DEVELOPMENT AND QUALITY EVALUATION OF FIBRE ENRICHED COOKIES

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DECLARATION

I hereby declare that this thesis entitled " **Development and quality evaluation of fibre enriched cookies"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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Certified that this thesis entitled " **Development and quality evaluation of fibre enriched cookies**" is a record of research work done independently by **Ms. SUMA. K (2013-16-102)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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EXTERNAL EXAMINER

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Dedicated to

MY FAMILY

CONTENTS

LIST OF TABLES

LIST OF TABLES CONTINUED

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDIX

LIST OF ABBREVIATIONS

%	-	Percentage
^0C	-	Degree Celsius
AACC	-	American Association for Clinical Chemistry
AOAC	-	Association of Official Analytical Chemistry
AUC	-	Area Under the Curve
BMI	-	Body Mass Index
CD	-	Critical Difference
CHD	-	Coronary Heart Disease
cm	-	Centimeter
CVD	-	Cardio Vascular Disease
dl	-	deciliter
et. al	-	and others
Fe	-	Iron
FFA	-	Free Fatty Acids
Fig	-	Figure
g	-	Gram
GI	-	Glycemic Index

GERD	-	Gastroesophageal Reflux Disease
K	-	Potassium
Kcal	-	Kilo calories
Kg	-	Kilogram
LDL	-	Low Density Lipoprotein
meq	-	Milliequivalent
Mg	-	Magnesium
mg	-	Milligram
min	-	Minutes
ml	-	Milliliter
Mn	-	Manganese
mT	-	Million Tone
No:	-	Number
PEM	-	Protein Energy Malnutrition
USA	-	United States of America
Viz	-	Namely
Wt	-	Weight

Introduction

1. INTRODUCTION

Enrichment of foods especially bakery foods is of current interest because of the increasing awareness of consumers towards health and quality of food. There is a lot of competition in the market which creates demand in the bakery industry to search for ingredients which impart specific functionalities to the baked products.

Bakery and confectionary products form a major segment of the food processing industry. The bakery industry utilises agricultural inputs such as wheat flour, sugar, vegetable oils and fats. Processing converts these products with short shelf-life into baked products with long shelf-life which are enjoyed by all age groups besides obtaining nutrients from them.

Bakery industry in India is considered to be one of the major food Processing Industries with a demand of over 2758 mT (Ministry of Food processing Industries, 2013). India is to be the second largest manufacturer of biscuits after USA. Bakery products are the most popular foods consumed by all age groups and are gaining popularity as processed foods because of their availability, ready to eat, convenience and comparatively good shelf life.

Consumption of snack foods has been on the increase as a result of urbanization and increase in the number of working women. Food based industry can exploit this development by fabricating nutritious snack foods. Cookies have become one of the most desirable snacks for both youth and elderly people due to their low manufacturing cost, convenience, long shelf life and ability to serve as a vehicle for important nutrients (Akubor, 2003; Honda and Jood, 2005). It represents the largest category of snack items among baked food products throughout the world (Pratima and Yadava, 2000).

Cookies are not considered as staple foods like breads, but can become feasible fibre carriers because of their long shelf life and thus enable large scale

production and widespread distribution. Biscuits/ cookies are defined as a small thin crisp cakes made from unleavened dough. Cookies hold an important position in snack foods due to variety in taste, crispiness and digestibility.

Alpaslan and Hayta, (2006) stated that bakery products such as biscuits/ cookies have high consumer acceptance and are important for delivering bioactive compounds into the human diet.

Today's health conscious consumers are increasingly making food choices based on a food's ability to provide health benefits, such as enhancing body functions or reducing the risk of certain diseases.

Spiller (2001) reported that dietary fibre is the endogenous plant component in the diet, which are resistant to digestive enzymes. Dietary fibre is considered as an important and essential component of diet with significant results. Health benefits of dietary fibre indicate that dietary fibre may give protection against cardiovascular disease, diabetes and obesity.

According to Boss and Shams, (2010) low intake of fibre has been linked with diseases such as diverticular disease, cancer of the colon and rectum, appendicitis, varicose veins, haemorrhoids, CHD, gallstone and diabetes mellitus. The deficit of fibre intake in the diet of the average consumer has necessitated the need for development and production of fibre enriched cookies from the point of interest of both producers and researchers.

In recent years, there has been an awakening of interest in the role of dietary fibres in human nutrition and thus tremendous importance is now being placed upon various cereal brans, legume husks and other potential sources of dietary fibre in the formulation of food products.

Amongst different sources of fibres, cereal bran is the most important and cheap sources of fibre. The outer bran layers of cereal grains are rich in dietary fibre and minerals. Wheat bran contributes about 14.5% of the kernel weight. They are rich in protein (~14.5%), carbohydrate (~27%), minerals (~5%), fat

(~6%) and B vitamins (Kent and Ever, 1998). Rice bran is rich in nutrients with 14-16 % protein, 12-23% fat and 8-10% crude fibre. They are also good sources of B complex vitamins and contain minerals such as iron, potassium, calcium, chlorine, magnesium and manganese (Saunders, 1990).

Nutritional and functional properties of rice/ wheat bran are well suited for baked products like cookies, muffins, crackers and biscuits (Young, 2001). "Cookies" are chemically leavened products, also known as "biscuits". Cookies are ideal for nutrient availability, palatability, compactness and convenience. They differ from other baked products like bread and cakes because of having low moisture content and are comparatively free from microbial spoilage and possessing long shelf life of the product (Akubor and Ukwuru, 2005).

The growing consumer demands for food with high dietary fibre having good nutritional and sensory quality as well as functional claims have called for research to develop new products which include not only the fibre, nutritional and functional characterization but also have good consumer acceptance.

Keeping in view of the nutritional significance of dietary fibre, cookies were standardized from wheat flour, substituting with rice bran and wheat bran. The objectives of the study were:-

1. To prepare fibre enriched cookies substituting wheat flour with rice bran /wheat bran at different proportions and to assess its sensory qualities.

2. To determine the physical properties, chemical and nutrient composition, shelf life and glycemic index of the cookies

Review of Literature

2. REVIEW OF LITERATURE

The literature of the present study entitled "Development and quality evaluation of fibre enriched cookies is given below:

2.1 Importance of processing

2.2 Importance of bakery products

2.3 Definition and components of dietary fibre

2.4 Health benefits of dietary fibre

2.5 Industrial application of dietary fibre

2.6 Importance of Cereal brans

2.1 Importance of processing

In developing countries like India with the increasing urbanization, the demand of processed food is also increasing rapidly. Among the processed foods, bakery products, particularly biscuits/ cookies command wide popularity in rural as well as urban areas among all the age groups. Breads and biscuits/ cookies are major products accounting for 80% of the total bakery products in India (Agarwal, 1990)

In the past, processed foods were mere refined and pure. Now there is a swing in consumer demand to "Natural foods", which contain a reasonable amount of dietary fibre. New demands include more types of food, less energy-dense foods, less fats, less salt having more dietary fibres (Sabapathy and Bawa, 2007).

Unprocessed foods are susceptible to spoilage by biochemical processes, microbial attack and infestation. The post-harvest practices such as good processing techniques, proper packaging, transportation and storage can play a significant role in reducing spoilage and extending shelf life (Venkatesh and Shah, 2004).

Processing may open up the food matrix, thereby allowing the release of tightly bound phytochemicals from the grains structure (Flucher and Rooney, 2002). Most research finds that the processing of whole grains doesnot remove biologically important compounds (Slavin, 2003)

The challenges in processing lie in retaining the nutritional value, flavor, aroma and texture of foods and processing them in more natural form with added convenience (IFIC, 2004).

The demand for bakery products is bound to increase further in the country due to an increasing demand for convenience products, shift in eating habits, better transport and distribution method (NIIR, 2004).

One of the ways to capture the market is possibly by providing therapeutic bakery products because of increasing health consciousness among urban people and health awareness among rural people with certainly lead to an increase in the demand for such products (Kamaliya, 2000)

Fibre has started to appear in processed foods and fast food restaurant chains due to increasing demand for convenience foods and dieting customers (Nutraceuticals World, 2004).

Research and development should be done to bring value added convenient products which should be made available to consumer at affordable prices. The continuous thrust should be to reduce cost, improve quality and improve convenience so as to attract consumers (Kalia, 2006).

