

Addis Ababa University
School of graduate Studies



**THE EFFECT OF BLEND PROPORTION AND
BAKING CONDITION ON THE QUALITY OF
COOKIE MADE FROM TARO AND WHEAT
FLOUR BLEND**

By: Abinet Tekle

June, 2009

**THE EFFECT OF BLEND PROPORTION AND
BAKING CONDITION ON THE QUALITY OF
COOKIE MADE FROM TARO AND WHEAT
FLOUR BLEND**

By:

Abinet Tekle

Under supervision of

Dr.Eng. Solomon Worku (Asso. Prof.)

Prof. Nigussie Retta

**A thesis submitted to the School of Graduate studies of Addis Ababa
University in partial fulfillment of the requirement for the Degree of
Master of Science in Food Science and Nutrition**

June, 2009

Acknowledgment

I want to acknowledge every one who has helped me in every step of this research. My deepest gratitude goes to my advisor Dr. Solomon Worku for his vital comments, Prof. Negussie Retta, Food Science and Nutrition department staff, Staffs of Kality food Share Company and ENHRI and also staffs of Areka Research Center.

Equally and importantly, I will like to express my gratitude to my mother Abeba G/Meskel, all members of my family and friends for their support and encouragement due course of this research.

Table of contents	pages
Acknowledgments	i
Table of contents	ii
List of tables	iv
List of figures	v
List of abbreviation	vi
Abstract	vii
1. INTRODUCTION	1
Objective	
2. LITERATURE REVIEW	6
2.1. Taro Corms	6
2.2. Value added products from taro	8
2.3. Limitations of taro flour for production of value added products	9
2.4. Cookies	10
2.4.1. Cookie baking	12
2.4.2. Sugar snap cookies and the role of its constituents	12
2.5. Use of composite flour for cookie making	17
2.6. Use of taro flour in cookie making	18
3. MATERIALS AND METHODS	19
3.1.Raw material sources	19
3.2.Raw material preparation	19
3.2.1. Taro flour preparation	19
3.2.2. Banana flour preparation	19
3.3.Formulation of blends and baking conditions	20

3.4.Cookie baking	21
3.5.Quality parameters evaluated	22
3.5.1. Functional properties of taro and wheat flour	22
3.5.2. Proximate analysis of the cookie and the taro flour	23
3.5.3. Textural characteristics of the cookies	27
3.5.4. Physical parameters of the cookie	27
3.5.5. Sensory evaluation	28
3.5.6. Oxalate content	28
3.6.Data analysis	30
4. RESULTS AND DISCUSSION	31
4.1.Proximate analysis of taro flour	31
4.2.Functional properties of taro and wheat flour	32
4.3.Proximate analysis of the cookie	33
4.4.Total gross energy	38
4.5.Breaking strength of the cookies (Textural quality)	39
4.6.Physical parameters of the cookies	41
4.7.Sensory analysis of the cookies	46
4.8.Limitation of taro usage as a value added product	49
5. CONCLUSION AND RECOMMENDATION	51
References	53
Appendix	60

List of Tables	Pages
3.1. Formulation of blend proportion of Taro and Wheat flour	20
3.2. Experimental design on effect of blend proportion and baking temperature	20
3.3. Formulation proportion of sugar snap cookie	21
4.1. Proximate analysis of taro flour (Mean \pm standard deviations)	31
4.2. Functional properties of taro and wheat flour (Mean \pm standard deviations)	31
4.3. Effect of blend proportion on proximate composition of the cookies	33
4.4. Effect of baking temperature on proximate composition of the cookies	34
4.5. Effect of blend proportion on energy values of the cookies	38
4.6. Effect of baking temperature on energy values of the cookies	38
4.7. Effect of blend proportion on breaking strength of the cookies	39
4.8. Effect of baking temperature on breaking strength of the cookies	39
4.9. Effect of blend proportion on physical parameters of the cookies	41
4.10. Effect of baking temperature on physical parameters of the cookies	41
4.11. Effect of blend proportion on sensory quality of the cookies	46
4.12. Effect of baking temperature on sensory quality of the cookies	46
4.13. Effect of blend proportion on oxalate content of the cookies	49
4.14. Effect of baking temperature on oxalate content of the cookies	49

List of figures	Pages
3.1 Simplex lattice design of taro and wheat flour blend proportion	20
4.1. Typical texture curves for cookie breaking strength	40

List of abbreviations

AACC	American Association of Cereal Science
AARC	Areka Agricultural Research Center
ANOVA	Analysis Of Variance
AOAC	Association Of analytical Chemists
BD	Bulk Density
EHNRI	Ethiopian Health and Nutrition Research Institute
FAO	Food and Agricultural Organization
LSD	List Significant Difference
OAC	Oil Absorption Capacity
SPSS	Statistical Package for Social Science
SD	Standard Deviation
USDA	United State Department of Agriculture
WAC	Water Absorption Capacity

Abstract

The influence of blending proportion of taro and wheat flour and baking temperature on the physicochemical characteristics and sensory qualities of cookie made from taro-wheat flour blend was investigated. Taro and wheat flour were blended using 33.33, 66.67 and 100% proportion using mixture simplex lattice design whereas 140, 150 and 160 °C baking temperature was used for baking. The physicochemical characteristics of cookies were evaluated in terms of proximate composition, energy value, water absorption capacity (WAC), oil absorption capacity (OAC), cookie diameter and thickness, spread ratio and cookie breaking strength (texture). The cookie sensory qualities were evaluated in terms of color, flavor, crispiness and overall acceptability.

Increase in the taro flour proportion increased the crude fiber, carbohydrate and ash content of the cookies and resulted in a decrease in the protein, fat, moisture content and energy value of the cookie. Temperature only had a significant effect on the moisture and carbohydrate content of the cookies and not on protein, fat, crude fiber and ash content of the cookies.

Breaking strength of the cookies significantly ($p < 0.05$) increased whereas cookie diameter, thickness and spread ratio significantly decreased with an increase in taro flour proportion. On the other hand, increase in baking temperature, significantly ($p < 0.05$) increased cookie diameter and thickness. The WAC and OAC were observed to increase with an increase in taro flour proportion in the composite.

The sensory quality scores of cookie decreased significantly with increase in taro flour proportion. Moreover, cookies baked at 160 °C had low sensory scores for color and flavor as compared those baked at 140 and 150 °C. The results of overall acceptability confirmed that replacing of wheat flour with taro flour up to 33.33% for cookie baking was fairly acceptable. Significant decrease in the oxalate content of the cookies with an increase in the taro flour proportion was also observed.

The 33.33% taro flour cookie was found not to be significantly different from the control cookies with all quality parameters except with protein, ash, carbohydrate, gross energy and crude fiber content.

In general, the study indicated that blending taro up to 33.33% with wheat flour and 150 °C baking temperature could result in cookies of acceptable quality.

1. INTRODUCTION

The term taro is used to refer to *Colocasia esculenta* (L.) It is a family of Aracea cultivated for its edible corms. Taro is a staple food throughout the subtropical and tropical regions of the world. And can be consumed as both a staple food and vegetable, and processed as a food ingredient, animal feed, etc (FAO, 1999). Taro has much importance in ensuring food security, in earning foreign currency as being a cash crop and also as a means for rural development. Moreover, it has been reported to have a wide range of uses in religious festivals, as mild laxative, in treatment of wounds and snake bites, reducing body temperature in a feverish patient and others (FAO, 1999).

Nutritionally, Taro contains more than twice the carbohydrate content of potatoes and yield 135 kcals per 100 g. Taro contains about 7% protein on a dry weight basis. This is more than yam, cassava or sweet potato (FAO, 1999). Patrick *et al.*, (1999) also stated that the protein content of taro is higher than the other root crops, 3.3 g and 2.2 g in leaves and tuber respectively.

The protein fraction is low in histidine, lysine, isoleucine, tryptophan, and methionine, but otherwise rich in all the other essential amino acids. The protein content of the corm is higher towards the corm's periphery than towards its centre. This implies that care should be taken when peeling the corm; otherwise a disproportionate amount of the protein is lost in the peel (FAO, 1999).

Taro is a good source of magnesium. It is a low fat food incorporating vitamin C, iron and potassium. The starch grains of taro are small, thus it improves digestibility which is an important factor when selecting a starchy food that will not be bulky on the digestive system. Thus taro can be used as a combination in the manufacture of infant meals, recovering patients with such problems that require carbohydrate as a source of energy which will not stress their metabolic process. Taro starch is also good for peptic ulcer patients, patients with pancreatic disease,

chronic liver problems and inflammatory bowel disease and gall bladder disease (Emmanuel-Ikpeme, *et al.*, 2007).

The bulk of world production of taro is in Africa, followed by Asia and then Oceania. The major producers in Asia are China, Japan, Philippines and Thailand; while in Oceania, production is dominated by Papua New Guinea, Samoa, Solomon Islands, Tonga and Fiji (FAO, 1999). In Africa, Zaire (Congo) and Cameroon are the dominant producers. In Ethiopia, root crops are grown widely in the south region. Among these crops, taro is one of the important food source as well as income source to the farmer. It has a great potential to supply high quality food and one of the cheapest source of energy (Patrick *et al.*, 1999).

Replacement of part of wheat flour with non-wheat ingredients such as barley, sorghum, millet, oatmeal and multi-grain mixtures for the production of cookies and baked products had been reported by various researchers (Sammy *et al.*, 1970). Nip *et al* (1994) have reported that taro flour can be used to partially replace regular wheat flour for cookie manufacturing. With the proper ratio of the various ingredients in the formulation, snap type cookies and drop (chocolate chip) cookies were found to be highly acceptable.

Nip *et al* (1994) has stated that with the development of a new process for efficient production of taro flour, development of value-added products from taro flour will certainly increase the opportunities to expand the utilization of taro in the tropics. This will definitely help improve the economy of various taro-producing areas. In addition, considering the nutritional status of taro that is twice the carbohydrate content of potatoes and containing high amounts of fiber, magnesium, vitamin C, iron and potassium, blending taro flour in cookie formulation with wheat flour is very beneficial.

Cookie is a baked flour confectionery dried down to low moisture content (Bender, 1999). It is principal food throughout the world which gives more nutrients than any other single food source (Bahatia *et al.*, 1980). Cookie is mainly made from cereals, sweeteners, shortenings and leavening agents. Wheat is the most widely used cereals for cookie making in that it provides necessary gluten to the biscuit structure.

In Ethiopia, some studies have been carried out and a good number of researches are going on higher institutions, research centers and institutes. For example, Areka Agricultural Research center (AARC) released one improved taro variety in the year 2004. This research center reported that it is now working on developing more upgraded varieties. As mentioned above, taro is reasonably economical tuber. This fact can be substantiated looking at the 60 t/ ha of taro that can be produced in Ethiopian climate with one production season, AARC reported. This figure is even better than some areas of the world that has a better practice in using taro as a staple food than Ethiopia. Moreover, its rich nutritional content makes it more attractive for Ethiopia in the fight for food security.

Cookie is the most consumed and nutritious of most of the produced foods in the world (Bahatia *et al.*, 1980). In Ethiopia, cookie producing industries have increased substantially in the last decade. Considering this as one big step forward, improving the different quality aspects of the cookies produced in the country is what is expected from the government and different higher institutions and research centers. Despite the research efforts in developing new varieties and analyzing the nutritional content, limited research is done to utilize the potential of taro to produce value-added products.

The possibility of increasing utilization of taro lies in developing suitable processing technology, securing consumer acceptance, developing marketable products and achieving economic

feasibility. The strategy for solving these problems include setting a criteria for processing technology and product development which could include energy and labor intensity, consumer appeal and convenience, nutritional and storage qualities and ease of packaging and transportation.

Studying the possibilities of increasing taro utilization as an important food is the basis of this research which tries to find alternative ways in which taro can be more accepted not only as a traditionally processed food but also as a value added product in Ethiopia. Therefore, this study is initiated to study the possibility of incorporating taro flour in cookie formulation and so as to harness its potential both in economic and nutritional terms.

OBJECTIVE

The general objective:

To study the possibility of cookie making by using taro and wheat flour blends and optimize blend proportion and baking condition which will result in acceptable cookie quality

Specific objective:

1. To study the effect of blend proportion of taro and wheat flour on the quality of cookie made using taro-wheat flour blends
2. To study the effect of baking condition variation specifically temperature variation, so that blend proportion and baking condition can be optimized
3. To optimize taro-wheat flour blends which will result in best acceptable cookie quality

2. LITERATURE REVIEW

2.1. Taro Corms

Taro is a tropical root crop belonging to the monocotyledonous family Araceae. It is widely produced throughout the world for its underground farinaceous corms (Njintang *et al.*, 2007). Because of a long history of vegetative propagation, there is considerable confusion in the taxonomy of the genus *Colocasia*. Cultivated taro is classified as *Colocasia esculenta*, but the species is considered to be polymorphic. There are at least two botanical varieties; *Colocasia esculenta* (L.) Schott var. *esculenta* and *Colocasia esculenta* (L.) Schott var. *antiquorum* (Schott) Hubbard & Rehder (FAO, 1999).

