, 2002). Malting of barley helps in the production of simple sugar and free amino acids i.e., it improves amino acid availability, particularly lysine, methionine and tryptophan that are lacking in cereals. The blending of whole malted barley flour, even at low ratio of inclusion (16.67%) caused increase in protein, ash and crude fiber contents.

Thus, incorporation of malted barley flour for the biscuits production can be milestone to overcome the nutritional short -comes mentioned above as well as it may be introduced in baking industries.

1.3 Objectives of the study

1.3.1 General objective

The general objective of this work is to study the effect of incorporation of malted barley flour in the quality of biscuit.

1.3.2 Specific objectives

The specific objectives of the study were to:

1. Prepare the flour of malted barley.
2. Analyze of malted and un-malted barley flour and wheat flour.
3. Prepare of biscuits.
4. Evaluate of sensory properties of prepared biscuits, and
5. Carry out chemical analysis of control and most rated biscuit.
6. Calculate the cost of prepared biscuit.

1.4 Significance of study

Snacks are the major food bulk consumed by a human every day. Hence, alike lunch, dinner and breakfast, snacks also should be rich in nutritional value. Biscuits have become a famous snack in developing country like ours due to its low price and ready to eat instant characteristics. Hence, such food must be nutritionally as rich as possible.

Many researches have been carried out in context of the nutritional value of normal wheat flour biscuits. Wheat biscuit is considered nutritionally poor due to deficiency of most indispensable amino acids especially lysine and fortification of wheat flour with non-wheat proteins and fiber at different ratios resulted in increase the protein and fibre quality through improving its amino acid profile (Stark *et al.*, 1975). Malted barley in many instances adds texture, flavor, aroma, and nutritional value to the product (Taylor, 2005).

There is renewed interest throughout the world in barley food because of its nutritional value. β-glucans (from barley) has also been regarded as important functional ingredients for the cereal foods industry (Brennan and Cleary, 2005). Germination of barley increases oligosaccharides and amino acids concentration. Decomposition of high molecular weight polymers cause generation of bio-functional substances and improvement of organoleptic qualities due to softening of texture and increase of flavor in grains which leads to particular flavor given to the derived products (Rimsten *et al.*, 2002).

1.5 Limitations of study

1. Study on the packaging material and shelf life of the product was not carried out.
2. Texture analysis was limited to sensory test.

Part II

Literature review

2.1 Biscuits

Biscuit, this word has its origin from the Latin word Bixcuit where Bix- means twice and cuit- means baked (Ed, 1976). Biscuit is a kind of crispy dry bread, more or less hard, variously flavored and usually unleavened, prepared usually in small, flat, thin cakes (Smith, 1972).

Biscuits are ideal for nutrient availability, palatability, compactness and convenience. They differ from other baked products like bred and cakes because of having low moisture content, comparatively free from microbial spoilage and long shelf life of the product (Wade, 1988). Although the first biscuit were dried-out rusks, useful as long-life food for sea journeys, early cooks making confections wit fat and sugar would have found that if little dough pieces are baked in a typical hot oven and taken out when they have a good colour and a stable structure they would not have been dry enough to be entirely crispy. Putting them back into somewhat cooler oven to dry them out improved their eating qualities and also their shelf life. Baking from the start in a cooler oven for a longer period allows drying but results in less coloration and structure development. However, the term biscuit was applied originally to dried bread pieces. These were also sweetened and flavored with spices. Other products like our modern biscuits were made but called by more cake-like names for example: shortcake ad shortbread etc. (Manley, 2000).

The definition of biscuit may differ from place to place, for example, biscuit is known as biscuit in the UK but called cookie in the USA. The USA biscuit may mean the equivalent of the English muffin.

Now biscuits are made mostly in factories on large production plants, these plants are large and complex and involve considerable mechanical sophistication. Forming, baking and packaging are largely continuous operations but metering ingredients and dough mixing are typically done in batches (Manley, 1998).

2.1.1 Classification of biscuits

Biscuits are generally classified as hard dough and soft dough type of biscuits as per the protein composition of the flour used. The soft dough group comprises all the sweet biscuits having many factors in common whereas the hard dough biscuits fall naturally into three sections: fermented dough, puff dough and the semi-sweet dough (Whitely, 2012).

2.1.1.1 Soft dough biscuits

Soft dough biscuits are generally sweet, thin and possess smooth surface with dimensions that are much more regular and consistence than the hard dough biscuits. Generally, they contain higher fat content (25-35%) and sugar (30-45%) and are low in moisture. The higher gluten network development should be avoided which can be achieved by:

a) Weak flour

b) Lower moisture content

c) Short mixing time

d) Less aerating agents

Soft dough biscuits are less versatile because of the inherent nature of the dough (Manley, 1983).

2.1.1.2 Hard dough biscuits

Hard dough biscuits generally contain less fat (10-20%) and low sugar content (10- 18%). The dough adheres due to its higher water content and relatively lower fat content. This type of formulation produces an extensive gluten structure. The long mixing time develops the gluten and the mixer action stretches and orients the gluten strands to a point where much of the elasticity is destroyed. The water content varies in accordance with the flour strength, which might be as high as 20% of the flour weight (George, 1981). Further according to the variance in composition of one or more parameters hard dough biscuits can be further divided into:

a) Semi – sweet biscuits

The flour used in semi-sweet biscuits should be the weakest possible to obtain. This is because of the low amount of fat and sugar and high amount of water. The dough produces and extensive gluten structure and system. To prevent this, a long mixing time and addition of sodium metabisulphite are followed. Slow cooling is important as this is notoriously susceptible to checking (George, 1981).

b) Puff dough biscuits

This is hard biscuit being well layered and puffed to a low density and has a typical flavor vaguely reminiscent of fried goods such as doughnuts. These biscuits are comparatively expensive to produce. The leavening in the dough is by fat application in the biscuits in between the dough sheets, the most efficient manner being with an actual layering of an elastic dough phase and sheets of fats. The dough and fat should have nearly the same flow properties and care need to be taken that the fat does not become part of the homogeneous dough phase as this will not contribute to layering but instead reduces the elasticity of the dough and gives undesirable outcome.

In order to ensure proper thickness of each layer and proper retention of each layer in this final dough piece, the following conditions need to be maintained:

- The gluten must be developed to a point which will properly stretch during reduction.
- The roll in, though plastic and semi-solid, must gradually stretch along with the dough in order to break the continuity of its ultimate shape.
- After mixing (15 min) and relaxation (30 min) 60% of the puff dough margarine is applied and sheeted. The sheet is laid off for 15 min. and rest of the fat is applied (George, 1981).

c) Fermented dough biscuits

These biscuits include the cream and soda crackers. Crackers (salty biscuits) are prepared from large amount of flour containing protein (8-11%) but small amount of sugar, oil of fat. Yeast is required for fermentation. Crackers have a flaky texture and crunchy bite. These biscuits can be either made by straight dough method or sponge dough method.

2.2 Chemical composition of biscuits

The chemical composition of biscuit may vary from type of biscuits, method of preparation and consumers' nutritional aspects, which is presented in Table 2.1.

Table 2.1 %Chemical composition of biscuit

Types	Protein	Fat	Total sugar	Other Carbohydrates	Moisture	Salt and chemicals
Soft Dough	6.00	15.80	25.88	49.18	1.25	1.34
Hard dough	7.18	12.26	19.15	59.40	0.90	0.56
Fermented Dough	7.20	27.40	7.20	54.10	1.50	2.10

Source: Rao *et al.* (1991)

2.3 Raw materials for biscuit making

A variety of raw materials are used in biscuits industry whereas raw materials requirements for conventional biscuits produced in mechanized units are well defined. Wheat flour and cereal products, sugar, fat, and water etc. are the major of primary ingredients because they are used in bulk on dough according to the quality of the products.

Salt, skim milk powder (SMP), ammonium bicarbonate, sodium bicarbonate etc. are minor ingredients. Beside these, many coloring and flavoring agents, emulsifiers and other product improvers are used for developing the taste, texture, flavor and appearance of the biscuits. Therefore, these minor ingredients are known as product improvers (Shrestha, 1995). All the ingredients are individually important to obtain more palatable and satisfactory products. These raw materials are found in the form of solid, liquid and paste (Shrestha, 1995).

The major ingredients

1. Flour

Flour is the basic raw material of biscuit production and probably the most variable (Whitely, 2012) and flours for biscuits and cracker use vary in strength and baking characteristics (Bohn, 1956).

Wheat is only the grain, which could yield flour capable of being made into low-density baked products. Wheat is known botanically as Triticum vulgare. Wheat flour is obtained by endosperm in the form of particle small enough to pass through a flour sieve, for example one having 100 mesh per linear inch (Kent and Amos, 1983).

Wheat flour is unique among 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. 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 not soluble in alcohol and water.

Gluten is elastic, cohesive and rubbery and holds together the various ingredients of the dough. It has the property of holding the gases during fermentation and gases given off by the leavening agent during baking. It sets in the 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 sustain wall of the whole structure of baked products (Bohn, 1956). The general requirements for flour characteristics is mentioned in Table 2.2.

Table 2.2 Requirements for flour characteristics

Characteristics	Requirements
Moisture content (%, max)	13.0
Gluten content (on dry basis) (%, max)	7.5
Total ash (on dry basis) (%, max)	0.5
Acid insoluble ash (on dry basis) (%, max)	0.05
Protein (Nx5.7) (on dry basis) (%, max)	9.0
Alcoholic acidity (as H_2SO_4) in 90% alcohol (%, max)	0.1
Water absorption (%, min)	55
Sedimentation value (%, min)	22
Uric acid (mg/100 g) (%, max)	10
Granularity	To satisfy the test

Source: Arora (1980)

Wheat flour (Maida) used for making biscuit should be the product obtained by milling cleaned hard or soft wheat or their blends in a roller flourmill and bolting. Considerable importance is attached to the flour protein level in determining the suitability of flour for a particular type of biscuit. However, protein quality is the factor of most interest to biscuits makers in the context of flour quality. The gluten may be strong and difficult to stretch or weak and easy to stretch. The former is preferred to bread and some crackers and the latter for biscuits. Soft wheat flour is found to be better for making the biscuits.

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. Requirement for flour characteristics are given in above Table 2.2.

The others cereals products are:

a) Corn flour

Corn flour and maize starch are prepared from the cereal *Zea mays*. Maize is Indian corn. The two chief varieties are known respectively as flint maize and dent maize (Sanchez *et al.*, 2002). Corn flour is milled from the endosperm of maize and is very nearly pure starch, because of its high starch content; it can be used to weaken flour which is too strong.

b) Rice flour

It is prepared from the cereal *Oryza sativa.* Rice contains a larger proportion of starch than any other cereals. Although rice is deficient in minerals, fat and protein its use in biscuit making is due to its very easily digestible carbohydrate (Corrêa *et al.,* 2007). Apart from nutritional value its used in biscuit making is done as dusting agent, when dough release from a rotary moulder die is not effective, dies are lightly dusted with rice cones before they receive the dough (Smith, 1972).

c) Oat flour and oat meal

The use of oat products in biscuit making is due to its high nutritive value owing to high proportion of protein and fats. Generally, the oat meal contains higher level of fat (about 6%). The major drawback of its use is due to the off-flavor development during baking and during long storage and baking. However stabilizers may be used to inhibit this problem (Worgan, 1972).

d) soya flour

Soya flour is used in dough due to its emulsifying property and higher level of protein content. The emulsifying action is due to its higher level of lecithin content (Whiteley, 1971).

e) Fats and shortenings

Fats are one of the most important ingredients in biscuit making after wheat flour. One of the most important functions of fat is to shorten baked products which otherwise might be solid masses firmly held together by strands of gluten. Being insoluble in water, fat prevents to cohesion of gluten strands during mixing. Thus, literally shortening then adds making the product tender (Whiteley, 1971).

The action of fat in dough is more one of preventing the gluten forming than actually modifying. Gluten does not form until the flour is in contact with water and mixing action, thus inclusion of fat tends to insulate the gluten forming proteins from the water and consequently, a less tough dough results. Eating qualities after baking are less hard, shorter and more inclined to melt in the mouth (Whiteley, 1971).