2.2 Importance of Bakery products

Bakery products are the important staple foods in most country and cultures. Bakery products and cereals are a valuable source of nutrients in our diet providing us with most of our food calories and approximately half of our protein requirements.

Bakery products are an important part of food expenditure. Consumption of bakery products have been falling since the end of World War II in some industrialized countries such as the USA, Canada, the UK and Australia. According to Hunt and Robbins (2009) bakery products accounted for 9 per cent of the average weekly food consumption.

Bakery products once considered as sick man's diet have now become essential food items of the vast majority of population. The contributing factors were urbanization, resulting in increased demand for ready to eat products at reasonable costs. Importance of bakery products has expanded especially the use of whole and natural grains and other natural ingredients. Furthermore, bakery products are considered as a source of carbohydrates because starch is the main chemical constituent

Cereals have been a basic food of man since pre historic times and were consumed long before bread making was developed. Variety breads and other bakery products have increased in sales within the past decades.

According to Nelson, (2001) fortification of bakery products is the most common application of fibre enrichment. Breads, cookies, cakes, muffins can be listed as food products that uses the effects of fibre on rheological properties. Firstly some of the fibre ingredients may increase the water holding capacity and it affects the consistency of dough. More water may be needed and it should be determined from the loaf volume, baking conditions and finished moisture. Secondly since hydrating of wheat gluten is retarded by fibres mixing time will be longer. Insufficient gluten hydration may cause crumbs on the final product. These crumbs can be prevented by strong gluten flours or adding methylcellulose as a gluten enhancing agent.

Biscuits and cookies – capturing taste buds

"Cookie" is chemically leavened product, also known as "biscuit". Generally the term biscuit is used in the European countries and cookies in the USA.

Biscuits and cookies represent the largest category of snack item among baked foods all over the world (Pratima and Yadava, 2000).

Biscuits and cookies have amazingly become one of the most desirable desserts for both youth and old people due to their low manufacturing cost, more convenience and long shelf life (Akubor, 2003; Honda and Jood, 2005).

Neelam et al. (2005) stated that, cookies are one of the best known quick snack products. Cookies are often referred to a small sweet cake. They are characterized by a formula high in sugar, shortening and low in water. Similar products in our country are called Biscuits.

2.3 Definition and components of dietary fibre

Dietary fibres are indigestible complex carbohydrates found in walls of plant cells. Fibre is resistant to the body's digestive enzymes. While it supplies no nutrients or calories, it performs many important biological functions (Jones, 2000).

According to IOM (2001), dietary fibre can be separated into many different factions. Recent research has begun to isolate these components and determine if increasing their levels in a diet is beneficial to human health. The separation of these fractions may give us a better understanding of how and why dietary fibre may decrease the risk for certain diseases.

2.3.1 Arabinoxylan

Arabinoxylan (AX), a constituent of hemicelluloses, is comprised of a xylose backbone with arabinose side chains. AX is a major component of dietary fibre in whole grains having considerable inclusions in both the endosperm and bran. In wheat, AX account for around 64–69 per cent of the NSP in the bran and around 88 per cent in the endosperm (Ring and Selvendran, 2000).

During wheat flour processing, a majority of the AX is removed as a by-product. In the gastro intestinal tract, AX acts as a soluble fibre being rapidly fermented by the microflora of the colon.

Lu et al. (2004) observed an inverse relationship between the intake level of an AX rich bread and postprandial glucose response in healthy adult subjects.

Higher AX also appears to control blood glucose and insulin in adults with an already impaired glucose tolerance. The lower glycemic index of AX may also play a role. Lu et al. (2004) stated that cereal flour rich in AX have a relatively low glycemic index of around 59. Whole wheat flour, although high in fibre, has a glycemic index of around 99.

2.3.2 Inulin

Inulin is a polymer of fructose monomers and is present in such foods as onions, garlic, wheat, artichokes and bananas and is used to improve taste and mouth feels in certain applications. It is also used as a functional food ingredient due to its nutritional properties (Abrams et al., 2005).

Inulin has also demonstrated the ability to contribute to the health of the human large intestine as a prebiotic. Rafter et al. (2007) observed that inulin decreased biological compounds associated with colonic cancer, including reduced colorectal cell proliferation and water induced necrosis, decreased exposure to genotoxins and decreased interleukin-2 release.

Increased mineral absorption may also contribute to the functionality of inulin. Increased calcium absorption by approximately 20 per cent was reported in adolescent girls supplemented with inulin (Griffin et al., 2003).

2.3.3.β-glucan

Keogh, et al (2003) β-glucan is a linear polysaccharide of glucose monomers and found in the endosperm of cereal grains, primarily in barley and oats. β-glucan is water soluble and highly viscous at low concentrations.

The physiological benefits due to β-glucan seem to stem from their effect on lipid metabolism and post prandial glucose metabolism. Many studies agree an inverse relationship exists between consumption levels of β-glucan and cholesterol levels.

Several recent studies in both hypercholesterolemic (Theuwissen and Mensink, 2007) and healthy (Naumann et al., 2006) adults found that the daily consumption of 5 g of β-glucan significantly decreased serum total and LDL cholesterol. β-glucan's viscosity in the gastro intestinal tract is the most probable mechanism in which it decreases serum cholesterol levels as well as improves post prandial glucose metabolism.

Nazare et al. (2009) observed that 5 g of oat β-glucan added to cereal significantly delayed total glucose absorption.

The production of short chain fatty acids from β-glucan and fermented oat β-glucan yield larger amounts of propionate (Kim and White, 2010) and inhibit cholesterol synthesis in humans.

Suortti et al. (2000) stated that heating such as in extrusion and baking, decreases the molecular weight of β-glucan therefore decreasing its viscosity inside the gastro intestinal tract.

Kerckhoffs et al. (2003) observed that β-glucan when added to bread or cookies, produced no change in the lipoprotein profile of mildly hypercholesterolemic adults. However, when the same β-glucan was added to orange juice, serum LDL decreased significantly.

Biorklund et al. (2005) found similar results in which 5 g of β-glucan derived from oats significantly lowered serum cholesterol and postprandial glucose while the same level of β-glucan derived from barley produced no effects.

2.3.4 Pectin

Pectin is a linear polymer of galacturonic acid. Pectin is a water soluble polysaccharide that bypasses enzymatic digestion of the small intestine but is easily degraded by the microflora of the colon. Citrus fruit contains 0.5% to 3.5% pectin with a large concentration located in the peel Rabbani et al. (2001).

According to Olano et al. (2002) commercially extracted pectins are also available and are typically used in food applications which require a gelling or a thickening agent. Inside the gastro intestinal tract, pectin maintains this ability to form a gel or thicken a solution.

Triplehorn and Millard (2002) demonstrated that oral pectin supplementation to children and infants reduced acute intestinal infections and significantly slowed diarrhoea due to a reduction in pathogenic bacteria such as Shigella, Salmonella, Klebsiella, Enterobacter, Proteus and Citrobacter.

Pectin may also have a potential role in the complicated area of cancer prevention. Nangia et al. (2002) found that pectin was able to bind and decrease tumor growth and cancerous cell migration in rats fed with modified citrus pectin.

2.3.5 Cellulose

Cellulose is a linear chain of glucose monomers and is the structural component of cell walls in green plants and vegetables. It is water insoluble and inert to digestive enzymes in the small intestine (Prola et al., 2006).

Nelson et al. 2000 reported that many modified celluloses such as powdered cellulose, microcrystalline cellulose and hydroxypropylmethyl cellulose have been developed and are used as food ingredients.

The difference between natural and modified celluloses is the extent of crystallization and hydrogen bonding. When these hydrogen bonds are disrupted and the crystallinity is lost, the cellulose derivative becomes water soluble (Takahashi,et al ., 2003).

According to Lightowler et al.(2009) Cellulose pills have been made available for human consumption with the theory that cellulose may decrease a person's caloric intake.

Modified celluloses may be more beneficial than natural cellulose. These modified cellulose sact like soluble fibre thus adding to the viscosity of the gastrointestinal tract. Therefore, it is assumed that increased intestinal viscosity delays nutrient absorption and increases bile acid excretion (Maki et al., 2009)

2.3.6 Resistant Starch

Resistant starches (RS) are defined as starches that do not digested in the small intestine (Higgins et al., 2004).

Altamimi et al. (2010) found that resistant starch behaves like soluble fibre without sacrificing palatability and mouth feel. Thus, resistant starch tries

combining the health benefits of dietary fibre/whole grain with the sensory feel of refined carbohydrates .

