ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

ADDIS ABABA INSTITUTE OF TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

Development of Cookies from Wheat, Quality Protein Maize and Carrot Composite Flour

Thesis submitted to the school of Graduate Studies of Addis Ababa University in partial fulfillment of the requirement of Masters Degree in Chemical Engineering (Food Engineering)

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Acronyms

AACC	-	American Association of Cereal Chemists
ANOVA	-	Analysis Of Variance
AOAC	-	Association of Analytical Chemists
BD	-	Bulk Density
CIMMYT	-	International Maize and Wheat Improvement Center
EARO	-	Ethiopian Agricultural Research Organization
OAC	-	Oil absorption capacity
OD	-	Optical density
QPM	-	Quality protein maize
RDA	-	Recommended dietary allowance
SF	-	Spread factor
WAC	-	Water absorption capacity

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Chapter 1

1.1Introduction

Cookies represent the largest category of snack items among baked foods all over the world. Cookies are a well-known product; it is categorized as a miscellaneous food category product. Cookies can serve as a vehicle for important nutrients if made readily available to the consumer. It consists of three major components: flour, sugar, and fat, which compose Cookie dough and influence the quality of the final product. The main ingredient of cookie dough is soft wheat flour (Taha *et al.*, 2006).

Wheat contain far from adequate amounts of vitamin A precursors (Berdanier *et al.*, 2008). Carrots on the other hand, are rich source of β-carotene, which is the most active form of carotenoids, which acts as provitamin A (Sharma *et al.*, 2006), which was used to fortify the wheat flour cookie, in this study, to increase its vitamin A precursor content as well as to meet the growing interest in finding high-nutritional cookies due to the possibility of using these fortified product.

Vitamin A is one of the most versatile vitamins, with roles in such diverse functions as vision, immune defenses, maintenance of body linings and skin, bone and body growth, normal cell development, and reproduction. Vitamin A helps form and maintains healthy teeth, skeletal and soft tissue, mucous membranes, and skin. Thus vitamin A and related nutrients may collectively be important in protecting against conditions related to oxidative stress, such as aging, cancer, cardiovascular disease, cataracts, diabetes mellitus and infection (Yeung and Laquatra, 2003).

Deficiency of vitamin A is of crucial importance as a worldwide nutritional problem, especially in developing countries (Berdanier *et al.*, 2008). The first symptoms of vitamin A deficiency are night blindness and drying of the conjunctiva of the eye. Bitot's spots may be present in the cornea of the eye. With continued vitamin A deficiency, Progressive damage to the eye results from drying of the cornea and irreversible corneal damage resulting in xerophthalmia, keratomalacia (night blindness), and blindness. In children, retarded growth may occur as a result of vitamin A deficiency (Yeung and Laquatra, 2003). In order to avoid vitamin A deficiency and its associated problems peoples need to include vitamin A or Pro vitamin A reach sources of food. One of provitamin A reach food source is carrot.

Carrot belongs to the family Umbelliferae and to the genus Daucus and species Carota is one of the important root crops cultivated throughout the world for its fleshy edible roots; and is used for human consumption. Carrots are rich source of beta-carotene and contain appreciable amounts of thiamine and riboflavin (Kalra *et al*., 1987). B-carotene is the most active form of carotenoids, which acts as provitamin A. Besides β-carotene, carrots also contain alpha-carotene, zeacarotene, lutein, lycopene, etc. Both alpha-carotene and β-carotene account for more than 90% of all carotenoids in carrots (Sharma *et al.*, 2006).

Along with the mentioned β-carotene, it also includes Vitamins B, C, and E, D and K, proteins, potassium, calcium, phosphorus, zinc, aluminum, sodium, manganese, iron, copper and a lot of other minerals. Carrots contain great amounts of nicotine acid, which is important for metabolism of fats and lipids. The vegetable is a great source of natural magnesium, which assists in decreasing bad cholesterol levels in the body, helps to relieve spasms and strengthen our blood vessels (Carla, 2009). The primary health benefits of carrot are combating vitamin A deficiency while carotenoid is converted to vitamin A in the liver (Yeung and Laquatra, 2003).

Carrots can be processed in a wide variety of products. Among these, carrot juice and flour is the most popular (Sharma *et al., 2006*). The dried carrot is generally used in instant powdered soups, sauces, seasonings and other kinds of ready-to-eat meals (Doymaz, 2004; Zielinska & Markowski, 2007).

Wheat also is deficient in some amino acids such as lysine and tryptophan (Taha *et al.*, 2006). Quality protein maize (QPMs) on the other hand is higher in essential amino acids. Essential amino acids are those nutrients that are required by the body and cannot be synthesized in the body in adequate amounts to meet requirements so must be provided by the diet (Berdanier *et al.*, 2008).

Quality protein maize (QPM) describes a range of maize cultivars with superior nutritional and biological value. QPM contains nearly twice as much usable protein (limiting amino acids lysine and tryptophan) than other maize grown in the tropics and yields 10% more grain than traditional varieties of maize. It was developed by Surinder and Evangelina at the International Maize and Wheat Improvement Center (CIMMYT) in the late 1990’s ,to help reduce human malnutrition in areas where protein deficiency is prevalent and where maize is the major protein source in the diet, as in various parts of Sub-Saharan Africa (SSA). And this maize is distributed throughout Africa including Ethiopia (Prasanna, 2001).

Given the above information on the nutritional content of carrot and quality protein maize this study was undertaken to produce cookies of high and good nutritional quality from carrot, quality protein maize and wheat composite flour.

1.2 Statement of the Problem

Malnutrition is a very common problem in developing countries, the problem includes both macro and micro nutrient deficiencies, among these vitamin A deficiencies and protein deficiencies are the most significant.

Deficiency of vitamin A is of crucial importance as a worldwide nutritional problem. The resultant xerophthalmia is a cause of blindness in at least half a million preschool children each year in the developing countries (Berdanier *et al.,* 2008). With the highest prevalence in Southeast Asia and Africa (ODS, 2010). In these areas, the diet is composed primarily of such items as rice, wheat, maize, and tubers, which contain far from adequate amounts of vitamin A precursors (Berdanier *et al.*, 2008)

Several studies have established that vitamin A deficiency is a major public-health problem in Ethiopia (Woldegebriel *et al.,* 1991). Except in the southern region where studies have consistently shown low levels of vitamin A deficiency (Woldegebriel *et al.*, 1991: Demisse *et al.*, 1998), the problem has continued to constitute a major public-health concern in other regions. In some regions, close to 8% prevalence rate of Bitots spot (clinical vitamin A deficiency) was reported, perhaps the highest rate ever recorded in the world (Demisse *et al.*, 2000). The fifth nutrition situation report of the Standing Committee on Nutrition of the United Nations indicates that the prevalence of xerophthalmia in Ethiopia is the highest in the world (Haddad *et al.*, 2004).

Deficiency of vitamin A can be prevented by a diet high in carotenes, which serve as precursors to vitamin A. The carotenes, particularly β-carotene, are derived exclusively from plant sources, the richest of which are palm oil, carrots, sweet potatoes, dark green, leafy vegetables, cantaloupe, oranges, and papaya. Preformed vitamin A is derived only from animal sources, such as dairy products, meat, and fish (Berdanier *et al.*, 2008).

Beside the low β-carotene content, wheat also deficient in essential amino acids such as lysine and tryptophan this could be alleviated by fortifying the wheat flour with QPM. These two amino acids allow the body to manufacture complete proteins, thereby eliminating wet-malnutrition.

Fortifying mostly used food products such as cookies with Beta carotene rich plant source such as carrot and essential amino acid rich maize can be one way to fortify a biscuit product to meet the growing demand of highly nutritious food products. Hence this study was meant to produce new cookies from wheat, quality protein maize and carrot composite flour.

1.3. Objectives

1.3.1 General Objectives

The general objective of the study was to develop a cookie from wheat, QPM and carrot composite flour.

1.3.2 Specific Objectives

The specific objectives are:

- To produce a cookie rich in β-carotene , tryptophan and lysine
- To study the functional properties of the composite flour
- To study the effect of blend proportions and temperature on the physicochemical properties of the developed cookie
- To suggest a modified process design for the cookie production

Chapter 2

2. Literature Review

2.1 Vitamin A status and supplementation in Ethiopia

Vitamin A and its metabolites play diverse roles in physiology, ranging from incorporation into vision pigments to controlling transcription of important genes. Vitamin A is commonly known as the anti-infective vitamin, because it is required for normal functioning of the immune system. Retinol and its metabolites are required to maintain the integrity and function of the skin and mucosal cells which function as a barrier and form the body's first-line of defense against infection (Yeung and Laquatra, 2003).

Vitamin A deficiency (VAD) remains a serious public health problem in developing countries. Pre-school aged children and women during pregnancy or lactation tend to suffer the most widespread and severe effect of VAD. Other segments of a population can also be vulnerable to the deficiency as a result of consumption of Vitamin A deficient staple diet or lack of access to Vitamin A rich foods due to climatic, seasonal and economical factors (Berdanier *et al.*, 2008).

Currently, about 7.2 million women in the developing countries are Vitamin A deficient and another 13.6 million have low Vitamin A status. Globally, 140–250 million children under five years of age are affected by vitamin A deficiency. These children suffer increased risk of death, blindness and illness . The UN Special Session on Children in 2002 had set the goal of eliminating vitamin A deficiency and its consequences by the year 2010. Especially in areas where the intake of vitamin A is inadequate, provision of the vitamin through a combination of breastfeeding, dietary improvement, food fortification, and supplementation is recommended. Such interventions should also be augmented by nutrition education.

Several studies over the years have established that vitamin A deficiency is a major public health problem in Ethiopia. Studies conducted starting from late 1950’s consistently indicated that the prevalence of Bitot’s spot among preschool children is well above the cutoff point of 0.5% which indicates its public health significance (6- 8). Recent studies reported the same (9-12). According to a recent WHO estimate, the national prevalence of vitamin A deficiency among preschool children in Ethiopia is 61.2% which is among the highest in Sub- Saharan Africa (Samson *etal.*, 2009).

Since 1987, WHO has advocated the routine administration of vitamin A supplement for children aged 6-59 months every four to six months and mothers soon after delivery. This is considered as an inexpensive, quick, and effective way to improve vitamin A status in areas where vitamin A deficiency is a public health problem. However, in Ethiopia the coverage of vitamin A supplementation among preschool children and women in the postpartum period is below satisfactory level. According to Demographic and Health Survey (DHS) Ethiopia 2005, among preschool children aged 12-59 months, only 45.8% received the supplement in the preceding 6 months of the survey and among women in the postpartum period, only 20.6% received the supplement in the first two months after their delivery (Samson *etal.,* 2009).

2.2 Carrot

2.2.1 Potential Health Benefits of Carrot

Carrots are an excellent source of antioxidant compounds, and the richest vegetable source of the pro-vitamin A carotenes. Carrots' antioxidant compounds help protect against cardiovascular disease and cancer and also promote good vision, especially night vision.

2.2.1.1 Cardiovascular Disease

When six epidemiological studies that looked at the association of diets high in carotenoids and heart disease were reviewed, the research demonstrated that high-carotenoids diets are associated with a reduced risk of heart disease. In one study that examined the diets of 1,300 elderly persons in Massachusetts, those who had at least one serving of carrots and/or squash each day had a 60% reduction in their risk of heart attacks compared to those who ate less than one serving of these carotenoids-rich foods per day (Whfood, 2010).

2.2.1.2Better Vision

Beta-carotene helps to protect vision, especially night vision. After beta-carotene is converted to vitamin A in the liver, it travels to the retina where it is transformed into rhodopsin, a purple pigment that is necessary for night-vision. Plus beta-carotene's powerful antioxidant actions help provide protection against macular degeneration and the development of senile cataracts, the leading cause of blindness in the elderly.

The macular of the eye predominantly contains two pigments, lutein and zeaxanthin . Because these two pigments account for less than 25% of plasma carotenoids, their uptake from plasma and deposition in the macula show specificity. These pigments might consequently play a role in protecting the macula from damage caused by light and particularly by blue light. In a recent study with patients suffering from age-related macular degeneration (ARMD) vs. matched controls, subjects in the highest quintile of carotenoids intake had a 43% lower risk. of suffering from ARMD than those in the lowest quintile. Of various carotenoids, the intake of spinach and collard greens, rich in these two carotenoids, was most strongly associated with reduced risk. However, not all studies support this finding (105). Nonetheless, higher plasma concentrations of lutein and zeaxanthin as well as β-carotene showed a significant trend toward a lower risk of developing ARMD. These interesting findings are currently being investigated (Rucker, 2001).

Cataract consists of gradual opacification of the lens with aging, which may in part result from oxidative stress. Carotenoids intake, as well as that of vitamins C and E, has been associated with a reduced risk of cataract. In the main Linxian, China trial, however, combined supplements of β-carotene, selenium, and α-tocopherol were not associated with a reduction in the incidence of cataracts, and inconclusive results have been reported by others. Thus, whereas the concept that antioxidant nutrients might prevent oxidative damage to a fairly exposed structure, such as the lens, is highly feasible, the data supporting a protective role of dietary components in the process are mixed (Rucker, 2001).

2.2.1.3 Carotenoids and Cancer

High carotenoid intake has been linked with a 20% decrease in postmenopausal breast cancer and an up to 50% decrease in the incidence of cancers of the bladder, cervix, prostate, colon, larynx, and esophagus. Extensive human studies suggest that a diet including as little as one carrot per day could conceivably cut the rate of lung cancer in half (Whfood, 2010)

2.2.1.4 HIV Infection

In HIV infection T-helper (CD4) cells are destroyed, thereby impairing the immune response. In humans as well as in experimental animals, both β-carotene, which is a provitamin A carotenoids, and canthaxanthin, which is not, can enhance the immune response. Indeed, in HIV-infected patients, large doses of β-carotene increased the CD4/CD8 ratio, which is usually depressed in HIV infection, and improved the response to vaccines. In phase II HIV-infected subjects, plasma carotenoid concentrations are reduced by 50%.AIDS patients treated daily with a combination of β-carotene supplementation (120 mg) and whole-body hyperthermia (42°C, 1 h) showed a better and longer lasting response than either treatment separately. Thus, carotenoids seem to ameliorate the condition of AIDS patients, probably, at least in part, by enhancing the immune response. The use of carotenoids in the treatment of subjects with HIV infections clearly merits further attention (Rucker, 2001).

2.2.1.5 Falcarinol in Carrots Promote Colon Health

Although best known for their high content of beta carotene, carrots also contain a phytonutrient called falcarinol that may be responsible for the recognized epidemiological association between frequently eating carrots and a reduced risk of cancers.

Falcarinol provides protection against colon cancer, suggests a study published in the Journal of Agricultural and Food Chemistry. Three groups of laboratory animals in whom precancerous colon lesions (aberrant crypt foci) had been chemically-induced were fed a standard diet, one supplemented with freeze-dried carrots naturally containing falcarinol, or one supplemented with an extract of falcarinol. After 18 weeks, precancerous lesions in the animals given diets containing carrots or falcarinol were much smaller than those in the control animals, and far fewer of the lesions had grown in size or progressed to become tumors (Whfood, 2010).

2.2.2 Process Technology of Carrot Drying

Dehydration is the application of heat under controlled condition to remove the majority of the water normally present in the food by evaporation (Fellow, 2000). Drying is the oldest method of food preservation practiced by man. For thousands of years he has dried and/or smoked meat, fish, fruits and vegetables, to sustain him during out of season periods in the year (Brennan, 2006).

The main reason for drying a food is to extend its shelf life beyond that of the fresh material, without the need for refrigerated transport and storage. This goal is achieved by reducing the available moisture, or water activity to a level which inhibits the growth and development of spoilage and pathogenic microorganisms, reducing the activity of enzymes and the rate at which undesirable chemical changes occur (Brennan, 2006), but the processing temperature is usually insufficient to cause their inactivation. Therefore any increase in moisture content during storage, for example due to faulty packaging, will result in rapid spoilage (Fellow, 2000).

Drying also reduces the weight of the food product. Shrinkage, which occurs often during drying, reduces the volume of the product. These changes in weight and volume can lead to substantial savings in transport and storage costs and, in some cases, the costs of packaging (Brennan, 2006).

Longer shelf-life, product diversity and substantial volume reduction are the reasons for the popularity of dried fruits and vegetables, and this could be expanded further with improvements which could increase the degree of acceptance of dehydrated foods in the market (Pitchiah, 2004). Carrot also dried for the purpose mentioned above and the process involved the raw material preparation, pretreatment and drying. These processes are reviewed here in under.

2.2.2.1 Raw Material Preparation

At the time of harvest most foods are likely to contain contaminants, to have components which are inedible or to have variable physical characteristics (for example shape, size or colour). It is therefore necessary to perform one or more of the unit operations of cleaning, sorting, grading or peeling to ensure that foods with a uniformly high quality are prepared for subsequent processing. It is not possible to produce high quality processed foods from substandard raw materials and these mechanical separation procedures, which are applied near the beginning of a process, are a highly cost-effective method of improving the quality of the raw material. The presence of contaminants (or foreign bodies) in processed foods is the main cause of prosecution of food companies (Fellow, 2000).

2.2.2.1.1 Cleaning

All food raw materials are cleaned before processing. The purpose is obviously to remove contaminants, which range from innocuous to dangerous. It is important to note that removal of contaminants is essential for protection of process equipment as well as the final consumer (Brennan, 2006). Cleaning is the unit operation in which contaminating materials are removed from the food and separated to leave the surface of the food in a suitable condition for further processing (Fellow, 2000).

Soaking is a preliminary stage in cleaning heavily contaminated materials, such as root crops, permitting softening of the soil and partial removal of stones and other contaminants. Metallic or concrete tanks or drums are employed; and these may be fitted with devices for agitating the water, including stirrers, paddles or mechanisms for rotating the entire drum. The use of warm

Water or including detergents improves cleaning efficiency. Spray washing is very widely used for many types of food raw material. Efficiency depends on the volume and temperature of the water and time of exposure. As a general rule, small volumes of high pressure water give the most efficient dirt removal (Brennan, 2006). Hence carrot can be soaked and then they are washed in conventional water washing machines.

2.2.2.1.2 Sorting

Sorting is the separation of foods into categories on the basis of a measurable physical property. Like cleaning, sorting should be employed as early as possible to ensure a uniform product for subsequent processing. The four main physical properties used to sort foods are size, shape, weight and colour (Fellow, 2000). Carrot should be of good color and free of defects (Maroulis and Saravacos, 2008).

2.2.2.1.3 Peeling

Peeling of fruits and vegetables is frequently carried out in association with cleaning. Steam peeling is particularly suited to root crops. The units are exposed to high pressure steam for a fixed time and then the pressure is released causing steam to form under the surface of the skin, hence loosening it such that it can be removed with a water spray (Brennan, 2006). The washed root vegetables are normally peeled in a steam peeler at 7 bars for 30 s (Maroulis and Saravacos, 2008).

2.2.2.2 Dicing

Dicing is one of the size reduction methods for fibrous food materials in which food materials are cut in to cubes. The purpose of size reduction is an increase in the surface-area-to-volume ratio of the food which increases the rate of heating, drying and other processing operations (Fellow, 2000). Peeled carrots are diced mechanically (sliced into die shape) to sizes 9.5x9.5x9.5 mm prior to blanching (Maroulis and Saravacos, 2008).

2.2.2.3 Blanching and Sulfating

Blanching serves a variety of functions, one of the main ones being to destroy enzymatic activity in vegetables and some fruits, prior to further processing. Blanching brightens the color by removing air and dust on the surface in some raw vegetables and thus alerting the wavelength of reflected light. Time and temperature of blanching influence on food pigments (Giese, 2000). As such, it is not intended as a sole method of preservation but as a pre-treatment which is normally carried out between the preparations of the raw material and later operations such as drying (Fellow, 2000). Blanching is also combined with peeling and/or cleaning of food, to achieve savings in energy consumption, space and equipment costs (Fellow, 2000). Carrots are blanched for 6 min on a conveyor belt, using saturated steam at atmospheric pressure . After blanching the vegetable should be dipped in to cold water to avoid further cooking. The blanched carrot dice are usually sulfated with sprays of sulfurous solutions to preserve the color (carotene) during dehydration and subsequent storage (Maroulis and Saravacos, 2008).

2.2.2.4 Drying, Milling and Packaging

In tropical countries dehydration of fruits and vegetables by sun drying is a popular practice due to its low cost. Sun drying of carrots has been reported by Sagar and others (1997) and Jayaraman and others (1991) as cited by (Pitchiah, 2004). The carrots are spread in open yards and solar energy is used for their dehydration. Carrots dehydrated by this method are susceptible to contamination during drying and poor quality products may result, especially from the organoleptíc changes due the direct light of sun. Covering the carrots with glass covers and concentrating the solar radiation on the surface can overcome the disadvantage.

A study by Prakash and others (2004) as cited by (Pitchiah, 2004) studied the evaluated performance of blanched carrots dried by 3 different driers, solar cabinet, fluidized bed drying and microwave oven. Carrots dried by fluidized bed drying showed better color, rehydration properties, greater beta carotene retention and better overall sensory acceptability than those dried in microwave oven and solar cabinet methods. According to Maroulis and Saranac’s (2008), the diced carrots are dehydrated in a conveyor belt air–dryer until moisture content of about 8% is reached. The product may require further dehydration to 3% moisture content in a bin dryer, using dehumidified air.