The secondary action of fat is to lubricate the gluten, which has formed allowing it to slip into a new position when sheeted or formed into biscuit shapes without the same desire to return to its original position. The fat also improves the softness, texture, palatability and keeping quality of biscuit. During mixing, fat also encourages entrapment and retention of considerable quantities of air, thereby contributing to the texture of the baked products (Whiteley, 1971).

To achieve the best performance, hydrogenated vegetable oils to be used in crackers and sweet goods production should have the following desired qualities:

The material should have the good white to creamy color.

- After keeping the fat at 50°C for 24 h and filtering, the color may be compared with control or standard.
- The fat should have a smooth, uniform texture, free from aby oil separation and large grains.
- The fat should have bland “clear” odor and taste.

- Melting point of the fat should be less than normal human body temperature.
- The fat should have a wide plastic range to suit particular production techniques and the product.
- The fat should have stability of crystal structure both at mixing stage and ager baking.
- The fat should have reasonable shelf-life on its own and in the baked product.
- The fat should be prepared from a blend of oils, which will not cause fat bloom during shelf life of biscuits.

2. Sweetening agent

Majority of sweetening agents are obtained from sugar in one form or another, and sugar (sucrose) is derived from two sources. The main source is sugar cane and the secondary source is sugar beet (Whiteley, 1971).

Sugar is another very important ingredient for the manufacture of biscuit of any variety. Quantity and crystal size of sugar exert a big influence on biscuit dimension and texture. Sugar being hygroscopic in nature as it assists moisture retention in the products and thus improves shelf life. It caramelizes during the process of baking and thus imparting appetizing crust color and acts as sweeteners, increases tenderness, contributes the volume and improves the flavor and controls the spread of the biscuit (Smith, 1972).

2.3.2 The minor ingredients

1. Leavening agent

Leavening agents is the term used to indicate a source of gas, which caused dough or batter to spring, giving a porous, open texture in the finished product. This gas can be released during mixing, after mixing and during baking by the influence of the heat of the oven (Bohn, 1956).

To increase the palatability and to improve texture, bite and appearance, it is necessary to achieve some form of aeration, which is done by mechanical, biological and chemical means.

- Mechanical aeration: Mechanical aeration is achieved without the use of ingredients, but by the method of handling the product. Beating and whisking are the main methods, and in this air is introduced to the product. Another method of mechanical aeration is in the use of layers of dough with an insulating material in between. Examples of this are production of crackers and puff biscuits (Whiteley, 1971).

- Biological aeration: To bring about aeration by biological means, yeast is used. Yeast is a microscopic, unicellular organism that relies mainly upon sugars in solution for life and reproduction. It is capable of breaking down sucrose and maltose into monosaccharides and glucose and fructose into alcohol and carbon dioxide (Whiteley, 1971).

- Chemical aeration: The most commonly used chemicals are sodium bicarbonate and ammonium bicarbonate. These chemicals when heated, volatilize or evolve a gas or mixture of gases. Ammonium bicarbonate, which is completely decomposed to give CO_2, ammonia and steam and sodium bicarbonate that gives off CO_2 and steam.

$$NH_4HCO_3 \longrightarrow NH_3 + CO_2 + H_2O$$

(Ammonium bicarbonate)

$$(NH_4)_2CO_3 \longrightarrow 2NH_3 + CO_2 + H_2O$$

(Ammonium carbonate)

The chemical equation for the reaction of soda and the commonly use baking acid are as follows:

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

(Sodium bicarbonate/soda) (acid)

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

(Sodium bicarbonate/soda) (cream of tartar) (sod. pot. tartarate)

Both sodium bicarbonate 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 of soapy taste, unless any acidic material is used to neutralize the residual sodium carbonate (Smith, 1972).

2. Emulsifying agent

Emulsifying agents are surface active agents promoting the formulation and stabilization of emulsions. These products play a very important role in biscuit formulation ensuring proper mixing of lipid and aqueous fraction and good texture. The unifying property of emulsion is the presence of a hydrophobic and lipophilic group on the same molecule. Most commonly used emulsifiers are lecithin, eggs, mono and diglycerides etc. Lecithin may be much more useful as an antioxidant also (Smith, 1972).

3. Milk solids

Milk solids increase the nutritive quality of the biscuit and also help in the retention of the improved flavor and also improve crust color. Milk solids in biscuit also enhance crust bloom tenderness and texture without altering the symmetry and crumb color.

Lactose helps the formation of melanoids, the principle coloring substance, formed by the reaction of sugars and amino acids from the proteins under influence of heat (Smith, 1972).

4. Common salt

Salt, though is least respected, is one of the most important ingredients in biscuits. It enhances the natural or others added flavors. Salt is used in almost all recipes for its flavor and flavor enhancing properties. Biscuits without salt do not always lack flavors but insipid. Its most effective concentration is about 1.0-1.5% based on the flour weight, but at a level more than 2.5%, the taste becomes unpleasant (Smith, 1972).

5. Flavoring agent

The majority of the flavors used in biscuits making are derived from natural sources and these are in many ways most satisfactory. To get good distribution in a dough, the flavor should be creamed with the sugar and shortening at the beginning of mixing. Commonly used flavoring materials are common salt, yeast, extracts, spices and essences (Whiteley, 1971).

6. Coloring agents

Color should be used to enhance the eye appeal of the product, and the use of correct color to suggest flavor should be linked directly to the type of flavor in use. Caramel is the most widely used color in biscuit making. The use of caramel is sage and will also impart a distinctive flavor of burnt sugar when used in fairly large quantities (Whiteley, 1971).

Coloring agents, flavoring agents, jams, jellies, fruits and nuts offer variety to the manufacturers (George, 1981).

7. Water

Quality of water has greater effect on the baking product. Dissolved mineral and organic matters present in water can affect the flavors, color and physical attributes of the finished baked products.

2.4 General requirement of biscuits according to Nepal standard

Biscuits should have been properly baked, crisp and uniform in texture and appearance. They should have characteristic flavor and should be free from bitterness after eating. They should be free from fungus, rancid taste, off odor and any insect infestation. For filled biscuits, any of filling materials like jam, jelly, marshmallow, cream, caramel, raisins etc. may be used. The biscuits may be coated with caramel of chocolate. The requirements for biscuit according to Nepal Bureau of Standard is presented in Table 2.3.

Table 2.3 Compulsory requirement of biscuit according to Nepal Bureau of Standard

Characteristics	Requirements
Moisture (% max)	6.00
Acid insoluble ash (on dry basis) (% max)	0.05
Acidity of extracted fat (as oleic acid) (% max)	1.00

Source : NBSM (2040)

2.5 Nutritive value of biscuits

Biscuit is a good source of nutrients because it contains carbohydrates, fats, proteins, minerals and vitamins. Carbohydrate and fats provide heat and energy to the body. The proteins are materials for growth and repair of tissues whilst minerals provide materials for bone growth and repair and in association with vitamins for the regulation of the processes and maintaining normal vitality. Nutritive value of biscuits is given in Table 2.4.

Table 2.4 Nutritive value of Biscuits.

Weight per serving	100 g
Calories (Kcal)	480
Protein (g)	5.2
Fat (g)	20.2
Carbohydrate (g)	71.0
Calcium (g)	0.004
Phosphorus (g)	0.16
Iron (mg)	1.8
Thiamine (mg)	0.003
Riboflavin (mg)	0.004
Nicotinic acid (mg)	0.8

Source: Swaminathan (1991)

2.5.1 Effect on nutritive value of biscuit during baking

Since biscuit is cereal based product, cereals have been studied in depth form the standpoint of their nutritive value. It usually contains valuable nutrients for the human being such as vitamins, mineral, salts, proteins, and enzyme. Biscuit needs to be processed at higher temperature. Nutritive value is modified during baking. The most interesting and evident phenomenon is the caramelization consisting of a series of modifications that occur specially in the presence of high temperature, between reducing sugar and amino acid of protein. Lysine by being present in protein is the most effective amino acid in this reaction. In the case of wheat, although it is the limiting amino acid, it would be first partly blocked and then destroyed leading to the loss in protein value. The caramelization finds ideal conditions in those oven products that belongs to the category of sweet.

2.6 Barley

2.6.1 Origin of barley

It is claimed that barley was man's ancient foodstuff and some modern scholars consider it, the oldest of all cultivated plants. The grain of six-row barley has been discovered in Egypt dating from pre-dynastic and early dynastic periods(Acharya and Karki, 2008). Barley played important role in ancient Greek and Roman culture as a staple bread-making grain as well as important food for athlete. The use of barley grain in social and religious ceremonies by Hindus, Greeks and Romans illustrates its antiquity. Carbonized grain discovered from archeological excavations at various site proves that barley was cultivated around 7000 to 5000 BC (Harlan, 1976) and the crop was domesticated about 8000 BC.

2.6.2 Classification of barley

Scientific classification of commercial barley is as follows:

Kingdom: Plantae

Subkingdom: Tracheobionta

Super division: Spermatophyta

Division: Magnoliophyta

Class: Liliopsida

Subclass: Commelinidae

Order: Cyperales

Family: Poaceae

Genus: *Hordeum*

Species: *vulga*re

Gina (2008)

On the basis of uses barley is classified as feed and malt barley. Similarly, on the basis of morphological characteristics barley is divided into hull and hull-less barley. So, in general barley is divided into:

a. Feed and malt barley

b. Hulled and hull-less barley (also known as naked barley)

c. Pearled barley

Bianchi *et al.* (1998)

Fig. 2.1 shows the structure of Barley (*Hordeum vulgare*)

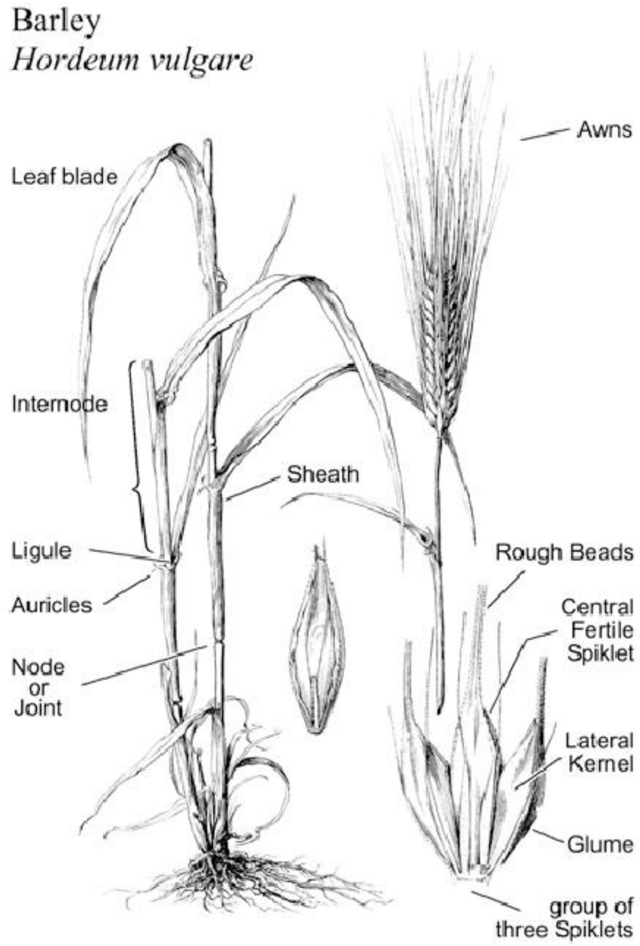

Fig 2.1 Barley (*Hordeum vulgare*)

Source: McCartney *et al.* (2006)

2.6.3 Production and utilization

The genus Hordeum has center of diversity in central and southwestern Asia, West North America, southern South America and in the Mediterranean (Bothmer, 1992). Cultivated barley grown in a range of diverse environment that vary from sun-Arctic to sun-Tropical, with greater concentration in temperate areas and high altitudes of tropics and subtropics. Other than cool highlands, barley is grown in the tropic as it is no suited to warm humid climates (Nevo and Shewry, 1992).

Most production of barley takes place in Europe (62%), followed by Asia (15%) and America (13%). Figures from 1991 show that the use of barley for food in 12 counties in Europe averaged around 0.3%, while the use in e.g. China, India and Ethiopia was above

60%. It is used worldwide for animal feed and human food, with its main use for human consumption being the production of alcoholic drinks (though proportions vary greatly for cultural reasons in different countries) (Newman and Newman, 2006). Malt usage worldwide is approximately 22 million tons per year of which 94% goes to beer production, 4% for distillation and 2% for other food uses (Euromalt, 2008).