Behall et al. (2006) found that women consuming RS had significantly lower postprandial glucose and insulin levels. Reader et al. (2002) reported that 7.25 g of RS added to an energy bar decreased blood glucose and insulin levels in healthy adults. But, ingredients, amount of ingredients and nutrient levels were different for each treatment.

Robertson et al. (2005) reported that 30 g of resistant starch added to healthy subjects habitual diet resulted in a significant decrease in subcutaneous abdominal adipose tissue non-esterified fatty acid (NEFA) and glycerol release.

2.4 Health benefits of dietary fibre

Dietary fibre and whole grains are an abundant source of nutrients including vitamins, minerals and a slowly digestible energy. In addition, they contain phytochemicals such as phenolic, carotenoids, lignin's, beta-glucan and inulin. These chemicals secreted by plants are not currently classified as essential nutrients but may be important factors in human health (Liu , 2003).

The synergistic effect of phytochemicals, increased nutrient content and digestive properties are believed to be the mechanism behind dietary fibres beneficial effects on the treatment and prevention of obesity and diabetes (Weickert and Pfeifer 2008), reduced CVD and decreased incidence of certain types of cancer (Ferguson *et al.*, 2001; Terry *et al.*, 2001).

Spiller (2001) reported that health benefit of dietary fibre may give protection against cardiovascular disease, diabetes and obesity.

High fibre diet are associated with the prevention, reduction and treatment of some disease such as diverticular and coronary heart disease (Figueroa *et al.*, 2002), large intestine cancer and diabetes (Nawinska and Kwasniewska, 2005).

Furthermore, increased consumption of dietary fibre improves serum lipids concentrations, lowers blood pressure, improves blood glucose, controls diabetes, promotes regularity in weight loss and improves immune function. (Anderson *et al.*, 2009).

2.4.1 CVD

Throughout the world, cardiovascular problems are the most common situation i.e. 17.1 million occurs in a year according to World Health Organization (WHO) research. Causes of these diseases include tobacco use, stress and inappropriate diet mainly.

High levels of dietary fibre intake are associated with lower prevalence rates for CHD, stroke, and peripheral vascular disease (Merchant *et al.*, 2003).

Increased fibre intake modestly lowers the blood pressure of the general population but is accompanied by reductions of systolic and diastolic blood pressure.

Anderson *et al.* (2009) reported that higher fibre intakes are associated with improved measures for body weight, visceral adiposity, insulin sensitivity, and inflammatory markers. Moderate increase in fibre intake, especially soluble fibre, is likely to have significant favorable effects on risk and progression of CVD.

James and Mark (2010) revealed that increasing dietary fibre intake has been shown to decrease circulating levels of C - reactive protein (CRP), a marker of inflammation and a predictor for CHD.

Anderson *et al.* (2009) found that oat bran doubled the serum concentration of 7α-hydroxy-4-cholesten-3-one (α-HC), which is a metabolite in the synthesis of bile acids that is oxidized from 7α-hydroxycholesterol. The reduction in serum triglyceride levels may be a result of a decreased absorption of fat from the small intestine.

Increasing dietary fibre consumption may decrease energy absorption by way of diluting a diet's energy availability while maintaining other important nutrients (Lattimer and Haub, 2010).

It is proved that if 3 g of fibre is consumed daily, it will decrease the risk of CHD mortality by 27 per cent (Vander *et al.*, 2004). There is a positively relation between reduction of risk of CHD and fibre consumption.

According to Tucker and Thomas (2009) there is an inverse relationship between dietary fibre intake and change in body weight.

2.4.2 Diabetes

Weickert and Pfeifer (2008) found that an increased intake of cereal fibre significantly improved whole body glucose disposal resulting in an 8 per cent improvement of insulin sensitivity.

Insoluble fibre can result in reduced appetite and food intake (Samra and Anderson, 2007) and this may lead to a decreased calorie intake and BMI.

The inverse relationship between cereal grains and diabetes may also be attributed to an increased consumption of magnesium. Increased intake of magnesium has been shown to decrease the incidence of type 2 diabetes (Meyer *et al.*, 2000).

According to Kelley and Mandarino (2000), increases in FFA in the blood can inhibit glucose metabolism through the inhibition of GLUT 4 transporters. Therefore, short chain fatty acids, by way of decreasing serum free fatty acids, may reduce blood glucose levels through competition in insulin sensitive tissues.

2.4.3 Gastro intestinal disease

Dietary fibres affect the entire gastro intestinal tract from the mouth to the anus. Soluble fibres usually delay gastric emptying and it may act to slow transit of food materials through the small intestine while insoluble fibres tend to create "intestinal hurry" (Cummings, 2001).

In the small intestine, dietary fibres can reveal responses of a wide variety of gastrointestinal hormones that serve as incretins to stimulate insulin release and affect appetite (Anderson, 2009).

In the colon, fermentable fibres increase bacterial mass with some acting as prebiotics to promote health-promoting bacteria.

Insoluble fibres are especially effective in increasing fecal mass and promoting regularity (Cummings, 2001).

Recently Drzikova et al. (2005) found that in *vitro* binding of bile acids increased with increasing proportions of oat bran, total and insoluble dietary fibre as well as β-glucan, in pre-digested oat-based extrudates.

Irritable bowel syndrome is one of the most common gastrointestinal functional disorders worldwide. It is a complex disorder and includes the symptoms like abdominal pain or discomfort, bloating, and diarrhoea and/or constipation. While wheat bran often increases symptoms other fibre supplements such as methylcellulose, partially hydrolyzed guar gum and psyllium have been reported to alleviate symptoms (Anderson et al. 2009).

Judicious use of soluble fibres may offer benefits for persons with ulcerative colitis in remission (Seidner *et al.* 2005).

Increased intake of dietary fibre is commonly used for the prevention and management of constipation or hemorrhoids. Wheat bran, high-fibre cereals and fibre supplements are widely used by consumers, which represents common knowledge of their beneficial effects (Anderson *et al.*, 2009).

Kahlon *et al.* (2001) found that high-fibre diets fed to rats resulted in significantly greater wet and dry fecal weights than low-fibre diets. Bran diets resulted in significantly higher fecal moisture than cellulose diets

2.4.4 Cancer

High levels of dietary fibre intake, compared to low levels, may be associated with a decreased prevalence of esophageal cancer (Wu et al. 2013), GERD (Elserag et al. 2005), gastric cancer (Wu et al. 2013), peptic ulcer, gallbladder disease (Tsai et al., 2004), diverticular disease, constipation and haemorrhoids (Cummings 2001).

Dewettinck.*et al.* (2008) opined that grains contain fibres which reduce the occurrence of colorectal cancer. Undigested fibre speeds intestinal transmit time, which decrease the opportunity to fecal mutagens to interact with intestinal epithelium. It also reduces the occurrence of breast cancers.

2.4.5 Constipation

Constipation occurs when bowel movements become difficult or less frequent. Constipation is usually caused by a disorder of bowel function rather than a structural problem. Dietary fibres present in grains which prevent constipation (Zielinski *et al.*, 2001).

Anderson *et al.* (2002) opined that bran is a very useful part of the grain which prevents constipation due to its cellulose content that forms a bulk in the intestine.

2.4.6 Weight Control

In the last years, balanced diet trend is increasing for weight control not only for aesthetic reasons but also for reduction of risks for diabetes, cancer types, cardiovascular diseases, high blood pressure, and sleep disturbances which are the causes of obesity mainly (Murdock, 2002). This diet includes consumption of all kind of food in proper amounts i.e. energy dense foods should not be consumed in high amounts. Insoluble fibre seems to have the opposite effect to that of soluble. Intake of insoluble fibre which helps in reduce body weight (Isken et al., 2010).

2.5 Industrial applications of dietary fibre

To be acceptable, a dietary fibre added to a food product must perform in a satisfactory manner as a food ingredient (Jaime et al, 2002; Figueroa et al, 2002). A functionally perspective fibre can play a number of roles:-

(i) It may be used as a tool for improving texture

(ii) As a bulking agent in reduced-sugar applications

(iii) To manage moisture in the replacement of fat

(iv) To add color, and

(v) As natural antioxidant

(Viuda et al., (2010); Ramirez *et al*,(2010).

Dietary fibres can provide a multitude of functional properties when they are incorporated in food systems. Thus, fibres in addition contributes to the modification and improvement of the texture, sensory characteristics and shelf-life of foods due to their water binding capacity, gel-forming ability, antisticking, anticlumping, texturizing and thickening effects (Dello *et al.*, 2004).