Taro is an ecologically unique crop because it has the ability to grow in ecological conditions which other crops may find difficult or adverse. There are at least three such situations: waterlogged soil, hydromorphic and saline soils and shady conditions (FAO, 1999).

Taro corms, depending on size, are used for human consumption (Arnavid-vinas and Lorenz, 1999). The nutritional value is the main concern when a crop is being considered as a food source. Due to the emphasis placed on the nutritional value of food by consumers, a great need exists for information on the nutritional contents of root crops (Huang, *et al.*, 2007).

The high starch content of most root crops is considered as an excellent energy source, but they are marginal to poor sources of protein. Root crops contain a wide variety of minerals and trace elements, including relatively substantial quantities of iron and calcium, as well as potassium and magnesium. Root crops are usually a good source of vitamins, e.g., yellow cultivars of the sweet potato or giant swamp taro are considered to provide ample b-carotene (Huang, *et al.*, 2007).

Starch is the most important component (73-80%) of taro (Njintang *et al.*, 2007). Taro proximal composition varies depending on the variety, growing conditions, kind of soil, moisture and fertilizer application, maturity at harvest, post-harvest management and storage. In general, protein and fat content are low but it is high in carbohydrates, fiber and minerals. About 11 % of the total protein in taro is albumin with high amounts of phenylalanine and leucine. The protein of taro is well supplied with hundred essential amino acids though in low histidine and lysine (Arnavid-vinas and Lorenz, 1999).

Taro is limiting in sulphur amino acids as is usual in vegetable origin proteins. When compared with other root crops, it has the highest content of phosphorus (P), magnesium (Mg) and Zinc (Zn) (Emmanuel-Ikpeme *et al.*, 2007). Ferredoxin has been isolated from taro and it is considered an electron carrier in the chloroplasts, containing nonheme iron, and it may contribute to the iron content in taro (Arnavid-vinas and Lorenz, 1999).

Among the various tropical root crops, taro is one of the most efficient producers of calories. The Bun long variety produced in Hawaii has an energy value of 4.2 to 4.4 cal/g (moisture free basis) as compared to 3.9 cal/g for sweet potato and 3.5 to 4.5 cal/g for rice and 1.3 to 1.5 cal/g for cassava (Emmanuel-Ikpeme *et al.*, 2007).

The size of the starch granules varies with the variety and ranges from 1.5 to 6.6 μm . The shape is polygonal. Taro starch contains about 50% less amylose and an amylopectin content which is higher compared to other cereals. The amylose/amylopectin ratio is 1:7. The taro starch forms a clear and soft paste similar to potato starch. Starch gelatinization temperature is dependent on the variety as well as of the maturity at harvest and is lower as the age increases, ranging from 63-73⁰C. The most important sugar in taro is sucrose, but fructose, maltose, glucose and raffinose

are also present. Malic acid is the most important organic acid (60%) followed by citric acid (25%) and oxalic acid (15%) (Arnavid-vinas and Lorenz, 1999).

2.2. Value added products from taro

Taro (*Colossian Esculenta* L. Schott) is a common root crop in the tropics. Engel (1975) suggested that exploring the potential of taro may increase its economic value and help ease the problem of world food supply. Crabtree & Baldry (1982) studied the bread making properties of taro (Nip *et al.*, 1994).

Moy *et al.* (1977) reported the dehydration and processing problems of raw taro. Nip (1990) discussed other problems related to the processing of taro. Taro flour produced by the process reported by Moy *et al.* (1979) was slow in the size reduction process due to the thickness and hardness of the dried taro slices. This process was modified to produce taro flour very efficiently for various studies (Jane *et al.*, 1992) and can be scaled up for pilot plant production of taro flour. Functional properties of raw and precooked taro flour were also studied by Tagodoe & Nip (1994) (Nip *et al.*, 1994).

Even though taro is not an industrial crop, it also has applications as a fried product, in soft drinks, and flour for home consumption (Arnavid-vinas and Lorenz, 1999). The starch grains of taro is small, thus it improves digestibility which is an important factor when selecting a starchy food that will not be cumbersome on the digestive system. For this reason, taro can be used as a composite in the manufacture of infant meals, foods for convalescing patients with problems that require carbohydrate as a source of energy that will not stress their metabolic process (Emmanuel-Ikpeme *et al.*, 2007)

More over, taro as a food ingredient is used in the production of a variety of foods including chips and bread (Njintang and Mbofung, 2003). Corms are boiled in water or steamed, fried or are mixed with other products like wheat flour in bread production (Arnavid-vinas and Lorenz, 1999). Composite flour incorporating taro has also been used in extruded products such as noodles and macaroni (Ojinnaka, *et al*, 2009). Arnavid-vinas and Lorenz (1999) had also studied the potential of using taro and chaya composite flour in the production of pasta products to add for the variety of valued added products made from taro corms.

2.3. Limitations of taro flour for production of value added products

Many food crops used for food contain natural chemical substances known to have effects on the nutritional status of the food. Some of these naturally occurring toxicants are anti-nutrients such as cynogenic glycoside, phytate, oxalate, lectin, saponins, alkaloids, pressor amines, etc. From these, the anti-nutritional factors found in taro include oxalates, phytates and tannins (Abdulrashid and Agwunobi, 2009).

Although taro contains the above anti-nutritional factors, oxalate has mainly been considered as the cause of one of the two major factors (the acrid nature and storage factor) associated with the effective use of taro corms. Acridity is the sharp irritation and burning of the throat and mouth when the uncooked material is ingested. Such a material is said to be acrid (Emmanuel-Ikpeme, *et al*, 2007). Acrid component may cause temporary sterility and has been directly linked to death of children and of many experimental and domestic animals. However, the level of acridity in edible tubers is too low for them to pose any serious problem unless very large quantity of the tuber is consumed (Emmanuel-Ikpeme, *et al*, 2007).

Acridity is thought to be caused by calcium oxalate raphides plus a chemical irritant. Removal of acridity by a traditional method involves anaerobic fermentation in an underground pit for several

weeks. The acidity factor can also be reduced by peeling, grating, soaking and fermentation operations during processing. Removal of the thick layer of skin and long period of cooking is required to remove acidity. There is also the selection and breeding of non-or low acid cultivars of aroids. Other method includes prolonged baking or extraction iswith ethanol (Emmanuel-Ikpeme, *et al.*, 2007).

Taro corms are highly perishable owing to their high moisture content (Njintang, 2007). Post harvest rot or spoilage of taro tubers is attributed to physical, physiological and pathological factors. Microorganisms take the lead in post harvest rot. Due to the difficulties in storage, taro is usually utilized or consumed shortly after harvest. Spoilage of taro is also associated to the high respiratory activity of the corm (Emmanuel-Ikpeme, *et al.*, 2007).

2.4. Cookies

The term cookies or biscuits as they are called in many parts of the world, refers to a baked product generally containing the three major ingredients; flour, sugar and fat. They have low final water contents (1-5%) (Pareyt and Delcour, 2008).Other ingredients include milk, salt and aerating agent (Olaoye *et al.*, 2007).

Most biscuits and cookies are chemically leavened baked products (Dogan, 2006). Cookies are nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in an oven. They are ready-to-eat, convenient and inexpensive food product, containing digestive and dietary principles of vital importance. Cookies are a rich source of fat and carbohydrate, hence are energy giving food and they are also a good source of protein and minerals (Olaoye *et al.*, 2007).

They are stable foods and have advantages such as long shelf life and good eating quality. The physical properties of the dough and the recipes in cookie depend on the type of cookie and the method used in the dough formation. Quality standards from the raw materials to the end product are essential in cookie making (Dogan, 2006).

As mentioned above, cookies major ingredients are mainly:

Flour: Flour is the main ingredient in cookie dough formula which provides the matrix around which other toughening or tenderizing ingredients in varying proportions are mixed to form dough. Flour derived from soft wheat is perfect for producing a wide range of confectionery and baked products including cookies, pastries, cakes, steamed buns and snack foods. Soft wheat is a unique blend of white, soft-grained wheat varieties (Pareyt and Delcour, 2008).

Soft wheat flour is the most suitable flour for the production of cookies and crackers because it has unique properties of relatively lower protein content (8-11%) and more mellow gluten properties than other flours including hard wheat flour. Wheat cookie flours can be specified as soft wheat flours with a moisture content of about 14% and a starch content of about 70-75%. They have lower absorption, finer granulation, and less starch damage than hard wheat flours (Pareyt and Delcour, 2008).

Sugar (sucrose): Sugar is an important ingredient of short-dough biscuits. It contributes to texture, flavor, sweetness and color in biscuits. The quantity, granulation and type of sugar used influence the quality of biscuits (Manohar, *et al.*, 1997). Sucrose, a non-reducing disaccharide, is the common sugar used in cookie preparation. It is a major and important ingredient of most cookies (Pareyt and Delcour, 2008).

Shortening (fats): The term “shortening” refers to the ability of a fat to lubricate, weaken, or shorten the structure of food components (Pareyt and Delcour, 2008). Fat functionality is very versatile in baked products which include providing of flavor and mouthfeel and also contributes to the appearance, palatability and texture of the cookies (Zoulias, *et al.*, 2002).

2.4.1. Cookie baking

Baking is a unit operation which uses heat to alter the eating quality of foods. A secondary purpose of baking is preservation by destruction of micro-organisms and reduction of the water activity at the surface of the food. Baking involves simultaneous heat and mass transfer; heat is transferred into the food from hot surfaces and air in the oven and moisture is transferred from the food to air that surrounds it and then removed from the oven (Fellows, 2000).

Cookie baking changes the physical and/or (bio-) chemical properties of the various flour constituents, sugar, and fat present in the cookie dough formula. Not only do complex transformations alter the properties of cookie dough ingredients, but the ingredients themselves have a marked influence on the relative occurrence and rates of these transformations (Pareyt and Delcour, 2008).

2.4.2. Sugar snap cookies and the role of its constituents

Cookies (biscuits) can be divided into cabin biscuits, semi-sweet and hard-sweet biscuits, sugar-snap cookies and so on. Among these, sugar-snap cookies are the cookies of concern in this research. Snap cookies contain 47.5 to 54% flour, 33.3 to 42% sugar and sweetener, and 9.4 to 18% fat. Moreover, as described in Method 10-50D of AACC (1983), sugar snap cookies typically are made from 225.0g of soft wheat flour, 64.0g shortening, 130.0g sucrose, 2.5g

sodium bicarbonate, 2.1g salt , 33g Glucose solution (8.9 g of glucose hydrous in 150 ml of distilled water) and 16.0g distilled water (Ryan and Brewer, 2006).

The levels of ingredients in the formula can also be expressed on a flour weight basis, which then, for sugar-snap cookies, gives ca. 60% sugar, 30% shortening, 20% water and sweetener, and 1% for each minor fraction. The term “snap” refers to the audible sound when the cookie fails under a load (Pareyt and Delcour, 2008).

2.4.2.1. Role of flour in baking sugar snap cookie

Much research has been done to understand the contribution of different flour constituents to the cookie quality. Most authors agree on the role of starch in cookies, which, although it is the main flour constituent, has a relatively small influence on cookie quality. Flour proteins, which are quantitatively less important than starch, seem to have a more pronounced role in cookie baking (Pareyt and Delcour, 2008). The major effect of wheat substitution with other flours has often been related to quantitative differences in gluten content of the composite flours (Njintang, *et al*, 2007).

Flour Starch

In soft wheat flour, the adhesion between the starch granules and the protein matrix is weaker than in hard wheat, and, upon physical release during the milling process, more of the starch granules remain intact, and thus un-fractured. Less starch damage thus occurs which favor an increase in cookie diameter (Pareyt and Delcour, 2008). Starch is an important part of wheat endosperm, not only because starch accounts for 65–73% of dry flour mass when milling extraction is less than 80% , but also because wheat starch has unique properties that are not replaceable by other starches from corn, potato, and cassava (Park *et al*, 2009).

Kaldy et al. (1991) noticed a statistically significant trend between the amylose content of the starch and cookie diameter. They related higher amylose content to a large cookie diameter. Because of high levels of sugar and insufficient water, most of the starch granules do not gelatinize. Cookies, in which the starch is not gelatinized, are softer eating. However, at the same time, it is emphasized that cookies that are rich in sugar as sugar snap cookies may become hard because of the effects of super-cooled sugar glass that may be formed when the baked cookie is cooled (Pareyt and Delcour, 2008).