While the present use of barley in food is low, an increase could be expected due to increasing health trends and an increasing number of reports on the possible health effects of consuming barley products (Baik, 2014)

In contest of Nepal, Barley is grown from the terai, up to an elevation of 4000 m in Nepal, but is a staple food crop mainly in the hills and mountains in the west of the country. Although reported barley production in the terai has declined in the past decade from 6000 to 3000 tons per year, production in the hills over the same period has increased from 9000 to 12,000 tons, and from 8000 to 10,000 tons in the mountains (Baniya, 1989). The average yield of barley from 1950 to 2006 is 959 kg per hectare (Bhandari, 2012).

Nowadays, this cereal continues to play an important socioeconomic role. Indeed, the statistics published by the FAO of the United Nations rank Morocco as first world user of barley for human consumption. Approximately, 20% of the barley available is dedicated to the human consumption (Yamlahi and Ouhssine, 2013).

2.6.4 Physical properties

Barley is a good source for many nutrients such as protein, fiber, minerals and B vitamins. Carbohydrates constitute the bulk of the total dry matter of the barley grain. Most of the carbohydrate in barley is starch which serves as energy source during germination (Duffus and Cochrane, 1993). Mono- and di-saccharides (sucrose, glucose, fructose and maltose) are present in lesser amounts, but their concentration is twice as high as in other cereals. Of the non-starch polysaccharide fraction the content of arabinoxylan and β-glucan is of relevance when barley is fed to young monogastric, due to the negative effects on digestion. It is noteworthy that contrary to this, the low-digestible carbohydrates especially β-glucan and resistant starch have a positive impact on human health due to their role in lowering post prandial blood glucose levels and in reducing the blood cholesterol level (Duffus and Cochrane, 1993). The content of nutrients in barley are shown in Table 2.5

Table 2.5 Proximate composition of barley grain.

Component	Percentage
Moisture	11.90
Crude protein	8.75
Crude fat	2.70
Crude fiber	3.83
Ash	2.86
Carbohydrates	81.86

Source: Youssef *et al.* (2013)

The vitamin content of barley grains varies widely. Un-germinated barley does not contain vitamins A, C and D, although the carotenoids and sterols that are present may act as precursors for vitamins A and D, respectively (Briggs, 2012). Vitamin E, a mixture of tocopherols, occurs in barley oil. Barley is unique among cereals in having all eight naturally occurring tocopherols. The tocopherols are found exclusively in germ tissue (embryo, scutellum) and tocotrienols in the starchy endosperm and aleurone (Morrison, 1993). Barley also contains B vitamins. These vitamins are mainly present in the embryo and the aleurone layer (Palmer, 1989).

The major constituents of the mineral fraction of barley are magnesium, phosphorus, potassium, calcium, and sodium. The average mineral content varies significantly, and this appears to be due to a number of factors, including the variety in question, the growing and soil conditions and fertilizer application. A high portion of phosphorus in barley grain is bound to the phytate complex (51-66%) making much of the phosphorous unavailable to monogastric animals (Harrold, 1999). The amounts of copper, iron, manganese and zinc present in barley grain may vary to a large extent due to growing conditions (Novus, 1996). As with vitamins these minerals are mainly concentrated in the embryo and the aleurone layer (Duffus and Cochrane, 1993). Typical amino acid composition of barley is shown in Table 2.6 whereas mineral composition is represented by Table 2.7

Table 2.6 Typical amino acid composition of barley (g amino acid/100 g crude protein).

Amino acid	Range
Alanine	4.6 ± 0.51
Arginine	5.8 ± 0.25
Aspartic acid	7.7 ± 0.45
Cystine	4.9 ± 0.66
Glutamic acid	24.7 ± 0.89
Glycine	4.4 ± 0.80
Histidine	2.4 ± 0.30
Isoleucine	4.7 ± 0.92
Leucine	7.6 ± 0.47
Lysine	3.3 ± 0.40
Methionine	4.9 ± 0.66
Phenylalanine	9.8 ± 0.57
Proline	1.01 ± 0.13
Serine	5.0 ± 0.54
Threonine	4.0 ± 0.25
Tyrosine	9.8 ± 0.57
Valine	5.3 ± 0.08

Source: Ortiz *et al.* (2021)

Table 2.7 Mineral composition of barley (mg/100 g; on dry weight basis)

Minerals	Content (mg/100 g)
Iron	5.67
Manganese	1.11
Copper	0.860
Zinc	5.67
Calcium	140
Sodium	43.25
Magnesium	180
Potassium	320
Phosphorus	370

Source: Youssef *et al.* (2013)

Barley also contains a number of other constituents, some of which, at higher intakes, have been suggested to have a role in protection against diseases (Thompson, 1994). These include simple phenolic acids, lignans, and the flavonoids. Ferulic, vanillic, o- and pcoumaric, syringic, p-hydroxybenzoic, sinapic and chlorogenic acids occur free in barley. Water soluble esters of p-hydroxybenzoic, protocatechuic, ferulic, vanillic, pcoumaric, syringic, caffeic, sinapic and isoferulic acids have been detected as have glycosides of several of these and of gentisic, chlorogenic and dihydroxybenzoic acids (Briggs, 2012)

Phenolic acids, principally ferulic but also p-coumaric acid, are covalently associated with arabinoxylans and constitute approximately 0.05% of cell walls in the starchy endosperm and 1.2% of aleurone walls. The insoluble, bound p-coumaric acid of barley grain is concentrated on the outer grain layers (MacGregor and Fincher, 1993). Bacterial enzymes in the human colon slowly and partially degrade the aleurone cell walls. This degradation results in the release of feruloylated oligosaccharides, which can then be further degraded to release ferulic acid. The phenolic acids are good antioxidants (Rice-Evans *et al.*, 1997).

The flavonoids are a large group of phenolic compounds that occur widely in plants, and many of them have good antioxidant properties. Barley contains a range of flavonoids. catechin, epicatechin, anthocyanins and proanthocyanins (Briggs, 2012).

Barley varieties also contains phytoestrogenic compounds, that is, isoflavones and lignans. Minor amounts of isoflavones are present in barley (Murphy and Hendrich, 2002). Lignans are phenolic dimers, which are predominantly present in the bran. Lignans are converted by fermentation in the large intestine to mammalian lignans (Thompson, 1994). The plant lignan secoisolariciresinol occurring in barley is converted by intestinal microbes into enterodiol and enterolactone which play a role in the cancer-protective effect of vegetarian diets (Murphy and Hendrich, 2002).

2.6.5 Anti- nutrients and allergen compounds in barley

The content of common anti-nutrients in cereals, including barley, is considered to be low when compared with legumes such as faba beans, peas and lupines. Protease inhibitors, especially trypsin inhibitors, decrease the digestibility and biological value of ingested protein and retard growth when sufficient amounts are present in the diet. Amylase inhibitors may affect the digestibility of starch. Both protease and amylase inhibitors have been identified in barley (Palmer, 1989). However, they do not appear to be responsible for any serious anti-nutritional activity in humans as both inhibitor types tend to be heat labile (Klopfenstein, 2000). Lectins, sometimes called phytohemagglutinins, are glycoproteins that bind to certain carbohydrate groups on cell surfaces, such as intestinal epithelial cells, where they cause lesions and severe disruption and abnormal development of the microvilli. Although more commonly associated with legumes, cereal grains including barley are also known to contain lectins (Liener, 1989). As lectins are usually inactivated by heat treatment, they are really only of interest when raw or inadequately cooked food or feed is consumed (Klopfenstein, 2000).

Phytic acid (myo-inositol hexa phosphate) chelates minerals such as iron, zinc, phosphorus, calcium, potassium and magnesium. The bioavailability of these minerals can thus be reduced by the presence of phytic acid in monogastric animals, although in humans, phytic acid does not seem to have a major effect on potassium, phosphorus or magnesium assimilation. Ruminants, on the other hand, are more readily able to utilize phytatecomplexed phosphorus because they have abundant amounts of microbial phytase which degrades phytate in the rumen (Harland and Spiller, 2001). Phytic acid level in barley varities ranges from 0.70 to 0.76% (Bull, 1995).

Barley, along with other gluten-containing cereals such as wheat and rye, is also associated with a condition known as gluten-sensitive enteropathy (also called coeliac disease), which affects genetically predisposed individuals. Gluten is a complex of two major storage proteins in cereals namely prolamin and glutelin. The sensitivity response is triggered by the prolamin fraction of the cereal storage proteins that are hordeins in barley (S. G, 2019).

2.6.6 Dietary fiber in barley

According to the American Association of Cereal Chemists' expert committee, dietary fiber is described as 'the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the small intestine with complete or partial fermentation in the large intestine'. Dietary fiber includes polysaccharides, oligosaccharides, lignin and associated plant substances. Dietary fiber three categories are used: insoluble dietary fiber (IDF); soluble dietary fiber (SDF); and total dietary fiber (TDF), the sum of IDF and SDF (Delcour and Hoseney, 2010). Total dietary fiber is important in the calculation for caloric reduction in foods formulated with these materials. However, the categorization is not always unambiguous, and the soluble fibers can sometimes be found as the structural material of insoluble fiber. Basically, though, soluble fibers form a solution when mixed with water, whereas insoluble fibers do not form solutions (Elleuch *et al.*, 2011).

On the other hand, dietary fiber can also be classified as cereal- based fiber and non-cereal- based fiber. Cereal based fiber includes, for example, wholegrain flour, resistant starch and bran (made of wheat, oat, rye, barley or corn). Oat and barley bran are classified as soluble dietary fiber and resistant starch, wheat and rye bran as insoluble fiber (Elleuch *et al.*, 2011). Non-cereal based fibers include inulin, psyllium, pea hulls, pea cell wall fibers and fibers from various fruit and vegetables origins, e.g. sugar beet, citrus fruits, algae, rice and asparagus (Collar *et al.*, 2006).

The usual beneficial effect is needed to fulfill the definition, but the criteria for substantiation of the effect are not defined. Improved bowel function (e.g. altered faecal frequency and quality of faeces), fermentability by colon microbiota and attenuated blood glucose and cholesterol levels are the physiological effects most commonly associated with increased use of DF (Raninen *et al.,* 2011). Insoluble fibres, both cereal based and non-cereal based, consist of cellulose, hemicellulose, lignin, arabinoxylans or xyloglucan (Harris and Smith, 2006) whereas, soluble dietary fibers include gums, fructans, pectins, psyllium or β-glucan separated from bran or from another plant (Theuwissen and Mensink, 2008).

Barley varieties have high total dietary fiber content (18.7 to 19.5 g per 100 g). The consumption of whole meal product is advisable, as the greatest percentage of dietary fiber is found in the bran or outer layers of barley (Šterna *et al.*, 2015).

2.7 Malting

Malting is controlled germination process which produces a complement of enzymes which are able to convert cereal starches (endosperm) to fermentable sugars, to secure an adequate supply of amino acids and other minor nutrient for yeast and modify the quality of the micro molecules which have such important effects on physical quality of beer.

The maltster is concerned with both degradation of the endosperm and the accumulation of the enzymes in the grains. But the growth of the germs of embryo is an incidental to making of malt and leads to unwanted depletion of the endosperm material through respiration of the embryo when degradation of the endosperm has progressed to only a limited extent, the maltsters terminate the growth of embryo by drying the grain. In order that the storage of malt is possible for long period in stable periods, it has been customary for the maltsters to continue the drying, beyond that required arresting growth, by kilning (Anon., 2017).

2.7.1 History of malting

Malting is the controlled germination process followed by drying and terminating the growth of the embryo, which activates the enzymes of the resting grains resulting the conversion of cereal starch into fermentable sugar and other particles, partial hydrolysis of protein and macromolecules into micro molecules (Kent and Amos, 1983). The most important ingredient from the stand point of quality and function is barley malt. This is the barley grain that has been germinated slightly and then been gently dried. Germination is done for the purpose of developing an active enzyme content which will later convert starches in the malted barley and in other cereals grains into sugars, which can be easily fermented during fermentation step (Kaaya, 2002).