Dietary fibres are added to food products such as baked goods, beverages, confectionery, dairy, frozen dairy, meat, pasta and soups. Most commonly, dietary fibres are incorporated into bakery products to prolong freshness, capacity to retain water, thereby reducing economic losses.

According to Sangnark and Noomhorm, (2004) fibres can modify loaf volume, its springiness, softness of the crumb and the firmness of the bread loaf.

In addition, introduction of dietary fibre in meat products has been shown to improve cooking yield, water binding, fat binding and texture (Cofrades et al., 2000).

Dietary fibre and soy protein preparations due to their functional properties are extensively used in many branches of the food industry, including the meat sector (Waszkowiak and Szymandera, 2008).

Rodríguez et al. (2006) reported that in the case of beverages and drinks, the addition of dietary fibre increases their viscosity and stability.

Dietary fibres from different sources have been used to replace wheat flour in the preparation of bakery products. Potato peel, a by-product from potato industry, rich in dietary fibre, was used as a source of dietary fibre in bread making (Sudha et al., 2007).

Among foods enriched in fibre, the most known and consumed are breakfast cereal and bakery products such as integral breads and cookies (Nelson, 2001; Rodríguez et al., 2006) as well as milk and meat derived products.

The addition of dietary fibre to bakery products also improves their nutritional quality since it makes possible to decrease the fat content by using it as a substitutive of fat without loss of quality (Rodríguez et al., 2006).

Jams and marmalades, the most common added-fibres are those consisting of pectins with different degree of esterification, which mainly comes from fruits are a factor in keeping the stability of the final product. In the case of low-calorie chocolates and derivatives, fibre compounds such as inuline and oligofructose are used as sugar substitutes (Rodríguez et al., 2006).

2.6 Importance of cereal bran.

Bran, an outer layer of most cereal grains is nutrient dense as it contains proteins, omega 3 and omega 6 fatty acids and antioxidants. Cereal bran is an excellent source of dietary fibre. It offers all the nutritional and nutraceutical benefits of whole grain (Devries, 2001)

Prolo et al, (2006) reported that brans are generally composed mainly of insoluble cellulose and hemicelluloses, with only about 5per cent soluble fibre and have little hypercholesterolemia effect. Bran contributes a pleasing sweet, nutty flavor when added as a flavor enhancer in baked products and pasta. Rice bran is

rich in protein, lipids, fibre, minerals (Mg, K, Fe and Mn), B-vitamins and an excellent source of choline and inositol.

According to Mckee and Latner (2000) barley contains a high level of soluble dietary fibre, making it a desirable food component for health benefits. Anti-nutritional factors in different cereal brans limit their potential as a food source. Phytic, trypsin inhibitors, oxalates, tannins, polyphenols, heamagglutinin and lectins are the important undesirable constituents which restrict the straight-away utilization of brans in the diet.

Rice bran has higher phytic content than wheat bran, corn bran and soy bran and oat hulls. Rice bran contains about 69% of the dietary fibre content of brown rice. Pigmented rice may be high in tannins, which are concentrated in the bran during milling.

Jiang and Wang, (2005) reported that, wheat bran is an important dietary fibre source, containing significant amounts of phytate, which has been reported to impair mineral retention under certain dietary circumstances. An extensive literature survey reveals that all these non-nutritional components are protein in nature, with the exception of phytate. To achieve effective utilization of brans for human nutrition, removal/elimination of these undesirable attributes is necessary. Processing treatments such as extrusion cooking, wet, dry, microwave heating and chemical methods can be used for elimination of undesirable components and for bran stabilization and the effect of the soluble oxalate intake could be mitigated by the consumption of high calcium food at the same time (Hoffpauer et al., 2005).

2.5.1 Nutritional composition and health benefits of rice bran

Rice bran contains 12 to 22 per cent oil, 11 to 17 per cent protein, 6 to 14 per cent fibre, 10 to 15 per cent moisture and 8 to 17 per cent ash. It is rich in vitamins including vitamin E, thiamine, niacin, and minerals. It also contains a significant amount of nutraceutical compounds and approximately 4 per cent

unsaponifiable fraction mainly comprised of naturally occurring antioxidant such as tocopherols, tocotrienols, and oryzanol (Ju and Vail, 2005).

Rice bran is a by-product of the rice milling process and it contains various antioxidants that impart beneficial effects on human health.

Anonymous (2009) described rice one of the most important cereal products in Asia. Milling of paddy yield 70 per cent of rice as the major product and by-product consisting of 20 per cent rice husk, 8 per cent rice bran and 2 per cent rice germ.

According to Jiang and Wang, (2005) the bran is the hard outer layer of rice consisting of aleurone and pericarp. Rice bran contains array of micronutrients like oryzanols, tocopherols, tocotrienols, protein and carbohydrates, dietary fibre like β -glucan, pectin and gum.

Rice bran, which was earlier used primarily as animal feed, is now finding major application in the form of rice bran oil.

Ling et al, (2002) reported that feeding bran fractions of certain colored rice varieties had improved antioxidants status in their blood and showed significant reduction in atherosclerotic plaque. Bucci et al. (2003) also reported the antioxidant action of rice bran.

According to Godber et al (2002) rice bran is a good source of antioxidant including vitamin E and oryzanol, high quality of oil and protein and cholesterol lowering waxes and anti-tumor compounds like rice bran.

Rice bran is rich in soluble fibre like beta-glucan, pectin, gums, which is helpful in the reduction of serum cholesterol, certain forms of cancer and constipation (Kantor et al., 2001).

Rice bran proteins are of high nutritional value. (Kennedy and Burlingame, 2003). Paucar et al. (2007) stated that rice bran rich is in lipids and intense lipase activity in the presence of endogenous lipooxygenase cause rapid deterioration of these lipids by rancidity.

Truwell (2002) stated that the consumption of dietary fibre have shown to reduce the risk of coronary heart disease mortality by reducing blood pressure lowering blood cholesterol levels and improving insulin sensitivity.

Abdul and Yu (2000) stated that defatted rice bran is rich in protein, minerals, and vitamins. Possible health benefits of consumption of bran include increased faecal bulk and reduced blood cholesterol.

Rice bran has hypocholesterolemic influence resulting from selective decrease of low density lipoprotein (LDL) cholesterol fraction.

Unsaponifiable fractions present in the rice bran were shown to significantly reduce liver cholesterol level (Berger et al., 2005).

2.6.2 Nutritional composition and health benefits of wheat bran

One of the most highly nutritious cereal bran is wheat bran. It is produced from the outer layer of wheat grain. It is rich in protein, fibre, vitamins, phyto nutrients, B complex vitamins and minerals includes, Mg, Mn, Zn, Ca, P and Fe.

The majority of beneficial antioxidant phyto chemical in whole wheat grain are present in the germ/ bran fraction. In whole wheat grains, the bran/ germ fractions contained 83 per cent of total phenolic content (Adom et al., 2005).

According to Yu et al. (2005), the phenolic antioxidant present in wheat bran has been shown to inhibit LDL oxidation possibly by binding with a lipoprotein B.

Wang (2009) reported that wheat bran contain phenolic compounds, such as feruloyl oligosaccharides which protect against free radical induced oxidative damage in human erythrocytes.

Ross et al. (2004) observed that alkyl resorcinols an antioxidant found in wheat bran has been shown to inhibit platelet binding to fibrinogen, stimulate

thromboxane production and inhibit triglyceride formation, suggesting a potential role for phenolic compound found in the bran fraction in cardiovascular disease.

The important component in whole grain fraction includes sulphur containing amino acids (Methionine and cystine). These amino acids are found higher level in wheat bran (Fradel ,2010). Both these amino acids are precursors of glutathione and contribute to the control of cell oxidative status (Metayer et al., 2008).

The rice bran contain 13-18g/100g of protein, 3-6g/100g of fat, 6-7g/100g of ash and 35-58g/100g of dietary fibre whereas in rice bran it contains 12-20g/100g of protein, 3-22g/100g of fat, 6-7g/100g of ash and 35-58g/100g of dietary fibre (Caballero et al., 2003).

Materials and Methods

3. MATERIALS AND METHODS

The methodology of the present study entitled "Development and quality evaluation of fibre enriched cookies" is undertaken to standardize fibre based cookies and to evaluate their physio-chemical properties, sensory qualities, nutritional composition, shelf life qualities, consumer acceptability and glycemic index.