Flour Protein

Flour protein has a major influence on cookie quality and, in particular, on its diameter. The quantity and quality of the proteins present in flour have a major role in influencing the rheological behavior of the dough, particularly when flour is the major constituent of the formula. For soft wheat flour, low gluten content and weak gluten strength are generally desired for good sugar-snap cookie baking. However, Souza et al, (1994) concluded that the total protein content is more important for sugar-snap cookie quality than is the composition of the protein (Pareyt and Delcour, 2008).

Sugar-snap cookie dough has a relatively high concentration of sugar and fat (shortening) and a low level of water. This results in dough with a sufficiently viscous and cohesive nature. The plastic nature of the shortening and, probably, some hydrogen bonding give the sugar-snap cookie dough the desired consistency of handling, without an extensive gluten network (Pareyt and Delcour, 2008).

Flour Lipids

Cookies baked from flours with the lipids removed have smaller diameters than those baked from un-extracted flours. The textural and dimensional (diameter, height) characteristics of sugar-snap cookies were completely restored when reconstituting defatted flour with both fractions at their natural level (Pareyt and Delcour, 2008).

Flour moisture content

Doescher and Hosney (1985), in the case of sugar-snap cookies, showed that moisture present in the flour and added water are not equivalent in terms of their effect on dough properties. They found that flour moisture content affects the surface cracking of sugar-snap cookies even when the difference in flour moisture content was compensated for by adjustment of the level of the added dough water. As flour moisture increases, the degree of cookie symmetry increases. Doescher and Hosney (1985) concluded that flour moisture is more critical than total moisture in determining surface cracking (Pareyt and Delcour, 2008).

2.4.2.2. Role of sucrose in sugar snap cookie

Essentially all cookies, except those that are dried to very low moisture content, are soft and quite flexible when they come out of the oven. With time, they become firm and often brittle. The continuing change in texture and development of the final crispness has been attributed to slow crystallization of sucrose from concentrated sugar syrup formed during the earlier stages of processing (Pareyt and Delcour, 2008).

Upon cooling, much of it crystallizes and strongly affects the texture of the baked cookie. Once the sucrose is crystalline, it no longer can affect water activity of the system or act as a solvent. In that manner, with less solvent in the cookie, the snap develops (Pareyt and Delcour, 2008).

Sugar's functionality in cookie systems includes more than only imparting sweetness. In fact, sugar's functionality holds different aspects and may not be underestimated. This may well explain why it is so hard to carry out a reduction or replacement of sucrose with other sugars, sugar alcohols, or intensive sweeteners (Pareyt and Delcour, 2008).

2.4.2.3. Role of shortening in sugar snap cookie

With the presence of shortening, the fat surrounds the proteins and the starch granules isolating them thereby breaking the continuity of the protein and starch structure. The produced dough will then be less elastic, which is desirable in cookie-making, since it does not shrink after lamination. This phenomenon results in eating properties after baking that are described as less hard, shorter, and more inclined to melt in the mouth (Pareyt and Delcour, 2008).

If the fat level is high as in sugar snap cookies, the lubricating function in the dough is so pronounced that little if any water is required to achieve a desired consistency, little if any gluten is formed, and starch swelling and gelatinization are also reduced giving a very soft texture. The dough breaks easily when pulled, because it is short. Where the sugar level is high again sugar snap cookies, the fat combines in the oven with the syrupy solution preventing it from setting to a hard vitreous mass on cooling (Pareyt and Delcour, 2008).

A second function of the fat includes enhancing aeration for leavening and volume. The entrapped air provides a framework for the leavening gases and water vapor released during baking. The stabilization of the gas cells results in a better sustained and increased volume, uniform and fine grain and a tender crumb (Pareyt and Delcour, 2008).

Some other functions fat plays in cookie (dough) systems include affecting heat transfer and spread (more fat gives more spread). However, it was found that varying the level of shortening

does not materially affect the cookie diameter, but alters top crumb in certain instances. Fat also influences the structural integrity and the shelf life of the product (Pareyt and Delcour, 2008).

2.5. Use of composite flour for cookie making

The concept of using composite flours is not new and has been the subject of numerous studies (Vieira *et al*, 2007). Experience gained in the use of composite flours has clearly demonstrated that for reasons of both product technology and consumer acceptance, wheat is an essential component in many of these flours. The percentage of wheat flour required to achieve a certain effect in composite flours depends heavily on the quality and quantity of wheat gluten and the nature of the product involved (Mepba, *et al.*, 2007).

Cookies have been suggested as a better use for composite flour than bread because of their ready-to-eat form, wide consumption, relatively long shelf life and good eating quality (Vieira *et al*, 2007).

Flours milled from other crops such as maize, millet, sorghum and rice had been added to wheat flour to extend the use of the local crops (Ojinnaka *et al*, 2009). Mepba *et al.* (2007) also tried to produce composite breads and biscuits from mixed flours of wheat and plantain, with up to 30% supplementation of plantain flour (Olaoye *et al.*, 2007).

Satisfactory cookies have been made from composite flour through a blend of wheat flour with other cereals. Considering studies made in the incorporation of tubers in cookie formulation, cassava and potato was used blended with wheat flour for cookie making. (Ojinnaka *et al*, 2009). Singh *et al*, (2008) also studied the effect of incorporating sweet potato flour to wheat flour on the quality characteristics of cookies with an objective of developing cookies with good taste, texture and appearance, which resembles as closely as possible to the wheat flour based product.

The textural property and sensory quality of cookies were taken into consideration to improve the quality of cookies.

2.6. Use of taro flour in cookie making

Ojinnaka *et al* (2009) had studied the effect of taro starch modification on functional and sensory qualities of a cookie. They concluded that substitution of some part of wheat flour with taro starch in the production of snack products will help minimize the rate of post harvest losses and encourage taro cultivation. In addition, they suggested that since taro has proved to be a good source of carbohydrates for meeting the energy requirement in human diets, efforts should be made to exploit its usage in the bakery industry.

Nip *et al* (1994) had also studied the application of taro flour in cookie formulations. They have found that taro flour can be used to partially replace regular wheat flour for cookie manufacturing. According to Njintang *et al.*, (2007), incorporation of taro into wheat flour modifies its functional properties as well as the alveographic characteristics of dough made from it. Nip *et al* (1994) reported that with the proper ratio of the various ingredients in the formulation, snap type cookies and drop (chocolate chip) cookies were found to be highly acceptable as indicated by the taste test.

3. MATERIALS AND METHODS

3.1. Raw material sources

The raw materials, especially taro corms (*boloso I cultivar*) were collected from Areka Agricultural Research Center (AARC), Wolita, south of Ethiopia. The banana for sweetening was collected from local market. The collection was on February, 2009. The soft wheat flour was obtained from Kality food Share Company.

3.2. Raw material preparation

3.2.1. Taro flour preparation

The corms were washed with water and peeled using a stainless steel knife. Peeled corms were cut in to 0.5 cm thick slices, dried to a constant weight in an oven set at $45\pm 2^{\circ}\text{C}$ before milling into flour using a grinder fitted with a 500- μm mesh sieve. The Flour obtained was packed in polyethylene bags and stored at 4°C until being used for analysis (Njintang *et al.*, 2006).

3.2.2. Banana flour preparation

The unblemished mature green bananas first were steamed for about 10 minutes to decrease sticky sap, improve the flour color and facilitate the peeling process. The steamed banana were peeled with sharp knife and sliced in to a size of 0.5-cm thick pieces. The sliced pieces then were soaked in anti-browning agent for 15 minute, drained on trays and placed on a drier. The drained sliced pieces were then dried in an oven-drier at 60°C for 24h. The oven dried product were then milled and sieved through 0.4 mm wire mesh screen and the flour was packed and sealed in a polyethylene bags (Ijarotimi, 2008).

3.3. Formulation of blends and baking conditions

3.3.1. Formulation of blend proportion: four different blend proportions including control were designed based on simplex lattice design. The proportions were similar to the blend proportions designed by Nip, *et al*, 1994 in their taro-wheat flour sugar snap cookies.

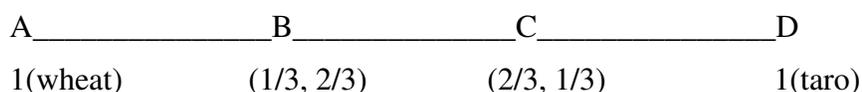


Fig. 3.1 Simplex lattice design of taro and wheat flour blend proportion

Table 3.1 Formulation of blend proportion of Taro and Wheat flour

Blend proportion	Taro flour (%)	Wheat flour (%)
BP1(D)	100 %	0%
BP2(C)	66.66 %	33.33 %
BP3(B)	33.33 %	66.66 %
Control(A)	0 %	100 %

3.3.2. Experimental design: the study has considered two factors namely blend proportion and baking condition to see their effects on the quality of the cookies.

Table 3.2 Experimental design on effect of blend proportion and baking temperature

Baking temperature (°C)	Blend proportion			
	BP1	BP2	BP3	Control (pure wheat)
140				
150				
160				

3.4. Cookie baking

Wheat (soft wheat) is the most widely used cereal for cookie making in that it provides necessary gluten to the biscuit structure. Although gluten was found to be crucial in making cookies, it has been stated by Hou *et al.* (1996) that low gluten content and weak gluten strength is generally desired for good sugar-snap cookie. In addition, Souza *et al.* (1994) concluded that the total protein content is more important for sugar-snap cookie quality than is the composition of the protein (Pareyt and Delcour, 2008). Therefore, since taro is in short of gluten, sugar snap cookie formulation was chosen for the study.

Similar amount of sugar, shortening, salt, water and other ingredients were used for each proportion in the preparation of the dough based on the standard AACC formulation for baking quality of cookie flour (Method 10-50-D, AACC, 1983).

Table 3.3. Formulation proportion of sugar snap cookie

Raw materials	Amount required (g)
Flour	225 g
Baking powder	2.50 g
Vegetable shortening	64.0 g
Sugar	130 g
Sweetener	33.2 g
Water	16 g
Salt	2.1 g
Banana flour	11.25g
Total	484.05 g

The same measuring apparatus, mixing bowls and electrical mixers were used for preparing the different formulations (Vieira, *et al.*, 2007).

Sugar, salt, sodium bicarbonate and shortening were creamed with a flat beater for 2 min at 90 rpm, scraped and mixed for 1 min at 130 rpm in Ornaldi B15 mixer. Water containing sweetener was added to the cream and mixed for 1 min at 60 rpm, scraped and mixed for another 1 min at 90 rpm. Finally, flour was added and mixed for 1 min at 60 rpm, scraping twice to obtain homogeneous dough. Total mixing time was 6 min (Dogan, 2006).

The cookie dough was then sheeted to a thickness of 0.4 cm and cut into circular shapes (Vieira, *et al.*, 2007). According to Dogan (2006), baking condition change with oven design and operating parameters. These parameters must be well established and controlled for each type of baked products. The optimum baking temperatures for the Orlandi electric oven used were determined in the preliminary study to be 140⁰C, 150⁰C and 160⁰C keeping the baking time 7 min based on Manley (2000), Lai and Lin (2006), Cauvain and Young (2006) cited in Pareyt and Delcour (2008) set for high sugar snap cookies Therefore, the cut-out pieces were baked on 3 different batches at a temperature of 140⁰C, 150⁰C and 160⁰C for 7 min. The cookies were finally cooled at room temperature of 28 ± 2⁰C and then packed in high density polyethylene bags (AACC, 2000 cited in Vieira, *et al.*, 2007).

3.5. Evaluation of quality parameters

3.5.1. Functional properties of taro and wheat flour

A) Bulk Density

A mass of 50 g of the sample was put in a 100 ml measuring cylinder. The cylinder was tapped continuously until a constant volume was obtained. The bulk density was calculated as weight of the grounded flour (g) divided by its volume (cm³) (Oladele and Aina, 2007).

B) Water and Oil Absorption Capacity

One gram of the sample was mixed with 10 ml of distilled water or oil in a centrifuge tube and allowed to stand at room temperature ($30 \pm 2^{\circ}\text{C}$) for one hour. It was then centrifuged at 200xg for 30 minute and the supernatant was noted in a 10 ml graduated cylinder. Water and oil absorption capacity was calculated as ml of water or oil absorbed per gram of the grounded flour blend (Aremu *et al.*, 2007).

3.5.2. Proximate analysis of the cookie and the taro flour

The nutritional/analytical parameters such as moisture content, carbohydrate, ash, crude fiber, fat and protein content will be determined with the following standard methods.