It was found that malting had significant effect on dry matter content, fat content, starch content, total free amino acids content, ascorbic acid content and amylase activity except protein in which it did not had significant effect (Shrestha, 1995). An increase in reducing sugars during malting could be due to starch hydrolysis by hydrolytic enzymes such as αamylase (Traoré *et al.*, 2004a). This increased solubility could be as a result of the increase in amount of soluble sugars which directly affect the water absorption capacity of malted flour (Gernah *et al.*, 2011). Both the smaller granular size and its higher amylase content formed during the malting process is responsible for the slightly increase in gelatinization temperature (Greenwood and Thomson, 1959).

2.7.2 Outline of malting

Malting is controlled germination process which produces a complement of enzymes which are able to convert cereal starches (endosperm) to fermentable sugars, to secure an adequate supply of amino acids and other minor nutrient for yeast and modify the quality of the micro molecules which have such important effects on physical quality of beer (Kent and Amos, 1983).

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2.7.2.1 Malting operation

The sequence of operation in malting is as follows:

1) The collection of stocks of suitable barley.
2) The storage of the cereals until it is required.
3) Steeping the grains in water, germination of the grains.
4) Drying and curing on a kiln.

Steeping an arranged so that sufficient moisture outers the grain to initiate germination. The moisture content of 42-46% (wet weight basic) that is eventually achieved is sufficient to support growth and biochemical alteration in the grains during the malting period, without, however, allowing excessive growth (Dewar *et al.*, 2004).

Since growth, results in the production of largely unwanted rootlets and loses in dry weight due to grain respiration. A balance must be struck between achieving sufficient growth to adequately alter the barley into malt but without excessive growth that would reduce the quality of malt eventually produced. In newer malting processes, the wetted grain may be drained and aerated at intervals and germination may commence before the grain contains sufficient to malt adequately. Thus, the steeping and germination tend to merge (Dewar *et al.*, 2004).

Germination traditionally carried out in darkness at relatively low temperature 12-15°C for choice but this could not be easily controlled. Originally it was processed in autumn, winter and spring to take advantage of the cool weather but never malting have temperature-controlled atmosphere. Regulating the moisture and temperature of the grain controls the intensity of germination process. The changes occurring in germination that are essential in converting barley into malt are collectively termed as “modification” and may be summarized as follows. First may hydrolytic enzymes appear and increase in amount, adding to those that are already present in the barley. These enzymes began to catalyze the hydrolytic degradation of the reserve substances at the starchy and endosperm and in the particular cell wall are partially or completely degraded resulting in loss of storage. Consequently, simple roller may readily crush dry malt in contrast to dry barley. Gummy polysaccharides are also degraded during malting so that the work derived from malt has a low viscosity compared with extracts of raw barley. Simple water-soluble product of hydrolysis accumulates in the grain during malting (Dewar *et al.*, 2004).

Kilning, the hot air drying and cooking stages, terminates germination and produces a dry, easily milled products from which the dry, brittle, rootlets or “coolness” are easily separated. The pored products belling dry, can be stored for long periods, in addition to drying, killing removes a raw flavor from the green malt and imparts other flavors and colors to eh products, at the same time, the chemical composition of the malt is modified in particular enzyme content is reduced (Hough *et al.*, 1981).

2.7.2.2 Chemical changes during malting

The percentage of starch decreases and the composition of the remaining starch alter. The proportion of amylase increases. The overall pentosans content of starchy endosperm declines while that of husk remain unchanged. The partial hydrolysis of the insoluble hemicellulose appears to give rise to the soluble gum, which in turn, when hydrolyzed, further provides mono-saccharides. The quantity of simple sugars alters dramatically, those produced by the hydrolysis of polysaccharides on the one hand and those consumed by the living parts of the grains on the other hand. The amount of sugar declines during kilning but the sucrose often increases in amount. Maltose is also increased. The grain as the first respiratory substrate uses up raffinose before other sugars is mobilized to support the growth of embryo (Shrestha, 1995). Sadasivam and Manickam (1997) reported that total free amino acid content was significantly affected ($p>0.05$) by germination time and watering regime.

During malting the reduction in phytate content as well as increase in α- amylase activity and the sweetness in the malt flours occurs (Sadasivam and Manickam, 1997). The complex organic phosphates of aleurone layer and starchy endosperm are hydrolyzed to yield inorganic phosphates and ultimate product of hydrolysis of phytic acid, are known to increase. Vitamins like riboflavin, pantothenic acid, pyridoxine, pyridoxal, and pyridoxamine group increases in the malting while others do not. Ascorbic acid also alters during germination but is completely destroyed during kilning. There is reduction in the quantity of inorganic materials during malting because the materials move to the roots and some is lost by leaching in the steep liquor (Shrestha, 1995). The statistical analysis done by Friend *et al.* (1995) showed that is no significant effect of malting of grain on the acidity.

2.7.2.3 Physical changes during malting

During steeping, the grains swell and increase its volume by about a quarter. Space is allowed in the steep tanks to accommodate the swollen grain. The first microscopic indication of germination after casting is the appearance of the 'chit'. The white coleorhizae or root-sheath that breaks through the pericarp and testa and produce from the base of the corn. In time seminal roots also called rootlets, culms, cooms, or malt sprouts bursts, through root sheath and form a tough at end of the grain, at the same time the first 'leaf- seat' or coleoptiles. Variously called by maltsters the 'acrospires', 'spire', 'blade', penetrates the apex between pericarp and the husk. In conventional malting practice, the malt is kilned and growth terminated before the acrospires grows beyond the end of the grain (Hough *et al.*, 1981).

Starch appears in small amounts in the embryonic structures after the onset of germination. Coincident with the appearance of this starch the first sign of the breakdown of the starchy endosperm are seen as an enzyme's partial dissolution of some cell walls. This process, cytolysis, begins in the compressed layer, adjacent to the scutellum and progressively spreads through the starchy endosperm towards the apex of the grains (Acharya and Karki, 2008).

As these hydrolytic breakdown processes precede alterations may be detected in protoplasm of cells of the aleuronic layer of columnar cells between the compressed cells endosperm and the scutellum. The products of the hydrolysis of endosperm are absorbed into the scutellum. The products of the hydrolysis of endosperm are absorbed into the scutellum epithelium and are transported through the scutellum into the embryo to provide necessary nutrients. As germination, proceeds the cells of epithelium tend to separate and elongate so forming a 'pile' which projects into the solubilized part of the endosperm. This alteration in similar form greatly increases the surface area of the cells and makes the epithelium a more efficient absorptive organ (Hough *et al.*, 1981).

The softening of endosperm that occurs during malting is easily and conveniently detected by 'rubbing out' the green malt by hand. Chewing grains to see that they are 'crunchy' and devoid of hard tips may check the degree of modification of finished malt (Hough *et al.*, 1981).

2.7.3 Moisture content and its effect

The moisture content is needed to control the germination process. Water sensitive grain will usually germinate only if steeped to about 35% moisture. Following and air rest and the onset of germination, the moisture of water sensitive grain may safely be increased further to allow satisfactory modification. In the past in floor malting, low nitrogen-grain was steeped to 43% moisture, steeply grain to about 45% moisture. However, in pneumatic malting where evaporation from the grain is inevitable, the grain has to be sprinkled with water during germination to maintain its moisture content. At higher moisture content, modification proceeds more rapidly than at lower moisture content. Without the methods of control, however, embryo growth and hence rootlet production and total malting loss may be proportionately greater (Hough *et al.*, 1981).

2.7.4 Temperature and its effect

In traditional floor malting, a long cool germination period of up to 13 days at 12 - 14°C was preferred. As the temperature of malting increases, the respiration rate of the grain, the rate of growth of roots and the rates at which enzymes formed also increases. However, these changes are not all accelerated in the same proportion by increases temperature so that carrying out germination at progressively higher temperature do not merely produce the same malt in shorter time. This is illustrated by the fact that at lower germination temperature enzymes such as a-amylase and protease increases in amount slowly but ultimately reach levels higher than those attained at higher germination temperature (Hough *et al.*, 1981).

2.8 Technology of biscuits making

All over the world, manufacturing processes have been replaced by new and advanced automatic machines with high output. Although why and where forces of material and chemical changes inherent in biscuit manufacturing have been analyzed and studied.

The general flowsheet of manufacturing process of biscuits is as shown in Fig. 2.2.

Preparation of ingredients

↓

Creaming

↓

Mixing and kneading

↓

Forming (molding and cutting)

↓

Molding (soft-dough biscuits)

↓

Baking (200°C, 15 min)

↓

Cooling (5-6 min)

↓

Wrapping and packaging

↓

Storage(40-59% RH, 23-27 °C)

Fig. 2.2 Flow sheet of general manufacturing process of biscuits

Source: Smith (1972)

2.8.1 Mixing biscuit dough

Various types of mixers with different blade configurations and motor speeds carry out mixing operations. The main objective of such mixing machines is blending together a variety of ingredients to form homogeneous mass. Therefore, mixing is the heart or the most important unit operation of the biscuit industry. Proper mixing equipment and mixing methods play a vital role in good biscuit production (Whiteley, 1971).

There are two basic methods for mixing soft dough but each may have variations designed to achieve the best result under the particular circumstance prevailing and depending upon the equipment used.

1. Creaming method

This consists of blending of sugar and fat (including syrup and other general ingredients) together with water to form a smooth homogeneous cream. During this stage; color, essence are added. While the cream is being prepared, aerating chemicals and salt are dissolved in some of the dough water and added to the cream for a short period. The flour is fed into the machine and as it starts to blend in with the cream and remaining water is added. Mixing continued until desired dough consistency is obtained (Whiteley, 1971).

2. All in one method

In this method, all ingredients are fed into the machine and as blending commences, the dissolved aerating chemical, salt, color, essence and water are added. This method is more direct and straight forward but produces dough rather more dense and tough than one produced by the creaming method (Whiteley, 1971).

2.8.2 Performing and forming

Hard dough and fermented dough are laminated and gauged (reduced) to suitable thickness according to the requirements. The dough sheets are cut or stamped and dough scraps are sent back to the laminator. Soft dough are directly fed into moulding disc and mould according to requirements, there is no dough scraped in soft dough.

2.8.3 Baking

The objective of baking is to remove extra moisture present in the dough pieces by gradually heating. The dough contains more than 25% moisture part of which is bound moisture in flour and other ingredients and balance due to the added water tender the dough machinable. Heat is transferred by three means that is conduction, convection and radiation. Within the oven dough pieces undergo two types of changes; i.e. physical and chemical. The changes taking place sequentially at different temperature during baking is mentioned in Table 2.8

1. Physical changes
   - Crust formation on top.
   - Melting of the fat in the dough.
   - Gas release and volume expansion.

2. Chemical changes
   - Starch gelatinizing
   - Protein changes
   - Caramelization of sugar and dextrinization

Source: Smith (1972)

Table 2.8 Sequential changes at different temperature during baking

Temperature (°F)	Changes take place
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 (biscuit structure)
170-190	Evaporation of alcohol, yeast action ceases.
170-250	Coagulation of protein
350-400	Caramelization (combustion of sugar like fructose and glucose)
370-400	Dextrinization (surface gloss)

Source: Smith (1972)

It may be noted that these changes all take place within specified baking time, which is shown in Fig. 2.3. The baking time for the biscuit is different from type of product.

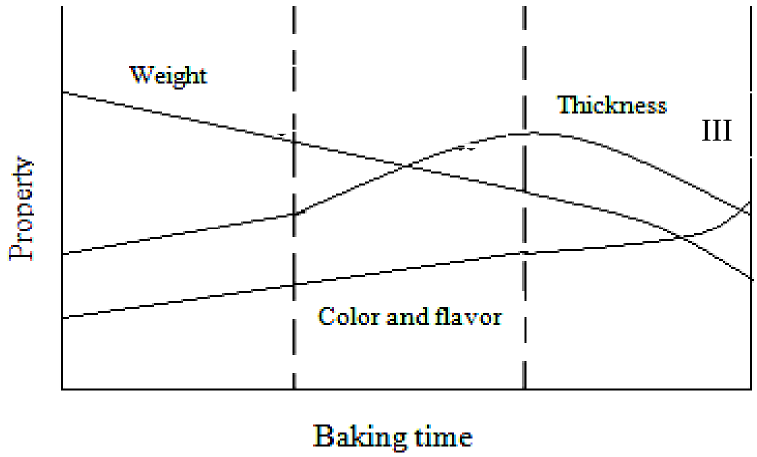

Fig 2.3 Changes taking place during baking of biscuit dough

Source: Smith (1972)

I. Expansion of dough and loss of moisture starts.

II. Expansion of dough and moisture loss reaches maximum, coloration starts.

III. Thickness and moisture loss decreases, color continues to increase.

2.8.4 Cooling

The biscuit coming out from the oven are in elastic form. They can easily bend without breaking while hot. This is attributed to the behavior of sugar in the product, which on cooling imparts physical strength and stiffness to the products. There is also appreciable loss of moisture as the biscuit cool and this is beneficial to the quality and shelf-life.