The methodology and procedures employed for the study have been presented under the following headings:-

3.1 Selection of raw materials
3.2 Preparation of composite flour
3.3 Standardization of cookies
3.4 Quality evaluation of cookies
3.5 Shelf life study
3.6 Glycemic index
3.7 Consumer acceptance of the cookies
3.8 Yield ratio
3.9 Cost of the product
4.0 Analysis of data

3.1 Selection of raw materials

The raw materials selected for the study were refined flour, wheat bran, rice bran, sugar and other adjuncts. Maida was selected (refined wheat flour which contains gluten protein) because it acts as a binder and provides strength and gives greater volume. It is also bland in taste and is easily digestible. The raw materials for the preparation of cookies were purchased from super market, Thiruvananthapuram. The brans (Rice and wheat) were collected from Elite Industries, Thrissur. It was sieved and stored in air tight containers under refrigeration (Plate.1).

3.2 Preparation of Composite flour

Composite flour was prepared by substituting refined flour with bran (rice bran /wheat bran / rice bran +wheat bran) up to maximum 50 per cent in different combinations and proportions. The treatments selected for the study was presented in Table 1.

Table 1. Treatments selected for the formulation of cookies

Treatments	Proportion
$T_{1control}$	100% Refined flour (control)
Rice bran based cookies	
$T_{2\ (50:50)}$	50% Refined flour + 50% Rice bran
$T_{3\ (60:40)}$	60% Refined flour + 40% Rice bran
$T_{4\ (70:30)}$	70% Refined flour + 30% Rice bran
$T_{5\ (80:20)}$	80% Refined flour + 20% Rice bran
$T_{6\ (90:10)}$	90% Refined flour + 10% Rice bran
Wheat bran based cookies	
$T_{7\ (50:50)}$	50% Refined flour + 50% Wheat bran
$T_{8\ (60:40)}$	60% Refined flour + 40% Wheat bran
$T_{9\ (70:30)}$	70% Refined flour + 30% Wheat bran
$T_{10\ (80:20)}$	80% Refined flour + 20% Wheat bran
$T_{11\ (90:10)}$	90% Refined flour + 10% Wheat bran
Rice bran + Wheat bran based cookies	
$T_{12\ (50:50)}$	50% Refined flour + 25% Rice bran + 25% Wheat bran
$T_{13\ (60:40)}$	60% Refined flour + 20% Rice bran + 20% Wheat bran
$T_{14\ (70:30)}$	70% Refined flour + 15% Rice bran + 15% Wheat bran
$T_{15\ (80:20)}$	80% Refined flour + 10% Rice bran + 10% Wheat bran

Plate 1. Types of bran selected

3.3 Standardization of cookies

A standardized recipe is one that has been tried, adopted retried several times for use by a given food service and which has been found to produce the same acceptable results and yield, each time when the exact procedures are used with the same type of equipment and same quantity and quality of ingredients (USDA, 2001). For the purpose of standardization of flour mix, a number of trials were conducted using different combinations of refined flour and bran viz 50:50, 60:40, 70:30, 80:20, 90:10 per cent to prepare 100g flour mix for the preparation of cookies.

3.3.1 Ingredients used

The ingredients used for the preparation of cookies are given in Table 2.

Table 2. Ingredients used for the preparation of cookies.

Ingredients for Sugar cookies	Ingredients for Savory cookies
Refined flour-100g	Refined flour- 100g
Sugar-50g	Butter – 50g
Butter -50g	Baking powder- 5g
Baking powder- 5g	Garam masala powder- 5g
Vanilla essence – 2-3 drops	Coriander leaf powder- 5g
Cashew nuts- 10g	Curry leaf powder – 5g
Bran (10 to 50g)	Sesame seed- 5 g
	Bran (10 to 50g)

3.3.2 Preparation of cookies

The above mentioned ingredients were mixed along with bran in different combinations and proportions. The batter was rolled with pin and cookies and was cut out with cookie cutter. It was baked in a pre-heated oven for 25 to 30 min at 150^0C. The cookies were allowed to cool at room temperature for 8-10 min. Cookies prepared with 100 per cent refined flour was treated as control sample. The developed cookies were compared with control sample for assessing the various quality parameters. The flow chart for the preparation of cookies (sweet and savory) is depicted in Fig 1 and Fig 2.

Fig 1. Flow chart for the preparation of cookies (Sweet)

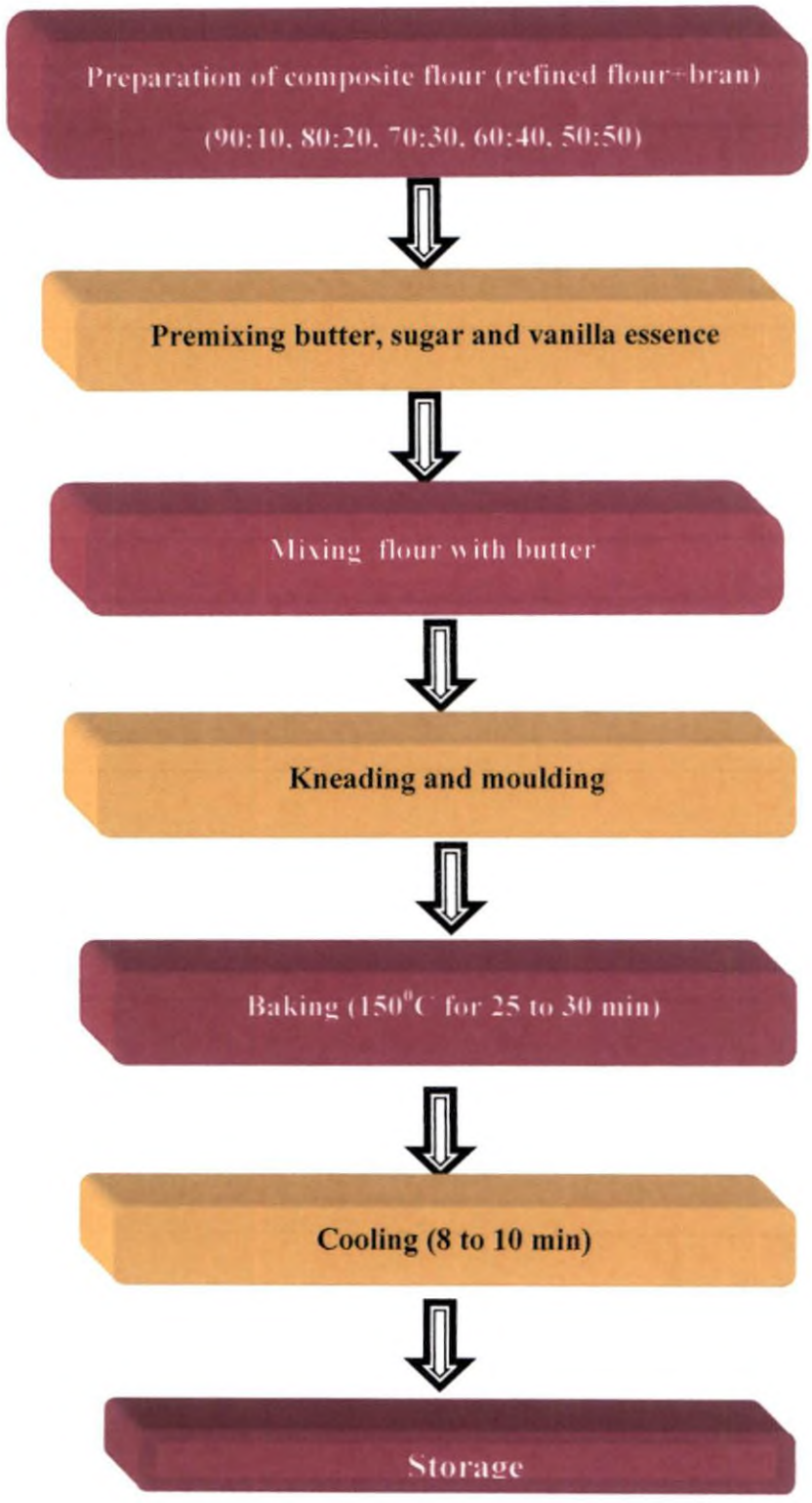
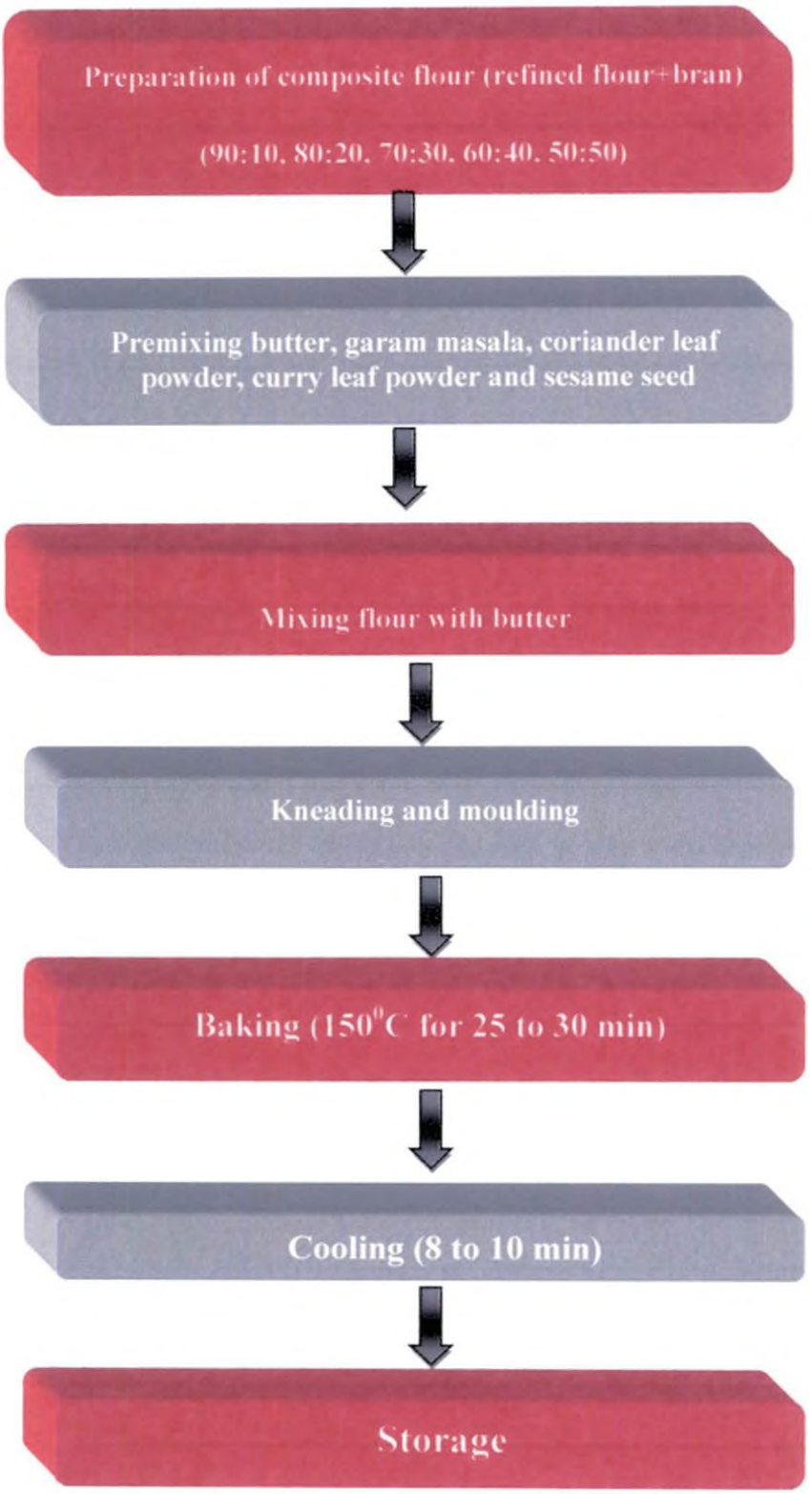