A) Moisture content

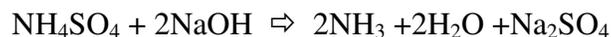
The dishes used for the moisture determination were dried at 130⁰C for 1 hr in Memmert drying oven of model 40050 and placed in desiccators for about 30 min. The mass of each dishes was measured (M₁) and about 5 g of the sample was weighed in to each of the dishes (M₂). The sample was then mixed thoroughly and dried at 100⁰C for 6 hr. After drying is completed, the mass was measured (M₃). The moisture content was calculated from the equation:

$$\text{Moisture}(\% \text{ w/w}) = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

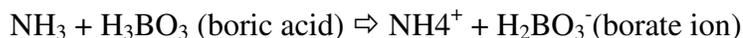
M_1 =mass of the dish, M_2 =mass of the dish and the sample before drying, and M_3 =mass of the dish and the sample after drying (AOAC 2000, 925.05).

B) Crude protein analysis (Kjeldahl method)

About 0.5 g of the sample was weighed by Adventurer analytical balance of model AR2140 and added to the digestion flask. Then 6 ml of acid mixture (concentrated orthophosphoric acid and concentrated sulphuric acid) and 3.5 ml of 30% hydrogen peroxide solution were added in to the digestion flask step by step. The tubes were shaken until the violet reaction disappeared. About 3g of the catalyst mixture made of 0.5 g of selenium and 100 g of potassium sulphate was added in to the digestion flask. The solution was then digested at 370⁰C for 1 hr by Tecator digester of model 722. After digestion was completed, the content in the flask was diluted by water and 40% sodium hydroxide was added to neutralize the acid and to make the solution slightly alkaline.



The ammonia was then distilled into receiving flask that consisted solution of excess 4% boric acid solution for reaction with ammonia. The borate ion was formed as the result of the reaction of the boric acid and the ammonia and this was titrated with standard acid (0.1N sulphuric acid solution).



The nitrogen content was calculated from the equation:

$$\text{Nitrogen}(\% \text{ w/w}) = \frac{(V_2 - V_1) \times 14}{W} \times 100$$

Where V_1 = volume (ml) standard H_2SO_4 solution used in the titration of the blank, V_2 = volume

(ml) standard H₂SO₄ solution used in the titration of the sample, W= sample weight and 14 is the molecular weight of nitrogen.

The protein content was calculated from the equation:

$$\text{Protein content (\% } W/W) = 6.25 \times \%N \text{ (AOAC, 2000, 979.09)}$$

C) Crude Fat content (Soxhlet extraction)

The flasks used for the extraction were cleaned by placing them in Memmert drying oven of model 40050 at 92 °C for 1 hr and cooled in desiccators. The masses of the cooled flasks were measured by Adventurer analytical balance of model AR2140 (M₁). About 2 g of the sample was weighed in to each of the thimbles lined with cotton at their bottom. The thimbles with there sample content were placed in to the Soxtec soxhlet extraction apparatus of model 2055. A 70 ml of diethyl ether was added in to each flask used for the extraction. The extraction process was done for about 4 hr and then after the flasks with there contents were removed from the soxhlet and placed in drying oven at 92 °C for 1 hr .The flasks were then placed in desiccators for 30 min. The masses of each flask together with its fat contents were measured (M₂).

The crude fat content was calculated from the equation:

$$\text{Lipid (\% } W/W) = \frac{M_2 - M_1}{W} \times 100$$

Where M₂=mass of flask and lipid extracted and M₁=mass of dried flask and W=sample weight (AOAC 2000, 4.5.01).

D) Dietary (crude) fiber

About 1.6 g of the sample was weighed in each of 600 ml beaker. A 200 ml of 1.25% sulfuric acid solution was added to each beaker and allowed to boil for 30 min by rotating and stirring periodically. During boiling the level was kept constant by addition of hot distilled water. After

30 min, 20 ml of 28% potassium hydroxide solution was added in to each beaker and again allowed to boil for another 30 min. The level was still kept constant by addition of hot distilled water. The solution in each beaker was then filtered through crucibles containing sand by placing each of them on Buchner funnel fitted with No.9 rubber stopper. During filtration the sample was washed with hot distilled water. The final residue was washed with 1% sulphuric acid solution, hot distilled water, 1% sodium hydroxide solution and finally with acetone. Each of the crucibles with their contents was dried for 2 hr at 130 °C and cooled in desiccators and weighed (M₁). Then again they were ashed for 30 min at 550 °C in furnace and were cooled in desiccators. Finally the mass of each crucible was weighed (M₂).

The crude fiber was calculated from the equation:

$$\text{Crude fiber (\% w/w)} = \frac{M_2 - M_1}{W} \times 100$$

Where M₁=mass of the crucible, the sand and wet residue, M₂=mass of the crucible and the sand and W= sample weight (AOAC 2000, 920.169).

E) Total ash

Crucibles for the analysis were cleaned by drying at 120 °C in a Memmert drying oven of model 40050 and ignited at 550 °C in furnace for 3 hr. Then the crucibles were removed from furnace and cooled in desiccators .The mass of each of the crucibles was measured by Adventurer analytical balance of model AR2140 (M₁) and about 2.5 g of the sample was weighed in to each crucible (M₂). The crucibles were dried at 120 °C for one hour on a Wagatech hot plate of model ST 15. The crucibles were then placed in a furnace at about 550 °C for 1 hr. The crucibles were then removed from the furnace and were cooled. A 5 drop of distilled water was then added to each of the crucible and placed in the furnace at 550 °C for 30 min. Crucibles were again removed from the furnace, allowed to cool and 5 drops of distilled water and nitric acid were

added to each. Then the crucibles once again were inserted in to the furnace until they became free from carbon and the residue appears grayish white. Then they were removed from the furnace and placed in desiccators. Finally the mass of each crucible was weighed as (M_3).

The total ash was calculated from the equation:

$$\text{Ash}(\% \text{ W/W}) = \frac{M_3 - M_1}{M_2 - M_1} \times 100$$

Where M_1 =mass of the dried dish, M_2 =mass of the dish and the sample, M_3 =mass of the dish and the sample (AOAC 2000, 941.12).

F) Carbohydrate determination

The content of other carbohydrates in the cookie were determined by difference method that is by subtracting the sum of the percentages of crude protein, lipid, crude fiber and ash content from 100 (Mathew *et al.*, 2006).

3.5.3. Energy values

Energy values were calculated applying factors 4, 9 and 4 for each gram of protein, lipid and carbohydrate respectively (Shrestha and Noomhorm, 2002).

3.5.4. Textural characteristics of the cookies

Breaking strength of the cookie: Breaking strength of cookies was measured using TA plus texture analyzer. The individual samples of biscuits were placed on the platform such that they were supported at two points and the blade was attached to the crosshead of the instrument. The texture analyzer setting was kept at preload stress 5.6N, preload stress speed of 2 mm/s and a test speed of 3 mm/s. This test simulates the evaluation of hardness by consumer holding the biscuit in hands and breaking the same by bending. The absolute peak force from the resulting curve was considered the breaking strength of the biscuit (Tyagi, *et al.*, 2006).

3.5.5. Physical parameters of the cookie

For the determination of the diameter, six cookies were placed edge to edge. The total diameter of the six cookies was measured in mm by using a ruler. The cookies were rotated at an angle of 90^0 for duplicate reading. This was repeated once more and average diameter was reported in millimeters (AACC, 2000).

To determine the thickness, six cookies were placed on top of one another. The total height was measured in millimeters with a ruler. The measurement was repeated thrice to get an average value and results were reported in mm (AACC, 2000). Spread ratio was calculated as diameter (length) to thickness ratio (Shrestha and Noomhorm, 2002).

3.5.6. Sensory evaluation:

Flavor, color, crispiness and overall acceptability of the cookies were evaluated with 22 sensory panelist comprising staff and students from the EHNRI, Food Science and Nutrition and Food Engineering department of Addis Ababa University in standard sensory analysis booth in EHNRI (Shrestha and Noomhorm, 2002). Panelists were trained in the use of sensory evaluation procedures and the meaning of the descriptive terms used (Giami *et al*, 2006).

Panelists were instructed to evaluate color first and then to taste each sample to evaluate flavor, texture and overall acceptability. A nine point hedonic scale with 1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely was used (Giami, *et al*, 2006). Water was provided to rinse the mouth between evaluations and covered expectoration cups were also provided when panelists didn't wish to swallow the samples.

Acceptable crispiness was evaluated on a 5-point rating scale, according to which a score of 5 indicated very crispy, 4-moderately crispy, 3- just crispy, 2-less crispy and 1 indicated not crispy (Amerine *et al.*, 1965).

3.5.7. Oxalate content

The oxalate content was determined using the method originally employed by Ukpabi and Ejidoh (1989) cited in Iwuoha and Kalu (1995). The procedure involves three steps: digestion, oxalate precipitation and permanganate titration.

Digestion

At this step, 2 g (db) of flour was suspended in 190 ml of distilled water contained in a 250-ml volumetric flask; 10 ml of 6M HCl was added and the suspension digested at 100°C for 1 h, followed by cooling, and then made up to 250 ml before filtration.

Oxalate precipitation

Duplicate portions of 125 ml of the filtrate were measured into a beaker and four drops of methyl red indicator added, followed by the addition of concentrated NH₄OH solution (drop wise) until the test solution changed from its salmon pink color to a faint yellow color (pH 4-4.5). Each portion was then heated to 90°C, cooled and filtered to remove precipitate containing ferrous ion. The filtrate was again heated to 90°C and 10 ml of 5% CaCl₂ solution was added while being stirred constantly. After heating, it was cooled and left overnight at 5°C. The solution was then centrifuged at a speed of 2500 rev/min for 5 min. The supernatant was decanted and the precipitate completely dissolved in 10 ml of 20% (v/v) H₂SO₄ solution.

Permanganate titration

At this point, the total filtrate resulting from digestion of 2 g of flour was made up to 300 ml. Aliquots of 125ml of the filtrate were heated until near-boiling, and then titrated against 0.05M standardized KMnO₄ solution to a faint pink color which persisted for 30 s. The calcium oxalate content was calculated using the formula

$$\frac{T \times (V_{me}) (D_f) \times 10^5}{(ME) \times m_f} \text{ (mg/100 g)}$$

Where T is the titre of KMnO₄ (ml), V_{me} is the volume-mass equivalent (i.e. that 1 cm³ of 0.05M KMnO₄ solution is equivalent to 0.00225g anhydrous oxalic acid), DF is the dilution factor VTA (2.4, where VT is the total volume of filtrate (300ml) and A is the aliquot used (125 ml)), ME is the molar equivalent of KMnO₄ in oxalate (KMnO₄, redox rxn+5) and m_f is the mass of flour used.

3.6. Data analysis

The effect of blend proportion and processing temperature on the quality of the product were analyzed with two factors ANOVA. When P values were found significant, the means of each parameter were compared using the least significant differences (LSD) procedures of the SPSS, version 15.

4. RESULT AND DISCUSSION

4.1. Proximate analysis of taro flour

Table 4.1: Proximate analysis of taro flour (Mean \pm standard deviations)

<i>Flour</i>	<i>Moisture</i> (%)	<i>Protein</i> (%)	<i>Fat (%)</i>	<i>Crude</i> <i>fiber (%)</i>	<i>Total ash</i> (%)	Carbohydrate(by difference)
Taro	8.49 \pm 0.05	6.43 \pm 0.04	0.47 \pm 0.1	2.63 \pm 0.06	4.817 \pm 0.054	77.163

According to the results in table 4.1, taro, compared to soft wheat flour, was found to have lower amount of protein. The level of crude proteins (6.43%) in taro flours was lower than that of soft wheat flour (7-9%). Although the protein content of *boloso I cultivar* is appreciable, the result is also evident that one of the major compositional differences between wheat and taro flours resides in their levels of protein (Tyagi *et al.* 2006). Cookie flours can be specified as soft wheat flours with a moisture content of about 14%, protein content in the range of 7-9% and a starch content of about 70-75% (Pareyt and Delcour, 2008).

Although Pyler, (1988) cited in Pareyt and Delcour, (2008) stated that lipids are minor soft wheat flour constituents (typically 2%), the taro flour has been observed to have even less (0.47%) amount of lipids. The taro flour contains appreciable amounts of minerals, as can be inferred from their mean ash content (4.817%) compared to that of soft wheat flour (typically 2%).

The moisture content of taro flour was found to be 8.49% which is in close agreement with results of Njintang *et al.*, (2007). This moisture content is lower than the moisture content of soft wheat flour (14%). More over, the level of available carbohydrates in wheat flour (70-75%) is similar to *boloso I variety* taro flour (77%). A crude fiber level of taro was analyzed to be 2.62% which in most cases is greater than soft wheat cookie flour. All the above results of the proximate

analysis are in close agreement with result of Tyagi *et al.*, (2006) except the fiber in this case was found to be superior to soft wheat flour.