2.2.3 Carrot Flour in Cookie Making

Akubor (2005) studied Functional properties of soybean-corn-carrot flour blends for cookie production. In his study he prepares soybean and corn flour blend in the ratio (SF/CF) 30:20. Then he use carrot flour to replace the soybean and corn flour blend at 5, 10 15, 20, 30 and 50% levels. In his study Proximate composition and functional properties of the flour and blends were studied and cookies prepared from the blends were evaluated for their physical and sensory properties.

In his compositional analysis he founds that the soy flour contains more crude fat, crude protein, ash and crude fiber but less carbohydrate than corn flour and carrot flour. Corn flour had more fat and protein but less ash, carbohydrate and crude fiber than carrot flour. Fat and protein contents decreased while fiber, ash and carbohydrate increased with increase in the level of carrot flour in the blends. Water and oil absorption capacities of the blend were increased as the carrot flour increased in the formulation and it was ranged from 124 to 295% and 126 to 176%, respectively.

Cookies prepared from the soybean, corn and carrot flour blends had similar width, thickness and weight. Cookies prepared at 5 and 10% carrot flour replacement levels of SF/CF showed no significant differences ($P > 0.05$) in the sensory properties evaluated. Such cookies were fairly acceptable; however, cookies containing high levels of carrot flour had lower sensory scores for the quality attributes studied.

2.3 Quality Protein Maize

2.3. Overview of Quality Protein Maize

Maize (*Zea mays* L.) is grown on more than 96.5 million hectares in the developing world and many millions of people worldwide are dependent on maize as a staple food. Maize accounts for 15 to 56% of the total daily calories of people in about 25 developing countries (Prasanna *et al*., 2001). In Africa, maize supplies at least one fifth of total daily calories consumed and accounts for 17 to 60% of people's total daily protein supply in 12 countries, as estimated by FAO food balance sheets. These values are average per capita estimates; specific groups within these countries (children being weaned, sick children, sick adults, and everyone, when crop production is low) are even more dependent on maize as the major source of dietary protein. Protein-containing foods are necessary for the rapid growth of children, and in some countries maize is a primary weaning food for babies (Vivek *et al.*, 2008).

Such dependence on maize as a protein source puts people at risk for dietary protein deficiency because maize protein (as most cereal protein) is deficient in two essential amino acids, lysine and tryptophan; therefore maize is a poor source of protein for both humans and monogastric animals. Thus, any maize-based diet lacking in complementary proteinaceous foods that contain greater levels of lysine and tryptophan, such as meat, pulses, and dairy products, is considered protein-deficient. Protein deficiency, especially in children, causes kwashiorkor, a potentially fatal syndrome characterized by initial growth failure, irritability, skin lesions, edema, and fatty liver. Thus, maize cultivars with an improved amino acid profile are a must (Vivek *et al.*, 2008).

In the early 1960s, that scientist at Purdue University discovered a peculiar gene that significantly increased the level of two essential amino acids, lysine and tryptophan, in the maize grain. The name "opaque-2" was coined for this gene because it gave the kernels a chalky appearance. Discovery of maize mutants containing the *opaque-2* gene (Mertz *et al*., 1964) which enhances levels of lysine and tryptophan in the endosperm protein, opened a new era in breeding for improvement of quality in maize. However these mutants also came with several undesirable traits such as, opaque and chalky grain texture, low grain yield, higher levels of ear rot, slow dry down and increased incidence of stored product pests. While most researchers in the developed world abandoned research on opaque-2 after a few years, CIMMYT scientists conducted two decades of work to incorporate modifier genes that remedied most drawbacks. Through an inter-disciplinary research involving breeders, biochemists and other disciplinary scientists, CIMMYT researchers slowly but steadily developed what we now call as QPM. This special type of maize has exactly the same qualities as normal maize in grain texture, taste and color but possess almost double the levels of lysine and tryptophan, high yield and tolerance to biotic and abiotic stresses.

In 1993, thirty three tropical and twenty two subtropical QPM lines were released as CIMMYT Maize Lines (CMLs) and hybrids derived from these lines and next generation of lines have created excitement in the developing world. CIMMYT and the national program partners working together tested these new QPM hybrids in their environments for release and adoption by farmers. The nutritive value of QPM both as human food, especially for women and children and as animal feed for pigs and poultry was widely demonstrated in many countries. Several QPM hybrids have been released for cultivation in the developing world. From less than four countries that grew QPM in 1997, today more than twenty three countries have released and are producing QPM in the developing world (Vivek *et al.*, 2008).

Research in QPM is of recent history in Ethiopia. The work was started by testing introduced CIMMYT QPM pools and populations in 1980. Alemaya University of Agriculture pioneered in testing these materials. Later, in 1981, two sets of QPM trials were introduced from the same source and evaluated at Melkasa Agricultural Research Center. In 1997, EARO and SG2000 organized a workshop on QPM during which Ethiopian scientists interacted with five Ghanaian scientists involved in the Ghana QPM program. The research is continued to date.

2.3.2 Nutritional Superiority and Biological Value of QPM

The nutritional benefits of QPM for people, who depend on maize for their energy and protein intake, and for other nutrients, are indeed quite significant. The lysine content in *o2* is 3.3 to 4.0 g per 100 g of endosperm protein, which is more than twice that of normal maize endosperm (1.3 g lysine/100 g endosperm protein). Several researchers later demonstrated the superior protein quality and protein digestibility of QPM over normal maize. The studies indicated that the QPM protein contains, in general, 55% more tryptophan, 30% more lysine and 38% less leucine than that of normal maize (Prasanna *et al.,* 2001).

Besides protein quality, another important factor is ‘biological value’, which refers to the amount of absorbed nitrogen needed to provide the necessary amino acids for different metabolic functions. The biological value of normal maize protein is 45%, while that of *o2* maize is 80%. Only 37% of common maize protein intake is utilized compared to 74% of the same amount of *o2* maize protein. A minimum daily intake of approximately 125 g of *o2* maize might guarantee nitrogen equilibrium. This could not be obtained by using even twice the amount of normal maize. The nitrogen balance index for skim milk and QPM is 0.80 and 0.72, respectively, which indicates that the protein quality of QPM is 90% of that of milk. Besides, around 24 g of normal maize per kg of body weight is required for nitrogen equilibrium, compared to only around 8 g for QPM (Prasanna *et al.,* 2001).

The other nutritional benefits of QPM include higher niacin availability due to a higher tryptophan and lower leucine content, higher calcium and carbohydrate, and carotene utilization. Further, high quality protein maize can be transformed into edible products without deterioration of its quality or acceptability, and can be used in conventional and new food products. Graham *et al*. stated that ‘To anyone familiar with the nutritional problems of weaned infants and small children in the developing countries of the world, and with the fact that millions of them depend on maize for most of their dietary energy, nitrogen and essential amino acids, the potential advantages of quality protein maize are enormous. To assume that these children will always be given a complementary source of nitrogen and amino acids is a cruel delusion (Prasanna *et al.,* 2001).

The nutritional and biological superiority of QPM has also been amply demonstrated in model systems such as rats, pigs, infants and small children as well as adults. In Guatemala, it was demonstrated that o2 maize has 90% of the nutritive value of milk protein in young children. Children in Colombia suffering from Kwashiorkor, a severe protein deficiency disease, were brought back to normalcy on a diet containing only o2 maize as the source of protein. QPM would have equally beneficial effects on adults, as in case of infants and children (Prasanna *et al.,* 2001).

Besides its obvious significance in human health, QPM could play an increasingly important role in reducing the protein supplement in animal feed, if used as a gradient. Gevers indicated the potential utility of high-lysine maize in feeds for monogastric animals, and how QPM could bring in significant immediate rewards through direct industrial exploitation. QPM can also be used as an ingredient in the preparation of composite flours to supplement wheat flour for bread and biscuit preparation. Composite flours (10% maize flour) are used commercially in sub-Saharan countries such as Zambia, Zimbabwe and Ghana. Brazil also uses composite wheat flours utilizing cassava and maize flours (Prasanna *et al.*, 2001).

2.3.3 Importance of QPM for Ethiopia

In Ethiopia, many chronically undernourished people live in areas where maize is the staple food. Also, many poverty stricken adults consume only maize. This is of concern because maize protein is deficient in two essential amino acids that people must get from food because they cannot synthesize them. Therefore, substituting the normal maize grown in Ethiopia with QPM would substantially improve the protein status and greatly reduce the malnutrition problems of resource poor people depending on maize as staple food. The occurrence of famine and drought is a common phenomenon in Ethiopia. During the hunger periods, QPM could serve as a source of protein and calories and reduce the country's dependence on foreign aid.

Food security in the broad sense includes sufficient food production in the agricultural sector as well as human nutrition and health aspects. In countries like Ethiopia, low-income people have limited access to protein sources like meat, eggs and milk. Quality protein maize could be a good source of protein for these people. It could also be used as a feed to promote poultry and pig production. These enterprises may enhance food security and increase disposable income for farm families (Mandefro *et al.*, 2001).

2.4 Cookies

2.4.1 Major Cookie Making Ingredient and Their Function

The ingredients of cookies are flour, shortening, eggs, and nonfat dry milk, salt, leavening agents, additives, flavors, water, and various other enriching ingredients, and so forth. Each one of these ingredients has its own role and function in the preparation of the product (Sumnu and Sahin, 2008). Among this sugar, shortening, water, baking powder and salts are the major components together with the flour and the function of each ingredients are discussed here in under.

2.4.1.1 Sugar

Cookies are Sweet baked products, as the name implies, they are made from a formula high in sugar. Sugar adds sweetness, acts as a tenderizing agent, and affects spread. Using a farinograph, an increase in sugar concentration in cookie dough reduces its consistency and cohesion. Sucrose acts as a hardening agent by crystallizing as the cookie cools and making the product crisp. However, at moderate amounts, it acts as a softener due to the ability of sucrose to retain water. Sugar makes the cooked product fragile, because it controls hydration and tends to disperse the protein and starch molecules, thereby preventing the formation of a continuous mass (Sumnu and Sahin, 2008).

2.4.1.2 Fat

Cookie dough characteristics depend on the quality and quantity of the ingredients used in the formulation. Cookie dough has high percentages of sugar or shortening and limited water. During baking, cookie diameter increases linearly and becomes suddenly fixed. The final cookie diameter depends upon the rate at which dough spreads and its setting time during baking. Cookie spread rate has been reported to be dependent on dough viscosity. The viscosity of cookie dough depends upon the ratio of ingredients used in the cookie formula. The addition of fat influences the texture and taste of cookies, making the cookies crispier because this allows the dough to spread as it cooks on the hot cookie sheet (Sumnu and Sahin, 2008)**.**

2.4.1.3 Baking Powder

Baking powder is a dry chemical leavening agent used in baking. There are several formulations all contain an alkali, typically sodium bicarbonate, and an acid together with starch to keep it dry. When dissolved in water, the acid and alkali react and emit carbon dioxide gas, which expands existing bubbles to leaven the mixture. There are two types of baking powders single acting and double acting. Baking powders that contain only the low-temperature acid salts, such as cream of tartar, calcium phosphate, and citrate, are called single acting. Double-acting baking powders contain two acid salts: one reacts at room temperature, producing a rise as soon as the dough or batter is prepared, and another reacts at a higher temperature, causing further rise during baking. Examples of high-temperature acid salts are aluminum salts, such as calcium aluminum phosphate. Cookies are mainly leavened by chemicals. The use of baking chemicals such as sodium bicarbonate and ammonium bicarbonate makes cookies porous and crisp (Edwards, 2007).

2.4.1.4 Water

Water has a complex role in cookies because it determines the conformational state of biopolymers, affects the nature of interactions between the various constituents of the formula, and contributes to dough structuring. It is also an essential factor in the rheological behavior of flour dough's. Adding water to the formula reduces the viscosity and increases dough extensibility. If the proportion of water is too low, the dough becomes brittle, not consistent, and exhibits a marked "crust" effect due to rapid dehydration of the surface. An increase in water results in the expansion of biscuits lengthwise with a smaller thickness (Sumnu and Sahin, 2008).

2.4.1.5 Salt

Salt is used in all biscuit recipes for its flavor and flavor-enhancing properties. It's most effective concentration is around 0.5 to 1.0%. Salt also toughens the gluten and hence reduces stickiness (Sumnu and Sahin, 2008).

2.4.2 Process Technology of Cookies Making

Cookies may be defined as small cake-like products from a dough or batter made from raw materials such as flour, fat, sugar, milk, eggs, salt, starch, cocoa, leavening agents, emulsifier, and essences, which is viscous enough to allow the pieces of dough to be baked on a flat surface. They come in an infinite variety of sizes, shapes, texture, composition, tenderness, tastes, and colors. Processing of cookies includes Dough-Making, Sheeting Gauging and Cutting, Baking, Cooling and packaging (Sumnu and Sahin, 2008).

2.4.2.1 Dough-Making Process

The first stage in dough processing is mixing, in which the development of the dough is established. The dough-making process is depends on the type of the dough required for different kinds of cookies cutting machine. The fat and sugar contents of cutting-machine dough are low, but their water content is high. As the formation of the gluten network is desired in cutting-machine dough, the mixing duration is long. During mixing, the protein in flour contacts with water and in the following steps it takes time for the protein to absorb water and swell. If mixing is continued, the protein containing water forms a three-dimensional gluten network. For cutting-machine dough, all the ingredients are put into the mixer at the same time, and the duration of mixing is long as stated before because formation of a gluten network is desired. The sugar should be dissolved by the water in the dough. Otherwise, the sugar crystals caramelize during baking, causing brown spots. The temperature of the dough is important in terms of the fat used. At high temperatures, fat melts and dough becomes fatty. Dough should be plastic, and the shape given should be maintained (Sumnu and Sahin, 2008).

In rotary-molded dough's, the amount of sugar and fat is high, and the amount of water is low (sugar: 20 to 45%, fat: 10 to 40%, water: 5 to 15 for 100% flour [flour weight basis]). This kind of dough can be crumbled easily, the maturity of gluten is undesired, and hence mixing duration is less. There are two steps in rotary-molded dough preparation: Creaming (premix) step and the Addition of flour.

In the creaming step, all ingredients except flour are mixed and converted to cream. The creaming step should be prolonged as much as possible, which plays a crucial role in the density of dough. The second step of dough preparation, the addition of flour, takes a short time as formation of a gluten network should be prevented. If the duration of mixing is longer, gluten network formation starts and the dough will gain elasticity. As a consequence, a reduction in volume will be seen in dough during leaving of the molds. In the creaming step, sugar is dissolved and fat is softened, so they surround the protein molecules in flour and this prevents the interaction with water, and therefore, the formation of a gluten network is more difficult and slow. Fat is the most important input because it binds the ingredients in rotary-type dough's. Unless the dough is mixed enough, it cannot be shaped and exit from the mold will be difficult.

Flour strength, product type, machinability of dough, dough temperature, mixer speed, and batch size are the most important factors affecting the mixing time for all of the cookie types. Although dough's that are too cold can cause machining difficulties, high temperature developed during mixing is the usual problem. In any case, uniform temperatures are crucial for making uniform Cookies as dough temperature affect spread, texture, and surface appearance of the cookie. The temperature should be below the upper limit of the plastic range of shortening for the best results (Sumnu and Sahin, 2008).

2.4.2.2 Sheeting Gauging and Cutting

If biscuits are made by hand the shaping process would be to roll out the dough and use a cutter to cut the biscuits to shape. The scrap dough is then re-rolled and more pieces are cut with the excess being re-rolled and the process repeated until there is insufficient dough to make any more biscuits. It is also possible to shape biscuits by a mechanized system that does the same process. This is called sheeting gauging and cutting. Some biscuits are shaped by extrusion and depositing, while others are wire cut. Alternatively, the biscuit dough can be fed to a rotary moulder, which shapes the biscuits in one step.

Sheeting is the equivalent of the domestic rolling pin. The dough is fed from a hopper between rollers to produce dough of controlled thickness. The problem with this process is that the rolling works the dough, which causes the gluten to develop. This problem can be minimized by using only one set of rollers. The rollers that determine the thickness of the dough are known as gauge rollers. If the dough is fed to the cutter under tension the dough pieces will shrink during cooking, tending to emerge thicker at the front and back. The answer to this problem is to allow the dough to relax before cutting (Edwards, 2007).

2.4.2.3 Baking

While biscuits can be and are baked in almost any type of oven, including deck ovens, rack ovens and travelling ovens, most biscuits are baked in travelling ovens. These ovens suit large plant bakeries. The throughput of these systems is measured in terms of kilos per hour. One of their advantages is that it is possible to arrange the oven in a series of zones so that the product passes first into the hottest part of the oven and is moved to cooler regions as cooking proceeds. This is what would happen with a clay oven fired by filling it with wood. In a tunnel oven it is sometimes best to arrange the zones so that the first zone is less hot than the second zone. This prevents the surface of the biscuit becoming too hard too quickly, which could produce a case hardened layer that resists the removal of moisture (Edwards, 2007).

Dough pieces undergo physical and chemical changes within the oven. Crust formation, melting of shortening in the dough, conversion of water to steam, gas expansion, and escape of carbon dioxide, other gases, and steam are the physical changes occurring by heat treatment (Sumnu and Sahin, 2008).

The first thing that will happen is that any gases, including air and carbon dioxide from leavening agents, will expand, causing the biscuit to expand. Water will be converted into steam, also causing the biscuit to expand. This expansion is the oven spring.

The Maillard reaction will take place between the proteins and reducing sugars on the surface. As the interior of the biscuit heats up by conduction this reaction will spread to the interior. If the biscuit is excessively alkaline from too much sodium bicarbonate a yellow color will be produced.The proteins present will start to denature and the starch will start to gelatinize. These processes cause the structure to set.

Throughout the cooking water is lost from the biscuits. At the end of the cooking process this is the only change that happens. The loss of water will be controlled by the rate of diffusion of water from the middle to the surface. It is at this point that the dockering, i.e. the holes in the biscuit, assist the water removal (Edwards, 2007).

2.4.2.4 Cooling

The cookies are cooled on a cloth band after leaving the oven, and they are very hot, very soft, and generally very moist as they emerge from the oven. Hence, even though cooling is a must for packaging, it may be the least crucial aspect, for so many other things are taking place as the cookie cools.

Moisture loss, temperature decrease, and the changes in the state of the main ingredients affect cookie dimensions, giving rise to shrinkage and maybe causing stresses to be set up within the cookie in reaching the set, non molten state. The mentioned stresses may cause cracking of the biscuits to a greater or a lesser degree under adverse conditions. Sudden cooling can be a reason for cracking, as it might firm up the crust and retard the moisture migration rate from the center crumb to the edges. This happens due to the excessive moisture gradient between these areas (Sumnu and Sahin, 2008).

2.4.2.5 Packaging

Packaging and storage are the last stages of cookie production. This stage is important in terms of its protection purpose. The time period from when the cookies are packaged to consumption is influenced by packaging and storage methods, and the flavor, taste, and appearance of the cookies should be protected during this time period.

The packaging material should protect the cookie from harmful environmental effects. The product must be protected from undue moisture change during its normal storage life as a primary requirement. When the packaging film protects against moisture transfer in an adequate manner, it likely excludes dirt, dust, mold spores, and other foreign particles, and in addition, it gives some protection against the absorption of off-odors.

As most cookies are very susceptible to crushing, mechanical strength should be present in the container if the cookie is to survive storage and transportation. The package should contribute to the dimensional stability of the cookie.

The packaging material of the cookies should be appropriate for being formed into the finished package easily and fast by mechanical ways. A fundamental need for packaging films is that the structure heat-seal readily. Moreover, the packaging material should not tear, crack, or stretch during the rapid transfers and folding in the wrapping equipment (Sumnu and Sahin, 2008).

2.4.3 Effects of Baking on Sensory and Nutritional Values of Foods

The purpose of baking is to alter the sensory properties of foods, to improve palatability and to extend the range of tastes, aromas and textures in foods produced from similar raw materials. Baking also destroys enzymes and micro-organisms and lowers the water activity of the food to some extent thereby preserving the food (Fellow, 2000). During baking sensory and nutritional values of foods are altered positively or negatively, the situation is reviewed here in under.

2.4.3.1 Effect of Baking on Sensory Qualities of Food

To the consumer, the most important quality attributes of a food are its sensory characteristics (texture, flavor, aroma, and color) and these characteristics are influenced during baking.

Biscuit structure and thickness are developed during baking. This takes place mainly in the first quarter or third of the baking period. The changes are all temperature related and involve several aspects of the recipe and formed dough piece. Liberation of gases from leavening chemicals or water vapor are formed which expand and result in a large reduction in the density of the dough. The open porous structure gives a biscuit a pleasant eating texture. The development of the structure is often known as oven spring as it relates to the thickness of the baked biscuit (Manley, 1998).

The aromas produced by baking are an important sensory characteristic of baked goods. The severe heating conditions in the surface layers of food cause Maillard browning reactions between sugars and amino acids. The high temperatures and low moisture contents in the surface layers also cause caramelisation of sugars and oxidation of fatty acids to aldehydes, lactones, ketones, alcohols and esters. The Maillard reaction and Strecker degradation produce different aromas according to the combination of free amino acids and sugars present in a particular food. Each amino acid produces a characteristic aroma when heated with a given sugar, owing to the production of a specific aldehyde. Different aromas are produced, depending on the type of sugar and the heating conditions used.

Further heating degrades some of the volatiles produced by the above mechanisms to produce burnt or smoky aromas. There are therefore a very large number of component aromas produced during baking. The type of aroma depends on the particular combination of fats, amino acids and sugars present in the surface layers of food, the temperature and moisture content of the food throughout the heating period and the time of heating (Fellow, 2000).