Fig 2. Flow chart for the preparation of cookies (Savory)



3.4 Quality evaluation of cookies

Quality is a very important parameter for judging the edible nature of any food products (Sharma, 2006). It is the ultimate criterion for the desirability of a food product. The quality of the cookies were assessed by sensory, physical parameters, chemical and nutrient composition and shelf life studies.

3.4.1 Sensory evaluation

Sensory quality evaluation plays an important role in the acceptability study of any new product. Sensory evaluation is designed to reflect common man's preference, so as to maintain the quality of a food at a given standard for the assessment of process variations, cost reduction, product improvement, market development and market analysis (Manay and Swamy, 2002). The overall acceptability of the cookies was assessed through organoleptic evaluation. Organoleptic quality i.e. eating quality consists of judging quality of foods by means of human sensory organs- eye, nose and mouth.

In order to select the best combinations of the developed cookies, organoleptic evaluation was conducted by a selected panel of judges using a score card.

3.4.1.1 Selection of Judges

A panel of 10 judges was selected using the triangle test at laboratory level comprising of both students and staff from the Department of Home Science. The best treatments of cookies were identified based on the quality attributes assessed through sensory evaluation and the identified cookies were compared with control.

3.4.1.2 Preparation of Score card

The score card used for the evaluation of cookies in given in Appendix I.

The sensory attributes such as appearance, crispiness, aroma, taste and mouth feel were assessed by assigning scores as described by Sudha et al. (2007).

3.4.1.3 Selection of best treatment

The best treatments of fiber supplemented cookies were determined based on the organoleptic qualities. The treatments which got the highest mean score were selected for in depth analysis.

3.4.2 Evaluation of physical parameters

The physical properties of cookies are important when evaluating the quality attributes from the point of view of consumer acceptance.

3.4.2.1 Weight

Weight of cookies were measured as average values of six individual cookies with the help of an electronic weighing balance (Ayo et al., 2007).

3.4.2.2 Thickness

To determine thickness, six cookies were measured by placing one on top of another using a ruler. This was repeated thrice to get an average value and the result was expressed in millimeter.

3.4.2.3 Diameter / Width

Diameter/ width of the cookies were determined by arranging 6 cookies in a row and taking their average diameter using a digital vernier caliper.

3.4.2.4 Spread ratio

Spread ratio is an indication of ability of the cookies to raise. The spread ratio was determined using the method of Zoulias et al. (2000). It is one of the parameter influencing the palatability and acceptability of cookies. The spread ratio was calculated using the formula:

$$\text{Spread ratio} = \frac{\text{Diameter (mm)}}{\text{Thickness (mm)}}$$

3.4.3. Chemical and Nutrient composition

The chemical and nutrient composition such as moisture, fibre, protein, energy, fat and total minerals were ascertained as per the following procedures.

3.4.3.1 Moisture

Moisture is an important factor which affects the crispiness and stability of cookies. The longevity of a food product is mainly affected by the activities of microorganisms. The moisture content provides medium for growth of microorganisms. So it is inevitable to control the presence of moisture for the stability of the products. The moisture content was determined using hot air oven according to AOAC method (2000).

3.4.3.2 Fat

The fat content was estimated using the soxhlet extraction method using petroleum ether as solvent (AOAC, 2000).

3.4.3.3 Protein

The nitrogen content of the formulated cookies was estimated by Lowry's method (Sadasivam and Manickam, 2008).

3.4.3.4 Energy

Calorific value of the cookies were estimated using bomb calorimeter (Goplan et al., 2009).

3.4.3.5 Crude fibre

Crude fibre was determined according to AOAC method (2000).

3.4.3.6 Total minerals

Total mineral content was estimated as per the method described by Raghuramalu et al. (1983).

3.5 Shelf life study

Shelf life indicates the period up to which the product remains intact in texture of physical, chemical and organoleptic character. To assess the shelf stability, the developed cookies were stored in laminated pouches at ambient conditions. The shelf life of the cookies was ascertained periodically for a period of three months in terms of sensory parameters, moisture and peroxide value.

3.5.1 Moisture

Moisture content of stored cookies was determined as per the method outlined in 3.4.3.1. It is the most important parameter deciding the quality and shelf life of the cookies. The moisture content of the stored cookies also compared with BIS standard specification (IS:1011-2002).

3.5.2 Peroxide value

Peroxide value was measured by AOAC method (2000). This gives a measure of the level of primary oxidation by determining mainly the hydro peroxide content. Compare BIS requirement of biscuit/ cookies was carried out for peroxide value.