2.8.5 Packaging

As biscuits are dried food products whose moisture content is low. The relative humidity of freshly baked biscuit is very low and hence to prevent rapid uptake of moisture from the atmosphere, packaging of good water vapor resistance is required. Since biscuit also contains fat which is sensitive to odor, a non-tainting material with good grease resistant properties is necessary. This may be achieved by wrapping the biscuit tightly together, which provides a mutual reinforcing effect, e.g. at retail level, they are generally packaged in triple laminates consisting of polyethylene, aluminum foil and paper. Some of the characteristics of packaging materials is presented in Table 2.9.

Table 2.9 Some characteristics of packaging materials

Component	Properties
Low density polyethylene	Moisture and water vapor barrier, heat sealing medium.
Paper	Stiffness, low cost, opacity and printable
Aluminum foil	Opacity, decorative effects, 100% barrier to gases
Oriented polyethylene terephthalate	Gas barrier, strength, grease resistance.
Poly vinyl chloride (PVC)	Transparency, rigidity, gas barrier

Source: Smith (1972)

2.9 Sensory attributes of biscuits

Biscuit is a low moisture product generally used as snack item. Moisture content has very significant bearing on overall sensory quality of product. The crispiness of the biscuit can only be protected by applying suitable quality of packaging material having low permeability of water vapor (moisture) and oxygen. There are numbers of sensory attributes, which are critically desired in a normal quality of biscuit. They are appearance, crispiness, crumb, color, flavor (taste and smell), overall acceptability etc.

Part III

Material and methods

3.1 Raw materials

White wheat flour (Maida) (656.25 g) and barley used for biscuit making was collected from local market of Dharan. The other raw materials such as sugar, salt, fat in the form of vegetable ghee (Delicious fat spread) and skimmed milk powder was collected from local market of Dharan. Sodium bicarbonate, ammonium bicarbonate and sodium meta-bisulphite were obtained from the laboratory of Central Campus of Technology, Dharan.

3.2 Preparation of barley malt

The malting procedure was adopted from Ojha *et al.* (2020) with slight modification. The steeping period and drying period were increased to obtain the similar condition that was described by Ojha *et al.* (2020) as shown in Fig. 3.1. The total amount of barley used for preparing the malt was 400 g.

3.2.1 Cleaning

Barley grain was first winnowed with woven bamboo trays (nanglo). In this step; husk, immature grains and light particles was winnowed away and heavier particles such as specks and stones were separated by gravity during winnowing.

3.2.2 Lime preparation

For lime preparation calculated amount of calcium oxide (CaO) was dissolved in calculated amount of hot water to prepare 2%. Alkaline agent like calcium hydroxide work by saponifying the lipid within the envelopes of microorganisms. De Campos *et al.* (1980) reported that lime concentration of 2% were effective in the reduction the aflatoxin in the cereals.

3.2.3 Steeping

The cleaned seed kernels were steeped in the alkaline water (2% lime solution) for 4 h and then in potable water in the ratio (barley: water/ 1:3) for 24 h with regular draining and 1 h air rest in every 8 h interval. Steeping was done at average ambient temperature condition of 28ºC till the moisture content reaches to 42-45%.

3.2.4 Germination

The steeped grains were first collected in a muslin cloth and swirled in order to drain excess water and then kept for germination at ambient temperature of average 28ºC and 85% RH. The drying out of grains is prevented by moistening muslin cloth and spraying the potable water at the interval of every 12 h. The grain bed was turned and mixed from time to time to aerate the mass and to equalize the temperature and moisture during germination. The germination was carried out for 5 days.

Barley grain
↓
Cleaning
↓
Steeping (barley:water, 1:3, Time, 24 h ← Lime preparation
↓
Germination (20ºC, 95% RH for 5 days
↓
Drying / kilning (45ºC for 6 h, 50ºC for 4 h,
55ºC for 8 h, 70ºC for 1 h, 80ºC for 3 h
↓
Removal of acrospires (hand rubbing)
↓
Milling with grinder to obtain flour
↓
Sieving (400 μ sieve)
↓
Barley flour
↓
Packaging (glass jar)

Fig. 3.1 schematic diagram for the preparation of barley malt

Source: Ojha *et al.* (2020)

3.2.5 Drying and kilning

Germinating barley were dried to stop further germination. Multistage Drying was carried out in a cabinet drier at 45ºC for 6 h, 50ºC for 4 h, 55ºC for 8 h, 70ºC for 1 h, 80ºC for 3 h.

until the constant weight was obtained. After drying, the rootlets were removed and the prepared malt was milled in a grinder and the obtained malted barley flour (320 g) packed in airtight glass bottles.

3.3 Experimental procedure

3.3.1 Physical analysis of raw materials and final product

3.3.1.1 1000 kernel weight

The 1000 kernel weight of barley was determined by measuring the weight of 1000 kernels of barley grains after selecting the appropriate sample size by quartering method as stated in Buffo *et al.* (1998).

3.3.1.2 Bulk density

The bulk density was measured as mentioned in Clementson *et al.* (2010) by pouring the grains into the funnel-shaped hopper, the hopper was centered over the measuring bushel, the hopper valve was opened quickly, and the grains were allowed to flow freely into the measuring bushel. After the bushel was filled, the excess material was leveled off with gentle zigzag strokes using the standard Seed buro striking stick. The filled measuring bushel was then weighed, and the mass of grains in the bushel was determined by subtracting the mass of the measuring bushel itself. The bulk density (ρ) of grain was then calculated using the following expression:

Bulk density = mass of grain / volume of bushel

3.3.1.3 Particle density

True density of grain was measured by turpentine displacement method as mentioned in Simonyan *et al.* (2007).

3.3.1.4 Porosity

Porosity of grain was measured as mentioned in Ndirika and Mohammed (2013).

Porosity = [1- Bulk density/ Particle density] × 100

3.3.1.5 Sphericity

Sphericity of grain was determined as mentioned in Simonyan *et al.* (2007).

Sphericity = $(lbt)^3/l$

Where, l = length of grain

b = breadth of grain

t = thickness of grain

3.3.1.6 Spread ratio

The spread ratio of the biscuit was determined by using the formula as per AOAC. (2005).

Spread ratio= Diameter (mm) /Thickness (mm)

Where, diameter was measured in mm by vernier caliper and thickness was measured in mm by screw gauge.

3.3.1.7 Volume

Volume of the biscuit was determined by the area of biscuit multiplied by thickness as per AOAC. (2005).

Volume (cm^3) = $\pi d^2 t/4$

Where, t = Average thickness of biscuit (mm)

d = Diameter of biscuit (mm)

3.3.1.8 Density

Density of biscuit was obtained by the ratio of mass to the volume of the biscuit as per (AOAC., 2005).

Density (g/cm^3) = Mass (g)/ Volume(cm^3)

3.4 Determination of threshold of malted barley flour

The independent variable of the experiment is malted barley flour. The determination of threshold for malted barley flour was carried out with the help of trial experiment. The result of trial experiment concluded that above 50%, the biscuit was not acceptable. Therefore, the threshold for malted barley flour is set between 0 to 50%.

3.5 Preparation of biscuits

The biscuit was made as per following the recipe formulation done and coded as A, B, C, D, E and F. Composite biscuit was of soft dough type method. Biscuit was prepared at laboratory of Central Campus of Technology. The amount of dough prepared was 1.676 kg and the ingredients used were as follows:

Ingredients	A	B	C	D	E	F
Wheat flour	75	83.33	66.67	62.5	50	100
Malted barley flour	25	16.67	33.33	37.5	50	0
Sugar	35	35	35	35	35	35
Fat	33	33	33	33	33	33
Sodium metabisulphite	1	1	1	1	1	1
SMP	4	4	4	4	4	4
Ammonium bicarbonate	2.5	2.5	2.5	2.5	2.5	2.5
Sodium bicarbonate	0.75	0.75	0.75	0.75	0.75	0.75
Water	10	10	10	10	10	10

Source: Ishimoto *et al.* (2007)

The biscuit was baked in an electric oven maintained at 200°C for 15 min. The baked biscuits were then collected, cooled and packed into polyethylene pouches (250 g) for further analysis.

3.6 Manufacturing process of biscuit

The process for preparing malted barley flour incorporated biscuit is shown in Fig. 3.2.

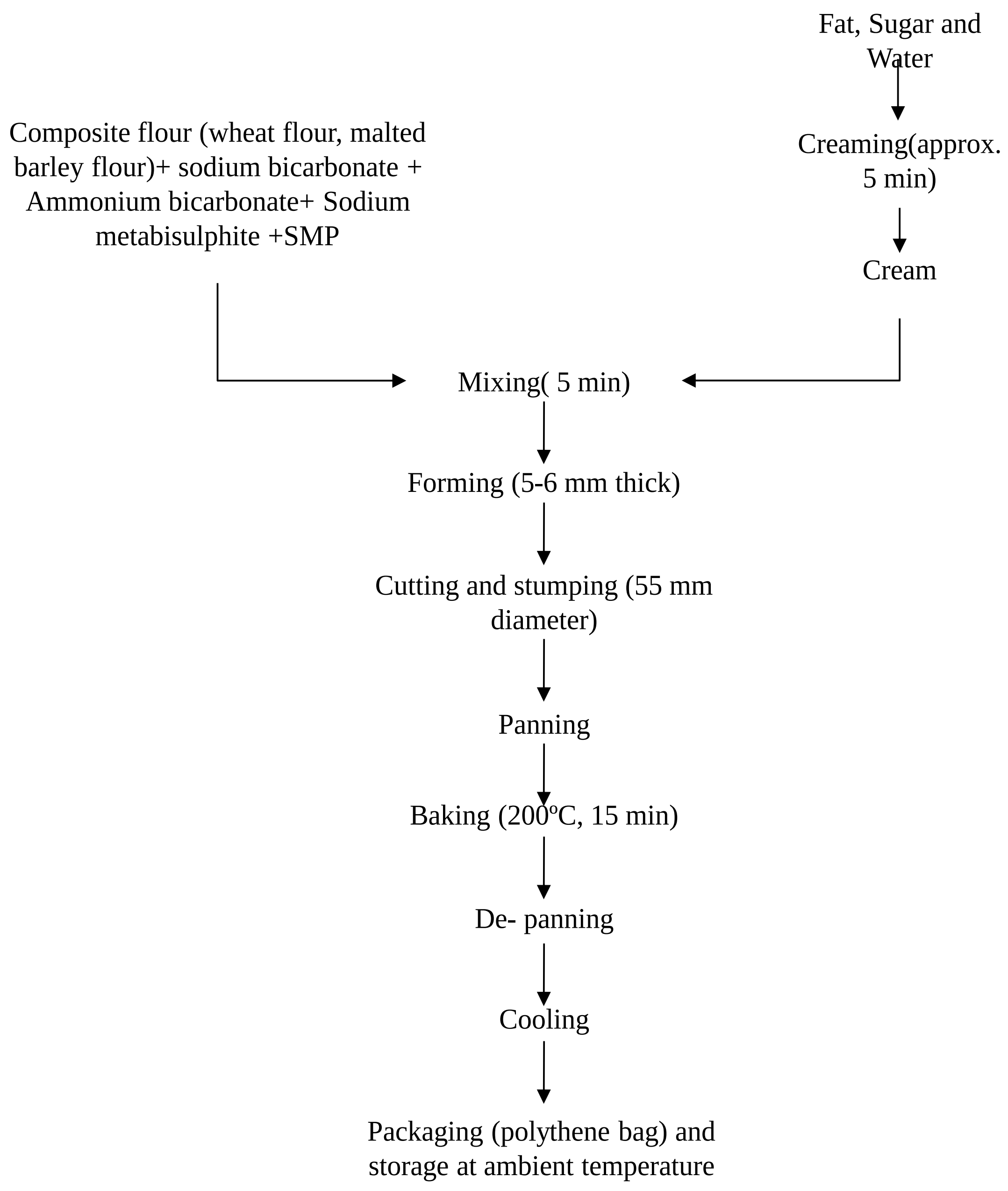

Fig. 3.2 Flow diagram of manufacturing process of biscuit. Source: Smith (1972)

3.7 Analytical procedures

3.7.1 Physicochemical analysis

3.7.1.1 Moisture content

Moisture content of the sample was determined by weight loss during heating in a thermostatically controlled oven at 105ºC by hot air oven method as given by Ranganna (1986).