Although there is usually a change to a yellow brownish hue during baking, the term color here is used to imply merely a darkening, reduction in reflectance, of the biscuit surface. There a number of reasons for the color changes. The main one is the Maillard reaction, non-enzymic browning, which involves chemical reaction between reducing sugars in the dough with proteins and produces attractive reddish brown hues. This occurs around 150-160°C and will occur faster in a mildly alkaline situation and only in a moist situation. Color also develops associated with dextrinisation of starch and caramelisation of sugars. At even higher temperatures the biscuit structure chars or burns (Manley, 1998).

2.4.3.2 Effect of Baking on Nutritional Values of Food

The main nutritional changes during baking occur at the surface of foods, and the ratio of surface area to volume is therefore an important factor in determining the effect on overall nutritional loss. During baking, the physical state of proteins and fats is altered, and starch is gelatinized and hydrolyzed to dextrins and then reducing sugars. However, in each case the nutritional value is not substantially affected. The loss of amino acids and reducing sugars in Maillard browning reactions causes a small reduction in nutritive value. In particular, lysine is lost in Maillard reactions, which slightly reduces the protein quality. The extent of loss is increased by higher temperatures, longer baking times and larger amounts of reducing sugars. In biscuits, a reduction in dough thickness from 4.9 mm to 3.8 mm each baked at 170ºC for 8 min, produced higher losses of amino acids as follows: tryptophan, from 8% to 44%; methionine, from 15% to 48%; lysine, from 27% to 61%. In maize, lysine loss is increased from 5% to 88% during the manufacture of breakfast cereals, which is corrected by fortification (Fellow, 2000).

Chapter 3

3. Materials and Methods

3.1 Source of Raw Materials and Sample Preparation

3.1.1 Source of Raw Materials

The raw material soft wheat was collected from Kojj Food Complex; quality protein maize (Melkasa 6Q Varity) was collected from melkassa agricultural research Center. Carrot (Nants varity), baking powder, granulated sugar and shortening were purchased from a market in Addis Ababa.

3.1.2 Preparation of Raw Material

3.1.2.1Carrot Flour Preparation

The carrot flour was prepared with a little modification of the method used by Kendall and Allen (1998) in which oven drying was replaced by fluidized bed drier. Since the later has an air velocity, fastest drying rate can be achieved hence fluidized bed drier was used for drying as follows. The raw carrot was washed and trimmed then it was cut longitudinally with approximately similar thickness, then it was blanched in boiled water for 3 minutes followed by immediate cooling to avoid further cooking. The cooled carrot was then grated with a grater then it was dried with a fluidized bed dryer (TG200model, Germany) at a temperature of about $65^{O}C$ and 90% air velocity, until the product is tough to be brittle. Then the dried carrot was milled and the resultant flour was sieved into a particle size of 100micrometer followed by packaged in polytlen plastic bag and aluminum packaging material.

3.1.2.2Quality Protein Maize Flour Preparation

The seeds of quality protein maize were milled and the resultant flour was sieved in to a particle size of 100 micrometer followed by packaged in polyethylene bag and aluminum packaging material.

3.1.3 Preparation of Cookie

3.1.3.1 Formulation of Composite Flour

The formulation of composite flour was done by considering some important facts about the characteristics of cookies and based on previous studies. The major components of cookies are soft wheat flour, since flours that produce cookies with larger spread and softer texture are favored (Sumnu and Sahin, 2008) and many studies shows that incorporation of non gluten flour to wheat flour will affect important quality indices of cookies such as sensory qualities and textural properties. Therefore in this study wheat was consider as a major ingredients and the lower limit was taken as 60% in the composite flour formulation and the rest 40 % was used for manipulation of the composite flour based on pervious studies. Akubor (2005) in his cookie development from soybean-corn-carrot flour blends, incorporate carrot flour at 5% interval up to 50% in his cookie flour formulation, however, cookies containing high levels of carrot had lower sensory scores for the quality attributes studied. Based on the result he found the carrot flour was incorporated up to 20% with the same interval as of the Akubour and anticipating that incorporating carrot flour more than 20% will decreased the quality of the cookies. QPM flour was also incorporated at 5% interval level as that of the carrot flour. Based on this reasons the formulation was made as given in the table 3.1 below.

Table 3.1; Formulation of composite flour (%) for cookie production

Flour blend	**Wheat flour**	**Carrot flour**	**QPM flour**
A(control)	100%	-	-
BP-1	90%	5%	5%
BP-2	80%	10%	10%
BP-3	70%	15%	15%
BP-4	60%	20%	20%

3.1.3.2 Cookies dough preparation

Cookie dough was prepared according to a commercial formulation and baking practices (Taha *et al.*, 2006) with the following formula: 100 g flour (contain different proportion of composite flour Table 1), sugar (34 g), shortening (28 g), salt (0.93 g), baking powder (1.12 g) and various proportion of water(48g) to make required consistency of dough.

Cookie dough was made in a laboratory mixer (Model 18Nr 16315) following the method of Dogan (2006) with some modification. Sugar, salt, baking powder and shortening were creamed with a flat beater for 2 min at 90 rpm, scraped and mixed for 1 min at 130 rpm. Finally, sifted flour was added and mixed for 1 min at 60 rpm, scraping twice to obtain homogeneous dough. Total mixing time was 4 min. The dough was removed from the mixer and allowed to rest for 10 min.

3.1.3.3 Cookie Baking

After dough preparation the dough was then sheeted to a thickness of 5 mm with a manual sheeting machine. Then cookies were cut with a cookies die of diameter 48 mm and transferred to a lightly greased baking tray. The cookies were baked at a temperature of 150,175 and 200^{0}C for 10 min in a baking oven (model, KF6512, Turkey). The baking temperature was selected based on some important facts. According to, Manely (1998), sweet goods are baked in the temperature zone of 160, 180 and 200^{0}C and based on this temperature zone the selected temperature was used considering the following important facts. According to Mudahar *et al.,* (2008), better beta carotene retention can be achieved at a temperature of 150^{0}C for exposure time of 12.5min in the heat treatment study on carrot hence 150^{0}C was selected at temperature zone 160 ^{0}C. 175^{0}C baking temperature was selected around after the temperature zone of 180 ^{0}C after preliminary test, and 200^{o}C was selected at the third zone of baking temperature, in order to keep the temperature gap constant. The cookies were baked for 10min. According, Adeniyi, (1998), the sheeted dough is baked for 10 to 15 min, and after preliminary test 10 min baking time was selected.

3.2 Methods of Analysis

3.2.1Determination of Functional Property of the Composite Flour

3.2.1.1 Bulk Density

The bulk density of the composite flour was analyzed according to the method stated by Oladele and Aina (2007) in which a mass of 50 g of the sample was put in to a 100 ml measuring cylinder. The cylinder was tapped continuously until a constant volume was obtained. The bulk density was then calculated as weight of the grounded flour (g) divided by its volume (ml).

3.2.1.2 Water and Oil Absorption Capacity

Water and oil absorption capacity of flour was determined with the method reported by Anderson *et al*., (1969) as cited by Sukhcharn *et al.,* (2008). Five gram flour of each sample was weighed into a centrifuge tube and 30 ml of distilled water or oil was then added and mixed thoroughly. This was allowed to stand for 30 min and centrifuged at 3,000 rpm for 15 min. The supernatant was then decanted and the sample weighed again. The amount of water or oil retained in the sample was recorded as weight gain and was taken as water or oil absorbed. The results were expressed as weight of water absorbed in grams per gram dry matter of the sample.

3.2.2 Determination of Physical Properties of Cookies

For the determination of diameter (width), thickness and spread factor, AACC (1995) methods were followed.

3.2.2.1 Diameter

To determine the diameter (D), six cookies were placed edge to edge. The total diameter of the six cookies was measured in cm by using a ruler. The cookies were rotated at an angle of 90^o for duplicate reading. This was repeated once more and average diameter was taken in centimeter.

3.2.2.2 Thickness

To determine the thickness (T), six cookies were placed on top of one another. The total height was measured in millimeters with the help of ruler. This process was repeated twice to get an average value and results were taken in mm.

3.2.2.3 Spread factor

Spread factor (SF) was determined from the diameter and thickness, with the following formula:

$$SF = D/T$$

3.2.2.4 Breaking Strength

Determination of the breaking strength of cookies was made following the method described by Singh *et al*., (2008) using a texture analyzer (Model TA-PLUS, LLOYD instrument, England). The distance between the two beams was 40 mm. Another identical beam was brought down from above at a Pre-Test Speed: 2.0 mm/s, Test Speed: 0.5 mm/s, Post-Test Speed: 10.0 mm/s Distance: 5 mm to contact the cookie. The downward movement was continued till the cookie breaks. The peak force was reported as braking or fracture strength.

3.2.3 Sensory Analysis of Cookies

The sensory evaluation was conducted in Addis Ababa university faculty of technology, food engineering laboratories with 15 panelists. The panelists were instructed to the following sensory attributes: Appearance, color, flavor, taste, crispiness and overall acceptability according to Hui, *et al.*, (2006). Then Coded samples of cookies were presented to panelists. A nine point hedonic scale with 1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely was used for attributes other than crispiness, and a 5- point hedonic scale, in which 1-very bad and 5- represented excellent crispness was used for crispiness test according to (Amerine *et al.*, 1965) .

3.2.4 Determination of Chemical Properties of Flour Samples and Cookies

The proximate composition and β-carotene analysis were done in EHNRI and Food science and nutrition department laboratories at science faculty of Addis Ababa University. Tryptophan analyses of the samples were done at Melekassa agricultural research institute

3.2.4.1 Proximate Analysis

3.2.4.1.1 Moisture Determination

The moisture content of the cookies was determined using a digital moisture analyzer. About 0.5 g milled sample was spread in the drying pan after cleaning and tarring the weight of the pan. Then the cover was closed. After that the reading of moisture percentage was taken when constant reading was achieved.

3.2.4.1.2 Crude Protein Determination

kjeldahal method of nitrogen analysis was used during determination of crude protein (AOAC, 2003) as follows. Samples of about 0.5 g were measured using digital balance in the tecator tubes, then about 6ml mixtures of sulphuric acid and orthophospheric acid were added in the tecator tubes and about 3g of selenium and potassium sulphate mixture was added, to facilitate the digestion process by catalyzing and by raising the boiling point temperature of sulphuric acid. After this, the mixture was placed in the digester at a temperature of about 370^0C for 1 and half hour. After digestion was completed, the digested sample was distilled using 40% NaOH (50ml/ sample) to neutralize the acid, after cooling with the addition of water and then titrated with 0.1N of HCl in the computerized distillation unit and the result was obtained from the displayed result from the screen of the distillation equipment.

Reaction occurred During Protein Determination

Digestion

Digestion converts any nitrogen in the sample in to ammonia and other organic matter to CO_2 and H_2O. In acidic solution, ammonia is not librated as gas because it exists as an ammonium sulfate salt (AOAC, 2003).

$$\text{N (in food)} + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

Distillation

After digestion is completed, the content in the flask was diluted by water then concentrated NaOH (40%) was added to neutralize the acid and to make the solution slightly alkaline.

$$(NH_4)_2SO_4 + 2NaOH \longrightarrow 2NH_3 + 2H_2O + Na_2SO_4$$

The ammonia was then distilled in to receiving flask that consist solution of excess boric acids (4%) for reaction with ammonia.

Titration

When ammonia and boric acid was reacted the following reaction will occur

$$NH_3 + H_3BO_3 \text{ (boric acid)} \longrightarrow NH_4^+ + H_2BO_3^- \text{ (borate ion)}$$

Because the ammonia is chemically equivalent in converting the boric acid (ammonia bound to an equivalent of borate ion) it was directly titrated with standard acid (0.1N HCl)

$H_2BO_3^- + H^+ \longrightarrow H_3BO_3$

Calculation for Protein Determination

$$\text{Nitrogen (\%)} = \frac{V_{HCl}\,(\text{in l}) * N_{HCl} * 14 * 100}{\text{Sample weight}}$$

Where:

V= volume of HCl consumed to the end point of titration

N= the normality of HCl used often is about 0.1N

14= the molecular weight of nitrogen

Conversion of nitrogen percentage in to % protein

% Protein = F * %N. where, F is the conversion factor in most case is 6.25

3.2.4.1.3 Determinations of Fat

Soxhlet method of solvent extraction was used during determination of fat as stated in AOAC (2003) as follows. About 2 g milled samples were measured in to an extraction thimble lined with fat free cotton. Then the thimbles with the samples were attached to the extraction apparatus. The aluminum cup with a boiling cheeps were placed in the oven at 100^0C for 30 minutes and cooled to room temperature in the desiccators for 30 minutes then the cup weight was measured using a digital balance and recorded as W_1 (weight of cup), then 50ml of diethyl ether was added in to each cup, after which set up of the extraction apparatus was done. The samples contained in the thimbles were soaked for about 1 hour by lifting down the thimble in to the cup, started from the apparatus hot plate temperature reached 55 ^{0}C, after soaking the thimbles were lifted up and extraction process was taken place for 5h. then the recycling process made by the diethyl ether was stopped to let the solvent to evaporate from the aluminum cup with the extract, in the process the evaporated solvent was recovered in the apparatus. Then aluminum cup and the content were dried in the oven for 30 min at 100^0C to evaporate the remaining solvent in the cup. After drying it was removed from the oven and cooled in the desiccators for 30 minutes then weighed and recorded as W_2 (cup + fat). The percentage fat was calculated using the following formula

$$\textbf{Fat (\%)} = \frac{W_2 - W_1}{\text{Sample Weight}} * 100$$

3.2.4.1.4 Determination of Crude Fiber

Weende method which is modified by hum as stated in AOAC (2003) was used to determine the crud fiber content of the sample as follows. About 1.8 g of samples were measured and transferred analytically in to the 600ml beaker. Then 200ml of H_2SO_4 (1.25%) was added in to the beaker the level of the volume was marked on the beaker, then it was boiled for 30min on the hot plate. The level of the mixture was kept constant by adding hot distilled water. After exactly 30 mints of boiling 20ml of 28% KOH was added with occasional stirring using glass rod for additional 30min of boiling. After boiling was completed the solution was poured in to wetted sintered glass crucible which is filled with 10mm sand and the, mixture was filtered by turning the vacuum pump on. The beaker wall was rinsed several times with hot distilled water and transfer to crucible. Then the residue in crucible was washed, with hot distilled water , and H_2SO_4(1%),and again with hot distilled water, then with NaOH (1%), and again with hot water, then with 1%H_2SO_4 , then with hot water, filtration was there in every washing process. Finally it was washed using water free acetone. The washed crucible with the digested sample was dried for 2hr in the oven at temperature of 130^0C. Then it was cooled in the desiccators for 30 min then it was weighed immediately after taking out from the desiccators and the mass was taken as W_1(crucible + fiber + ash). After that the crucible was transferred to the furnace for 30min at a temperature of about 550^0C for ashing then it was cooled in the desiccators and weighed, the mass was taken as W_2 (crucible + ash) and the percentage was calculated using the following formula.

$$\textbf{Crude fiber (\%)} = \frac{W_1 - W_2}{\text{Wt of sample}} * 100$$

<u>Where</u>

W_1 crucible wt after drying

W_2 crucible weight after ashing

3.2.4.1.5 Determination of Ash

The washed crucible with water and HCl was placed in the oven at 110^0C for 30 min to dry. After 30min the hot crucible was placed in to the desiccators to cool it to room temperature. Then its mass was weighed using digital balance and the mass was recorded as W1. About 2.5 g of sample was measured and transferred into the crucible then the mass of sample and the crucible together were weighed and recorded as W_2. The crucible with the sample was placed on the hot plate at low temperature, to char the sample until it turns black. Then the charred sample was transferred to the furnace at 550^0C for 1 h. then the crucible was cooled and 4 drop of water was added then it was placed on the hot plate for 15min until all the water is evaporated. After the water was evaporated, the crucible was placed in a furnas for 1h at 550 ^0C, and then after cooling 5 drops of HNO_3 (oxidizing agent) was dropped. To dry the sample the crucible was placed on a hot plate for 15min. again the crucible was placed in the furnace at 550^0C for 1 h. then after cooling in the desiccators for 30min, the ash and the crucible was measured and recorded as W_3(ash+ crucible). The percentage ash was calculated using the following formula:

$$\textbf{Ash (\%)} = \frac{(W_3 - W_1)}{(W_2 - W_1)} * 100$$

3.2.4.1.6 Determination of Energy Value

The energy value was estimated from Atwater factors

Energy value = protein*4+ carbohydrate*4+ fat*9.

3.2.4.2 Tryptophan Determination

Tryptophan percentage was determined using Glyooxilic Acid following the method developed by (Nurit *et al*., 2008) as it is cited by (Galicia *et al.*, 2008) as follows. The sample was grinded finely and defatted for 6hours in a soxhelt apparatus after that the defatted sample was air dried to make sure that all the solvent was evaporated. From each of the defatted sample about 80 mg were weighed in a 15ml falcon tubes then 3ml of papain solution (papain dissolved in 0.165 M sodium acetate solution) was added in each of them followed by closing of the tubes to ensure that no evaporation will take place during incubation. Then the mixture was Vortexed thoroughly and incubated in an oven at 64 ºC for 16 h. Then the tube was taken out from the oven and was cooled to room temperature after that the sample was vortexed followed by centrifuging at 3,600rpm for 5min. After that 1ml of supernatant was taken from each sample and transferred to a new glass tube. Then 3ml of calorimetric reagent (a mixture of ferric chloride dissolved in 0.1M Glyoxilic Acid and 30N sulfuric acid) was slowly poured down to the inner wall of each of tube. After that they were closed and vortexes followed by incubation in the oven at 64^0C for 30min for color development. Then the sample was taken out of the oven and cooled to room temperature. Finally the absorbance of each sample was read at 560nm in a spectrophotometer (model GENESYSLOUX, USA).

Standard Curve for Tryptophan Determination

A stock solution of 100 µg/ml tryptophan was prepared in 0.1 M sodium acetate solution at pH 7 and was stored in the refrigerator at a temperature of 4^0C. Then a dilution of 0, 10, 15, 20, 25, and 30 µg/ml was prepared in 0.1 M sodium acetate solution pH 7 followed by vortexing the mixture then calorimetric reaction was done using 1ml of this solution and calorimetric reagent, then the absorbance was read at 560nm after it was incubated, cooled and vortexed .

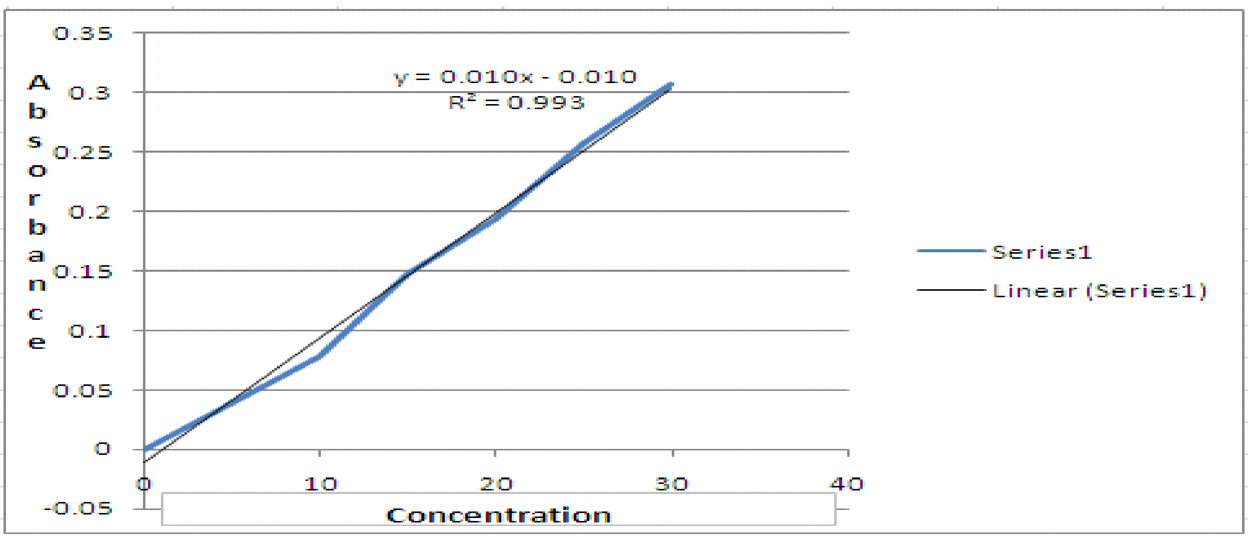


Fig 3.1. A Typical standard curve for tryptophan determination

Calculation of percentage of tryptophan

%Try = OD $_{560\text{nm corrected}}$ * Factor

Where:

OD $_{560\text{nm corrected}}$ = OD $_{560\text{nm sample}}$ - OD $_{560\text{nm average of papine blank}}$

Factor = (0.00375/ slope)

Note that: (3ml of papain /80,000 µg of sample) * 100 = 0.0037

3.2.4.3 β-carotene Determination

The β-carotene content of the flours and the most selected cookies by the panelists were analyzed following the procedure developed by, Kimura & Amaya (2004) as follows. About 2-50 g of a homogenous representative sample was weighed depending on the sample, then blended and macerated with acetone in a mortar with a pestle. Then the extract was filtered in to 100ml conical flask. After filtration the residue of the food material was returned in to the mortar and was macerated again with fresh acetone and filtered as before, this process was repeated until the sample was devoid of any color. Then 25ml of petroleum ether was placed in a separatory funnel and the acetone extract of the sample was added in to it after that the mixture was swirl, then small amount of distilled water was added, in order to separate the acetone and the petroleum ether phase, in which colored material left the acetone phase and join the petroleum ether phase, and the mixture was lefts for some time until the two phases are separated. Then after, the lower aqueous acetone phase was collected in a conical flask. Then petroleum ether phase was washed with water to remove the residual acetone. After discarding the acetone phase again, the petroleum ether phase was collected in the volumetric flask. This process was repeated by returning the acetone phase in the separatory funnel until no color was transferred in to the petroleum phase. Then the collected petroleum ether phase was transferred to drying flask and was evaporated to dryness on a rotary evaporator at 40^0C. Then after the residue in the round bottom drying flask was dissolved with about 1mliliter petroleum ether and was introduced in to the petroleum ether rinsed, open chromatographic column. The introduced residue in to the chromatography was eluted with petroleum ether and the β-carotene which goes through a column as a yellow pigment was collected in a measuring cylinder and the volume was recorded until no color is eluted through the chromatogram, then the absorbance was read at 450nm using a spectrophotometer after the mixture was shakes well.