3.5.3 Organoleptic evaluation of stored cookies

The organoleptic evaluation of stored cookies was carried out as per the method outlined in 3.4.1

3.6 Glycemic index

Blood sugar levels raises after eating foods containing carbohydrates (sugar and starches). Various carbohydrate containing foods affect blood sugar levels differently. The glycemic index compares the rise in blood sugar levels after eating a particular food to a reference food, often sugar (glucose).

For determining glycemic index, 10 healthy individuals were selected and they were asked to attend the tasting session after 10-12 hours over night fast. The subjects were instructed not to consume unusually large meals, drink alcohol or exercise vigorously on the previous day, and to avoid cycling. On the first day subjects were given the standard or reference carbohydrate. i.e. 50g glucose dissolved in 100ml of water. Blood was taken by finger prick method using a glucometer and measured at 0, 30, 60, 90 and 120 minutes (Plate 10).

Blood glucose curve and the incremental area under the curve (IAUC) were calculated by the trapezoidal rule (Gibaldi and Perrier, 1982).

Equal quantity of cookies having 50g carbohydrate were given for testing against the reference carbohydrate (glucose) on the following two consecutive days. The AUC can be calculated as per the procedure used for calculating reference food.

Calculation of Glycemic Index

The GI was calculated by dividing the AUC of the test food by the AUC of the reference food and multiplying by 100 for each individual using the following formula (Wolever and Boume, 1990).

$$GI = \frac{\text{AUC for test food}}{\text{AUC for reference food}} * 100$$

The final GI for each test food was calculated as the mean of the respective GI's of the ten individuals.

3.7 Consumer acceptance of the cookies.

The best treatments were selected based on organoleptic evaluation. The cookies were assessed by 30 volunteers selected among technical experts, college

Plate 2. Monitoring of blood glucose level

students and school children for their preference and acceptability on a nine point hedonic score system described by Meilgaard et al. (2007) (Appendix II).

3.8 Yield ratio

Yield ratio of developed cookies were analyzed using the formula.

$$\text{Yield} = \frac{\text{Weight of cookies after baking}}{\text{Weight of raw materials}}$$

3.9 Cost of production

Cost of the developed cookies were analyzed based on input cost i.e., cost of different ingredients used for the preparation of the product, cost of packaging materials and output cost (10 per cent of the cost of products were added as overhead charges for fuel and labour to the total input cost).

4.0 Analysis of data

In order to obtain suitable interpretation, the generated data was subjected to statistical analysis like one way analyses of variance (ANOVA) at 0.05% significance level and paired 't' test to calculate significant difference in the treatments means. Graphical interpretation of analyzed data is also prescribed.

Results

4.RESULT

The result of the present investigation entitled "Development and quality evaluation of fibre enriched cookies" are detailed in this chapter under the following headings.

4.1 Standardization of cookies

4.2 Sensory evaluation and selection of best treatment

4.3 Quality evaluation of cookies

4.4 Shelf stability of the cookies

4.5Glycemic index

4.6 Consumer acceptance and preference

4.7 Cost of the product and yield ratio

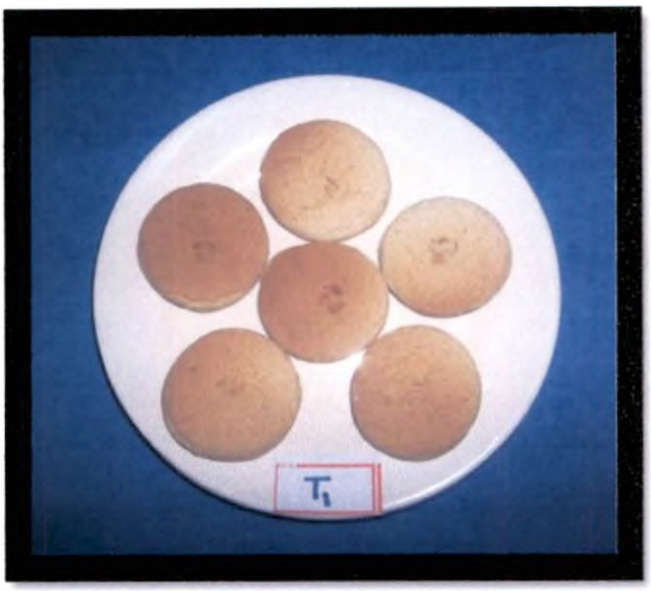
4.1 Standardization of cookies

Standardization and product development play a key role in the growth of food industries. According to Poduval (2002) one of the most important purposes of standardization is to facilitate the movement of materials and products through all stages of production, in any industrial activity starting from the raw material to the finished product through the dealers and finally to the retailers and customers.

Preliminary trials of both sweet and savory cookies were tried using different flavors and were subjected to evaluationamong judges. Sweet cookies were prepared with vanilla, chocolate, cardamom powder and dry ginger powder, whereas savory cookies were prepared with pepper powder, garam masala, dry ginger powder and pav baji masala.

Among the various treatments, sweet and savory cookies with vanilla and garam masala respectively were found to be better in all the parameters. Hence, vanilla flavor and garam masala was selected for the formulation of sweet and savory cookies in different combinations and treatments (Plate 2).

Fibrebased cookies were standardized in the laboratory as detailed in Table 1. of the chapter Materials and Methods (Plate. 3 to 8).