4.2. Functional properties of taro and wheat flour

Table 4.2: Functional properties of taro and wheat flour (Mean \pm standard deviations)

<i>Flour</i>	<i>Water Holding Capacity (WHC)</i>	<i>Oil Holding Capacity (OHC)</i>	Bulk Density
Taro	2.37 ml/g \pm 0.12	1.13 ml/g \pm 0.1	0.80 g/ml \pm .0032
Wheat	1.2 ml/g \pm 0.18	0.5 ml/g \pm 0.16	0.50 g/ml \pm 0.17

The functional properties of wheat and taro flours are given in Table 4.2. The Water Absorption Capacity (WAC) of taro flour was found to be 2.375 ml/g which is in close agreement to the range of WAC values (270–375 g/100 g) observed by Njintang *et al.*, (2007). Taro flour was found to show higher WAC as well as higher oil absorption capacity (OAC) than wheat flour.

WAC is an important functional property required in food formulations especially those involving dough handling (Oselebe *et al.*, 2008). Increase in water absorption capacity implies increase in digestibility of the starches. The difference might depend on the amount and nature of hydrophilic constituents (Ayele and Nip, 1994 cited in Ojinnaka *et al.*, 2009). The result justify that taro flour is indeed easily digestible.

According to Tyagi *et al.*, (2006), an increase in the WAC is observed with an increase in the proportion of taro flour in the wheat-taro composite flour. A similar increase in WAC and OAC of wheat flour following incorporation of plantain flour has been reported by Mepba *et al.*, (2007). WAC plays a major role in the functionality of dough. In particular, WAC has been shown to be related to dough consistency (Tyagi *et al.*, 2006). Increase in water absorption lead to the weakened dough and decrease dough development and dough stability (Singh *et al.*, 2008).

Fat absorption is an important property in food formulations because fats improve the flavor and mouth feel of foods (Odoemelam, 2005). As mentioned above, the OAC of taro flour (1.13 ml/g) in table 4.2 was found to be superior to the wheat flour (0.5 ml/g). The result show that taro flour may be is better flavor retainer than wheat flour (Oladele and Aina, 2007).

Bulk density (BD) gives an indication of the relative volume of packaging material required. Generally, higher bulk density is desirable for the greater ease of dispersibility and reduction of paste thickness (Udensi and Okoronkwo, 2006). The result in table 4.2 shows that BD of taro flour (0.80 g/ml) is greater than of the wheat flour (0.50 g/ml). With this respect, taro flour seems to have better dispersibility and reduced pasting thickness as seen

4.3. Proximate analysis of the cookie

Table 4.3: Effect of blend proportion on proximate composition of the cookies

Blend proportion	Proximate composition					
	Moisture content (%)	Protein content (%)	Fat content (%)	Fiber content (%)	Ash content (%)	Carbohydrate content (%)
control(100% wheat)	1.746 ^a	5.366 ^a	17.069 ^a	0.531 ^a	2.098 ^a	73.178 ^a
33.33% taro	1.871 ^{ab}	4.840 ^b	16.553 ^a	0.770 ^b	2.536 ^b	73.320 ^b
66.66% taro	1.955 ^{bc}	4.097 ^c	15.343 ^b	0.864 ^b	2.736 ^c	74.980 ^c
100% taro	2.153 ^c	3.701 ^d	13.350 ^c	1.674 ^c	3.890 ^d	75.303 ^d

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

Table 4.4: Effect of baking temperature on proximate composition of the cookies

Baking Temperature	Proximate composition					
	Moisture content (%)	Protein content (%)	Fat content (%)	Fiber content (%)	Ash content (%)	Carbohydrate content (%)
140 °C	2.167 ^a	4.534 ^a	15.534 ^a	0.975 ^a	2.812 ^a	73.954 ^a
150 °C	2.073 ^a	4.487 ^a	15.404 ^a	0.931 ^a	2.835 ^a	74.253 ^b
160 °C	1.554 ^b	4.483 ^a	15.798 ^a	0.974 ^a	2.798 ^a	74.380 ^c

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

Moisture content

According to table 4.3 and table 4.4, there is a significant difference ($p < 0.05$) in the moisture content of the cookies due to temperature, blend proportion and their interaction. With an increase in the taro flour proportion in the cookies, there was an increase in the moisture content from average value 1.746% of the control to 2.153% of the 100% taro flour cookie. This increase could be attributed to the water binding capacity of taro flour.

As it can be seen from the results of WAC analysis of taro and wheat flour, the water binding capacity of taro flour was observed to be high to cause a greater water holding capacity of the taro flour than the wheat flour. This is the reason why the moisture content of the cookies increased with an increase in the taro flour proportion (Njintang *et al.*, 2007). Similarly, Tyagi *et al.*, (2006), also reported that the slight increase in moisture content of mustard fortified biscuits might be due to the higher water binding capacity of mustard flour used.

With an increase in baking temperature, the moisture of the cookies has been observed to decrease significantly ($p < 0.05$). This result is attributed to the fact that when a food is placed in a

hot oven, the low humidity of air in the oven creates a moisture vapor pressure gradient, which causes moisture at the surface of the food to evaporate and this in turn creates movement of moisture from the interior of the food to the surface (Fellows, 2000). Farris and Piergiiovanni, (2008) also reported the same result in their 'Amaretti' cookies. Moreover, according to the LSD analysis, the moisture content of the 33.33% taro flour cookies was found not to have a significant difference from the control.

Protein content

As it can be seen from the two factors ANOVA analysis (table 4.3 and 4.4), significant differences ($p < 0.05$) exists between the protein content of the cookies. Blend proportion and the interaction of blend proportion and baking temperature was observed to have a significant effect on the protein content unlike baking temperature that did have a non significant effect. The protein content of the taro-wheat blend cookies ranged from 3.634-4.937%. This is in close agreement to the cookies of taro-wheat blend by Ojinnaka *et al.*, (2009).

According to the results of LSD analysis, each of the 4 blends' population means seem to have a significant difference among each other. The average protein content has been observed to decrease with an increase in the amount of the taro blends from 4.84% at 33.33% taro blend cookie to 3.701% at 100% taro blend cookie. The average protein content of the control (100% wheat) cookies was observed to be 5.366%. This decrease is may be due to the low protein content of the taro flour (6.43%) compared to soft wheat flour (7-9%). According to Njintang *et al.*, (2007), as a result of the low level of proteins in the taro flour, their incorporation into wheat flour is expected to reduce the protein content of the composite and thus has a significant effect on the rheology of dough made from such composites.

Fat content

The fat content of the cookies was observed to be significantly affected ($p < 0.05$) by blend proportion and not by temperature and their interaction. As the amounts of taro flour in the formulation increases, the amount of fat in the cookie decreases. This is may be due to the presence of fat in the taro flour in smaller amount (0.47%) than is present in wheat flour (2%) (Nassar *et al*, 2008). According to the research by Njintang *et al*, (2007), wheat flour has much higher fat content than taro flour. Similarly, a decrease in the fat content of mustard biscuit of Tyagi, *et al.*, (2006) was reported and explained to be largely due to the incorporation of defatted mustard flour. The LSD analysis has showed that 33.33% taro flour cookies were not significantly different from the control cookies.

Crude fiber

The interaction of the two factors (temperature and blend proportion) and blend proportion was found to have a significant effect on the crude fiber content of the cookies. To the contrary, temperature didn't have a significant effect. The LSD analysis revealed that cookies of 33.33% and 66.66% taro flour blends are not significantly different with each other. The mean crude fiber content of the cookies has increased with an increase in amounts of taro flour in the composite flour.

This result is in agreement with the result reported by Arnavid-vinas and Lorenz, (1999), where taro has high amount of crude fiber. The mean crude fiber content of the control cookies was 0.531%. In contrast with the mean crude fiber content of the 100% taro flour cookies (1.674%), the control cookies were found inferior. An increase in the crude fiber content of cookies was also reported by Nassar *et al.*, (2008) in blending of citrus by-products flour with wheat flour.

Inyang and Wayo, (2005) also have mentioned an increase in crude fiber content in their sesame fortified cookies from 0.46 to 1.09%

Ash content

Blend proportion was found to significantly affect ($p < 0.05$) the ash content of the cookies whereas, variation of temperature did not. It was observed that with an increase in the amount of taro flour, the ash content of the cookies increased. Similarly, the ash contents of breadfruit-wheat flour cookies by Olaoye *et al.*, (2007) were observed to increase with an increase in the percentage of breadfruit flour.

Since taro flour was found to have higher ash content (4.814%) than soft wheat flour (typically 2%), this could be responsible for the higher ash contents of cookies with higher proportion of taro flour. This entails that incorporation of taro flour in the process of cookie making could enhance the mineral intake, as ash is indicative of the amount of minerals contained in any food sample (Olaoye *et al.*, 2007).

Carbohydrate content

The carbohydrate contents were found to be highest for the cookies with respect to all proximate composition parameters (crude protein, crude fibre, ash, moisture and carbohydrate) determined in this study. This was expected as the ingredients were composed of mainly carbohydrate rich materials, which are wheat and taro flours.

Effect of both the blend proportion and baking temperature had a significant effect ($p < 0.05$) on the carbohydrate content of the cookies. The carbohydrate content had increased with an increase in taro flour proportion from 73.17% of the control to 75.3% of the 100% taro flour cookies. This increment is attributed to the amount of the carbohydrate content of the taro flour (77%) being

slightly higher than soft wheat flour (70-75%). This result is in close agreement with the cookies made by Ojinnaka, *et al.*, (2009). With an increase in temperature, a slight increase in the carbohydrate content (73.5%-74.38%) was observed. The reason is probably due to a slight reduction in the moisture content of the cookies having increased the proportion of the carbohydrate. From the proximate, it was only moisture and carbohydrate contents which were significantly affected by baking temperature.

4.4. Total gross energy

Table 4.5: Effect of blend proportion on energy values of the cookies

	Blend proportion			
	Control(100% wheat)	33.33% taro	66.66% taro	100% taro
Energy value (Kcal)	467.675 ^a	462.002 ^b	454.285 ^c	436.153 ^d

^{a-d}any two means in the same raw not followed by the same latter are significantly different

Table 4.6: Effect of baking temperature on energy values of the cookies

	Baking temperature		
	140 °C	150 °C	160 °C
Energy value (Kcal)	454.069 ^a	453.479 ^b	457.539 ^c

^{a-c}any two means in the same raw not followed by the same latter are significantly different

The energy values of the taro-wheat flour cookies ranged from 436.15 to 467.67 Kcal/100g which is above 20% of the requirement for energy (1790–2500 kcal/ day), as recommended by FAO/WHO (1973) cited in Vieira *et al.*, (2007) for children aged between 5 and 19 years.

Both temperature and blend proportion was found to significantly affect ($p < 0.05$) the energy value of the cookies. With an increase in the proportion of taro flour, a decrease in the gross energy level was observed. This is may be due to the increment of the carbohydrate content with an increase in the taro flour proportion outweighs the decrease in fat and protein content.

4.5. Breaking strength of the cookies (Textural quality)

The breaking strength of a cookie (the absolute peak force from the resulting curve) is one criterion that measures the hardness of a biscuit (Tyagi, *et al.*, 2006). The mechanical characteristics of biscuits are important in determining the perception of biscuits in the mouth and play an important role in product acceptance (Shrestha and Noomhorm, 2002).

Table 4.7: Effect of blend proportion on breaking strength of the cookies

	Blend proportion			
Textural quality	control(100% wheat)	33.33% taro	66.66% taro	100% taro
Breaking strength (N)	13.548 ^a	15.443 ^a	23.317 ^b	28.689 ^c

^{a-c}any two means in the same raw not followed by the same latter are significantly different

Table 4.8: Effect of baking temperature on breaking strength of the cookies

	Baking temperature		
Textural quality	140 °C	150 °C	160 °C
Breaking strength (N)	20.468 ^a	20.222 ^a	20.058 ^a

^{a-c}any two means in the same raw not followed by the same latter are significantly different

As it can be seen from table 4.7, blend proportion was found to have a significant effect ($p < 0.05$) on the breaking strength of the cookies. On the other hand, baking temperature was found to have no significant effect (table 4.8). According to the LSD analysis, there is a significant difference

between the means of the blend proportions except between the control and the 33.33% taro flour cookies. It appears the control sample and the 33.33% taro flour blends were softer than the cookies made using the other blend proportion.

The increase in the breaking strength of the cookies is believed to be due to the addition of taro flour, which has different characteristics as compared to that of gluten obtained from wheat flour alone (Tyagi, *et al.*, 2006). Singh *et al.*, (2005) also reported a high compression force requirement for breaking biscuits prepared by incorporating 15% Bengal gram flour.