Calculation

$$\beta\text{- Amount } (\mu g/g) = \frac{(A * V(ml) * 10^4)}{A^{1\%}_{1cm} * W}$$

Where:

A = absorbance

V = volume of the β-carotene which goes through a column as a yellow pigment in ml.

W= weight of the sample in g.

$A_{1cm}^{1\%}$ = absorption coefficient of carotenoids. In petroleum ether its value is 2592

Conversion of β-carotene in to Vitamin A

1 retinol equivalent = 1 µg of retinol= 12 µg of β-carotene (Whiteny and Rolfes, 2008)

3.3 Experimental design and data analysis

The aim of the study was to study the effect of blend proportion and baking temperature on the physico- chemical properties of the cookies hence it was considered two factors and based on that experimental design was made in the table given below. And the result was analyzed using two factor ANOVA using SPSS soft ware version 15.

Table 3.2: Effect of blend proportion and baking temperature on the physicochemical properties of cookies made from wheat, carrot and QPM composite flour experimental design

	Blend proportion				
Baking temperature	Control	B1	B2	B3	B4
150^0C					
175^0C					
200^0C					

Where:

Control= 100% wheat

B1= 90% wheat, 5%carrot, 5%QPM

B2= 80% wheat, 10% carrot, 10% QPM

B3= 70% wheat, 15% carrot, 15% QPM

B4= 60% wheat, 20% carrot, 20% QPM

Chapter 4

4. Results and Discussion

4.1 Functional Properties of the Composite Flours

The functionality of a raw material is the combination of properties which determine product quality and process effectiveness. These properties differ greatly for different raw materials and processes, and may be measured by chemical analysis or process testing (Brennan, 2006). Hence some of the functional properties of the flours such as water absorption capacity, oil absorption capacity and bulk density of the flours were analyzed and the result is presented in the table given below followed by discussion.

Table 4.1: Functional properties of the flours

FLOUR	WAC(g/g)	OAC (g/g)	Bulk density(g/cc)
Wheat	0.85	0.935	0.529
QPM	1.6	0.811	0.759
Carrot	5.4	1.380	0.700

4.1.1Water Absorption Capacity

The water absorption capacity of carrot, QPM and wheat flour was found 5.4, 1.6 and 0.85 grams of water per grams of sample respectively. This high water absorption capacity of carrot and QPM flour was because of more fiber content than wheat flour. According to Rosell *et al*., (2006) as cited by Nasser *et al*., (2008), The differences in water absorption is mainly caused by the greater number of hydroxyl group which exist in the fiber structure and allow more water interaction through hydrogen bonding .Water absorption results of the composite flour **(**Figure 4.1) showed that as the proportion of carrot and QPM flour increased in the formulation, the water absorption capacity increased. Increase in water absorption lead to the weakened dough and decrease dough development and dough stability. According to Doescher *et al*., (1987) as cited by Manoela *et al* ., (2006) water absorption capacity is strongly correlated to cookie spread, the higher water absorption capacities could have contributed to the lower spread ratio. McWatters (1978) as cited by Manoela *et al.*, (2006) reported that rapid partitioning of free water to hydrophilic sites during mixing increased dough viscosity, thereby limiting cookie spread. Similar result was also observed by Akubor (2005) in his study replacing soybean and corn flour with carrot flour and as the proportion of carrot flour in the blend increased the water absorption capacity was increased this was related to the higher fiber content of the carrot flour compared to soya and corn flour. Sukhcharn *et al*., (2008) also found the same result in their study of incorporating sweet potato flour in wheat flour for cookie making. In their study sweet potato contain more fiber than wheat flour in turn has a larger water absorption capacity than wheat flour. More over the water absorption of the blend proportion was increased as the proportion of sweet flour was increased.

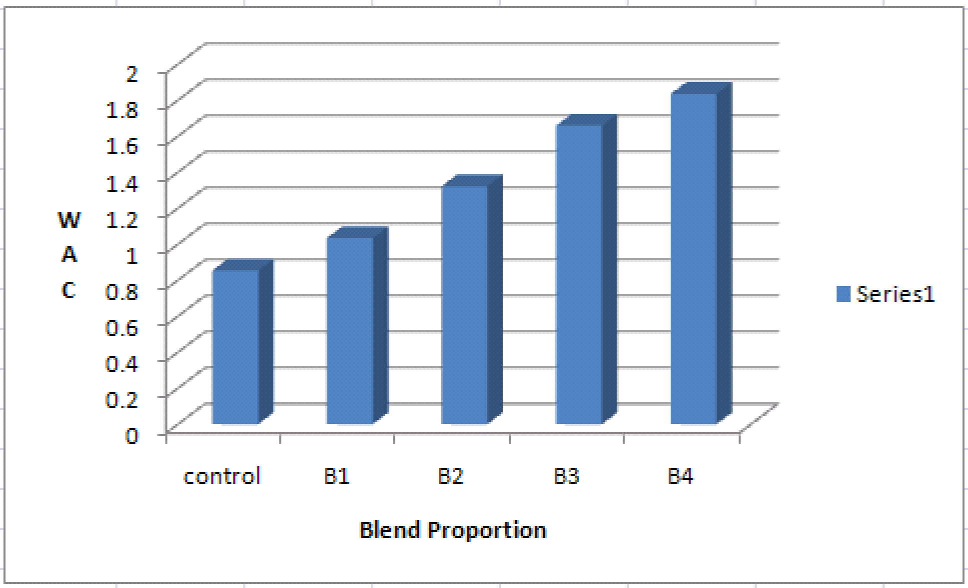


Fig 4.1 Water absorption capacity of the blend proportion

4.1.2 Oil Absorption Capacity

Oil absorption capacity (OAC) is another important functional property since it plays an important role in enhancing the mouth feel while retaining the flavor of food products (Kinsella, 1976) as cited by Choonhahirun (2010). As can be seen from the table 4.1 the oil absorption capacity of carrot flour was found higher (1.38 g oil per g of sample) than wheat (0.935) and QPM flour (0.811). According to Adebowale and Lawal, (2004) as cited by Choonhahirun (2010) the variations in the presence of non-polar side chains, which might bind the hydrocarbon side chains of oil among the flour, explain differences in the oil binding capacity of the flour and as the result showed that carrot flour may be a better flavor retainer than both wheat and QPM flour.

4.1.3 Bulk Density

When mixing, transporting, storing and packaging matters such as flours, it is important to know the properties of the bulk material (Lewis, 1990). Hence bulk density measurement was done. As can be seen from the table 4.1 QPM flour was found higher (0.759g/ml) in bulk density than carrot (0.700g/ml) and wheat (0.529g/ml) flour. Bulk density gives an indication of the relative volume of packaging material required and high bulk density is a good physical attribute when determining the mixing quality of a particulate matter (Lewis, 1990).

4.2 Physical Properties of Cookie

The physical properties of cookie such as, diameter, thickness, spread ratio and breaking strength of the cookies were analyzed and the result is presented in the table given below.

Table 4.2: Effect of blend proportion on the physical properties of cookie

Blend proportion	Diameter(cm)	Thickness(cm)	Spread ratio	Breaking strength(N)
Control	4.932^{d}	0.570^{a}	8.658^{b}	18.822^{a}
B1(5C,5Q,90W)	4.805^{c}	0.568^{a}	8.457^{a}	23.258^{b}
B2(10C,10Q,80W)	4.717^{b}	0.560^{a}	8.423^{a}	23.875^{b}
B3(15C,15Q,70W)	4.702^{b}	0.560^{a}	8.395^{a}	23.622^{b}
B4(20C,20Q,60W)	4.648^{a}	0.560^{a}	8.305^{a}	26.200^{c}

$^{a-d}$ any two means in the same column not followed by the same letter are significantly different

Table 4.3: Effect of temperature on the physical properties of cookie

Baking Temperature	Diameter(cm)	Thickness(cm)	Spread ratio	Breaking strength(N)
150	4.800^{c}	0.573^{a}	8.377^{a}	20.058^{a}
175	4.782^{b}	0.564^{a}	8.481^{a}	23.950^{b}
200	4.700a	0.554^{a}	8.485^{a}	25.458^{C}

$^{a-c}$ any two means in the same column not followed by the same letter are significantly different

4.2.1 Diameter

The data on the physical properties of cookies are shown in the table 4.2 and 4.3. There was a significant difference ($p \leq 0.05$) between the value obtained for the cookie diameter supplemented with carrot and quality protein maize flour, and baked with different baking temperature. As the proportion of carrot and quality protein maize flour increased in the formulation a decreased in the average cookie diameter was observed. This decreased in diameter could be the reason that an increased in fiber content due to the proportion of carrot flour and quality protein maize increased in the formulation. The cookie which was made from the control (100% wheat flour) showed a larger diameter (4.932cm), and a lower diameter (4.648 cm)was observed for the cookies which was made with blend proportion four(20% carrot flour, 20% QPM and 60% wheat) .A similar decreased in diameter was also reported for cookie prepare with Wheat and sweet potato flour (Singh *et al.*, 2008) , and wheat and residue from king palm processing (Manoela *et al*., 2006) in which both sweet potato flour and residue from king palm processing contains a higher fiber content than wheat, and as their proportion increased in the formulation a gradual deceased in diameter was found. And according to LSD analysis the control cookie was found significantly different from all of the blend proportion in cookie diameter value, and also all of the baking temperature was found significantly different from each other in their effect on cookie diameter.

4.2.2 Thickness

Result shows that the thickness of the cookies was found not significantly influenced both by blend proportion and baking temperature ($p > 0.05$). However a decreased in the average thickness of the cookies was observed as the proportion of carrot and quality protein maize flour was increased in the formulation. The control cookie showed a larger thickness(0.570cm) as compared to the other blend proportion .A similar decreased in the average cookie thickness was also reported for cookie prepared with Wheat and sweet potato flour (Singh *et al*., 2008), and wheat and residue from king palm processing (Manoela *et al*., 2006), however in both of the study the reduction in cookie thickness was significantly influenced as the proportion of sweet potato flour and residue from king palm processing increased in the formulation, this is unlike with this study in which the average cookie thickness was reduced not significantly. And also a decreased in thickness of the cookies were observed as the baking temperature was increased this could be the reason that as the baking temperature increased a reduction in moisture content may reduce the cookie thickness.

4.2.3 Spread ratio

Spread factor is the ratio that depends on the values of the thickness and diameter of the cookies and it is one of the main factors in achieving a good quality product was also studied. As the result indicated, the average spread ratio of the cookie was found significantly influenced by blend proportion ($p \leq 0.05$)

but not by baking temperature and their interaction ($p>0.05$). The average spread ratio of the cookies showed significantly decreased as the proportion of carrot and quality protein maize flour was increased in the formulation. The cookie which was made from 100% wheat flour spread larger as compared to the blend proportion. According to (Doescher *et al.,* 1987) as it is cited by (Manoela *et al.*, 2006) the spread ratio of cookies is strongly correlated to the water absorption capacities of flour. The water absorption capacity of the composite flour in this study was increased as the proportion of carrot and quality protein maize flour was increased in the formulation, this was the reason that the fiber content of the carrot flour was higher as compared to wheat and QPM flour. This increase in water absorption capacity of the composite flour could have contributed to the lower spread ratio of the cookie. According to McWatters (1978) as it is cited by (Manoela *et al.*, 2006) rapid partitioning of free water to hydrophilic sites during mixing increased dough viscosity, thereby limiting cookie spread. Hence it can be concluded that an increasing in the water absorption capacity of the composite flour as the proportion of carrot and QPM flour increased in the formulation was the reason for a decreased in the spread ability of the cookies. And according to the LSD analysis the control cookie was found significantly different from all of the blend proportion. A Similar decreased in cookie spread ratio was also observed for cookie prepared with Wheat and sweet potato flour (Singh *et al.,* 2008), and wheat and residue from king palm processing (Manoela *et al.*, 2006) in which both sweet potato flour and a residue from king palm processing showed a larger water absorption capacity.

4.2.4 Breaking Strength

Breaking strength is one of the textural properties of a food products and it is an important determinant of the food quality (Lewis, 1990). As can be seen from the result given in the table 4.2 and 4.3, the breaking strength of the cookies was found significantly influence by both blend proportion and baking temperature ($p \leq 0.05$). An increased in cookie breaking strength was observed as the proportion of carrot and QPM flour increased in the composite flour formulation. During sensory analysis the internal crumb of the cookie which was made from 100% wheat flour was showed a pores structure. During baking a bubble of gas from the baking powder when it gets heat and water vapor are formed, which expand and result in a large reduction in the density of the dough and gives an open pores structure in turn it gives a biscuit a pleasant eating texture(Manley,1998). However the internal crumb of the cookies which was made form incorporation of carrot and QPM flour showed a compacted structure. This could be the reason that as the proportion of carrot and QPM flour increased in the formulation, the gluten content of the flour which is contributed by the wheat is decreased hence when the released gas from the baking powder and the water vapor has nothing to hold them, hence they can escape easily and no pores structure would be formed that's why a compacted structure was observed as the proportion of carrot and QPM flour increased in the formulation and it is obvious that a compacted matter requires a larger force to be broken, that way an increased in breaking strength of the cookies were observed as the proportion of carrot and QPM flour increased in the formulation. More over during the sensory analysis of the crispiness the cookie which was made from 100% wheat score the highest as compared to the other blend proportion. The other reason for increasing in cookie breaking strength could be the higher the water absorption capacity of the blend, which could limit the spread ability of the cookie this was observed because of an increasing in fiber content as the carrot and QPM flour increasing in the formulation .Similar increased in fracture strength of cookies was also reported by (Singh *et al*., 2008) in his study on incorporation of sweet potato flour in wheat and he concluded that an increase in fiber content in the formulation was the reason .And according to LSD analysis the control cookies was found significantly different from all of the other blend proportion and blend proportion one , two and three shows no significant difference between them.

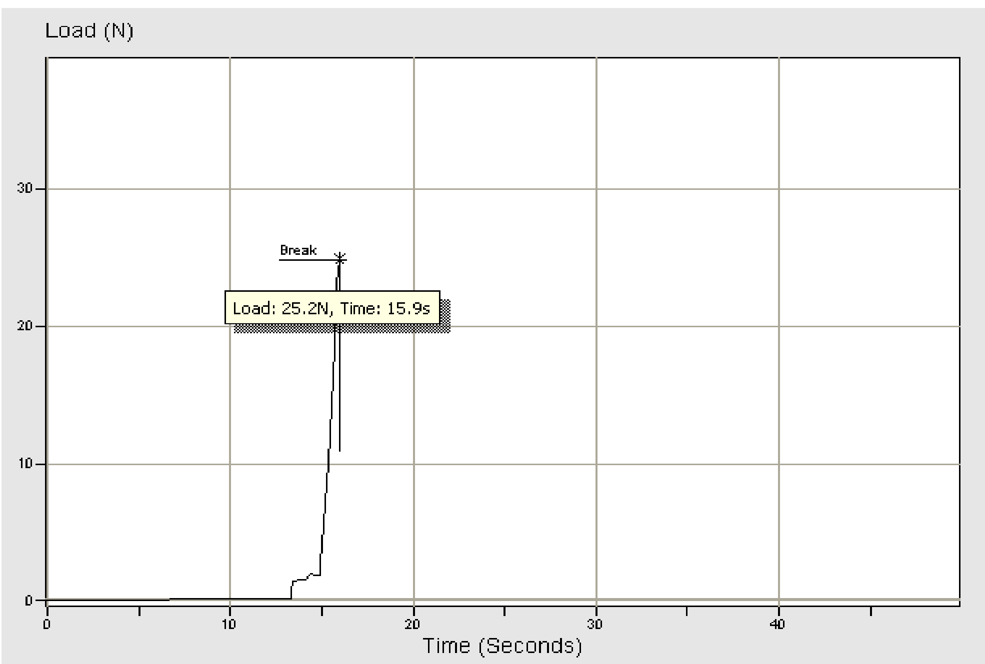


Fig 4.2: A typical texture curves for cookie breaking strength

4.3 Sensory Analysis

Sensory analysis is a scientific discipline used to evoke measure, analyze and interpret reactions that are the characteristics of foods and other materials as they are perceived by the senses of sight, smell, taste, touch and hearing. Sensory attributes include Appearance, Color, odor, texture, and flavors, and are important in determining the overall characteristics of a product. Traditionally these attributes are evaluated independently of each other by receptors of the different senses, although the possibility of a multimodal perception by human beings has recently been suggested (Hui, 2006). Industries and academia have embraced sensory evaluation as an invaluable tool for creating successful products and understanding the sensory properties of materials (Ötles, 2005). Hence Since this study was a product development sensory analysis was made and the result is listed in the table given below followed by detail discussion on each of the sensory attributes as follows;

Table 4.4: Effect of temperature on Sensorial properties of cookies

Temperature	Appearance	Color	Aroma	Crispiness	Taste	Flavor	Overall Acceptability
150	6.731^{b}	6.562^{b}	6.129^{b}	2.686^{a}	6.138^{b}	6.150^{b}	6.441^{b}
175	7.276^{b}	7.375^{b}	7.180^{c}	3.929^{b}	7.584^{c}	7.705^{c}	7.501^{c}
200	5.243^{a}	5.114^{a}	5.229^{a}	3.786^{b}	5.243^{a}	5.400^{a}	5.614^{a}

$^{a-c}$ any two means in the same column not followed by the same letter are significantly different

Table 4.5: Effect of blend proportion on Sensorial properties of cookies

Blend Proportion	Appearance	Color	Aroma	Crispiness	Taste	Flavour	Overall Acceptability
Control	5.809^{a}	5.809^{a}	5.929^{a}	3.691^{a}	6.262^{ba}	6.405^{b}	6.286^{a}
5C,5Q,90W(B1)	6.559^{ab}	6.728^{a}	6.466^{a}	3.690^{a}	6.703^{cb}	6.806^{b}	6.851^{cb}
10C,10Q,80W(B2)	6.905^{b}	6.714^{a}	6.714^{a}	3.643^{a}	6.905^{c}	6.976^{b}	7.167^{c}
15C,15Q,70W(B3)	6.500^{ab}	6.405^{a}	5.976^{a}	3.167^{a}	6.071^{ba}	6.309^{b}	6.409^{ba}
20C,20Q,60W(B4)	6.309^{ab}	6.095^{a}	5.810^{a}	3.143^{a}	5.667^{a}	5.595^{a}	5.881^{a}

$^{a-c}$ any two means in the same column not followed by the same letter are significantly different

4.3.1 Appearance

Appearance of a food product is one of the important quality parameters which can influence the acceptability of a food product. As it can be seen in the table 4.4 and 4.5, the appearance of the cookies was found significantly affected by temperature ($p \leq 0.05$) but not by blend proportion and their interaction ($p>0.05$). The highest score of judgment on appearance was observed at a baking temperature of 175^0C and baking temperature 200^0C score the least and according to LSD analysis it was significantly different from baking temperature 150^0C and 175^0C which didn't have a significant difference between each other. On the other hand the appearance of the cookie was not significantly affected by blend proportion ($p>0.05$) as it can be seen from the table 4.5 the appearance of cookie which was baked from blend proportion two (10% carrot, 10% quality protein maize and 80% wheat) on average temperature scores the highest 6.905 and it was found to be only significantly different from the cookie baked from the control which scores the least 5.809. The cookie which was baked from other than the controls contains a carrot flour which gives them a beautiful yellow color this could be the reason why the control cookie score the least but according to LSD analysis the score was only significantly different with blend proportion two but not with blend proportion one, three and, four.

4.3.2 Color

Color is also one of the most important sensory qualities of food product. As can be noted from the table given above the cookie color made from different blend proportion was found significantly affected by baking temperature ($p \leq 0.05$) but not by blend proportion and their interaction. The baking temperature 175^0C scores the highest (7.375) on cookie color than 150^0C and 200^0C but it was only significantly different with 200^0C but not with 150^0C which scores second. At a baking temperature 175^0C an attractive golden brown color was observed on all of the cookie made from different blend proportion, this was due to Maillard reactions, caramelization of sugars and dextrin's (either presents in the food or produced by hydrolysis of starches) to furfural and hydroxymethyl furfural, carbonization of sugars, fats and proteins (Fellows, 2000). Maillard browning is an important cause of both desirable changes in food color and in the development of off-colors. At 150^0C baking temperature no browning color was observed this is may be baking temperature 150^0C is not intense enough to develop a Maillard reaction at a given baking time and at 200^0C a burned color was observed this could be the reason why it got the lowest score on cookie color judgment by the panelist. On the other hand it was found that blend proportion did not significantly affect cookie color however all the blend proportion score higher than the control cookie this is because of the beautiful yellow color imparted by the carrot flour, but as the proportion of carrot flour increased the score on cookie color decreased this could be because of the deep yellow color formed.