3.7.1.2 Ash content

Ash content of the biscuit samples and the flour was determined using muffle furnace as described by Ranganna (1986).

3.7.1.3 Crude fat

The crude fat content of the sample was determined by solvent extraction method as described by Ranganna (1986).

3.7.1.4 Crude fiber

The crude fiber content of the flour and biscuits was determined as described by Ranganna (1986).

3.7.1.5 Crude protein

The crude protein content of the flour and the biscuit sample was calculated indirectly by measuring total nitrogen content by micro kjheldahl method. Factor 6.25 was used to convert the nitrogen content to crude protein as described by KC and Rai (2007).

3.7.1.6 Carbohydrate

Carbohydrate content was determined by difference method.

3.7.1.7 Reducing sugar

Reducing sugar is determined by Lane and Eynon method as mentioned in KC and Rai (2007).

3.7.1.8 Iron content

Iron content in flour samples were determined colorimetrically at 480 nm, as described in Ranganna (1986).

3.7.1.9 Calcium content

Calcium content in flour was determined by titration method as described in Ranganna (1986).

3.8 Sensory analysis

The sensory evaluation for overall quality was carried out with 10 semi-trained panelists (teachers and student of Central Campus of Technology). The parameters for sensory evaluation are color, flavor, crispiness, texture, taste and overall acceptability. Sensory evaluation was performed by hedonic rating test as described by Ranganna (1986).

3.9 Statistical analysis

All the data obtained in this research work was analyzed by the statistical program GenStat Discovery Edition 3. From this mean ANOVA (No blocking at 5% Level of significance), LSD and interaction effects was obtained to determine whether the sample are significantly different from each other and also to determine which one is superior among them.

Part IV

Results and discussion

The wheat flour and the malted barley flour were collected to formulate malted barley flour incorporated biscuit of 0, 16.67, 25, 33.33, 37.5 and 50 parts. Proximate composition of the flour as well as biscuit was carried out. The best product among the five variations was determined by carrying out sensory evaluation and the detailed nutritional value of the best product was analyzed.

4.1 Proximate composition

The proximate composition of wheat flour, un-malted and malted barley flour was obtained as given in Table 4.1

Table 4.1 Proximate composition of wheat flour, un-malted and malted barley flour

Proximate composition	Wheat flour	Un-malted barley flour	Malted barley flour
Moisture content (%) (wb.)	12.35±0.25	11.90±0.51	4.09±0.04
Crude protein (%) (db.)	0.47±0.08	12.01±0.04	14.03±0.05
Crude fat (%) (db.)	1.55±0.02	4.71±0.07	2.25±0.04
Crude fiber (%) (db.)	0.61±0.01	5.90±0.06	8.15±0.03
Total ash (%) (db.)	0.57±1.23	2.86±0.07	2.45±0.04
Carbohydrate (%) (db.)	84.45±0.45	62.62±0.06	69.03±0.05
Reducing sugar (%) (db.)	0.35±0.03	1.09 ± 0.02	5.23 ± 0.08
Calcium (mg/100g) (db.)	34±0.15	140±2.64	165±1.52
Iron (mg/100 g) (db.)	3.0±0.3	5.67±0.03	8.52±0.05

[Values are the means of three determinations ± standard deviations.]

The moisture content increased initially during the soaking process of germination. Later, the moisture content of malted flour is reduced to 4.09% which is similar to the studies reported by Arif *et al.* (2011) i.e. 4.5%. which is due to enzyme inactivation process during malting i.e., kilning. The hydration process during germination activated a wide array of enzyme which hydrolyzed and solubilized food reserves. The crude protein content of the malted flour sample increased. It was observed that protein content increased during malting of barley grains. As malting process activates enzymes and nutrients made more bio-available might have contributed for the increment. The results are supported with studies showing that malting increases protein and decreases ash content (Traoré *et al.*, 2004a).

The crude fiber content of the malted sample increased. This increase could be attributed due to increased bran matter and the building of dry matter during the growth and development (germination) of plant. Traoré *et al.* (2004b) reported the decrease in ash content of barley during post malting process of barley which can be attributed to the germination and dehydration of grains respectively which is similar to the results of our study. Germination would increase the mineral content due to an increase in phytase enzyme activity during germination. The enzyme will hydrolyze the bond between the protein-enzyme minerals become free, therefore increasing the availability of minerals (Narsih, 2012). The carbohydrate content was found to be increase in malted flour; this increase may be due to the activity of enzymes. The carbohydrate may have been digested to simple sugar by amylolytic enzymes as a result there is increase of reducing sugar on the malted sample.

The moisture content of wheat flour was 12.35% which is common in commercial wheat flour as previously reported by Kent and Amos (1983). The moisture content of the malted barley flour was found to be 4.09% which is similar to the studies reported by Arif *et al.* (2011) i.e. 4.5%. The value obtained was slight lower than those obtained in literature and the reasons for this difference could be attributed to species and intense drying of malt after germination. The protein content was found to be 14.03% in malted barley flour. However, compared to wheat flour, which was 10.47%, the protein content in malted barley flour is high.

Malted barley contains a lot of minerals, confirmed by its higher ash content as 2.45%. The ash content of in the present study (2.45%) is higher than ash contents of wheat flour (0.57%). Higher ash content indicates higher mineral contents.

The calcium content in malted barley flour was found to be 165 mg/100 g, which varies from the calcium content as calculated by Youssef *et al.* (2013). In his literature, Ca content obtained in genotypes Giza 126 (160 mg/100 g) and Giza 130 (140 mg/g) respectively.

The iron content in malted barley flour was found to be 8.52 mg/g. The differences in value may be because germination would increase the mineral content due to an increase in amylase enzyme activity during germination. The enzyme will hydrolyze the bond between the protein-enzyme minerals become free, therefore increasing the availability of minerals (Narsih, 2012).

The crude fiber of the malted barley flour was found to be 8.15% (db.) which is comparatively greater than that of wheat flour 0.61% (db.). The reason for high fiber content in barley is due to increase in bran matter and the building of dry matter during the growth and development (germination) of plant. This means it supplies even more fiber, in addition to many other crucial nutrients. High-fiber content of barley is important for digestion, hormone production and cardiovascular health (Anon., 2017).

4.2 Physical properties of prepared biscuits

Table 4.3 Physical parameters of prepared biscuits

Samples	Thickness (mm)	Diameter (mm)	Spread ratio	Weight (g)	Volume (cm^3)	Density (g/cm^3)
E	6.56±0.2	62.14±0.1	9.74±0.15	12.86±0.2	19.88±0.1	0.646±0.15
C	6.29±0.3	61.30±0.1	9.47±0.2	13.58±0.2	18.55±0.1	0.731±0.15
B	6.75±0.3	53.58±0.1	7.93±0.16	12.64±0.2	14.88±0.1	0.88±0.10
A	6.45±0.1	52.96±0.1	8.21±0.1	13.14±0.3	14.21±0.2	0.92±0.26
F	6.56±0.2	53.14±0.1	8.10±0.15	12.86±0.2	14.55±0.1	0.88±0.15
D	6.42±0.1	61.96±0.1	9.65±0.1	13.14±0.3	19.34±0.2	0.679±0.6

Physical characteristics of biscuits such as thickness, diameter, spread ratio, weight, volume and density were affected by the substitution increment of the level of malted barley flour which is presented in Table 4.4. The results indicated that diameter and thickness of biscuit were slightly increased with increasing substitution percentage of malted barley flour. 50 parts malted barley flour incorporated biscuit revealed the maximum diameter and thickness (62.14 and 6.56 mm). The results agree with work done by Hussain *et al.* (2016) who found that diameter and thickness of cookies showed gradually increase as the level of flour substitution.

Moreover, the results of spread ratio of biscuit revealed a reduction in spread ratio from 7.93 to 9.74. It is clear that as the malted barley flour level increased, spread ratio for different treated biscuits gradually increased. These results are on the line with the findings of Awodi *et al.* (2017), who reported that the increase in spread ratio might be due to the difference in particle size between wheat flour and malted barley flour.

4.3 Sensory properties of biscuits

Statistical analysis of the sensory scores was obtained from 10 semi-trained panelists using 9- point hedonic rating scale (9=like extremely, 1= dislike extremely) for composite biscuit formulations. Sensory analysis was performed with the aid of different panelists evaluating texture, crispiness, color, taste flavor and overall acceptability malted barley flour incorporated biscuit.

4.3.1 Color

The mean sensory score for color of sample B was found to be 8.95 and was highest of all other biscuit formulations which was significantly different ($p<0.05$) from other samples. Statistical analysis showed that the partial substitution of wheat flour with malted barley flour has significant effect ($p<0.05$) on the color. Fig. 4.1 shows the mean sensory score for color attributes.

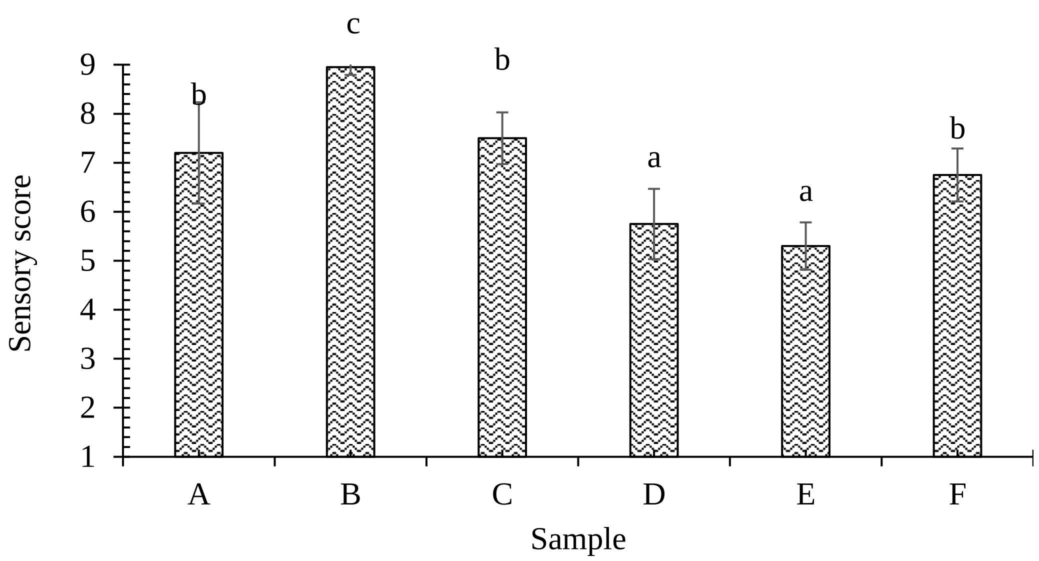

Fig. 4.1 Mean sensory scores for color of biscuit samples of different formulation

[A, B, C, D, E and F, denotes 25 parts, 16.667 parts, 33.33parts, 37.5 parts, 50 parts, 0 parts. Vertical errors bar represents ± standard deviation of scores given by 10 panelists.]

The product B got the higher score may be due to the appropriate amount of malted barley flour (16.67%). The effect of higher amount of incorporation of the malted barley flour may be the cause of dark brown color that is observed in the case of sample E which could be the cause of lower acceptance of the color. The result is in accordance with Masoodi and Bashir (2012) who found that the color of the fortified biscuits attained more dark color as the supplementation was increased.

4.3.2 Texture

The mean sensory score for texture of sample B was found to be 8 which was the highest score of all the biscuit formulations. Statistical analysis showed that the partial substitution of wheat flour with malted barley flour had significant effect ($p<0.05$) on the texture. Fig.4.2 shows mean sensory score for texture of biscuits sample of different formulations.