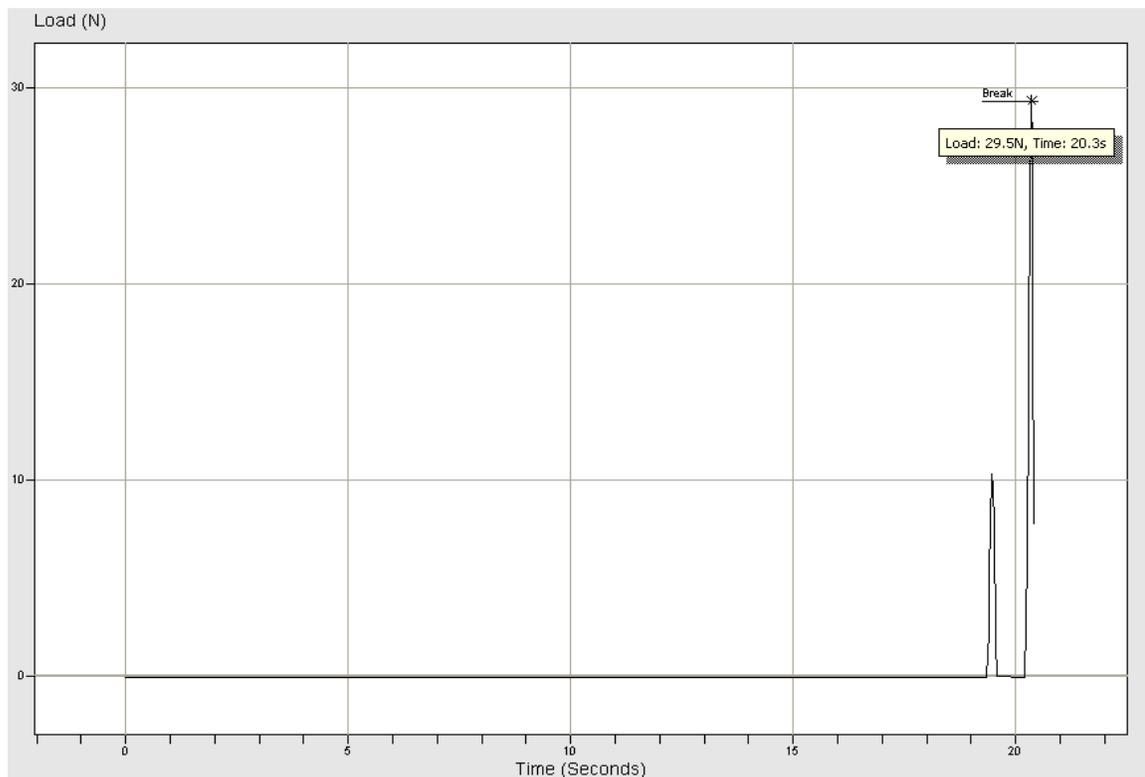


Fig 4.1. Typical texture curves for cookie breaking strength

According to Sindhuja *et al.*, (2005), with a reduction in the breaking strength, cookies become crispier. From the above statement, it can be concluded that the observed increment in the breaking strength of the cookies with an addition of more taro flour in the composite formulation was accompanied by a reduction in the crispiness of the cookies. The results of the sensory

evaluation discussed below also support this finding. Moreover, as discussed above, moisture content of the cookies increased with an increase in the taro flour proportion. This might be the reason why crispiness decreased and breaking strength increased with an increase in the proportion of taro flour in the cookies.

4.6. Physical parameters of the cookies

Table 4.9: Effect of blend proportion on physical parameters of the cookies

Blend proportion	Physical parameters		
	Diameter (cm)	Thickness (cm)	Spread ratio
control(100% wheat)	4.853 ^a	0.570 ^a	8.518 ^a
33.33% taro	4.877 ^a	0.572 ^a	8.533 ^a
66.66% taro	4.342 ^b	0.532 ^b	8.175 ^b
100% taro	4.063 ^c	0.515 ^c	7.887 ^c

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

Table 4.10: Effect of baking temperature on physical parameters of the cookies

Baking Temperature	Physical parameters		
	Diameter (cm)	Thickness (cm)	Spread ratio
140 °C	4.490 ^a	0.539 ^a	8.324 ^a
150 °C	4.549 ^b	0.553 ^b	8.223 ^a
160 °C	4.562 ^b	0.550 ^b	8.289 ^a

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

Diameter

The results of the analysis revealed that blend proportion, temperature and their interaction had a significant effect ($p < 0.05$) on the diameter of the cookies. Diameter of the cookies showed a

decrease (from mean diameter of 4.853cm of the control to 4.063cm of the 100% taro flour cookie) with an increase in the proportion of the taro flour in the composite. This result is in agreement with the results of cookies containing residue from king palm processing by Vieira, *et al.*, (2007).

Pareyt and Delcour, (2008) stated that cookies baked from flours with the lipids removed have smaller diameters than those baked from unextracted flours. From the above, it can be inferred that since taro flour has a smaller fat content (0.47%) than soft wheat flour (typically 2%), thus is probably the reason why the diameter of the cookies had decreased with an increase in the taro flour proportion.

More over, Gaines *et al.* (1988) studied the effect of flour moisture on cookie dough handling properties and cookie size. They noticed that, when flour moisture content is increased, the cookie diameter and dough flow and adhesion increase. At the same time, they noticed that increased flour moisture contents decrease dough stiffness, consistency, and cohesion (Pareyt and Delcour, 2008).

Based on the above finding, since soft wheat flour has larger moisture content (14%) than taro flour (8.49%), the cookies with more wheat flour proportion were found to have larger diameter. According to Pareyt and Delcour, (2008), cookie diameter is affected more by flour moisture content than by holding the dough at elevated temperature. The 33.33% taro flour and the control cookies didn't show a significant difference in their diameter whereas the means of the other blends had a significant difference among each other and also with the control and 33.33% taro flour blend cookies.

The LSD analysis had also revealed that the increase in diameter at a temperature of 140⁰C and the increase at temperatures of 150⁰C and 160⁰C were significantly different. This may be is

attributed to the escaping of water due to temperature increase. The reduction in the moisture content will make the dough less viscous allowing easy spreading. The more the cookies spread, the more the diameter became wider. The principal criterion for good biscuit-making quality is the diameter increase during the baking process. A large biscuit diameter is considered superior (Labuschagne *et al.*, 1996). From the above findings, it can be concluded that baking at a temperature of 150⁰C and 160⁰C give a better diameter than 140⁰C.

Thickness

The mean thickness of the cookies had a significant difference ($p < 0.05$) due to both factors and their interaction. The LSD analysis had revealed that the control and the 33.33% taro flour cookie were not significantly different with each other. The other two cookies (66.66% and 100% taro flour cookies) were significantly different from each other and also from the control and 33.33%.

The thickness of the cookies had decreased with an increase in the amounts of the taro flour proportion. This result is in agreement with the results of cookies containing residue from king palm processing by Vieira, *et al.*, (2007). Hussain *et al.*, (2006) had also found that thickness of the cookies showed gradual increase as the level of flaxseed flour replacement increased.

On the other hand, the thickness of the cookies had significantly increased with an increase in temperature where a significant difference between temperature of 140⁰C and temperatures of 150⁰C and 160⁰C was observed. Therefore, it can be concluded that baking at temperatures 150⁰C and 160⁰C produce a cookies of better thickness than baking at 140⁰C.

Spread ratio

Spread ratio is one of the main factors in achieving a good quality product. It is an indication of the viscous property of the dough and is influenced by the recipe, ingredients, procedures and conditions used in biscuit production (Dogan, 2006).

Cookie spreads during cookie baking. This is a result of a decrease in apparent viscosity, which itself results from the increase in temperature and the creation of an additional volume of dissolved phase because of the progressive solubilization of sugar. The cookie flows (spreads) during baking until the point at which the viscosity suddenly increases. However, the cause for the rapid viscosity increase is not clear. Because starch is not gelatinized, the viscosity is presumably a property of the flour proteins which dictates the flow behavior of the cookie dough during baking (Pareyt and Delcour, 2008).

The degree of spread resulting in final cookie diameter is controlled by the spread rate and the set time. The set time is determined by the level of water in the dough that is free to act as solvent and the strength of the dough. However, it is emphasized that the spread rate itself is most likely also influenced by the water-binding components of the dough. Sugar-snap cookies spread in the oven during baking, while some other cookies, with less sugar and a well-established protein network, do not (Pareyt and Delcour, 2008).

Table 4.9 and 4.10 show the effect of temperature and blend proportion on the spread ratio of the cookies. The data analysis has shown that only blend proportion had a significant effect on the spread factor of the cookies and not temperature and their interaction. The increase in the proportion of the taro flour in the composite flour has caused the cookies to decrease in the spread factor. The decrease in spread ratio and in diameter of the cookies with an increase in taro flour proportion shows that the cookies had become denser.

The post hoc analysis of the spread ratio of the cookies has showed that the 100% and 66.66% taro flour blend cookies were significantly different from each other and also from the 33.33% taro flour and control cookies. The control and 33.33% taro flour cookies are not significantly different with respect to spread ratio.

Nip, *et al.*, (1994), in their work of application of taro flour in snap cookies formulation had justified the above result. They concluded that the higher the percentage of commercial cookie flour replaced with taro flour, the lower the spread ratio of the cookies except when the ratio of the commercial cookie flour to taro flour was three to one (33.33% taro flour).

There are several views on the mechanisms by which the spread ratio of cookies is reduced when wheat flour is supplemented with non-wheat flours. It has been established that cookie spread is strongly correlated to the water absorption capacities of the flour (Vieira *et al.*, 2007).

As it can be seen from table 4.2, since the WAC of the taro flour (2.375ml/gm) has been observed to be higher than the WAC of wheat flour (1 ml/gm), rapid partitioning of free water to hydrophilic sites of taro flour is presumed to be higher than wheat flour. Therefore, it could be concluded that taro flour addition have limited the spreading of the cookies. McWatters (1978) reported that rapid partitioning of free water to hydrophilic sites during mixing increase dough viscosity, thereby limiting cookie spread.

More over, Pareyt and Delcour, (2008) in their review reported that in sugar snap cookies, more of the water is held by the flour (insoluble components) making it less available to dissolve the sugar (soluble components). Therefore, the viscosity will be higher causing slower rate cookie spreads.

4.7. Sensory quality of the cookies

Table 4.11: Effect of blend proportion on sensory quality of the cookies

Blend proportion	Sensory qualities			
	Color	Flavor	Crispiness	Overall acceptability
control(100% wheat)	7.178 ^a	7.378 ^a	3.872 ^a	7.412 ^a
33.33% taro	7.343 ^a	7.003 ^a	3.777 ^{ab}	7.278 ^a
66.66% taro	6.635 ^b	5.920 ^b	3.437 ^b	6.162 ^b
100% taro	6.493 ^b	5.622 ^b	2.917 ^c	5.725 ^b

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

Table 4.12: Effect of baking temperature on sensory quality of the cookies

Baking Temperature	Sensory qualities			
	Color	Flavor	Crispiness	Overall acceptability
140 °C	7.194 ^a	6.814 ^a	3.411 ^a	6.851 ^a
150 °C	7.074 ^a	6.644 ^a	3.530 ^a	6.938 ^b
160 °C	6.470 ^b	5.985 ^b	3.560 ^a	6.144 ^a

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

Color and flavor

Color is very important parameter in judging properly baked cookies. It doesn't only reflect the suitable raw material used for the preparation but also provides information about the formulation and quality of the product (Hussain, *et al.*, 2006). As it can be seen from table 4.11 and 4.12, color has been observed to be significantly affected by both temperature and blend proportion but not their interaction.

A decrease in the acceptability of the cookies' color was observed with an increase in the amount of taro in the blend. The color of the 33.33% taro flour cookie was found superior than the rest of the blends scoring 7.343. This result is not significantly different from the control cookie signifying that replacement of wheat flour with taro flour up to 33% didn't bring a difference on the acceptability of the cookies with respect to color. This result is in agreement with the report by Nip, *et al.*, (1994) on similar cookies.

On the other hand, the mean quality score of the color had decreased with an increase in temperature. Color of cookies baked at temperatures of 160⁰C was significantly lower (6.47) than the other two (140 and 150⁰C) which didn't have a significant difference with each other.

Flavor is the main criterion that makes the product to be liked or disliked. Flavor, as color, was observed to be significantly affected by blend proportion and temperature but not by their interaction. The mean flavor score of the cookies was found to decrease with an increase in the proportion of taro flour in the cookie and also with an increase in baking temperature. As with color, 33.33% taro flour cookies were observed not to be significantly different from the control cookies with respect to flavor. Moreover, means of flavor scores had exhibited similar scores and statistical interpretation to color.

Crispiness

Crispiness was found to be significantly affected by blend proportion but not by temperature and interaction. Crispiness was observed to decrease with an increase in the taro flour proportion in the cookies. As with flavor and color, cookies of 33.33% taro flour were observed to not be significantly different from the control cookies.

Crispiness, which is related to the formation of the spongy-like structure of the cookies, is dependent on the moisture content. Crispiness fundamentally is important in determining the consumer acceptability of cookies (Pareyt and Delcour, 2008). In cookies, loss of moisture from the interior is required to produce the desired crisp texture (Fellows, 2000).