4.3.3 Aroma

Aroma which is imparted by volatile compounds and perceived by the odor receptor sites of the smell organ, i. e. the olfactory tissue of the nasal cavity (Hui *et al*., 2006) is also one of the sensory quality parameters of a particular food product was also studied. The aroma of the cookies was found significantly influenced by baking temperature ($p \leq 0.05$) but not by blend proportion and their interaction. According to Fellows (2000),the high temperatures and low moisture contents in the surface layers cause caramelisation of sugars and oxidation of fatty acids to aldehydes, lactones, ketones, alcohols and esters. More over the Maillard reaction and Strecker degradation produce different aromas according to the combination of free amino acids and sugars present in a particular food. Each amino acid produces a characteristic aroma when heated with a given sugar, owing to the production of a specific aldehyde, this could be the reason why temperature was significantly affect the aroma of the cookies and from the result obtained baking temperature 175^0C was found to be superior in aroma development followed by baking temperature 150^0C. The baking temperature 200^0C was scored the least in aroma development, according to Fellows (2000), further heating degrades some of the volatiles compound produced and a burnt or smoky aroma is developed this could be the reason why baking temperature 200^0C score the least.

4.3.4 Crispiness

Crispiness which is one of the textural properties of a food product in which attributes of a food material resulting from combination of physical and chemical properties, perceived largely by the sense of touch, sight and hearing is also one of the most important quality parameters of a food product was also studied. As it can be seen from the result that the crispiness of the cookies was found significantly influenced by baking temperature ($p \leq 0.05$), but not by blend proportion and their interaction ($p > 0.05$). The highest score on crispiness was found on the baking temperature 175^0C and baking temperature 150^0C scores the least. According to Fellow (2000) the texture of foods is mostly determined by the moisture, and at baking temperature 150^0C, higher moisture content was observed as compared to baking temperature 175^0C and 200^0C and According to Manely (1998) at higher a moisture level the structure of a biscuit will not be crisp, the centre will be wetter than the edges and flavor changes associated with staling will be more rapid this may be the reason baking temperature 150^0C scores the least. Even though the blend proportion did not significantly affect the crispiness of the cookies, the cookie which was made from hundred percent wheat score the highest and a deceased in crispiness was observed as the proportion of quality protein maize and carrot flour increases.

4.3.5 Taste

Taste attributes consist of saltiness, sweetness, bitterness and acidity which is detected by the taste buds at the tip, sides, and back of the tongue is one of the important sensory quality parameters of a food product was also studied and it was found that significantly influenced by both baking temperature and blend proportion ($p \leq 0.05$). The baking temperature 175^0C and the blend proportion two score the highest as compared to the other treatment. And it was found that blend proportion 1 and 2 is not significantly different from each other.

4.3.6 Flavor

Flavor which is a combination of taste and smell, and one of the sensory qualities of a food product was also studied and it was found that baking temperature, blend proportion and their interaction had a significant influenced on it ($p \leq 0.05$). Since flavor is a combination of taste and smell or aroma, as the aroma and taste of the cookie were influenced by baking temperature it was also influenced because of the reason mention above. And as it can be noted from the result that baking temperature 175^0C was superior in flavor development followed by 150^0C, and as can be seen from the table given above only blend proportion four was significantly different from all of the other blend proportion which did not have significant difference among them.

4.3.7 Overall Acceptability

The final sensory analysis conducted by the panelist was the overall acceptability of the cookie. The overall acceptability of the cookie was significantly influence by both baking temperature and blend proportion ($p \leq 0.05$). The highest score of judgment on over all acceptability was observed at Baking temperature 175^0C and baking temperature 200^0C scores the least. According to LSD analysis all of the baking temperature was found to be significantly different from each other. On the other hand blend proportion two score the highest on overall acceptability than others, and blend proportion scores the least. According to LSD analysis blend proportion two was significantly different from all the other formulas including the control. Hence it can be concluded that blend proportion two (10% carrot, 10% quality protein maize and 80% wheat) baked at baking temperature 175^0C is the superior cookies than all other cookie made from different formulas.

4.4 Proximate Composition of Flours and Cookies Samples

Investigation in food science and technology, whether by the food industries, governmental agencies, or universities, often requires determination of food composition and characteristics. All food products require analysis as a part of quality parameter throughout the development process, through production, and often a product is in the market. The chemical composition of foods is used to determine the nutritive value, functional characteristics and acceptability of the food product. Hence proximate chemical composition analysis was made for both the flours and cookies which was made from different composite flour and baking temperature. The result is listed in the following tables and followed by detailed discussion as follows.

4.4.1 Proximate Composition of Flours

The proximate compositions of the flours result are listed in the table given below followed by a detailed discussion.

Table 4.6: Proximate composition of the flours

Flour sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crud Fiber (%)	CHO (%)	Energy value(kcal/g)
Wheat	13	11	2.00	0.69	2.00	71.31	347.24
QPM	10.93	10.05	4.95	0.46	3.24	70.37	366.23
Carrot	12.1	6.87	2.77	5.4	10.12	62.74	303.37

Moisture, protein, fat, ash, crude fiber, Carbohydrate content and energy value of wheat, QPM and Carrot flours are presented in Table 4.6. As can be seen from the result wheat flour had the highest protein Content (11%) followed by quality protein maize (10.05%) and carrot is the least (6.87%). But in fat content wheat is the least (2%) followed by carrot (2.77%), and quality protein maize had the highest fat content (4.95%) than the other composite flour, since maize kernel contains larger germ high in fat than other cereals, this may have been responsible for high fat content in corn flour. The ash and crude fiber content of carrot flour was found to be higher than quality protein maize and wheat. This indicated that carrot flour contains appreciable amount of mineral than both of the other flours. Carrot is a tuber plant this could be the reason why it contains higher fiber content than wheat and quality protein maize. According to Yeung & Laquatra (2003), Dietary fiber has been postulated to have beneficial effects on diabetes, atherosclerosis, cancer, and appendicitis, prevention of duodenal ulcer formation, ischemic heart disease, ulcerative colitis and varicose veins. As it can be noted from the table given above the carbohydrate content of carrot flour was found to be lowest (62.74%) as compared to wheat (71.31%) and quality protein maize (70.37%) this is because carrot flour has higher fiber and ash content and when carbohydrate was calculated by difference the carbohydrate content was lower than the other composite flour. In regarding energy value of the flours, quality protein maize had the highest energy value than the other flours this is because quality protein has the highest fat content (4.95%) than wheat (2%) and carrot flour (2.77%). According to Yeung & Laquatra (2003) Dietary fat is the most concentrated source of energy; supplying 9 kcal/g.

4.4.2 Proximate composition of cookies

The proximate composition of cookies are listed in the table given below

Table 4.7: Effect of temperature on Proximate Composition of Cookie

Temperature	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crud Fiber (%)	CHO (%)	Energy Value(kcal/g)
150^0C	8.312[c]	6.532[b]	15.066[a]	1.186[a]	4.498[a]	64.405[a]	419.344[a]
175^0C	5.577[b]	6.470[b]	15.093[a]	1.178[a]	4.436[a]	67.246[b]	430.704[b]
200^0C	3.64[a]	6.254[a]	15.096[a]	1.180[a]	4.512[a]	69.319[c]	438.149C

[a-c] any two means in the same column not followed by the same letter are significantly different

Table 4.8: Effect of Blend Proportion on Proximate Composition of Cookie

Blend Proportion	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crud Fiber (%)	CHO (%)	Energy Value(kcal/g
Control	5.617[a]	6.921[d]	13.991[a]	0.726[a]	2.783[a]	70.294[e]	433.454[e]
5C,5Q,90W	5.692[b]	6.529[c]	14.007[a]	0.850[b]	3.313[b]	69.610[d]	430.614[c]
10C,10Q,80W	5.898[c]	6.416[b]	15.682[b]	1.232[c]	4.513[c]	66.258[c]	431.835[d]
15C,15Q,70W	5.977[d]	6.394[b]	15.804[c]	1.439[d]	5.333[d]	65.058[b]	428.046[b]
20C,20Q,60W	6.037[e]	6.167[a]	15.941[d]	1.661[e]	6.467[e]	63.728[a]	423.048[a]

[a-c] any two means in the same column not followed by the same letter are significantly different

4.4.2.1 Moisture

As it can be seen from the table given above the moisture content of the cookies were significantly influence by baking temperature, blend proportion and their interaction ($p \leq 0.05$). Decreased in average moisture content of the cookies was observed as the baking temperature was increased. A similar result was also found by Piergiovanni & Farris (2007) in which baking temperature and time was negatively affecting the amaranth cookie moisture. On the contrary as the proportion of carrot flour and QPM flour increased in the formulation the moisture content of the cookies were also increased. This increasing in moisture could be the higher water absorption capacity of the carrot flour since it contains the highest fiber content than wheat and QPM flour. A similar increase in cookie moisture content is reported by Manoela *et al*., (2006) in their study of blending wheat flour with residue from king palm processing which contains a higher fiber content than wheat flour.

4.4.2.2 Protein

The protein content of the cookies was found significantly influenced by baking temperature, blend proportion and their interaction ($p \leq 0.05$). The average protein content was decreased with increasing in baking temperature. During baking, the physical state of proteins is altered (Fellow, 2000) and According to Hui *et al.*, (2006), the Maillard reaction, which occurs between reducing sugars such as glucose, fructose, lactose, or maltose and free amino groups of amino acids or proteins, is favored at temperatures above 50^0C. In Maillard reactions the loss of amino acids, in particular, lysine is significant, which slightly reduces the protein quality. The extent of loss is increased by higher temperatures, longer baking times and larger amounts of reducing sugars. In biscuits, baked at 170^0C for 8 min produced higher losses of amino acids as follows: tryptophan, from 8% to 44%; methionine, from 15% to 48%; lysine, from 27% to 61% (Fellow, 2000). This could be the reason that a reduction in crude protein was observed as the temperature of baking temperature increased. And according to LSD analysis baking temperature 200^oC was found significantly different from baking temperature 150^0C and 175^0C which did not have a significant difference between them.

On the other hand a decrease in protein content was also observed as the proportion of carrot flour and quality protein maize was increased in which both have a lower amount of protein content than wheat flour. Especially carrot flour has low amount of crud protein (6.87%) than quality protein maize (10.05%) and wheat (11%) this could be the reason that a decreased in crud protein was observed. And according to LSD analysis the control was found significantly different from all of the other blend proportion in crude protein content.

4.4.2.3 Fat

The fat content of the cookies were found significantly influenced by blend proportion ($p \leq 0.05$) but not by temperature and their interaction. The average fat content of the cookies were found increasing with increasing in the proportion of the quality protein maize(4.95%) and carrot flour(2.77%), which both contain larger fat content than wheat(2%). This could be the reason that an increasing in fat content was observed. And according to the LSD analysis the control cookie was found significantly lower in fat content than blend proportion Two, Three and four but not with blend proportion one in which only five percent carrot and five percent quality protein maize flour was incorporated with ninety percent wheat flour. However the fat content of the cookies which was found might not be the exact fat content. Even though the procedure used during fat determination was a standard method described by AOAC (2003), there should be some modification of fat content determination for beta carotene rich products such as carrots, mango, papaya and the like. This is because beta-carotene is also dissolved with diethilyether, a solvent which was used for extracting fat in the cookies samples. And during the analysis it was observed that the samples of the cookie which was made with the incorporation of carrot flour were changed their color from yellow to white after extraction this indicate that the beta carotene and other colored components of the cookies were leached out from the sample and get in to the extraction cup and weighted together with the fat hence there would be an increasing in fat percentage of the sample since beta carotene and other colored components weight also incorporated, this might not be significantly affect the cookie sample in this study since the maximum percentage of carrot flour incorporated was 20% but for the product very high in beta carotene the amount of beta carotene and other colored components shall be determined and subtracted from the amount of fat, beta carotene and other colored components mixture which was regarded as a fat percentage alone, in order to get the real fat content of a food sample reach in beta carotene. In this study this hypothesis was not used because there is no single standard method for the determination of fat for different foods (AOAC, 2003)

4.4.2.4 Ash

Ash which is one of the proximate components of food which provide estimates of the total mineral content of the food was also studied. The ash content of the cookie was found significantly influenced by the blend proportion ($p \leq 0.05$) but not by baking temperature and their interaction. As it can be seen from the table 4.8 an increasing in ash content was observed as the proportion of quality protein maize and carrot flour was increased, in which carrot flour has the highest ash content (5.4%) than wheat (0.69%) and QPM (0.46%), hence the increasing in ash content of the cookie could be because of the carrot flour incorporated since it contains higher ash content than wheat and QPM. And the ash content was found not significantly influenced by baking temperature($p > 0.05$) According to (Fenema ,1996) Mineral elements, unlike vitamins and amino acids, cannot be destroyed by exposure to heat this could be the reason that baking temperature was not influence ash content of the cookie significantly. And according to LSD analysis the control cookie was found significantly lower than all of the other blend proportion.

4.4.2.5 Crude Fiber

The crude fiber content of the cookies was found significantly affected by blend proportion ($p \leq 0.05$) but not by baking temperature and their interaction ($p > 0.05$). An increasing in crude fiber content of the cookies was observed as the proportion of carrot and QPM flour was increased in the formulation. As it can be seen from the raw material proximate composition table 4.6 the fiber content of the carrot flour was found higher (10.12%) as compared to QPM (3.2 %) and Wheat (2%). This result indicated that both carrot flour and QPM contain larger amount of crud fiber than wheat flour. This could be the reason that an increasing in fiber content was observed as the proportion of carrot and QPM flour was increased. Similar result was also observed by Manoela *et al*., (2006) in their study of blending wheat flour with residue from king palm processing which contains higher fiber content than wheat flour. And according to the LSD analysis the control cookie was found significantly lower than all of the other blend proportion.

4.4.2.6 Carbohydrate

The carbohydrate content of the cookie was also studied and found significantly influenced both by baking temperature and blend proportion ($p \leq 0.05$). The increasing in carbohydrate content was observed as the baking temperature was increased. The carbohydrate content of the cookie was calculated by difference, after analyzing all of the proximate composition and their sum was subtracted from 100 to get the carbohydrate content of the cookie. When the baking temperature was increased a deceased in moisture and protein content of the cookies was observed this reduction in moisture and protein contributes for an increasing in carbohydrate content, since the sum of proximate composition other than carbohydrate was reduced and when their sum was subtracted from 100 larger carbohydrate content was found. Hence the reason of increasing in carbohydrate content when baking temperature was increased could be the reduction in cookie moisture and protein content when baking temperature was increased. And according to LSD analysis all of the baking temperature was found significantly different from each other.

On the other hand a reduction in carbohydrate content of the cookies was observed, when the proportion of QPM and carrot flour in the formulation was increased. The reason of reduction in carbohydrate content of the cookie could be an increasing in moisture, fat, ash and fiber content of the cookies as the proportion of carrot and QPM flour in the formulation was increased which leads a reduction in carbohydrate content since carbohydrate is calculated by difference. A similar reduction in carbohydrate content was also reported by Manoela *et al.*, (2006) in their study of blending wheat flour with residue from king palm processing which contains a higher fiber, ash and fat content than wheat flour. And according to LSD analysis the control cookies was found significantly larger in carbohydrate content than all of the other blend proportion.

4.4.2.7 Energy Values of Cookies

The energy value of cookies was found significantly influenced by both baking temperature and blend proportion ($p \leq 0.05$). An increasing in energy values of the cookies was observed as the baking temperature was increased. This is related to an increasing in carbohydrate content since the moisture content was reduced as the baking temperature was increased as discussed above. On the other hand a reduction in carbohydrate content was observed as the proportion of carrot and QPM flour was increased. This is associated with a reduction in protein and carbohydrate content and an increasing in ash, crude fiber and moisture content. A similar reduction in energy values of cookie were found by Manoela *et al.*, (2006) in their study of blending wheat flour with residue from king palm processing. And according to LSD analysis the control cookies were significantly larger in energy value than all of the other blend proportion.

4.5 Tryptophan content of the Flours and Cookies

A tryptophan which is one of the essential amino acids was also studied separately since one of the objectives of the study was supplementing wheat flour in order to increase its essential amino acid. The tryptophan content of the flours and the cookies were analyzed and the result is presented in the table given below, followed by a discussion.

4.5.1Trypthophan Content of the Flours

Table 4.9; Tryptophan content of the flours

Flour sample	Tryptophan (%)
Wheat	0.09683
QPM	0.146
Carrot	0.047

Each of the composite flours were analyzed for tryptophan content and as can be seen from table 4.9 given above the amount of tryptophan concentration of quality protein maize (0.146%) was found to be higher than wheat (0.09683%) and carrot (0.047%) flour.

4.5.1Trypthophan Content of the Cookies

The cookies which was made from different blend proportion and baking temperature was analyzed for tryptophan content to study both of the factors on individual cookies tryptophan content and the result was given in the table given below.

Table 4. 10: Effect of temperature on tryptophan content of Cookie

Baking Temperature	Tryptophan (%)
150^0C	0.069^c
175^0C	0.062^b
200^0C	0.056^a

$^{a-c}$ any two means in the same column not followed by the same letter are significantly different

Table 4.11: Effect of blend proportion on tryptophan Content of Cookie

Blend Proportion	Tryptophan (%)
Control	0.046^a
(B-1) 5C,5Q,90W	0.070^d
(B-2)10C,10Q,80W	0.068^d
(B-3)15C,15Q,70W	0.066^c
(B-4) 20C,20Q,60W	0.061^b

$^{a-c}$ any two means in the same column not followed by the same letter are significantly different

As can be seen from the table 4.10 and 4.11 the tryptophan content of the cookies was found influenced significantly by both baking temperature and blend proportion ($p \leq 0.05$). A decrease in tryptophan content of the cookie was observed as a baking temperature was increased. As discussed above in the protein section, a reduction in the tryptophan content was because of the Maillard reaction which is occurred between the amino acids and reducing sugars and this lose will be increased as a temperature increased. From the wheat alone a reduction in tryptophan contents at a baking temperature of 150,175 and 200^0C was 44.07%, 50.15%, and 60.5% respectively. And according to LSD analysis all of the baking temperature was significantly different from each other. On the other hand even though all of the blend proportion was found higher in tryptophan content as compared to the control a reduction in tryptophan was observed as the proportion of quality protein maize and carrot flour increased in the formulation. This could be the reason that the contribution of tryptophan made by the wheat was deceased as the proportion of carrot flour was increased which is deprived of tryptophan content. According to LSD analysis the control cookie is significantly different in tryptophan content from all of the blend proportion.

4.6 β-Carotene Contents of the Flour and Cookies

The beta carotene contents of the composite flours, the control and the most selected cookies by the panelists were analyzed, since one of the objectives of the study was supplementing the wheat flour with carrot flour in order to increase its beta carotene content. The sensory result reveled that at baking temprature175^0C which scores higher as compared to the other baking temperature, the control; blend proportion one, two, three and four scores, 7.572, 7.2915, 7.5716, 7.443 and 7.429, respectively. This result indicated that all of the blend proportion which was baked at 175^0C has a potential to be liked by the consumer with some modification such as incorporating gluten protein or by removing QPM flour from the blend if the objective is enriching wheat in beta-carotene in order to get a more crisp cookies. Hence beta carotene analysis was conducted for all. The result is listed in the tables 4.12 and 4.13 followed by discussion in regarding to recommended daily allowance (RDA) of preformed vitamin A after converting the beta carotenes in to retinol. According to Whitney and Rolfes (2008), 1µg retinol is equivalent to 12 µg dietary beta-carotene. And the discussion is based on the consumption of 200gram cookies.

4.6.1β-carotene Content of the Flours

Table 4.12; β-carotene content of the flours

Flour sample	**β-carotene(μg/g)**
Wheat	0.69
QPM	Nil
Carrot	410.84

As can be seen from the table 4.12 the beta carotene content of carrot flours was found to be higher than both quality protein maize and wheat. Carrots are rich source of beta-carotene (Kalra *et al*., 1987). According to (Berdanier *et al*., 2008) wheat and maize contain far from adequate amounts of vitamin A precursors. Hence the contribution of beta-carotene in to the cookies was largely due to carrot flour.

4.6.2 β-Carotene Content of the Selected Cookie

Table 4.13: β-carotene content of the cookies baked at 175^{0}C

Cookies baked at 175^{0}C	β-carotene(μg/g)	β-carotene(μg/200g)	Vitamin A equivalence
Control(100% wheat)	0.124	24.8	2.1
B1(5%C, 5%QPM,90%Wheat)	20.53	4106	342.17
B2(10%C,10%QPM,80%Wheat)	39.76	7952	662.67
B3(15%C,15%QPM, 70% wheat)	57.76	11552	962.67
B4(20%C, 20QPM, 60% Wheat)	73.50	14700	1,225

As can be seen from table 4.13 the beta-carotene content of the control cookie (100% wheat) found the lowest as compared to the blend proportion and as the percentage of the carrot flour increased in the formulation the beta carotene content was also increased .