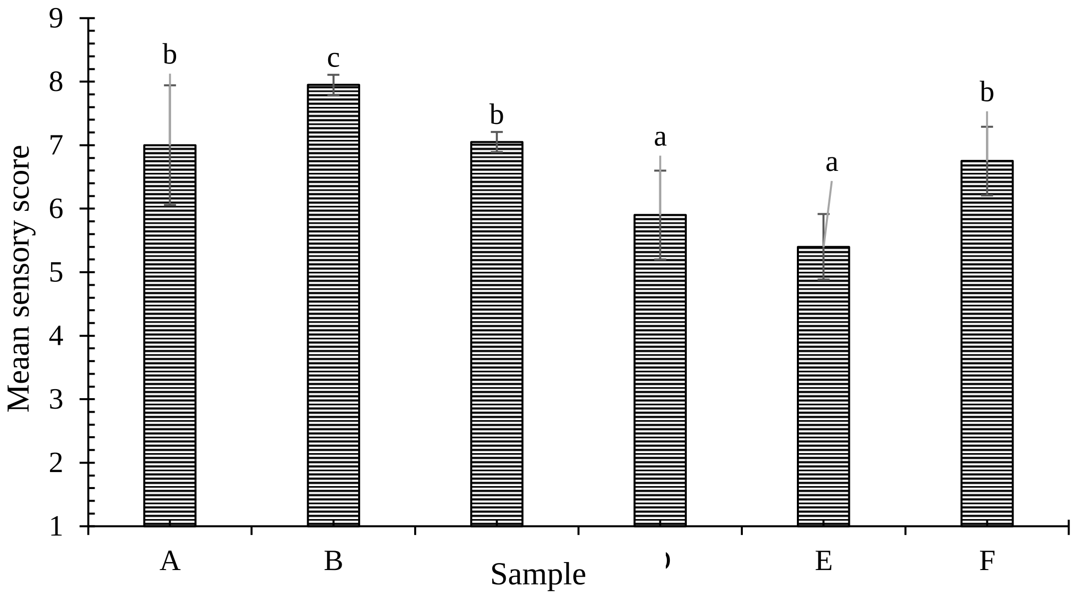

Fig. 4.2 Mean sensory scores for texture of biscuit samples of different formulation

[A, B, C, D, E and F, denotes 25 parts, 16.667 parts, 33.33parts, 37.5 parts, 50 parts, 0 parts. Vertical errors bar represents ± standard deviation of scores given by 10 panelists.]

Sample B got highest score which is significantly different with the all-other samples. The probable cause of highest score for the texture of sample B may be the amount of fiber present in the formulation because of all the formulations product B had the optimum fiber incorporated in it. The result is in accordance with Sudha *et al.* (2007) who found similar result with the addition of fiber in biscuit. Samples D and E were found to have the lowest mean score due to the least gluten development as higher amount of malted barley flour is used which has lower gluten than the wheat flour affecting the formation of gluten development in wheat flour. As proportion of malted barley flour increases texture score decreased which may be due to tougher texture and cracks on the crust. Sample B showed firm texture and no cracks, which might be due to adequate amount of gluten development. Texture is an important factor of comparing the biscuit as it greatly affects consumer acceptance of the product (Eisa, 2006).

4.3.3 Crispiness

Statistical analysis showed that partial substitution of wheat flour with malted barley flour had significant effect ($p<0.05$) on the crispiness. The sample B got highest sensory score and is significantly different with all other samples. Optimum formulation of malted barley may have created optimum water holding capacity of product that contributed to the development of the crust crispiness. Fig. 4.3 shows mean sensory score for crispiness of biscuits samples of different formulation.

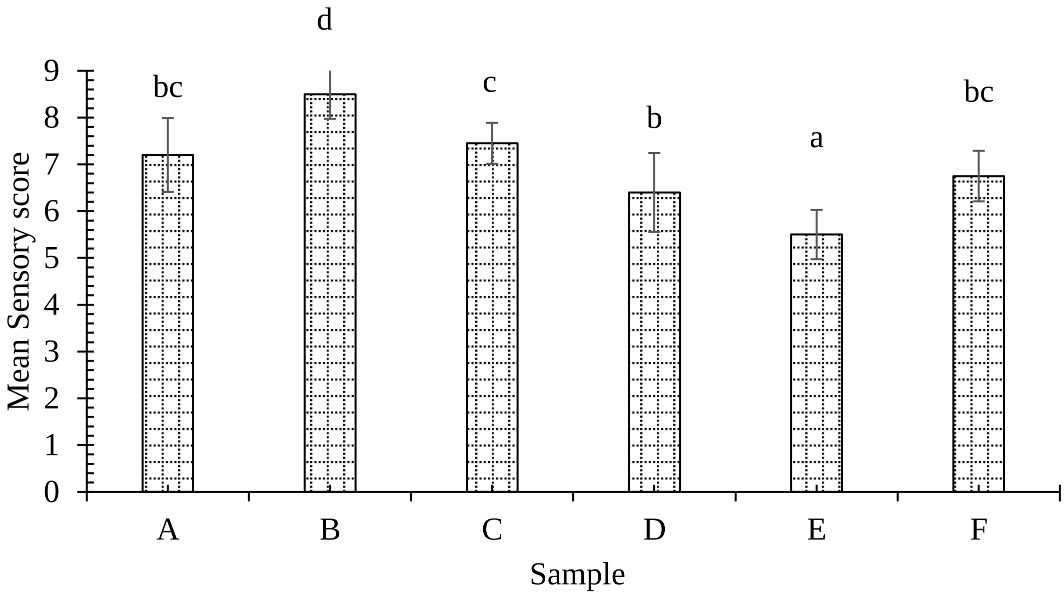

Fig. 4.3 Mean sensory scores for Crispiness of biscuit samples of different formulation

[A, B, C, D, E and F, denote 25, 16.667, 33.33, 37.5, 50, 0. Vertical errors bar represents ± standard deviation of scores given by 10 panelists.]

The reduced water content increases the glass transition temperature of the crust and contributes to the development of the crust crispiness. A glassy state of the solids would provide brittleness to the product, but the porous structure of the product and the solid, thin pore membranes may significantly contribute to the sensory properties of the product as stated by Roos and Drusch (2015).

4.3.4 Flavor

The mean sensory score for flavor of sample B was 8.65 and was the highest score scored among the different formulations. The lowest mean sensory score was of sample E. Statistical analysis showed that the partial substitution of wheat flour with malted barley flour had significant effect ($p < 0.05$) on the flavor. Fig. 4.4 shows mean sensory scores for flavor of biscuit samples pf different formulations.

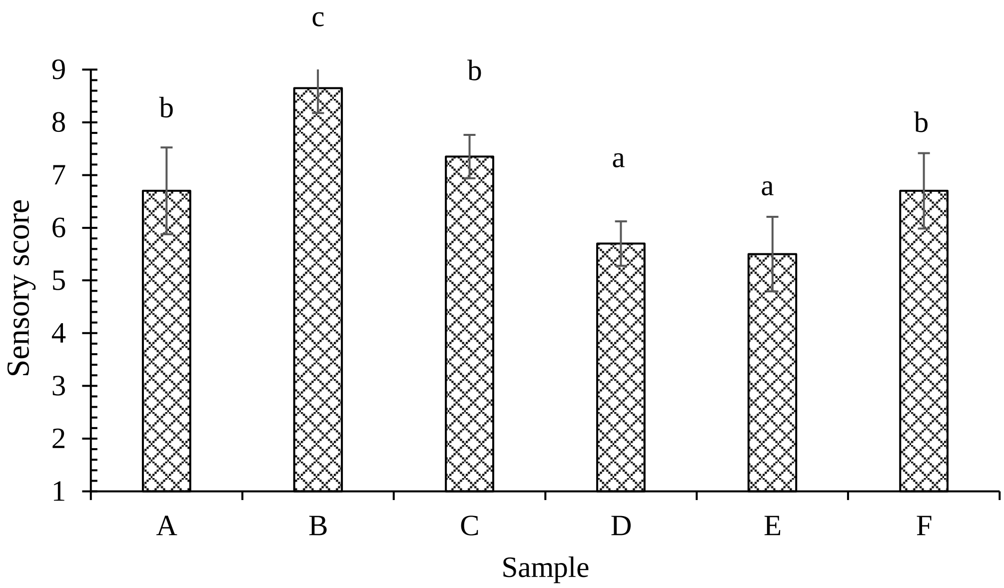

Fig. 4.4 Mean sensory scores for flavor of biscuit samples of different formulation

[A, B, C, D, E and F, denotes 25 parts, 16.667 parts, 33.33parts, 37.5 parts, 50 parts, 0 parts. Vertical errors bar represents ± standard deviation of scores given by 10 panelists.]

The biscuit with the highest amount of malted barley such as sample E had low score which could indicate that due to the more amount of total phenolic and flavonoid content in malted barley it resulted unacceptable flavor to the panelists (Udeh *et al.*, 2018). 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.

4.3.5 Taste

Statistical analysis showed that the partial substitution of wheat flour with malted barley flour had significant effect ($p<0.05$) in the taste. Fig. 4.5 shows mean sensory scores for taste of biscuit samples pf different formulations.

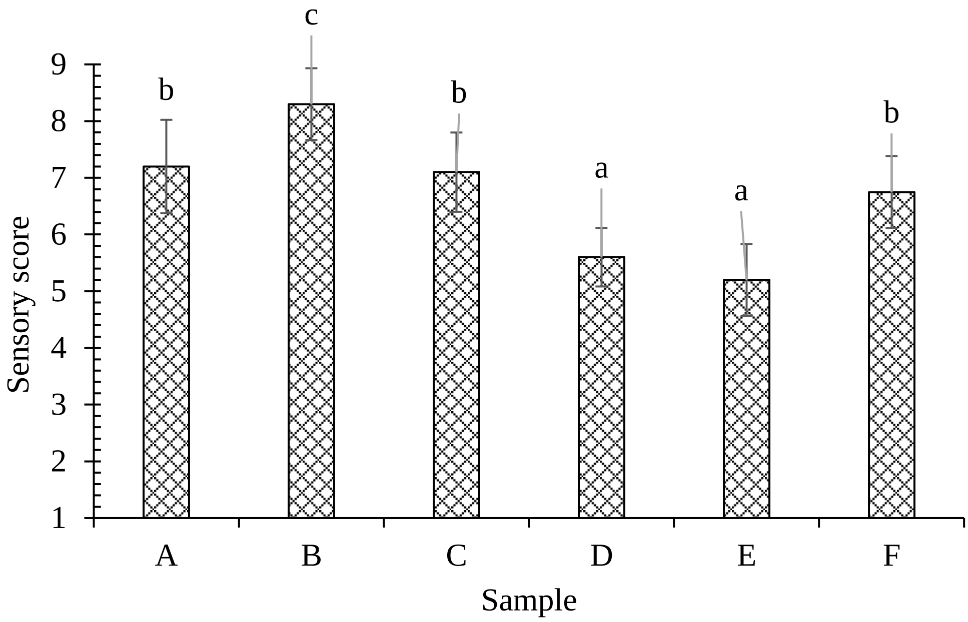

Fig. 4.5 Mean sensory scores for taste of biscuit samples of different formulation

[A, B, C, D, E and F, denotes 25 parts, 16.667 parts, 33.33parts, 37.5 parts, 50 parts, 0 parts. Vertical errors bar represents ± standard deviation of scores given by 10 panelists.]

Sample B is found to be scoring highest in taste as compared to other samples. It is found sample B is significantly different with all other samples. Sample E is the lowest scoring formulations of all which indicates that higher amount of malted barley flour in the formulations could lower the score and acceptability for taste of the product. This also shows the formulation of sample B is very balanced for good taste of Biscuits as theses have typical pleasant malty flavor.

4.3.6 Overall acceptability

Sample B scored highest in overall acceptability of the sensory conducted among the panelists. It was found to be not significantly different from the control sample F. Statistical analysis from the experimental data showed that the partial substitution of malted barley flour in samples showed significant difference ($p<0.05$) in overall acceptability. Fig. 4.6

shows mean sensory scores for overall acceptability of biscuit sample of different formulations.