With this respect, it can be concluded that the reason why the cookies have showed a decrease in their crispiness score (with an increase in taro flour proportion) is due to a parallel increase in the moisture content.

Over all acceptability

Overall acceptability was significantly affected by blend proportion and not by temperature and their interaction. A decrease in the acceptability was observed with an increase in the amount of taro flour in the composite flour cookie. This result is in agreement with cookies of Ojinnaka, *et al.*, (2009) made from modified taro starch and cookies of Nip, *et al.*, (1994) made from taro flour.

According to the LSD analysis of the means, overall acceptability of 33.33% taro flour cookies was not significantly different from the control. More over, the average mean score of overall acceptability of 33.33% taro flour cookie is well above 7 (like moderately) suggesting that it is well above minimum acceptable score. Therefore, as with all other sensory parameters, supplementation of taro flour up to 33% was observed to not have a significant difference with wheat flour snap cookies (control) with respect to overall acceptability. The other two blend cookies were observed to be significantly different from the control and their mean score was observed to be below the minimum acceptable score (7, like moderately).

In general, the mean score of the overall acceptability of the cookies ranged from 5.725 of the 100% taro flour cookie to 7.412 of the 33.33% taro flour cookie. These results very clearly indicated that taro flour can be used to replace the majority of the wheat flour for snap-type cookies. Nip, *et al.*, (1994) also reported that eight two percent of their panelists indicated that they would buy the taro snap cookies they have produced in a similar manner.

4.8. Limitation of taro usage as a value added product

Table 4.13: Effect of blend proportion on oxalate content of the cookies

	Blend proportion			
	control(100% wheat)	33.33% taro	66.66% taro	100% taro
Oxalate content(mg/100g)	96.403 ^a	108.213 ^b	128.793 ^c	151.220 ^d

^{a-c}any two means in the same raw not followed by the same latter are significantly different

Table 4.14: Effect of baking temperature on oxalate content of the cookies

	Baking temperature		
	140 °C	150 °C	160 °C
Oxalate content(mg/100g)	121.222 ^a	121.189 ^a	121.061 ^a

^{a-c}any two means in the same raw not followed by the same latter are significantly different

The use of taro as a value added product is challenged with two major factors; the acid nature and storage factor. The Acridity is thought to be caused by Calcium oxalate raphides plus a chemical irritant. According to the analysis of two factors ANOVA, a significant decrease in the oxalate content of the cookies with an increase in the taro amount in the formulation was

observed. As compared to the taro flour oxalate content (238.4mg/100g), a significant reduction was observed. Moreover, no taste panelist reported irritation of the mouth or throat during or after the sensory evaluation of the taro-wheat based cookies. According to Ojinnaka, *et al.*, (2009), this indicates the very low level of oxalate in the cookies.

This decrease may be attributed to the incorporation of other ingredients to lessen the proportion of oxalate in the cookies and also may be attributed to the incorporation of wheat flour which has lesser oxalate content than taro flour. Baking temperature didn't show a significant reduction in the amount of oxalate content of the cookies. This may be because baking a food causes rather an effective concentration of oxalates in the food due to the loss of water from the baked food (Oscarsson and Savage, 2007).

Considering storage factor; Fresh taro corm has about two-thirds water (FAO, 1999). On the other hand the moisture content of the cookies was found to be below 3%. A reduction in the moisture content will reduce the amount of water available and the presence of a good amount of sugar in the formulation will bound the available water to reduce the water activity (Fellows, 2000). Moreover, the incorporation of taro flour into wheat-based products has been reported to increase their keeping quality (Njintang, 2007). Nip, *et al.*, (1994) have also reported taro snap cookies prepared in a similar manner were stable for at least seven months.

6. CONCLUSION AND RECOMMENDATION

Conclusion

The study attempted to investigate the possibility of using taro flour for the production of sugar snap cookies by blending with wheat flour. The effect of blend proportion of taro and wheat flour and baking temperature on the physicochemical properties and sensory qualities of cookie was studied.

The results found indicated that taro flour could be blended with wheat flour to produce cookies with required physicochemical properties and acceptable sensory qualities. It was found that the more the taro flour in the composite, the more the carbohydrate, fiber and ash content of the cookies. Incorporation of the taro flour up to 33.33% resulted in cookies of comparable in most quality parameters considered (nutritional, textural, physical and sensory parameters) with those produced using 100% wheat flour except protein, carbohydrate, gross energy and crude fiber. The study also indicated that the 150°C baking temperature resulted in better physical characteristics and sensory qualities of cookies as compared to baking temperatures 140 and 160°C. Moreover, revealed that blending taro flour with wheat flour in the cookie formulation could significantly reduce the oxalate content.

As per the results of this study, taro-wheat flour cookies are both nutritious and exhibited acceptable sensory quality. Thus it could be concluded that the composite flour will reduce our dependence in the wheat flour for the production of cookie and other similar products. The results of this study are good indicators of the possibility for better utilization of taro through developing variety of new food products.

Finally, at present the cost of bread and biscuits is very high in Ethiopia and it is showing no sign of price decline. Thus it is believed that this study could give impetus for further research into the use of composite flour in general and taro-wheat flour blends in particular for making bakery products. .

Recommendations

In view of the results of this study, the use of taro-wheat flour blend in cookie formulation appeared to be promising from nutritional, quality, acceptability and economical point of view. Therefore, the following recommendations are made:

- Cookies production from taro-wheat composite flour should be given due emphasis and processors should be encouraged to utilize the potential of taro flour thereby diversify their products for better income and service for the consumer. .
- The use of taro in cookie production by substituting with wheat flour should also be encouraged and advocated since it has easily-digestible starch which makes it a very good alternative for the consumer.
- A comprehensive study on optimization of ingredient and baking condition and shelf life stability of baked products of taro blended with other cereals should be conducted to come-up-with complete and usable information.

References

- Abdulrashid, M., and Agwunobi, L.N. (2009). Taro Cocoyam (*Colocasia esculenta*) Meal as Feed Ingredient in Poultry. *Pakistan Journal of Nutrition* 8 (5), 668-673
- American Association of Cereal Chemists (1983). Approved Methods of the AACC, Method 10-50D., 8th ed., St. Paul, Minnesota, USA
- American Association of Cereal Chemists (2000). Approved Methods of AACC, 10th edn. 10-50D. St Paul, Minnesota, USA
- Aremu, M.O., Olaofe, O., and Akintayo, E.T. (2007). Functional Properties of Some Nigerian Varieties of Legume Seed Flour and Flour Concentration Effect on Foaming and Gelation Properties. *Journal of Food Technology* 5(2), 109-115.
- Arnavid-vinas, M.D.R., and Lorenz, K. (1999). Pasta products containing taro (*Colocasia Esculenta* L. schott) and chaya (*Cnidoscolus Chayamansa* L. Mcvaugh). *Journal of Food Processing Preservation* 23, 1-20
- Association of Official Analytical Chemists (AOAC) (2000). Official Method of Analysis, 16th Edn. Washington, DC.
- Bender, A.E., (1999). Benders' Dictionary of Nutrition and Food Technology, (P.56) Cambridge (England), woodhead publishing limited.
- Bahatia, S.C., Arora, S.M., Kumar, S.R., (1980). Hand Book on Food Industries (p.103), Delhi (India)
- Bolade, Mathew, K., Bello, Saleh, B. (2006). Selected Physicochemical Properties of Flour from the Root of African Fan Palm (*Borassus aethiopum*). *International Journal of Food Properties*, 9(4), 701-713

- Dogan, I.S. (2006). Effect of Oven Types on the Characteristics of Biscuits Made from Refrigerated and Frozen Dough. *Journal of Food Technology and Biotechnology*, 44 (1), 117–122
- Emmanuel-Ikpeme, C.A., Eneji, C.A., Essiet, U., (2007). Storage Stability and Sensory Evaluation of Taro Chips Fried in Palm Oil, Palm Olein Oil, Groundnut Oil, Soybean Oil and Their Blends. *Pakistan Journal of Nutrition* 6 (6), 570-575
- FAO (1999). Taro Cultivation in Asia and the Pacific. Regional Office for Asia and the Pacific, Bangkok, Thailand
- Farris, S., and Piergiovanni, L. (2008). Effects of Ingredients and Process Conditions on ‘Amaretti’ Cookies Characteristics. *International Journal of Food Science and Technology*, 43, 1395–1403
- Fellows, P., (2000). Food Processing Technology: Principles and practice. Woodhead Publishing Limited (Cambridge, England) and CRC Press LLC (Boca Raton, USA)
- Giami, S.Y., Achinewhu, S.C., & Ibaakee, C. (2006). The quality and Sensory Attributes of Cookies Supplemented with Fluted Pumpkin (*Telfairia occidentalis* Hook) Seed Flour. *International Journal of Food Science & Technology*, 40(6), 613-620
- Huang, C.C., Chen, B., Wang, C.C.R., (2007). Comparison of Taiwan paddy- and upland-cultivated taro (*Colocasia esculenta* L.) cultivars for nutritive values, *journal of Food Chemistry*, 102 , 250–256
- Hussain, S., Anjum, F.M., Butt, M.S., Khan, M I., Ashaghar, A., (2006). Physical and Sensory Attributes of Flaxseed Flour Supplemented Cookies. *Turk Journal of Biol.*, 30, 87-92

- Ijarotimi, O.S., (2008). Nutritional composition, Microbial Status, Functional and Sensory Properties of Infant Diets Formulated from Cooking Banana Fruits (*Musa spp*, ABB genome) and Fermented Bambara Groundnut (*Vigna subterranean L. Verdc*) Seeds. *Journal of food science and nutrition*, 38 (4), 325-340
- Inyang, U.E., and Wayo, A.U. (2005). Fortification of Cookies with Dehulled Sesame Seed Meal. *Journal of Tropical Science*, 45(3), 103 –105
- Iwuoha, C.I., and Kalu, F.A. (1995). Calcium Oxalate and Physico-Chemical Properties of Cocoyam (*Colocasia esculenta* and *Xanthosoma sagittifolium*) Tuber Flours as Affected by Processing. *Journal of food Chemistry*, 54, 61-66
- Labuschagne, M.T., Brooks Coetzee, M.C., and Deventer, C.S., (1996). Biscuit-Making Quality Prediction Using Heritability Estimates and Correlations. *Journal of Science, Food and Agriculture* 70, 25-28
- Manohar, R.S., and Haridas Rao, P. (1997). Effect of Sugars on the Rheological Characteristics of Biscuit Dough and Quality of Biscuits. *Journal of Science, Food and Agriculture*, 75, 383-390
- Mepba, H.D., Eboh, L., and Nwaojigwa, S.U., (2007). Chemical Composition, Functional and Baking Properties of Wheat-Plantain Composite Flours. *African Journal of Food, Agriculture, Nutrition and Development*. 7(1)
- Nassar, A.G., AbdEl-Hamied, A.A., and El-Naggar E.A., (2008). Effect of Citrus by-Products Flour Incorporation on Chemical, Rheological and Organoleptic Characteristics of Biscuits. *World Journal of Agricultural Sciences* 4 (5), 612-616

- Nip, W.K., Whitaker, C.S., Vargo, D., (1994). Application of taro flour in cookie formulations. *International Journal of Food Science and Technology*, 29, 463-468, 9(4), 701-713
- Njintang, Y.N., Mbofung, C.M., Balaam F., Kitissou P., Scher J. (2007). Effect of Taro (*Colocasia esculenta*) Flour Addition on The Functional and Alveographic Properties of Wheat Flour and Dough. *Journal of the Science of Food and Agriculture*. 88 (2), 273-279
- Njintang, Y.N., and Mbofung, C.M., (2003). Kinetics of Starch Gelatinisation and Mass Transfer during Cooking of Taro (*Colocasia esculenta* L. Schott) Slices. *Journal of Food Engineering*, 55, 170–176.
- Njintang, Y.N., and Mbofung, C.M., Moates, G.K., Parker, M.L., Craig, F., Smith, A.C., Waldron, W.K. (2007). Functional Properties of Five Varieties of Taro Flour and Relationship to Creep Recovery and Sensory Characteristics of Achu (Taro Based Paste). *Journal of Food Engineering* 82, 114–120
- Odoemelam, S.A., (2005). Functional Properties of Raw and Heat Processed Jackfruit (*Artocarpus heterophyllus*) Flour. *Pakistan Journal of Nutrition* 4 (6), 366-370
- Ojinnaka, M.C., Akobundu, E.N.T., and Iwe, M.O. (2009). Cocoyam Starch Modification Effects on Functional, Sensory and Cookies Qualities. *Pakistan Journal of Nutrition* 8 (5), 558-567.
- Oladele, A. K., and Aina, J. O. (2007). Chemical Composition and Functional Properties of Flour Produced from Two Varieties of Tigernut (*Cyperus esculentus*). *African Journal of Biotechnology*, 6 (21) 2473-2476.