From the result of vitamin A equivalency, substitution of wheat with 5% carrot flour contains beta-carotene (4106 μg/200g), this is equivalent to 342.17 μg preformed vitamin A (retinol). This amount of beta-carotene of the cookies fulfills 114.06% for the age group (1-3), 85.5425% for the age group (4-8),57.03% for the age group (9-13) and 38.02% for the age group(>14), of the daily requirements of vitamin A as recommended in the recommended dietary allowance table(RDA) (Whitney and Rolfes , 2008). And substitution of wheat flour with 10% carrot flour contains beta-carotene (7952µg/200g), this is equivalent to 662.67µg preformed vitamin A (retinol). This fulfills 220.89% for the age group(1-3), 165.6675% for the age group (4-8), 110.445% for the age group(9-13) and 73.63% for the age group(>14) of the daily requirements of vitamin A. 15% carrot flour incorporation contains (11,552µg/200g), this is equivalent 962.67µg preformed vitamin A and it fulfill, 320.89% for the age (1-3), 240.6675% for the age group(4-8), 160.445% for the age group(9-13) and 106.96% for the age group (>14) of the daily requirements of vitamin A. Blend proportion four which incorporate 20% carrot flour contain (14,700µg/200g), this is equivalent to 1,225µg preformed vitamin A and it fulfill 408.33for the age group (1-3), 306.25% for the age group (4-8), 204.17% for the age group(9-13) and 136.11% for the age group (>14) of the daily requirement of vitamin A, hence it can be concluded that carrot flour can be potentially used for cookie making with the objective increasing vitamin A precursor.

Chapter 5

5. Suggested Process Technology

5.1 Suggested Process Technology for Carrot Flour Production

Carrot dehydration process is designed in this step. Carrots are commercially dehydrated vegetables in the world. Carrots contain about 12% TS and they can be stored for long time at 0^oC and 95% RH before dehydration. They should be of good color and free of defects. The carrots are first dry-cleaned on a conveyor belt to remove any dirt and external materials, and then they are washed in conventional water washing machines. The washed root vegetables are normally peeled in a steam peeler at 7 bar for 30 s. Peeled carrots are diced mechanically (sliced into die shape) to sizes 9.5x9.5x9.5 mm, and then they are blanched for 6 min on a conveyor belt, using saturated steam at atmospheric pressure. The diced carrots are dehydrated in a conveyor belt air–dryer until moisture content of about 8% is reached. The product may require further dehydration to 3% moisture content in a bin dryer, using dehumidified air. The over all suggested process flow diagram is presented here in under.

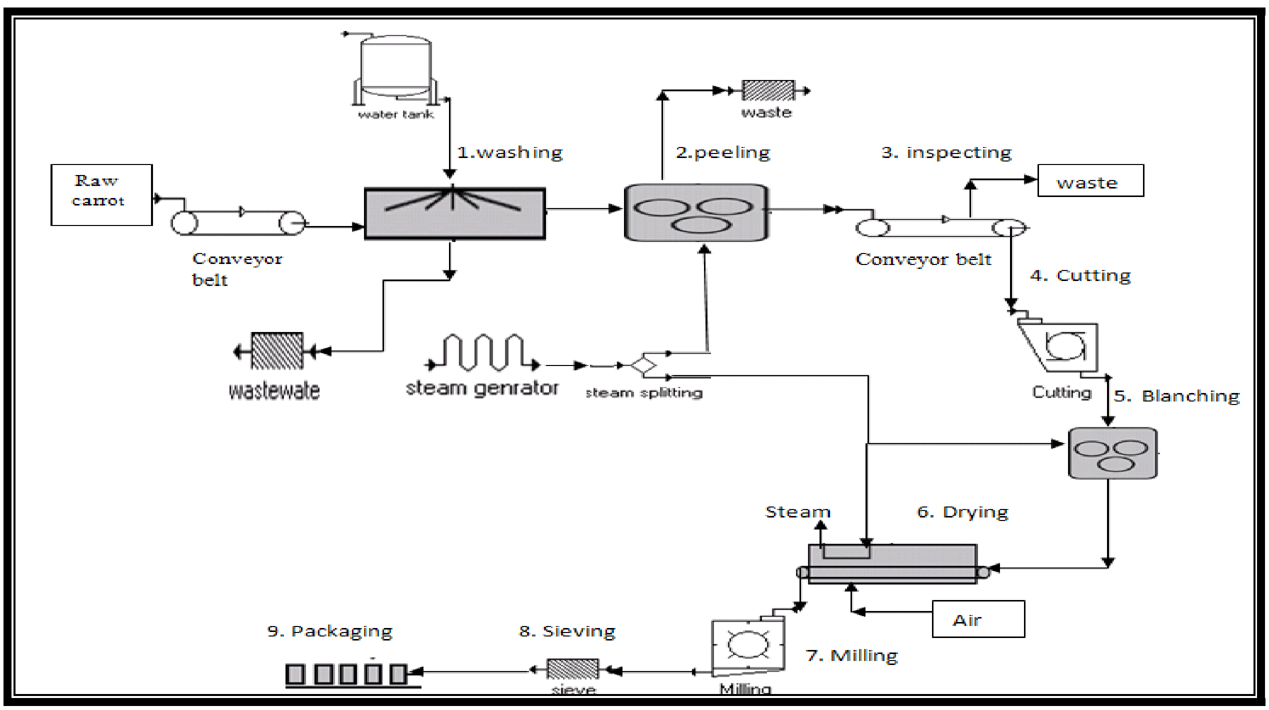


Fig 5.1. Process flow sheet of carrot flour plant

5.1.1 Material and Energy Balance

The material and energy balance is based on a 1 kg product.

5.1.1.1 Material Balance

The raw carrot is first dry cleaned then washed and a one to one ratio of water to carrot is used. Assume negligible change in weight in the washing section. After washing steam peeling is followed, in which 8% of the carrot is peeled off. In the inspection section it is assumed that 5% of the carrot has defects and it is considered as a waste. Since the cutting/dicing section is a continuous operation it is assumed that no mass change is occurred. Again it assumed that no mass change is occurred in the blanching and cooling section, in which both operations is carried out in the same equipments. Carrot contains 12% total solid and after drying the moisture content of the dried mass is expected to be 8%. After drying, milling operation is followed and it is assumed that no mass change is occurred and in the sieving section about 96% of the flour passes 100 micro meter sieve size. Considering this important assumption the material balance was done and presented in the following material and energy balance flow diagram (Fig 5.2).

5.1.1.2 Energy Balance

<u>Energy balance on steam peeler</u>

Assume an increasing in temperature of carrot during steam peeling is rise from room temperature (25^0C) to 50^0C since the exposure time of steam peeling is only 30second. After peeling the wastes is removed by spraying cold water.

$Q_{steam} = M_{raw\ carrot} * Cp_{of\ raw\ carrot} * \Delta T$

$Q_{steam} = 9.25 kg/h * 3.81 kJ/kg^0C * (50-25)^0C$

$Q_{steam} = 881 kJ/h = 0.245 kW$

<u>Energy Balance on Blencher</u>

In the blancher diced carrot is blanched for 6min with saturated steam at atmospheric pressure and it is assumed that the temperature of the carrot will rise to steam temprature150^0C, since the surface area of diced carrot is larger, from its room temperature.

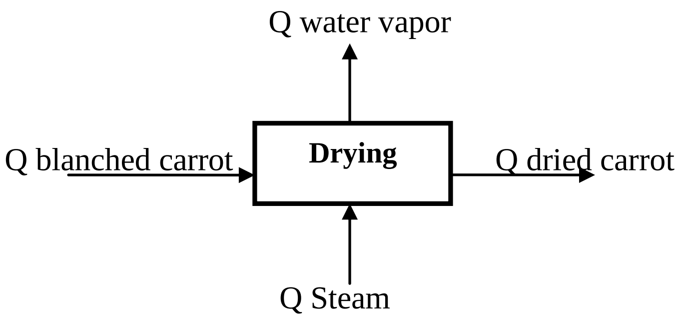
$Q = M$ diced carrot * Cp of diced carrot *ΔT

$Q = 8kg * 3.81kJ/kg^0C * (150 – 25)^0C$

Q = 3810kJ/h = 1.06kW

<u>Energy balance on the dryer</u>

The dryer require steam energy in order to heat the incoming air



Input Energy = output energy

$Q_{blanched\ carrot} + Q_{steam} = Q_{water\ vapor} + Q_{dried\ carrot}$

$Q_{blanched\ carrot}$

$Q_{blanched\ carrot} = M * Cp* (25^0C – T_{ref}(^0C))$

$Q_{blanched\ carrot} = 8kg/h * 3.18kJ/kg^0C * 25^0C$

<u>$Q_{blanched\ carrot} = 762kJ/h$</u>

$Q_{water\ vapor}$

$Q_{water\ vapor} = M*\lambda$ (latent heat of vaporization of water (100^0C)

$Q_{water\ vapor} = 6.96\ kg/h * 2257\ kJ/kg$

<u>$Q_{water\ vapor} = 1.5 * 10^4\ kJ/h$</u>

<u>$Q_{dried\ carrot}$</u>

According to Mudahar *et al*., (2008) at industrial scale carrots are dried at 150^0C.

The result of proximate analysis revealed that the dried carrot contain 6.87% protein, 2.77% fat, 5.4% ash, moisture 8% and total carbohydrate 76.96%.

Cp dried carrot= (∑Cpi Mi)

Where

Mi= mass of fraction of dried carrot component

Cpi= specific heat capacity of individual components of dried carrot

Specific heat of the component at the temperature of 20^0C

Protein, $Cp = 2.0082 + 1.2089 * \mathbf{10^{-3} T} – 1.3129 *10^{-6} T^2$

$Cp = 2.0082 + 1.2089 * 10^{-3} (150\ ^0C) – 1.3129 *10^{-6} (150\ ^0C)^2$

Cp= 2.16 kJ/kg ^{0}C

Fat , $Cp =1.9842 + 1.4733*10^{-3}T- 4.8008 * 10^{-6}T^2$

Cp = 2.1 kJ/kg ^{0}C

Ash $Cp = 1.0926 + 1.8896*10^{-3}T- 3.6817 * 10^{-6}T^2$

Cp = 1.29 kJ/kg^{0}C

Cho Cp $= 1.54884 + 1.9625* 10^{-3}T – 5.9399*10^{-6}T^2$

Cp = 1.71 kJ/kg ^{0}C

Water $Cp = 4.1762 – 9.0864 * 10^{-5}T + 5.4731*10^{-6} T^2$

Cp = 4.286 kJ/kg^{0}C

$Cp_{dried\ carrot}$ **= 2.16** kJ/kg ^{0}C **(0.0687) + 2.1** kJ/kg ^{0}C (0.0277) + 1.29 kJ/kg ^{0}C (0.054) + 4.286 kJ/kg ^{0}C (0.08) + 1.71 kJ/kg ^{0}C (0.7696)

$Cp_{dried\ carrot}$= 1.935 kJ/kg ^{0}C

$Q_{dried\ carrot} = M_{dried\ carrot} * Cp_{dried\ carrot} * (150^0C – 25^0C)$

$Q_{dried\ carrot} = 1.0435 kg/h * 1.935\ kJ/kg\ ^0C * 125^0C$

$Q_{dried\ carrot}$ = 252.4 kJ/h

Over all energy balance

$Q_{\text{blanched carrot}} + Q_{\text{steam}} = Q_{\text{water vapor}} + Q_{\text{dried carrot}}$

$762\text{kj/hr} + Q_{\text{steam}} = 1.5 * 10^4 \text{ kJ/h} + 252.4 \text{ kJ/h}$

$Q_{\text{steam}} = 15002.524 \text{ kJ/h} - 762\text{kJ/h}$

$\mathbf{Q_{steam} = 14,490.4 \text{ kJ/hr} = 4.025 \text{ kW}}$

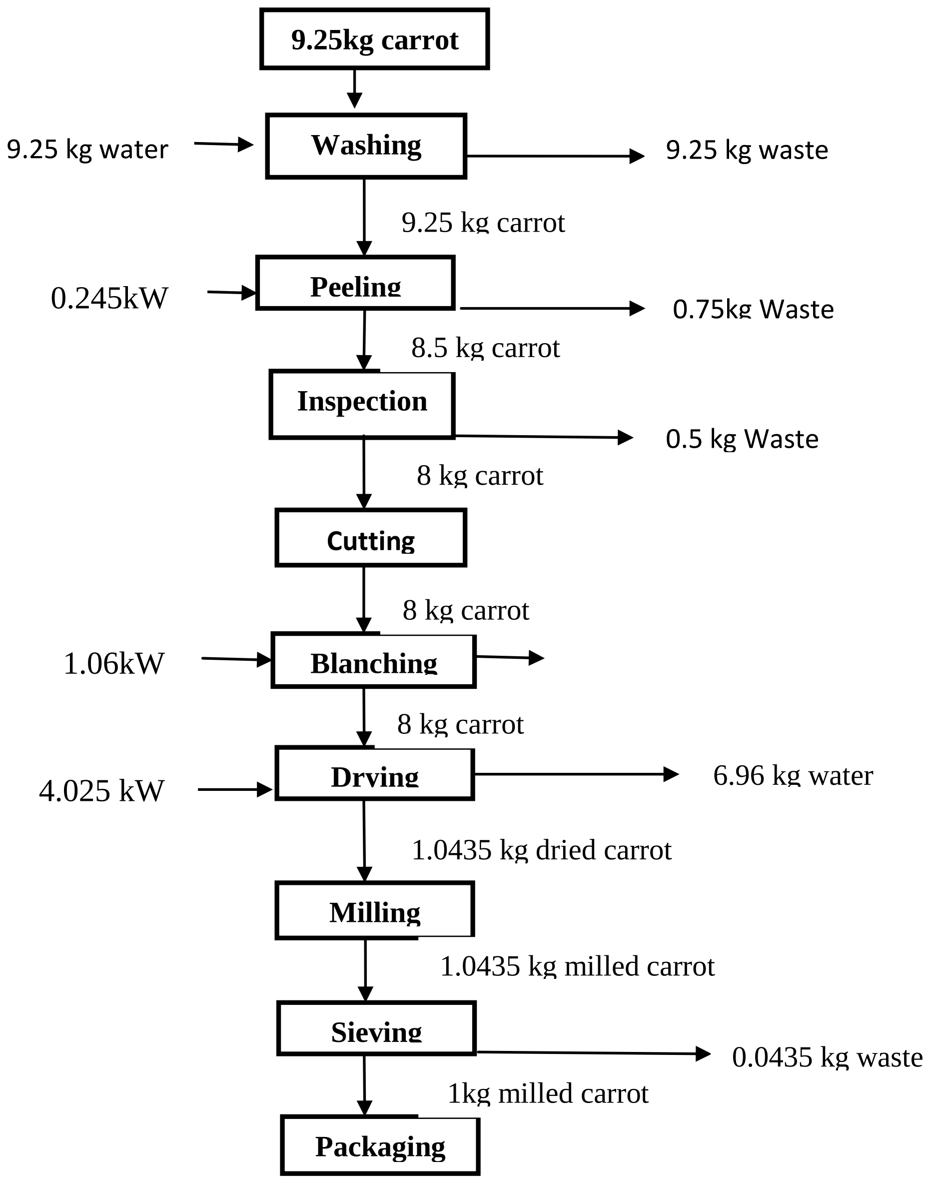


Figure 5.2 Material and energy balances of the carrot dehydration plant.

5.2 Suggested Process Technology of Cookie Production

The process of making cookies comprises of various unit operations. Following the formulation, the raw materials are carefully measured out and mixed in the dough mixer. The dough when formed is passed through the moulds. This is then stamped either before or after cutting depending on the design of the plant. The dough pieces are taken to the oven where they are baked for 10 minutes at 175^0C temperatures. The baked cookies are removed and sorted out. They are then packed in polyethylene or waxed paper previously printed and finally sealed on the sealing machine. The wrapped biscuits are in turns packed in cartons and taken to the market. The overall suggested process flow diagram is presented here in under.

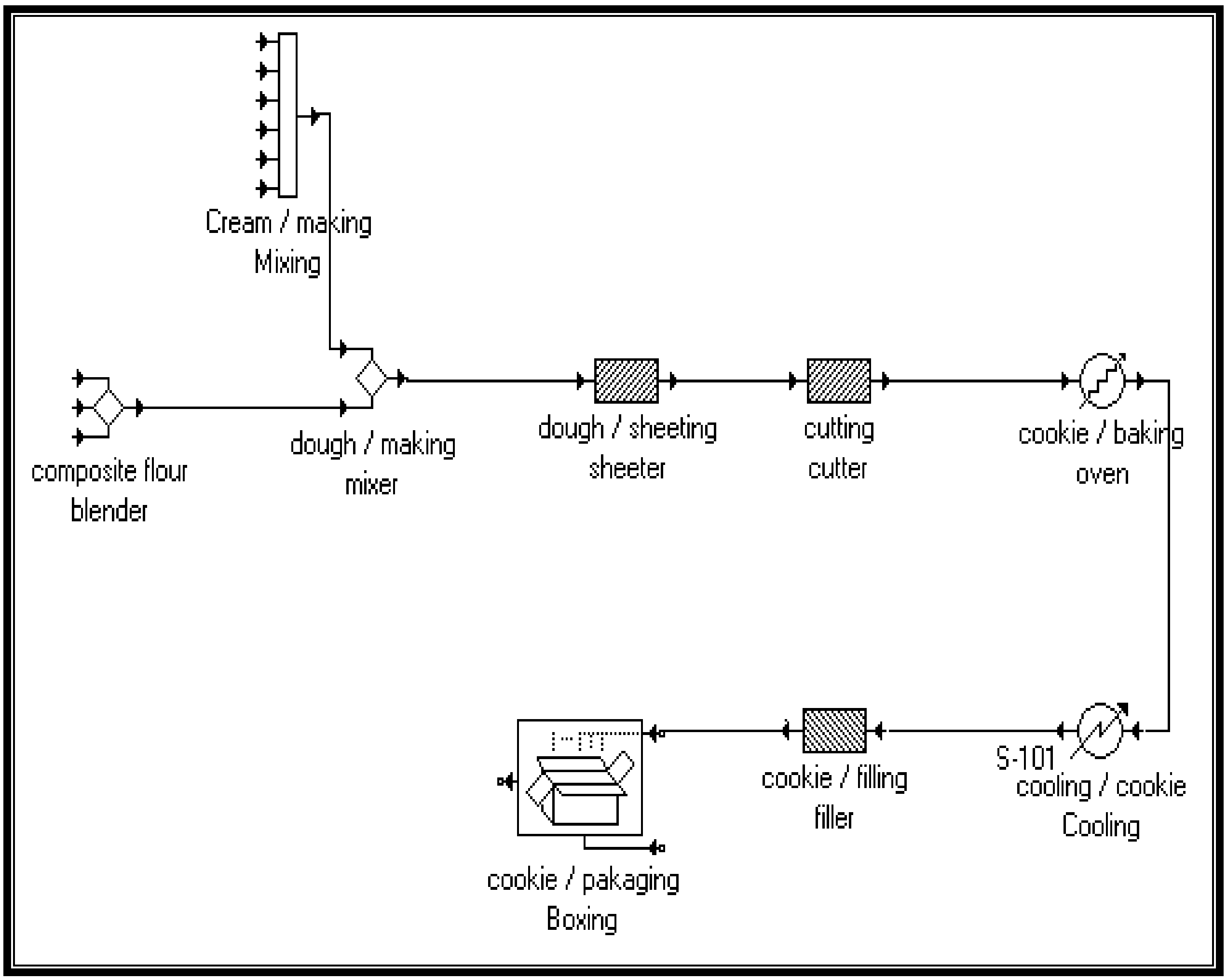


Fig 5.3 Process flow diagram of cookie making

5.2.1 Material and Energy Balance

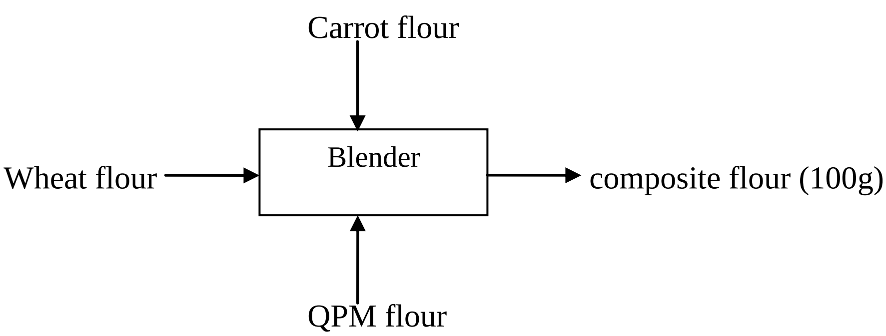
The material and energy balance is based on a 1 kg product.

5.2.1.1 Material Balance

Based on the formulation made the composition of the dough mix contain 47% composite flour, 16% sugar, 13.2% shortening, 0.44% salt, 0.53% baking powder, 22.83% water. The selected cookies was made from a composite flour containing 80% wheat, 10% carrot flour and 10% QPM flour and were blended. The moisture content analysis revealed that wheat flour contains 13%, QPM flour contains 10.93 %, and carrot flour contains 12.1%.