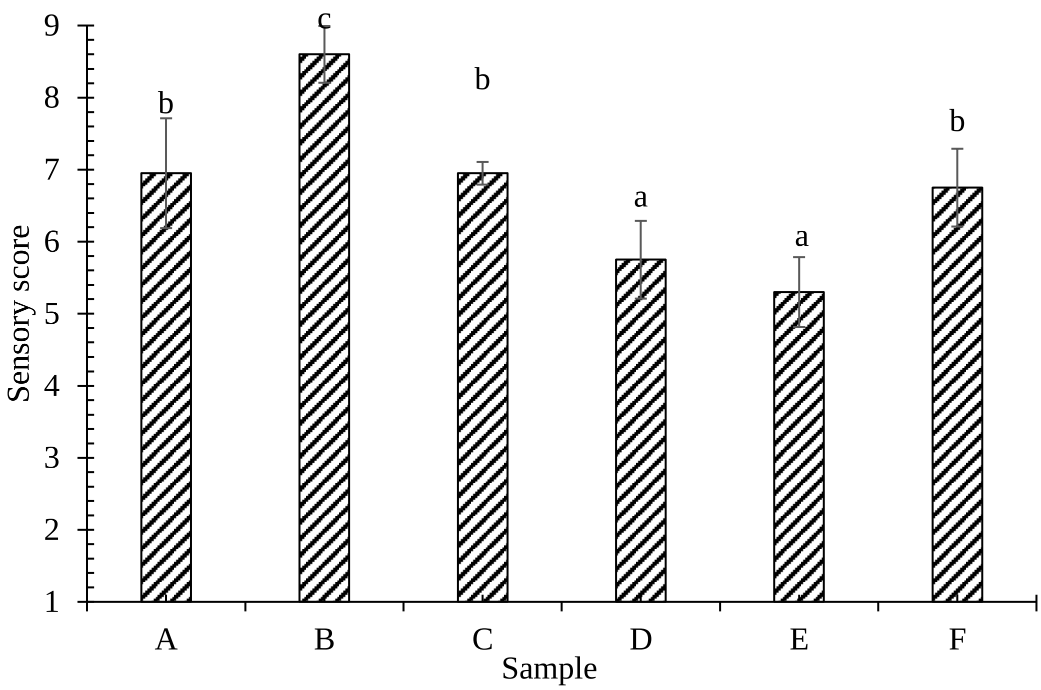

Fig. 4.6 Mean sensory scores for overall acceptability of biscuit samples of different formulation

[A, B, C, D, E and F, denotes 25, 16.67, 33.33, 37.5, 50, 0 parts. Vertical errors bar represents ± standard deviation of scores given by 10 panelists.]

Sample B scored highest in overall acceptability of the sensory conducted among the panelists, which might be due to good taste, texture and crispiness. It is found to be not significantly different from all other samples. Sample E showed lowest score in overall acceptability which could be as a result of highest amount of malted barley flour incorporated in it. Optimum amount of malted barley flour formulation provided good texture and mouth feel in sample B.

Thus, from statistical sensory analysis, the best product was found to be sample B biscuit whose formulation was as malted barley flour: wheat flour :: 16.67: 83.33 The formulation of sample is considered as optimized.

4.4 Optimized product

The composition of the best product and the control biscuit from chemical analysis was carried out. The result of the analysis is given in the Table 4.4.

Table 4.4 Composition of product

Proximate composition (db.)	Product A (Whole biscuit)	Product B (Malted barley biscuit)
Moisture content (%)	2.82±0.18	2.5±0.02
Crude protein (%)	6.8±0.12	11.21±0.05
Crude fat (%)	15.80±0.25	20.45±0.31
Crude fibre (%)	1.23±0.01	3.05±0.15
Total ash (%)	1.30±0.02	1.71±0.11
Carbohydrate (%)	72.05 ±0.5	61.08±0.95
Calcium (mg/100 g)	52.3±0.13	57.7±0.21
Iron (mg/100 g)	3.30 ± 0.2	3.42±0.3

[Values are the means of three determinations ± standard deviations. Figures in the parenthesis are standard deviations.]

The ash content of biscuits increased in malted barley flour incorporated biscuit. The increase in ash content may be due to the high mineral content in the malted barley flour incorporated biscuit i.e. calcium and iron. The high ash content in the malted barley flour supplemented food would be of nutritional importance in most developing countries like Nepal. Barley flour contains a lot of minerals, confirmed by its higher ash content. The higher level of minerals in barley incorporated biscuit is also demonstrated by higher level of the calcium in the malted barley as reported by Khatkar (2013). The concentration of Fe varied from 3.30 mg/kg to 3.42 mg/kg (El *et al.*, 2018).

The moisture content ranged from 2.82% in wheat biscuit to 2.5% in the malted barley flour incorporated biscuit. The lower moisture content of optimized may be due to incorporation of barley malt flour which had quite low moisture content compared to wheat flour. The fat content of malted barley flour incorporated biscuit was higher than wheat flour biscuits. This is due to the higher fat content of malted barley flour than wheat flour. Barley is also found to be one of the richest sources of crude fiber. Therefore, malted barley flour incorporated biscuit showed an increase in the fiber content. The cost of malted barley incorporated biscuit was found to be NRs. 17.843 (as of 2020) which excludes the processing, packaging, manpower cost and profit margin.

Part V

Conclusion and recommendations

5.1 Conclusion

On the basis of the work done, following conclusions can be drawn.

1. Malting of barley was carried out which shows the increase in crude protein, crude fiber, total ash, reducing sugar while decrease in crude fat.
2. Analysis of wheat flour and malt flour showed the significant increase in case of fat, fiber, ash and minerals in the latter as a result of which the nutritional quality of the biscuit also seemed to be enhanced in the case of the same.
3. The malted barley flour can be successfully incorporated up to 16.67%, with no adverse effect on the acceptable quality on the basis of sensory score.
4. Sensory evaluation of prepared biscuits was carried which showed that sample B (16.67%) was best in terms of color, texture, crispiness, flavor, taste and overall acceptability.
5. Chemical analysis of control and most rated biscuits was carried out which showed increase in crude protein, crude fat, crude fiber, minerals, calcium and iron in the most rated biscuits than the control biscuits.
6. Cost of biscuit per 100 g was found to be Rs.17.67 that excludes processing, packaging, manpower cost as well as profit margin.

5.2 Recommendations

1. Entrepreneur can utilize malted barley flour up to 16.67 parts to enrich nutritional value of general biscuits without hampering consumer acceptance.
2. Study on the incorporation of malted barley flour with wheat flour to prepare other baked foods like breads can be carried out.
3. Study of the shelf life of biscuit and texture analysis can be carried out.

Part VI

Summary

Biscuits are the low cost, processed food which offers good taste along with nutritional values at affordable price with a good shelf life in comparison to most of the other snack items. Biscuits owing to their shelf life can be beneficial for feeding programs and other immediate catastrophic conditions. Further value of biscuit can be added by incorporating malted barley flour. Incorporation of wheat flour with malted barley flour to make biscuits provides a good opportunity to improve the nutritional quality of the fiber and minerals consumed by many people especially growing children and old people due to which helps to rise the nutritional status of the population.

A study was carried out to evaluate the effects of incorporation of malted barley on the biscuit quality. The recipe was formulated as through the Design expert v7.1.5 for mixture method. Barley collected from local market of Dharan (Sunsari) was used for malting. Grains were steeped for 4 h in a lime water (2%) to prevent the mold growth during germination. After steeping the grains were germinated for 96 h at 20ºC and 95% RH. Then, the germinated grains were dried in cabinet dryer at (45ºC for 6 h, 50ºC for 4 h, 55ºC for 8 h, 70ºC for 1h, 80ºC for 3 h) to obtain desired moisture content of 3-5%. The grain and dried malt samples were then taken for analysis of physical, chemical and functional properties.

The 1000 kernel wt., bulk density and sphericity were found to decrease after malting from 41.9 g to 16.19 g, 64.1 kg/HL to 48.1 kg/HL and 49.5 % to 29.38% respectively. While porosity of grain varies after malting from 37.95 % to 45.63%. Moisture content, crude fat, total ash was found to decrease after malting from 11.90% to 4.09%, 4.71% to 2.25% and 2.86% to 2.45% respectively. While crude protein, crude fiber, reducing sugar, calcium and iron were increased after malting from 12.47 to 14.03%, 5.90 to 8.15%, 1.09 to 5.23%, 140 to 165 mg/100 g and 5.67-8.52 mg/100 g.

This study was mainly focused on the nutritional value addition of normal wheat biscuit by incorporating malted barley flour at various levels of incorporation. Thus, formulated biscuits were subjected to proximate analysis, iron content and calcium estimation. The proximate analysis of the flour used was also carried out. The incorporation was carried out

as 16.67, 25, 33.33, 37.67, 50, 0% and the best product was found out. The wheat flour and malted barley flour was analyzed for moisture, protein, fat, crude fiber, total ash and carbohydrates. The values were found to be 12.35, 10.47, 1.55, 0.61, 0.57 and 84.45% for wheat flour and 4.09, 14.03, 2.25, 8.15, 2.45, 69.03%for malted barley flour respectively.

The biscuit formulated was of soft dough type. The product was subjected to sensory analysis. The sensory analysis was carried out based on crust color, flavor, crispiness, texture and overall acceptance. The data obtained were subjected to statistical analysis at 95% confidence level. The best product among the six varieties was found out. The biscuit with 16.67% (Sample B) malted barley flour was found to be best among the six varieties.

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Appendices

Sensory evaluation score sheet for biscuit

Date:……………………

Name of Panelist:

Name of the product: Malted barley flour incorporated biscuits

Dear panelist, you are provided 5 samples of Malted barley Incorporated Biscuit on each proportion with variation on malted barley flour content. Please test the following samples of biscuit 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**					
Color	A	B	C	D	E	F
Texture						
Crispiness						
Flavor						
Taste						
Overall acceptability						

Any comments: Signature:

Appendix B

Two-way ANOVA (No blocking) for Color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	5	87.633	17.526	44.56	<.001
Panelist	9	3.750	0.416	1.06	0.410
Residual	45	17.700	0.399		
Total	59	109.083			

Two-way ANOVA (No blocking) for Texture

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	5	41.987	8.397	27.37	<.001
Panelist	9	3.620	0.402	1.31	0.258
Residual	45	13.804	0.3068		
Total	59	59.412			

Two-way ANOVA (No blocking) for Crispiness

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	5	51.583	10.316	24.43	<.001
Panelist	9	2.350	0.261	0.62	0.775
Residual	45	19.00	0.422		
Total	59	72.933			

Two-way ANOVA (No blocking) for Flavor

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	5	66.383	13.276	32.09	<.001
Panelist	9	1.733	0.192	0.47	0.890
Residual	45	18.616	0.413		
Total	59	86.733			

Two-way ANOVA (No blocking) for Taste

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	5	64.320	12.864	36.36	<.001
Panelist	9	7.920	0.880	2.51	0.020
Residual	45	15.804	0.351		
Total	59	88.045			

Two-way ANOVA (No blocking) for Overall acceptability

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Sample	5	66.237	0.3616	55.61	<.001
Panelist	9	3.254	13.247	1.52	0.171
Residual	45	10.720	0.238		
Total	59	80.212			

Appendix C

Cost calculation of malted barley biscuits

Materials	Weight in lot(g)	Cost per Kg (NRs)	Cost (NRs)
Wheat flour	83.33	50	4.16
Barley flour	16.67	100	1.667
Sugar	35	90	3.15
Fat	33	200	6.6
Potassium metabisulphite	1	180	0.18
Bicarbonate	3.25	125	0.40625
Skimmed milk powder	4	420	1.68
Biscuit (NRs/ 100 g)			17.843

Note: The cost excludes processing, packaging, manpower cost and profit margin.

Appendix D

Physical properties of Barley grain and malt

Physical properties	Barley grain	Malted barley
Sphericity (%)	49.5±0.52	29.38±0.39
1000 kernel wt. (g)	41.9±0.2	16.19±0.58
Bulk density (kg/HL)	64.1±0.59	48.1±0.53
Porosity (%)	37.95±0.01	45.63±0.75

Color plates

Germination Bed

Germinated barley

Drying oven

Germinated barley flour

packaging

Sensory panelists