- Olaoye, O.A., Onilude, A.A., and Oladoye, C.O. (2007). Breadfruit Flour in Biscuit Making: Effects on Product Quality. *African Journal of Food Science*, 020-023.
- Osborne, D.R., and Voogt, P., (1978). The Analysis of Nutrients in Foods. LTD Official methods 6.2 and 6.3. Academic press, Inc. (London)
- Oscarsson, K.V., and Savage, G.P. (2007). Composition and Availability of Soluble and Insoluble Oxalates in Raw and Cooked Taro (*Colocasia esculenta* var. Schott) Leaves. *Journal of Food Chemistry*, 101, 559–562
- Pareyt, B. and Delcour, J.A. (2008). The Role of Wheat Flour Constituents, Sugar, and Fat in Low Moisture Cereal Based Products: A Review on Sugar-Snap Cookies. *Journal of Critical Review in Food Science and Nutrition*, 48(9), 824 – 839
- Park, S.H., Wilson, J.D., Seabourn, B.W. (2009). Starch Granule Size Distribution of Hard Red Winter and Hard Red Spring Wheat: Its Effects on Mixing and Bread Making Quality. *Journal of Cereal Science*, 49, 98–105
- Patrick, M. M., Grace, W. N., and Christine, H.S. K., (1999). Traditional Food Plants of Kenya: National Museum of Kenya. P. 288, Nairobi, Kenya
- Ryan, K.J., and Brewer, M.S., (2006). Physical Properties of Sugar Snap Cookies using Granule Surface Deproteinated Wheat Starch. *Journal of Texture Studies* 37, 442–457.
- Shrestha, A.K., and Noomhorm, A. (2002). Comparison of Physico-Chemical Properties of Biscuits Supplemented with Soy and Kinema Flour. *International journal of food science and nutrition*, 37, 361-368.

- Sindhuja, A., Sudha, M. L., and Rahim, A. (2005). Effect of Incorporation of Amaranth Flour on the Quality of Cookies. *Journal of European food research and technology*, 221(5), 597-601
- Singh, S, Riar, C. S., and Saxena, D. C. (2008). Effect of Incorporating Sweet Potato Flour to Wheat Flour on the Quality Characteristics of Cookies. *African Journal of Food Science*, 2, 065-072,
- Tagodoe, A., Nip, W.K. Functional properties of raw and precooked taro (*Colocasia esculenta*) flour. *International Journal of Food Science and Technology*, 29, 457–482.
- Tattiyakul, J., Asavasaksakul, S., Pradipasena, P. (2006). Chemical and Physical Properties of Flour Extracted from Taro *Colocasia esculenta* (L.) Schott Grown in Different Regions of Thailand. *Journal of Science Asia* 32, 279-284.
- The United Nations University Press. Food and Nutrition Bulletin Volume 7, Number 4, December 1985. Retrieved from <http://www.unu.edu/unupress/food/> on Feb. 2, 2009
- Tyagi, S.K., Manikantan, M.R., Harinder, S.O., and Gurlen, K. (2006). Effect of Mustard Flour Incorporation on Nutritional, Textural and Organoleptic Characteristics of Biscuits. Central Institute of Post-Harvest Engineering and Technology, Ludhina, Punjab, India
- Udensi, E. A., and Okoronkwo, K. A., (2006). Effects of Fermentation and Germination on the Physico-Chemical Properties of *Mucuna cochinchinensis* Protein Isolate. *African Journal of Biotechnology*, 5 (10), 896-900,

- Udensi, E.A., Oselebe, H.O., and Iweala, O.O. (2008). The Investigation of Chemical Composition and Functional Properties of Water Yam (*Dioscorea alata*): Effect of Varietal Differences. *Pakistan Journal of Nutrition*, 7 (2), 342-344,
- Vieira, M.A, Tramonte, K.C., Podesta, R., Avancini, S.R.P., Amboni, R. D. de M. C., and Amante E.R., (2007). Physicochemical and Sensory Characteristics of Cookies Containing Residue from King Palm (*Archontophoenix alexandrae*) Processing. *International Journal of Food Science and Technology*, 43, 1534–1540
- Zoulias, E.I., Oreopoulou, V., and Kounalaki, E., (2002). Effect of Fat and Sugar Replacement on Cookie Properties. *Journal of the Science of Food and Agriculture*, 82, 1637–1644

Appendix

1. Appendix on proximate compositions of the cookies

1.1. Tests of Between-Subjects Effects on moisture content on the cookies

Dependent Variable: moisture content

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.386(a)	11	.308	11.587	.000
Intercept	89.533	1	89.533	3370.167	.000
temp	1.745	2	.873	32.845	.000
blend	.526	3	.175	6.603	.007
temp * blend	1.115	6	.186	6.994	.002
Error	.319	12	.027		
Total	93.238	24			
Corrected Total	3.705	23			

a. R Squared = .914 (Adjusted R Squared = .835)

1.2. Tests of Between-Subjects Effects on protein content of the cookies

Dependent Variable: protein content

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10.149(a)	11	.923	122.675	.000
Intercept	486.234	1	486.234	64647.698	.000
temp	.013	2	.006	.860	.448
blend	9.995	3	3.332	442.946	.000
temp * blend	.142	6	.024	3.145	.043
Error	.090	12	.008		
Total	496.474	24			
Corrected Total	10.240	23			

a. R Squared = .991 (Adjusted R Squared = .983)

1.3. Tests of Between-Subjects Effects on fat content of the cookies

Dependent Variable: fat content

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	52.811(a)	11	4.801	26.117	.000
Intercept	5824.705	1	5824.705	31685.590	.000
temp	.647	2	.323	1.759	.214
blend	49.170	3	16.390	89.159	.000
temp * blend	2.995	6	.499	2.715	.066
Error	2.206	12	.184		
Total	5879.722	24			
Corrected Total	55.017	23			

a. R Squared = .960 (Adjusted R Squared = .923)

1.4. Tests of Between-Subjects Effects on crude fiber content of the cookies

Dependent Variable: crude fiber

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.708(a)	11	.428	58.675	.000
Intercept	22.112	1	22.112	3031.673	.000
temp	.010	2	.005	.675	.527
blend	4.435	3	1.478	202.682	.000
temp * blend	.263	6	.044	6.005	.004
Error	.088	12	.007		
Total	26.907	24			
Corrected Total	4.795	23			

a. R Squared = .982 (Adjusted R Squared = .965)

1.5. Tests of Between-Subjects Effects on ash content of the cookies

Dependent Variable: Ash content

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10.562(a)	11	.960	72.093	.000
Intercept	190.210	1	190.210	14281.715	.000
temp	.005	2	.003	.206	.816
blend	10.517	3	3.506	263.213	.000
temp * blend	.040	6	.007	.496	.800
Error	.160	12	.013		
Total	200.931	24			
Corrected Total	10.722	23			

a. R Squared = .985 (Adjusted R Squared = .971)

1.6. Tests of Between-Subjects Effects on carbohydrate content of the cookies

Dependent Variable: carbohydrate content

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	28.274(a)	11	2.570	2693.807	.000
Intercept	132119.037	1	132119.037	13846536 5.769	.000
temp	.766	2	.383	401.323	.000
blend	21.863	3	7.288	7637.792	.000
temp * blend	5.645	6	.941	985.975	.000
Error	.011	12	.001		
Total	132147.322	24			
Corrected Total	28.285	23			

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

2. Appendix on energy value of the cookie

Tests of Between-Subjects Effects on energy values of the cookies

Dependent Variable: Energy value

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3558.215(a)	11	323.474	558.557	.000
Intercept	4969227.920	1	4969227.920	8580579.184	.000
temp	76.994	2	38.497	66.474	.000
blend	3392.249	3	1130.750	1952.514	.000
temp * blend	88.973	6	14.829	25.606	.000
Error	6.950	12	.579		
Total	4972793.085	24			
Corrected Total	3565.165	23			

a. R Squared = .998 (Adjusted R Squared = .996)

3. Appendix on breaking strength of the cookies

Tests of Between-Subjects Effects on breaking strength of the cookies

Dependent Variable: breaking strength

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	905.480(a)	11	82.316	30.939	.000
Intercept	9840.783	1	9840.783	3698.742	.000
temp	.684	2	.342	.129	.881
blend	891.857	3	297.286	111.737	.000
temp * blend	12.940	6	2.157	.811	.581
Error	31.927	12	2.661		
Total	10778.190	24			
Corrected Total	937.407	23			

a. R Squared = .966 (Adjusted R Squared = .935)

4. Appendix on physical parameters of the cookies

Tests of Between-Subjects Effects on diameter of the cookies

Dependent Variable: cookie diameter

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.904(a)	11	.264	728.229	.000
Intercept	493.317	1	493.317	1360875.414	.000
temp	.024	2	.012	32.724	.000
blend	2.867	3	.956	2636.762	.000
temp * blend	.013	6	.002	5.797	.005
Error	.004	12	.000		
Total	496.225	24			
Corrected Total	2.908	23			

a. R Squared = .999 (Adjusted R Squared = .997)

Tests of Between-Subjects Effects on thickness of the cookies

Dependent Variable: cookie thickness

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.016(a)	11	.001	18.770	.000
Intercept	7.183	1	7.183	90735.211	.000
temp	.001	2	.000	5.421	.021
blend	.014	3	.005	60.544	.000
temp * blend	.001	6	.000	2.333	.100
Error	.001	12	7.92E-005		
Total	7.200	24			
Corrected Total	.017	23			

a. R Squared = .945 (Adjusted R Squared = .895)

Tests of Between-Subjects Effects on spread ratio of the cookies

Dependent Variable: cookie spread ratio

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.966(a)	11	.179	7.812	.001
Intercept	1644.739	1	1644.739	71874.986	.000
blend	1.720	3	.573	25.058	.000
temp	.042	2	.021	.924	.423
blend * temp	.204	6	.034	1.484	.264
Error	.275	12	.023		
Total	1646.980	24			
Corrected Total	2.241	23			

a. R Squared = .877 (Adjusted R Squared = .765)

5. Appendix on sensory characteristics of the cookies

5.1. Tests of Between-Subjects Effects on color of the cookies

Dependent Variable: cookie color

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8.579(a)	11	.780	5.004	.005
Intercept	1146.784	1	1146.784	7357.073	.000
temp	2.407	2	1.204	7.722	.007
blend	3.054	3	1.018	6.531	.007
temp * blend	3.118	6	.520	3.334	.036
Error	1.870	12	.156		
Total	1157.233	24			
Corrected Total	10.450	23			

a. R Squared = .821 (Adjusted R Squared = .657)

5.2. Tests of Between-Subjects Effects on flavor of the cookies

Dependent Variable: cookie flavor

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	19.338(a)	11	1.758	5.866	.002
Intercept	1008.029	1	1008.029	3363.740	.000
blend	12.787	3	4.262	14.224	.000
temp	3.066	2	1.533	5.115	.025
blend * temp	3.485	6	.581	1.938	.155
Error	3.596	12	.300		
Total	1030.963	24			
Corrected Total	22.934	23			

a. R Squared = .843 (Adjusted R Squared = .699)

5.3. Tests of Between-Subjects Effects on crispiness of the cookies

Dependent Variable: cookie crispiness

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.215(a)	11	.383	5.744	.003
Intercept	294.070	1	294.070	4408.570	.000
temp	.099	2	.050	.742	.497
blend	3.354	3	1.118	16.760	.000
temp * blend	.762	6	.127	1.903	.161
Error	.800	12	.067		
Total	299.085	24			
Corrected Total	5.015	23			

a. R Squared = .840 (Adjusted R Squared = .694)

5.4. Tests of Between-Subjects Effects on overall acceptability of the cookies

Dependent Variable: overall acceptability

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	18.004(a)	11	1.637	3.513	.020
Intercept	1059.479	1	1059.479	2274.007	.000
temp	3.035	2	1.517	3.257	.074
blend	12.413	3	4.138	8.881	.002
temp * blend	2.556	6	.426	.914	.517
Error	5.591	12	.466		
Total	1083.074	24			
Corrected Total	23.595	23			

a. R Squared = .763 (Adjusted R Squared = .546)

6. Appendix on oxalate content of the cookies

Tests of Between-Subjects Effects on oxalate content of the cookies

Dependent Variable: oxalate content

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10454.677(a)	11	950.425	7024.577	.000
Intercept	352299.355	1	352299.355	2603838.547	.000
temp	.116	2	.058	.428	.662
blend	10454.280	3	3484.760	25755.803	.000
temp * blend	.281	6	.047	.346	.899
Error	1.624	12	.135		
Total	362755.656	24			
Corrected Total	10456.301	23			

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