Material balance for laboratory cookie making

<u>Material balance on the flour blender</u>



<u>Overall balance</u>

90g wheat + 10g QPM flour + 10g carrot flour = 100 g composite flour

Moisture balance

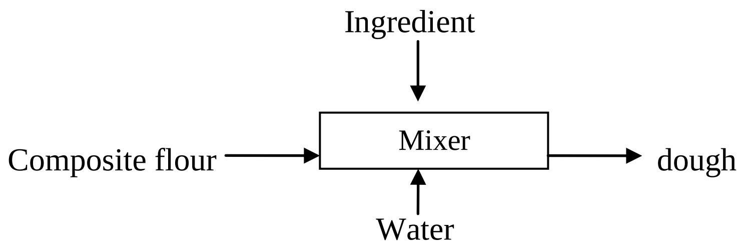
90g (0.13) + 10g (0.1093) + 10gr (0.1210) = 100 g(X)

14.003 = 100g(X)

X = 0.14003

Hence the moisture content of the composite flour is 14.003%

Material balance on the mixer



During dough making (100g) composite flour, sugar (34 g), shortening (28 g), salt (0.93 g), baking powder (1.12 g) and various proportion of water (48g) were used.

Total material balance

100 g flour + 48g water + 34g sugar + 28g shortening + 0.93g salt + 1.12g baking powder = 212.05g dough

Moisture balance on the mixer

Assuming the other ingredients contain 2.5% moisture content. The sum of the ingredient is 64.05g

Composite flour 100 g (14.003%) + ingredients 64.05g (2.5%) + water 48g (100%) = 212.05g(X)

63.60425 = 212.05 g(X)

X = 63.60425/212.05

X = 0.29995 * 100 = 29.995%, approximately = 30%

Hence the moisture content of the dough is about 30% moisture

After baking the final moisture content of the most selected cookies was about 5 %

Based on this laboratory result data the following material balance was made for the plant producing 1500 tons per day.

Material balance for cookie production 1500 tone per day

Preliminary data

Plant will have annual production capacity of 1,500 tones. The plant will operate in a single shift, 8 hours a day, and for 300 days a year.

Hence the production capacity of the plant per day and per hour will be

1500tonne / 300day = 5tonne/day= 5tonne/8 h = 0.625tonne/h = 625kg/h

Based on the formulation made the composition of the dough mix contain 47% composite flour, 16% sugar, 13.2% shortening, 0.44% salt, 0.53% baking powder, 22.83% water, of the dough.

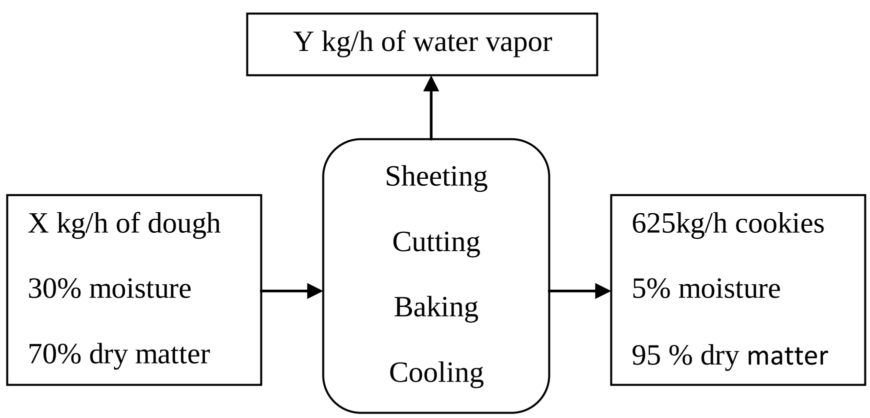
The moisture content of the final product will be 5% and 95% dry matter

The moisture content of the dough will be 30% and 70% dry matter

Assume 10% moisture lose during sheeting and cutting

Assume the cookies after baking contains 9% moisture and contain 5% after cooling.

Assuming there is no lose in the mixer the overall material balance will be



Over all material balance

X kg/h dough = Y kg/Wv + 625kg/h cookie……………………………eq-1

Moisture balance

X kg/h dough (0.3) = Y kg Wv(1) + 625kg/h cookie(0.05)……………………eq-2

Dry matter balance

X kg/h dough (0.7) = Y kg/h Wv(0) + 625kg/h cookies(0.95) …………………eq-3

From eq-3 the mass of the dough can be calculated

X kg/h (0.7) = 625kg/h (0.95)

X kg/h = 625kg/h (0.95) / 0.7 = **848.2143kg/h**

Hence 848.2143 kg/h dough is require to produce 625kg cookies per hour

From eq- 2 the mass of water removed can be calculated by substituting the mass of the dough

848.2143kg/h (0.3) = Y kg/h (1) + 625kg/h (0.05)

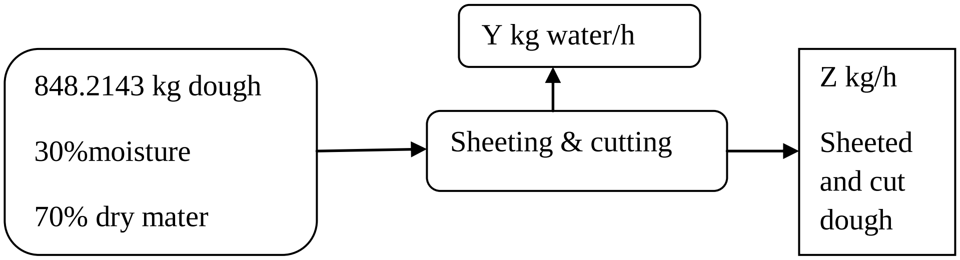
Y kg/h = 254.4643 – 31.25

Y kg/h = 223.2143

Hence 223.2143kg/h water is lost from the system

Material balance on the sheeting and cutting

Assumption there will be a 10% moisture lose on this unit operation



The moisture content of the dough is

848.2143kg/h * 0.3 = 254.46429 kg out of which 10% is lost in the process

Hence 254.46429kg * 0.1 = 25.446 kg water is lost

254.46429 kg – 25.446kg = 229.02 kg moisture is remaining in the dough

The dry mater content of the dough is

848.2143kg/h * 0.7 = 593.75kg

Hence the mass of the sheeted and cut mass will be

593.75kg + 229.02kg= 822.77kg

Z= 822.77kg with 27.84 moisture content and 72.16% dry matter

Material balance on the oven

After baking the cookies have 9% moisture content and 91% dry matter

Total material balance

822.77 kg/h = Wv(kg/h) + baked cookie(kg/h) eq……………1

Moisture balance

822.77kg/h (27.84%) = Wv (100%) + baked cookie (9%)………2

Dry mater balance

822.77kg/h (72.16%) = Wv(0%) + baked cookie(91%)…………3

The mass of the baked cookie can be calculated from eq…..3

822.77kg/h (72.16%) = baked cookie (91%)

Baked cookie (kg/h) = (822.77 * 0.7216) / 0.91

Baked cookie (kg/h) = 652.43kg/h

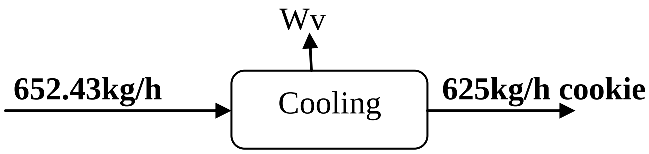
The mass of water vapor leaving the oven can be calculated from eq…..2

822.77kg/h (27.84%) = Wv (100%) + baked cookie (9%)………2

229.05kg/h = Wv + 58.72kg/h

Wv = 170.33 kg water vapor is leaving the oven per hour

Material balance during cooling



Total material balance

652.43 kg/h = Wv + 625kg/h

Wv = 652.43kg/h – 625kg/h

Wv = 27.43kg/h

Hence 27.43kg of water is leaving the baked cookie during cooling

Over all material balance

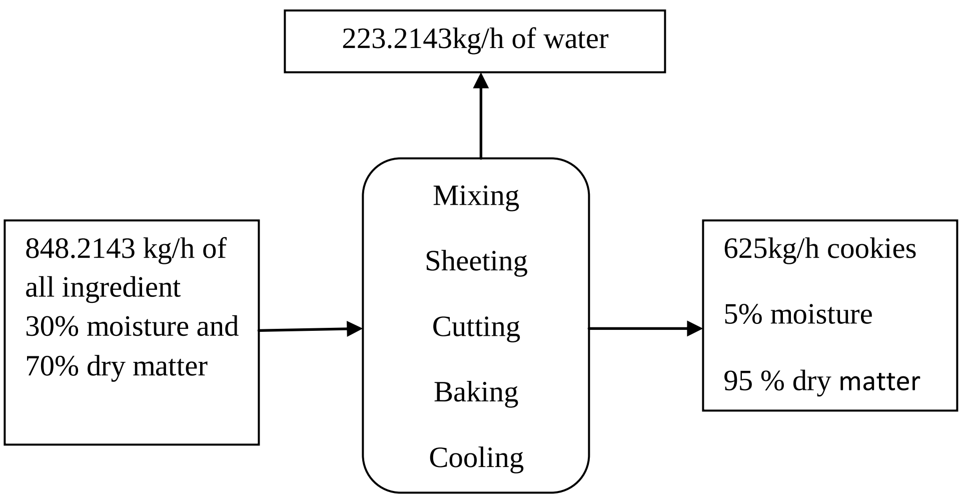
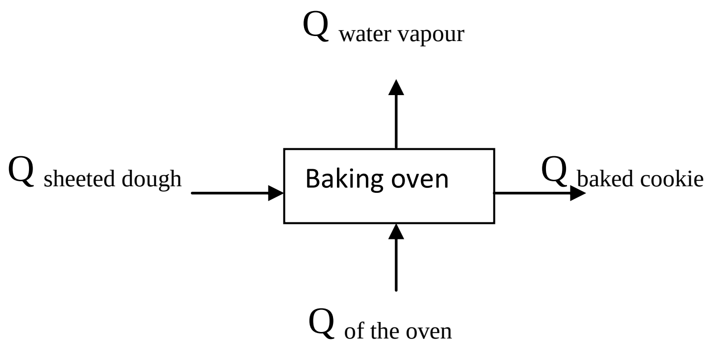


Fig 5.4 over all material balance for cookie making

5.2.1.2 Energy Balance on Cookie Baking Oven



Total energy balance

$Q_{in} = Q_{out}$

$Q_{sheeted} + Q_{oven} = Q_{baked\ cookie} + Q_{water\ vapor}$

$Q_{sheeted}$

The composition of the composite flour after Component balance flour results in 10.537% protein, 2.372% fat, 1.138% ash, moisture 14.003%, and 71.957% total carbohydrate. The dough mix contain 47% composite flour, 16% sugar, 13.2% shortening, 0.44% salt, 0.53% baking powder, 22.83% water. This means that 212.02g dough contain (100g) composite flour, sugar (34 g), shortening (28 g), salt (0.93 g), baking powder (1.12 g) and various proportion of water (48g) were used. On assumption sugar contains 1.25% moisture and 98.75 carbohydrates, shortening contain 100% fat, salt contain 1.25% moisture and 98.75 ashes, baking powder contain 100% ash, and water contain 100% moisture. After conducting a component balance the dough contains 4.97% protein, 14.33% fat, 1.43% ash, 30% moisture and 49.263% total carbohydrate.

Cp sheeted dough= (∑Cpi Mi)

Where

Mi= mass of fraction of dough component

Cpi= specific heat capacity of individual components of dough

Assuming during mixing, sheeting and cutting the temperature of dough is raise from 24^{0}C room temperature to 50^{0}C

Specific heat of the component at average temperature of 37 (24 + 50)/2)^{0}C

Protein, $Cp = 2.0082 + 1.2089 * \mathbf{10^{-3} T} – 1.3129 *10^{-6} T^2$

$Cp = 2.0082 + 1.2089 * 10^{-3} (37\ ^0C) – 1.3129 *10^{-6} (37\ ^0C)^2$

Cp= 2.05 kJ/kg ^{0}C

Fat , $Cp =1.9842 + 1.4733*10^{-3}T- 4.8008 * 10^{-6}T^2$

Cp = 2.03 kJ/kg ^{0}C

Ash $Cp = 1.0926 + 1.8896*10^{-3}T- 3.6817 * 10^{-6}T^2$

Cp = 1.16 kJ/kg^{0}C

Cho Cp $= 1.54884 + 1.9625* 10^{-3}T – 5.9399*10^{-6}T^2$

Cp = 1.61 kJ/kg ^{0}C

Water $Cp = 4.1762 – 9.0864 * 10^{-5}T + 5.4731*10^{-6} T^2$

Cp = 4.18 kJ/kg^{0}C

$Cp_{sheeted\ dough}$ = 2.05 kJ/kg ^{0}C (0.0497) + 2.03 kJ/kg ^{0}C (0.1433) + 1.16 kJ/kg^{0}C (0.01437) +1.61 kJ/kg ^{0}C (0.49263) +4.18 kJ/kg^{0}C (0.3) =

$Cp_{sheeted\ dough}$ = 2.235 kJ/kg^{0}C

$Q_{sheeted\ dough}$ = $MCp\Delta T$

$Q_{sheeted\ dough}$ = 822.77kg * 2.235 kJ/kg^{0}C * (175 - 50)

$Q_{sheeted\ dough}$ = **$2.298614 * 10^5$ kJ**

$Q_{baked\ cookie}$

From the proximate analysis result on the cookies which was baked at 175 was revealed that the cookie contain 6.41% protein, 15.8624% fat, 1.2040 ash and on assumption it will contain 9% moisture before cooling hence the total carbohydrate is 67.5236%. When it leaves the oven the baked cookies will reach to 175^0C.

Specific heat of the component at average temperature of 175^0C

Protein, $Cp = 2.0082 + 1.2089 * \mathbf{10^{-3}\,T} - 1.3129 * 10^{-6}\, T^2$

$Cp = 2.0082 + 1.2089 * 10^{-3}\,(175\ ^0C) - 1.3129 * 10^{-6}\,(175\ ^0C)^2$

Cp= 2.18 kJ/kg ^{0}C

Fat , $Cp = 1.9842 + 1.4733 * 10^{-3}T - 4.8008 * 10^{-6}T^2$

Cp = 2.1 kJ/kg ^{0}C

Ash $Cp = 1.0926 + 1.8896 * 10^{-3}T - 3.6817 * 10^{-6}T^2$

Cp = 1.31 kJ/kg^{0}C

Cho Cp $= 1.54884 + 1.9625 * 10^{-3}T - 5.9399 * 10^{-6}T^2$

Cp = 1.71 kJ/kg ^{0}C

Water $Cp = 4.1762 - 9.0864 * 10^{-5}T + 5.4731 * 10^{-6}\, T^2$

Cp = 4.33 kJ/kg^{0}C

$Cp_{\text{baked cookie}}$ = 2.18 kJ/kg ^{0}C (0.0641) + 2.1 kJ/kg ^{0}C (0.158624) +1.31 kJ/kg^{0}C (0.01204) + 1.71 kJ/kg ^{0}C (0.675) +4.33 kJ/kg^{0}C (0.09) =

$Cp_{\text{baked cookie}}$ = 2.033 kJ/kg^{0}C

$Q_{\text{baked cookie}}$ = $MCp\Delta T$

$Q_{\text{baked cookie}}$ = 652.43 kg *2.033 kJ/kg^{0}C *(175^{0}C)

$Q_{\text{baked cookie}}$ = **$2.32118 * 10^5$ kJ**

$Q_{\text{water vapor}} = M\lambda$ (latent heat of water vapor)

Where

λ (latent heat of water vaporization) = 2257 kJ/kg

$Q_{\text{water vapor}}$ = 170.33 kg *2257 kJ/kg

$Q_{\text{water vapor}}$ = **$3.84435*10^5$ kJ**

Therefore from the overall energy balance on the oven heat energy provided by the oven can be calculated

$Q_{\text{sheeted}} + Q_{\text{oven}} = Q_{\text{baked cookie}} + Q_{\text{water vapor}}$

$Q_{\text{oven}} = Q_{\text{baked cookie}} + Q_{\text{water vapor}} - Q_{\text{sheeted}}$

$Q_{\text{oven}} = 2.32118 * 10^5 \text{ kJ} + 3.84435*10^5 \text{ kJ} - 2.298614 * 10^5 \text{ kJ}$

$Q_{\text{oven}} = 3.87 * 10^5 \text{ kJ}$

On a hourly basis

$Q_{\text{oven}} = 3.87 * 10^5$ kJ/h = 107.4 kwh

5.2.2 Project Cost Estimation

The following economic evaluation is for the establishment of a modern medium cookie making plant with a capacity of producing 1500 tons per year. The plant should operate for 8hr per day with one shift and 300 days per year. The evaluation includes the estimated required investment and working capital for the establishment and the operation of the factory as well as the estimated operating costs and the expected profitability of the project. The factory is supposed to be established in a place where all basic industrial requirements such as water, power, transportation facilities and raw materials are available.

MACHINERY AND EQUIPMENT REQUIREMENT

Table 5.1: Equipment cost for cookie making

No. Sr.	**Description**	Qty (No)
1.	Cream mixer	1
2.	Dough mixing machine	1
3.	Laminator	1
4.	Cutting machine	1
5.	Rotary moulding machine	1
6.	Steel belt oven	1
7.	Cooling conveyor	1
8.	3-step cooling conveyor	1
9.	Stacking machine	**1**
10.	Wire cut attachment	1
11.	Oil spray machine	1
12.	Revolving salt duster	1
13	**Cost of identified required equipment:**	**12,580,000 birr**
14	Additional miscellaneous equipment (15%)	**1,887,000 birr**
15	**Total equipment cost:**	**14,467,000 birr**

The cost estimate for equipment and other materials are based on previous studies and in this study the current foreign exchange rate is considered. Machinery can easily be purchased from India. Addresses of machinery suppliers are given below:- KDR industries 1072, Bhandup Industrial State,West Mumbai-400078Maharashtra, India , TEL. 91-22-2596 4534/ 5555 4049,FAX : 91-22-2596 8883 , E-MAIL: maitto:kdrinds@boms.vsnl.net.in.

MANPOWER REQUIREMENT AND ANNUAL LABOUR COST

Table 5.2: Manpower requirements for cookie plant

No	Description	Req.No	Salary, birr	
			Monthly	**Annually**
1.	Supervisor/engineer	1	3,000	36,000
2.	For Mixing unit	2	2,136	25,632
3.	For Sheeting and cutting unit	2	2,136	25,632
4.	For Baking oven unit	4	4,272	51,264
5.	For Packaging unit	6	3,000	36,000
6.	Plant manager	1	3,000	36,000
7.	accountant	1	1,068	12,816
8.	Store keeper	1	600	7,200
9.	Purchaser/sales man	1	1,068	12,816
10.	driver	1	600	7,200
11.	Guard	2	1000	12,000
12.	Cleaner	1	350	4,200
	Total	**23**	**22,230**	**266,760**

Cost of Raw Materials

The plant capacity is 625kg cookies per hour. To produce this amount of cookies 848.2143kg/hr dough is required according to mass balance result. The ingredient required was, 47% flour, 16% sugar, 13.2% shortening, 0.44% salt, 0.53% baking powder, and 22.83% water. The calculation result revaled that 398.67 kg flour per, 135.71kg/hr sugar, 111.96 kg/hr shorteing, 3.73kg/hr salt, 4.5kg/hr baking powder and 193.65 kg/hr water is needed. And the composite flour contains 10%carrot flour, 10% QPM and 80% wheat. Hence 39.8667kg/hr carrot flour, 39.8667kg/hr QPM and 318.938kg/hr wheat flour is required.

Table 5.3; Raw material costs (annual requirement)

Item	**Req per day**	**Req per year`**	**Unit price birr**	**Total cost(birr)**
Wheat flour	2,551.504kg/day	765,451.2kg	10	7,654,512
Carrot flour	318.9336kg/day	95,679.9kg	32	3,061,756.8
QPM flour	318.9336kg/day	95,679.9kg	4.5	430,559.55
sugar	1,085.68kg/day	325,704kg	13.5	4,397,004
shortening,	895.68kg/day	268,704kg	24	6,448,896
salt	29.84kg/day	8,952kg	3	26,856
baking powder	36kg/day	10,800kg	60	648,000
water	1,549.2kg/day	464,760kg	0.00315birr/liter	1,440.756
Total				**22,669,025.11**

UTILITIES REQUIREMENT AND COST

Table 5.4: Costs of utilities

No	description	Quantity per annum	Unit price(birr)	Total cost (Birr)
1	Electricity (Kwh)	1,140,000	0.4993	569,202
2	Water (m^3)	1000	3.1	3,100
3	Packing material (625kg/h *300day *8h)* 10pack/kg)	15,000,000	0.57Birr/100g biscuit	8,550,000
			Total	**9,122,302**

Fixed Capital Investment

Table 5.5 Fixed capital cost estimation

Item		Description / factor	Total Cost(birr)
I. Direct Costs	A. a. Equipment		**14,467,000 birr**
	b. Installation	0.47* **14,467,000**	6,799,490
	c. Instrumentation	0.18* **14,467,000**	2,604,060
	d. Piping	0.66* **14,467,000**	9,548,220
	e. Electrical	0.11* **14,467,000**	1,591,370
	B. Building +auxiliary	0.70***14,467,000**	10,126,900
	C. Service facilities	0.70***14,467,000**	10,126,900
	D. Land	0.06* **14,467,000**	868,020
	Total direct cost	**A+B+C+D**	**41,664,960**
II. Indirect Costs	A. Engineering& supervision	0.1***41,664,960**	4,166,496
	B. Construction +contractor fee	0.1***41,664,960**	4,166,496
	C. Contingency	0.06***41,664,960**	2,499,897.6
	Total indirect cost	**A+B+C**	**10,832,889.6**
III. Fixed capital investment		**Direct +Indirect cost**	**52,497,849.6**
IV. Working capital		**0.15*52,497,849.6**	**7,874,677.4**
V. Total capital investment		**III +IV**	**60,372,527.04**

Estimation of Total Production Cost

Table 5.6 Estimation of total production cost

Item		Description/factor	Total cost
I. Manufacturing cost	**A. Direct production cost**		
	a. Raw material	Calculated	22,669,025.11
	b. Utilities	,,	9,122,302
	c. Operating labor (ol)	,,	266,760
	d. Supervisory	0.1*ol	26,676
	e. Maintenance	0.05*FCI(**52,497,849.6)**	2,624,892.5
	f. Lab charges	0.12*ol	32,011.2
	Total of A		**34,741,666.81**
	B. Fixed Charges		
	a. Depreciation	0.1*mach. + 0. 02*build cost	1,649,238
	b. Local taxes	0.02*FCI(**52,497,849.6)**	1,049,956.99
	c. Insurance	0.006* FCI	314,987.1
	Total of B		**3,014,182.1**
	Total product cost (tpc)	Raw material cost/0.3	75,563,417.03
	C. Plant overheads	0.1*tpc	**7,556,341.703**
	Total manufacturing cost	A+B+C	**45,312,190.61**
II. General Expenses	a. Administrative cost	0.05*tpc 75,563,417.03	3,778,170.852
	b. Distribution	0.1*tpc	7,556,341.703
	c. Research &development	0.05*tpc	3,778,170.852
	d. Interest	0.05*tpc	3,778,170.852
	Total general expenses		**11,334,512.56**
III. Total Production Cost		**I +II**	**56,646,703.17**

Total product cost / annual cookie produced = **56,646,703.17 birr/1500000 = 37.7645 birr/kg**

Profit analysis

Selling price of 1kg of the cookie = 48.51 birr

Assuming the entire product will be sold

Total income = 48.51birr * 1,500,000 = **72,763,215.39**

Gross income = total income – total product cost

= **72,763,215.39 - 56,646,703.17** = **16,116,512.22birr**

Let the tax rate be 35% (income tax of Ethiopia)

Taxes = 0.35* 16,116,512.22birr = 5,640,779.3 birr

Net profit = gross income – tax

= 16,116,512.22 birr - 5,640,779.3 birr

= 10,475,732.94 birr

Rate of return

$$ROI = \frac{net\ profit}{total\ capital\ investment} x100 = \frac{10,475,732.94}{60,372,527.04} x100 = 17.4\ \%$$

$$payback\ period = \frac{FCI}{NP + Depre} = \frac{52,497,849.6}{10,475,732.94 + 1,649,238} = 4.33\,year$$

Break even analysis

$$BEP = \frac{TFC}{(Sup - Vcup)} = \frac{TPC - DPC}{(Sup - Vcup)}$$

Where, BEP = Break-even point (units of production)

Vcup = Variable costs per unit of production

Sup = Selling price per unit of production= 48.51birr birr/kg

TPC = Total production cost = **56,646,703.17**

DPC = Direct production cost = **34,741,666.81**

$$Vcup = \frac{Direct\ production\ cost}{Amount\ of\ biscuit\ produced}$$

$$= \frac{34{,}741{,}666.81\ birr/year}{1{,}500{,}000\ kg/year} = 23.16 birr/kg$$

$$BEP = \frac{TPC - DPC}{Sup - Vcup}$$

$$= \frac{56{,}646{,}703.17\ birr/year - 34{,}741{,}666.81\ birr/year}{48.51 birr/kg - 23.16\ birr/kg} = 864{,}103.9984\ kg/year$$

$$BEP(\%) = \frac{864{,}103.9984\ kg/year}{1{,}500{,}000\ kg/year}\ x\ 100 \quad where, \quad capacity\ of\ the\ plant = 1{,}500{,}000\ kg/year$$

$$= 57.6\%$$

Chapter 6

6. Conclusion and Recommendation

6.1 Conclusion

This study was aiming to develop a cookie from wheat, carrot and quality protein maize flour in order to increase the beta carotene and tryptophan content of the cookies and to study the effect of blend proportion and baking temperature on the physicochemical properties the cookies. The study indicated that both beta carotene and tryptophan contents of the cookie can be increased by incorporating carrot and quality protein maize in to wheat flour and acceptable and nutritious cookies could be obtained.

From the study it can be concluded that an increasing in the proportion of carrot and quality protein maize flour in the formulation increase, cookie moisture, fat, ash, β-carotene and crud fiber. This was largely because of the carrot flour incorporation since it contains larger amount of ash, beta carotene and crude fiber as compared to QPM and wheat flour. The reason of increasing in fat content was because of the QPM flour incorporation, were as protein, carbohydrate and energy value of the cookies was deceased. This was again largely because of the carrot flour since it contains low amount of protein, higher amount of ash and crude fiber. More over this high amount of crude fiber of the carrot flour reduce cookie diameter and spread ability, and increase cookie breaking strength. Cookie taste, flavor and overall acceptability can also be caused by incorporating carrot and QPM flour in wheat flour for cookie making. Even though the tryptophan content of the cookies was increased as compared to the control cookie due to QPM flour increased in the formulation, how ever the contribution of tryptophan by the wheat was decreased when the carrot flour was increased in the formulation, which contains low amount of tryptophan as compared to QPM and wheat flour.

Baking temperature was the other parameter which was studied. From the result found it can be concluded that, baking temperature causes a decrease in cookie moisture, protein and tryptophan. The decease in moisture content was due to the evaporation of moisture when the temperature was increased. The reduction of the protein and tryptophan was due the Maillard reaction, a reaction which is occurred between the amino acids and reducing sugars, and favored at a higher temperature, lower moisture content, higher amount of amino acids and reducing sugar's. In this study the cookies was found an ideal for this reaction. Hence, QPM shall not be used in cookie making since the loss of amino acids is significant. On the other hand as the baking temperature increased cookie carbohydrate and energy values was increased. This was due to the reduction of protein and moisture. Since carbohydrate was calculated by difference the reduction in moisture and protein could increase the carbohydrate content as a result the energy values also increased since carbohydrate is the major energy provider in cereal based foods. On the contrary cookie fat, ash and crude fiber, and cookie spread ability was not affected significantly by baking temperature. There was also some loses of β-carotene during baking.

6.2 Recommendation

From the study result, partial substitution of wheat with carrot and QPM flour for cookies making appeared to promising in nutrition point of view. Based on the result found the following recommendation are made.

- Even though an increasing in tryptophan content was increased when QPM was increased in the formulation the contribution of tryptophan by the wheat was decreased when the carrot flour was increased. Hence for the objective of supplementing wheat in order to increases the amino acid profile of the cookie, QPM shall be incorporated alone in wheat. More over a reduction of tryptophan content was also observed after baking due to Maillard reaction, since it is favored at higher temperature and lower moisture content. Hence for a better utilization of QPM it shall be prepared in the form of flour for making a potage or other kind of food which has higher moisture content.

- Incorporation of carrot flour in the formulation was increase the beta carotene content of the cookies. Since cookies are consumed largely it could be used as a vehicle to transport this very important nutrient for the consumer. Hence producing these cookies could contribute for the efforts made by different stake holders to alleviate vitamin A deficiency of our country. Moreover producing these cookies could help to retain this important nutrient for a very long time, since cookies contain lower moisture content than raw carrot. Beside the proposed dehydration plant could contribute to extend the shelf life of carrot and other vegetables and root crops such as potato, sweet potato and other since they follow the same dehydration procedure. Hence food processor or new investors shall be encouraged to utilize the potential use of carrot for cookie making.

- A comprehensive study on, optimization of ingredient and baking condition, amino acid profile and shelf life Stability of the cookies should be conducted to come up-with complete and usable information.

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Appendix

1. Tests of Between Subject Effect on Sensory Analysis of Cookies

1.1 Apperance

Tests of Between-Subjects Effects

Dependent Variable: Appearance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	34.433[a]	14	2.460	4.882	.002
Intercept	1235.131	1	1235.131	2451.530	.000
Temp	22.142	2	11.071	21.974	.000
Blend	3.875	4	.969	1.923	.159
Temp * Blend	8.416	8	1.052	2.088	.104
Error	7.557	15	.504		
Total	1277.122	30			
Corrected Total	41.990	29			

a. R Squared = .820 (Adjusted R Squared = .652)

1.2 Color

Tests of Between-Subjects Effects

Dependent Variable: Cookie color

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	42.723[a]	14	3.052	4.071	.005
Intercept	1209.827	1	1209.827	1613.874	.000
Temp	26.226	2	13.113	17.493	.000
Blend	3.815	4	.954	1.272	.324
Temp * Blend	12.682	8	1.585	2.115	.101
Error	11.245	15	.750		
Total	1263.795	30			
Corrected Total	53.968	29			

a. R Squared = .792 (Adjusted R Squared = .597)

1.3 Aroma

Tests of Between-Subjects Effects

Dependent Variable: Cookie aroma

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	26.624[a]	14	1.902	3.251	.015
Intercept	1145.414	1	1145.414	1957.866	.000
Temp	19.070	2	9.535	16.298	.000
Blend	3.656	4	.914	1.562	.235
Temp * Blend	3.898	8	.487	.833	.588
Error	8.775	15	.585		
Total	1180.813	30			
Corrected Total	35.399	29			

a. R Squared = .752 (Adjusted R Squared = .521)

1.4 Crispiness

Tests of Between-Subjects Effects

Dependent Variable: Cookie Crispiness

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	13.528[a]	14	.966	5.090	.002
Intercept	360.533	1	360.533	1899.216	.000
Temp	9.249	2	4.624	24.360	.000
Blend	1.958	4	.489	2.578	.080
Temp * Blend	2.322	8	.290	1.529	.228
Error	2.847	15	.190		
Total	376.909	30			
Corrected Total	16.376	29			

a. R Squared = .826 (Adjusted R Squared = .664)

1.5 Taste

Tests of Between-Subjects Effects

Dependent Variable: Cookie Taste

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	38.344[a]	14	2.739	11.322	.000
Intercept	1198.854	1	1198.854	4955.798	.000
Temp	27.908	2	13.954	57.684	.000
Blend	5.886	4	1.472	6.083	.004
Temp * Blend	4.549	8	.569	2.351	.073
Error	3.629	15	.242		
Total	1240.826	30			
Corrected Total	41.973	29			

a. R Squared = .914 (Adjusted R Squared = .833)

1.6 Flavor

Tests of Between-Subjects Effects

Dependent Variable: Cookie Flavor

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	42.026[a]	14	3.002	11.039	.000
Intercept	1235.819	1	1235.819	4544.646	.000
Temp	27.639	2	13.820	50.821	.000
Blend	6.905	4	1.726	6.348	.003
Temp * Blend	7.482	8	.935	3.439	.019
Error	4.079	15	.272		
Total	1281.924	30			
Corrected Total	46.105	29			

a. R Squared = .912 (Adjusted R Squared = .829)

1.7 Overall Acceptability

Tests of Between-Subjects Effects

Dependent Variable: Cookie overall acc.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	30.293[a]	14	2.164	12.449	.000
Intercept	1274.856	1	1274.856	7334.691	.000
Temp	17.893	2	8.946	51.472	.000
Blend	6.021	4	1.505	8.660	.001
Temp * Blend	6.379	8	.797	4.588	.005
Error	2.607	15	.174		
Total	1307.756	30			
Corrected Total	32.900	29			

a. R Squared = .921 (Adjusted R Squared = .847)

2. Tests of Between Subject Effect on Proximate Analysis of Cookies

2.1 Ash

Tests of Between-Subjects Effects

Dependent Variable: Cookie Ash

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.715[a]	14	.265	102.463	.000
Intercept	41.877	1	41.877	16170.469	.000
Temp	.000	2	.000	.076	.927
Blend	3.696	4	.924	356.796	.000
Temp * Blend	.019	8	.002	.893	.545
Error	.039	15	.003		
Total	45.631	30			
Corrected Total	3.754	29			

a. R Squared = .990 (Adjusted R Squared = .980)

2.2 Fat

Tests of Between-Subjects Effects

Dependent Variable: Cookie fat

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	23.841[a]	14	1.703	195.630	.000
Intercept	6826.738	1	6826.738	784235.3	.000
Temp	.005	2	.003	.316	.734
Blend	23.788	4	5.947	683.179	.000
Temp * Blend	.048	8	.006	.683	.700
Error	.131	15	.009		
Total	6850.710	30			
Corrected Total	23.972	29			

a. R Squared = .995 (Adjusted R Squared = .989)

2.3 Proteins

Tests of Between-Subjects Effects

Dependent Variable: Cookie Protein

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.535[a]	14	.110	21.739	.000
Intercept	1235.957	1	1235.957	245028.4	.000
Temp	.428	2	.214	42.387	.000
Blend	.626	4	.157	31.049	.000
Temp * Blend	.481	8	.060	11.923	.000
Error	.076	15	.005		
Total	1237.567	30			
Corrected Total	1.611	29			

a. R Squared = .953 (Adjusted R Squared = .909)

2.4 Fibers

Tests of Between-Subjects Effects

Dependent Variable: Cookie fiber content

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	54.427[a]	14	3.888	157.013	.000
Intercept	602.650	1	602.650	24339.649	.000
blend	53.495	4	13.374	540.139	.000
temp	.033	2	.016	.661	.531
blend * temp	.899	8	.112	4.537	.006
Error	.371	15	.025		
Total	657.448	30			
Corrected Total	54.798	29			

a. R Squared = .993 (Adjusted R Squared = .987)

2.5 Cookie Moisture

Tests of Between-Subjects Effects

Dependent Variable: Cookie moisture conntent

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	111.121[a]	14	7.937	4015.461	.000
Intercept	1024.219	1	1024.219	518154.9	.000
blend	.788	4	.197	99.601	.000
temp	110.199	2	55.100	27875.024	.000
blend * temp	.134	8	.017	8.500	.000
Error	.030	15	.002		
Total	1135.370	30			
Corrected Total	111.151	29			

a. R Squared = 1.000 (Adjusted R Squared = .999)

2.6. Cookie Carbohydrate

Tests of Between-Subjects Effects

Dependent Variable: Cookie carbohydrate

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	318.867[a]	14	22.776	592.834	.000
Intercept	134629.089	1	134629.089	3504214	.000
blend	196.128	4	49.032	1276.238	.000
temp	121.727	2	60.864	1584.199	.000
blend * temp	1.011	8	.126	3.290	.022
Error	.576	15	.038		
Total	134948.532	30			
Corrected Total	319.443	29			

a. R Squared = .998 (Adjusted R Squared = .997)

2.7. Cookie Energy

Tests of Between-Subjects Effects

Dependent Variable: Cookie energy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2212.501[a]	14	158.036	209.774	.000
Intercept	5531509.330	1	5531509.330	7342439	.000
blend	396.121	4	99.030	131.451	.000
temp	1793.683	2	896.841	1190.453	.000
blend * temp	22.697	8	2.837	3.766	.013
Error	11.300	15	.753		
Total	5533733.131	30			
Corrected Total	2223.801	29			

a. R Squared = .995 (Adjusted R Squared = .990)

2.8. Cookie Tryptophan

Tests of Between-Subjects Effects

Dependent Variable: Cookie Tryptophan

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.003[a]	14	.000	85.496	.000
Intercept	.117	1	.117	43654.008	.000
Temp	.001	2	.000	166.094	.000
Blend	.002	4	.001	202.250	.000
Temp * Blend	.000	8	1.86E-005	6.969	.001
Error	4.00E-005	15	2.67E-006		
Total	.120	30			
Corrected Total	.003	29			

a. R Squared = .988 (Adjusted R Squared = .976)

3. Tests of Between Subject Effect on Physical Property Analysis of Cookies

3.1 Cookie diameter

Tests of Between-Subjects Effects

Dependent Variable: Cookie Diameter

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.369[a]	14	.026	103.981	.000
Intercept	679.918	1	679.918	2683888	.000
Blendp	.295	4	.074	291.566	.000
Tem	.057	2	.028	112.158	.000
Blendp * Tem	.017	8	.002	8.145	.000
Error	.004	15	.000		
Total	680.291	30			
Corrected Total	.373	29			

a. R Squared = .990 (Adjusted R Squared = .980)

3.2 Cookie Thickness

Tests of Between-Subjects Effects

Dependent Variable: Cookie Thickness

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.003[a]	14	.000	2.399	.052
Intercept	9.532	1	9.532	98602.793	.000
Blendp	.001	4	.000	1.586	.229
Tem	.002	2	.001	9.345	.002
Blendp * Tem	.001	8	.000	1.069	.433
Error	.001	15	9.67E-005		
Total	9.536	30			
Corrected Total	.005	29			

a. R Squared = .691 (Adjusted R Squared = .403)

3.2 Cookie Spread Ratio

Tests of Between-Subjects Effects

Dependent Variable: Cookie Spread Ratio

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.549[a]	14	.039	1.661	.170
Intercept	2140.892	1	2140.892	90600.599	.000
Blendp	.409	4	.102	4.328	.016
Tem	.075	2	.037	1.587	.237
Blendp * Tem	.065	8	.008	.346	.933
Error	.354	15	.024		
Total	2141.796	30			
Corrected Total	.904	29			

a. R Squared = .608 (Adjusted R Squared = .242)

3.4 Breaking Strength

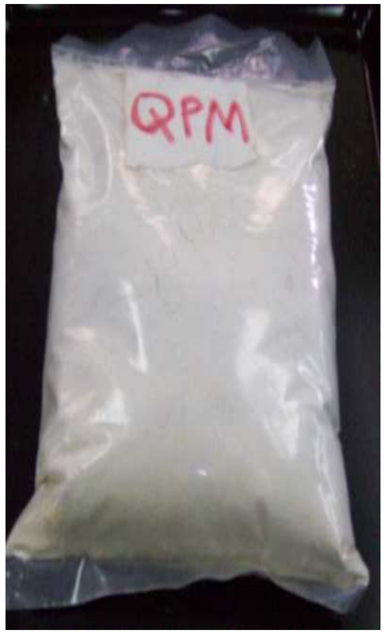
Tests of Between-Subjects Effects

Dependent Variable: Cookie Breaking Strength

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	499.366[a]	14	35.669	59.228	.000
Intercept	16085.084	1	16085.084	26709.352	.000
Blendp	172.780	4	43.195	71.725	.000
Tem	155.272	2	77.636	128.915	.000
Blendp * Tem	171.313	8	21.414	35.558	.000
Error	9.033	15	.602		
Total	16593.483	30			
Corrected Total	508.399	29			

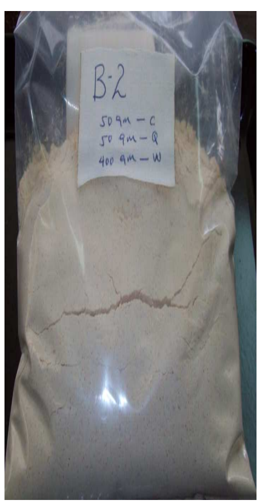
a. R Squared = .982 (Adjusted R Squared = .966)

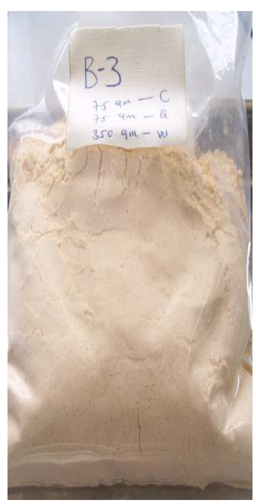
4. Flours used during Cookie Making

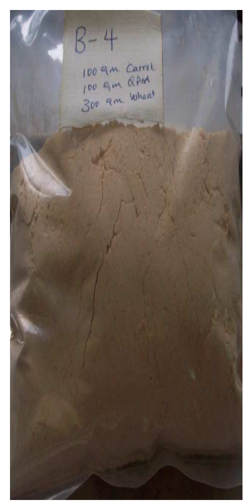


A. Carrot **B. Quality Protein Maize** **C. Wheat Flour**

5. Composite Flours







A.Blend Proportion -1 **B. Blend Proportion -2** **C. Blend proportions- 3** **D. Blend proportion-4**

6. Cookies Made from Composite Flours at Different Temperature

6.1 Cookies Made from 100% Wheat at Different Temperature

A. Baked at 150^{0}C **B. Baked at 175^{0}C** **C. Baked at 200^{0}C**

6.2 Cookies Made from Blend proportion 1 at Different Temperature

A. Baked at 150^{0}C **B. Baked at 175^{0}C** **C. Baked at 200^{0}C**

6.3 Cookies Made from Blend proportion 2 at Different Temperature

A. Baked at 150^0C **B. Baked at 175^0C** **C. Baked at 200^0C**

6.4 Cookies Made from Blend proportion 3 at Different Temperature

A. Baked at 150^0C **B. Baked at 175^0C** **C. Baked at 200^0C**

6.5 Cookies Made from Blend proportion 4 at Different Temperature

A. Baked at 150^0C

B. Baked at 175^0C

C. Baked at 200^0C

Declaration

I, the undersigned, declare that this thesis is my original work, has not been presented for a degree in any other University, and that all sources of materials used for the thesis have been duly acknowledged.

Name: Biniyam Tesfaye Banjaw

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Date of submission: _____________________________

This thesis has been carried out under my supervision and submitted for examination with my approval as University Advisors.

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