Sweet cookies

Savory cookies

Plate 3. Control cookies

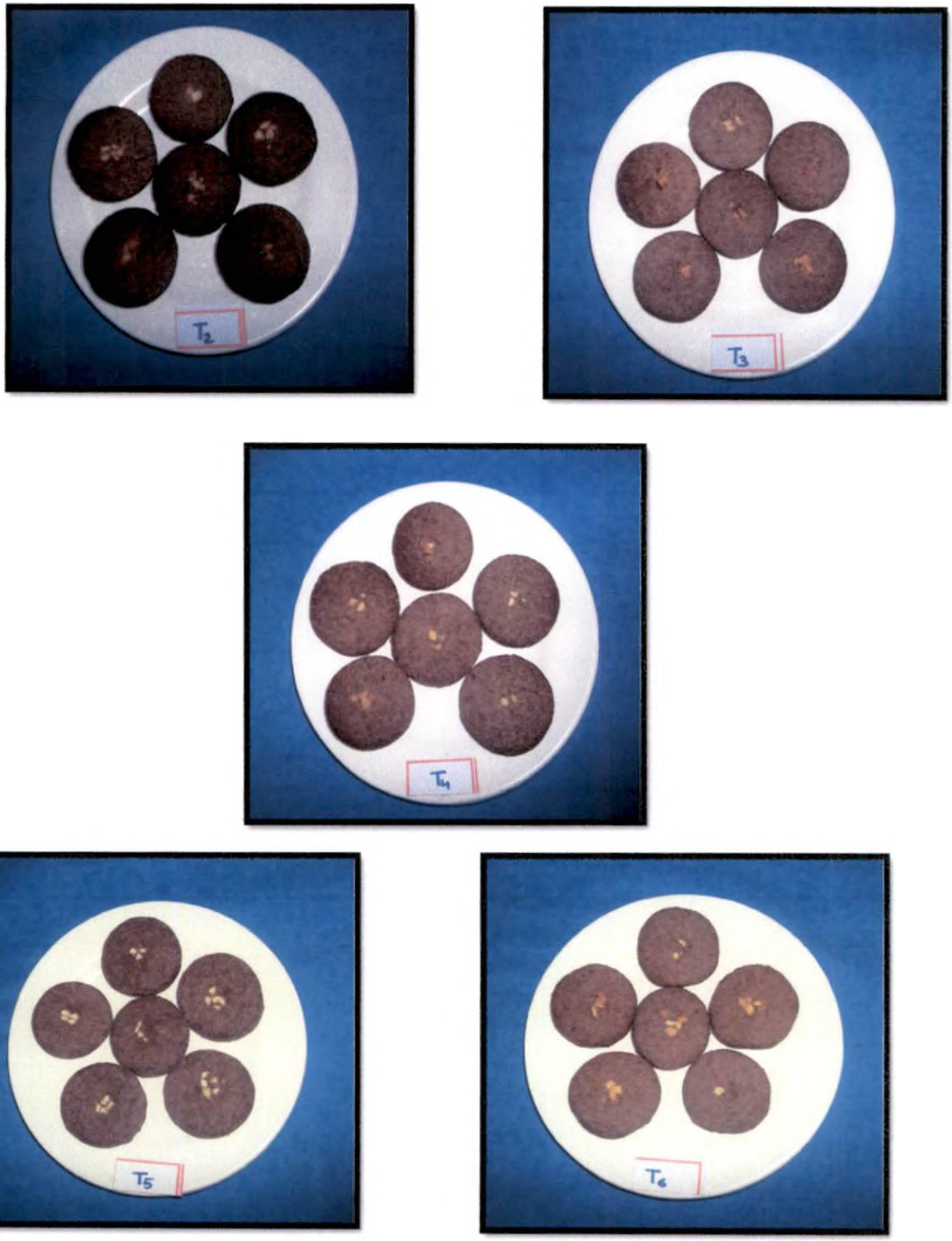


Plate 4. Rice bran based sweet cookies

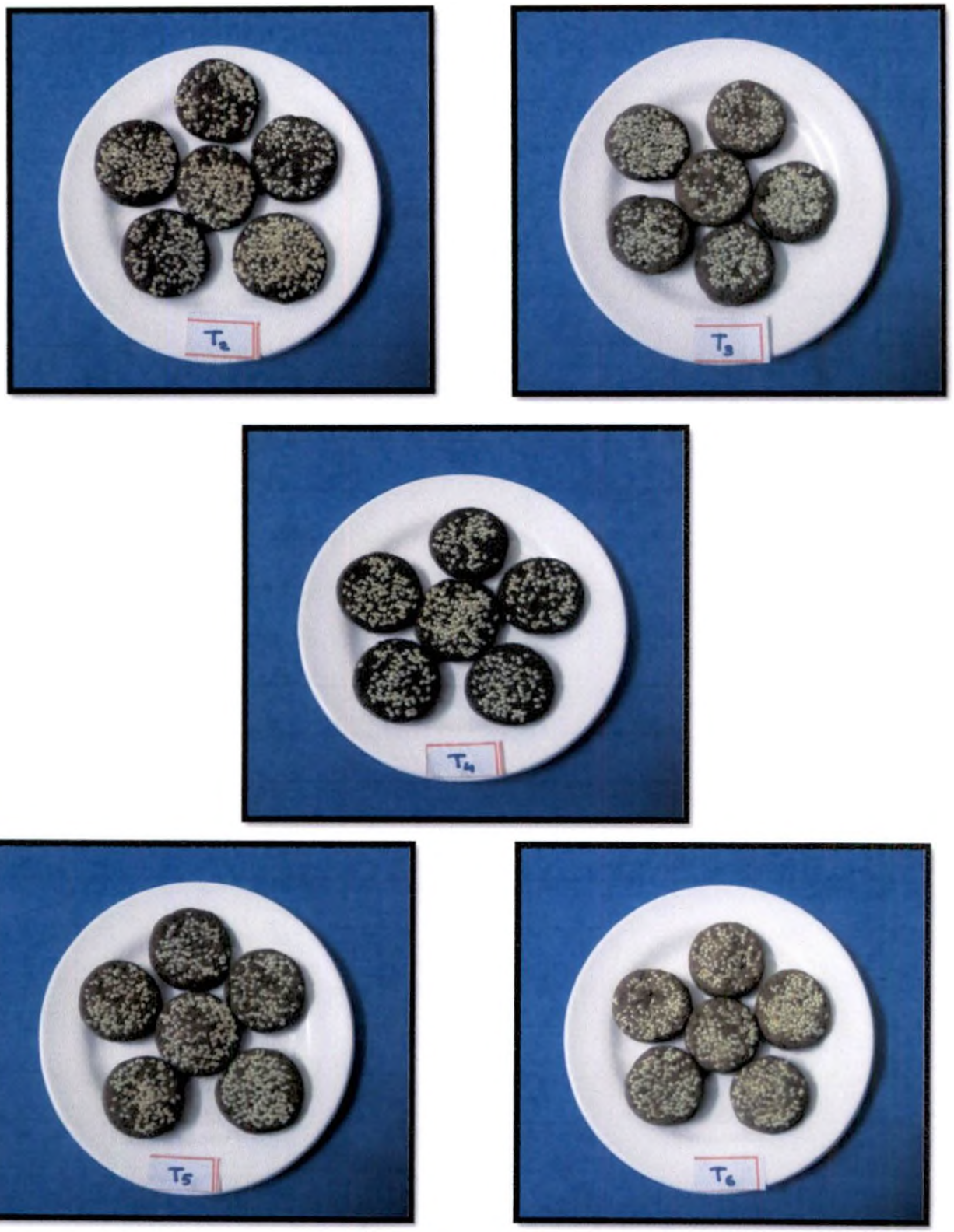


Plate 5. Rice bran based savory cookies

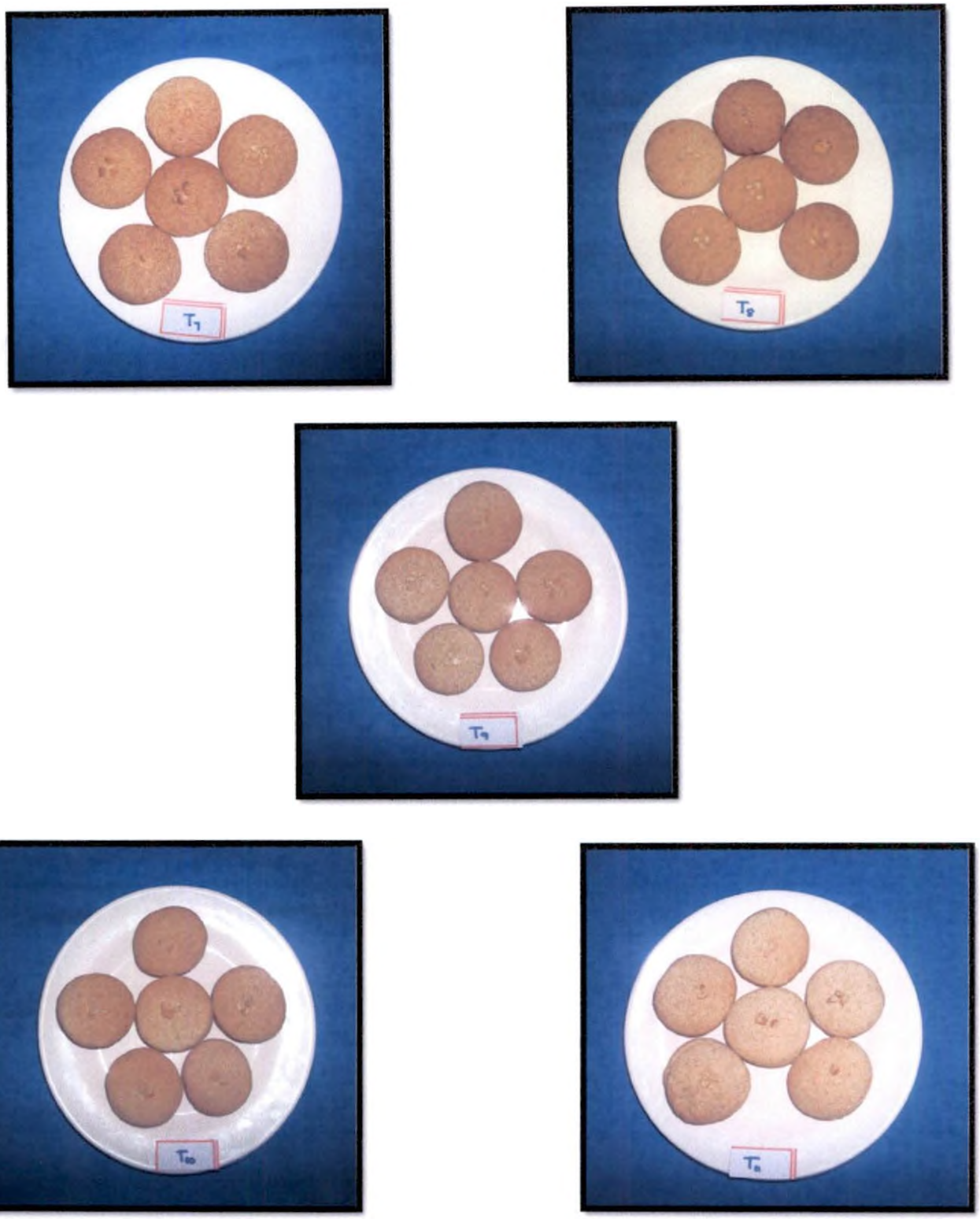


Plate 6. Wheat bran based sweet cookies

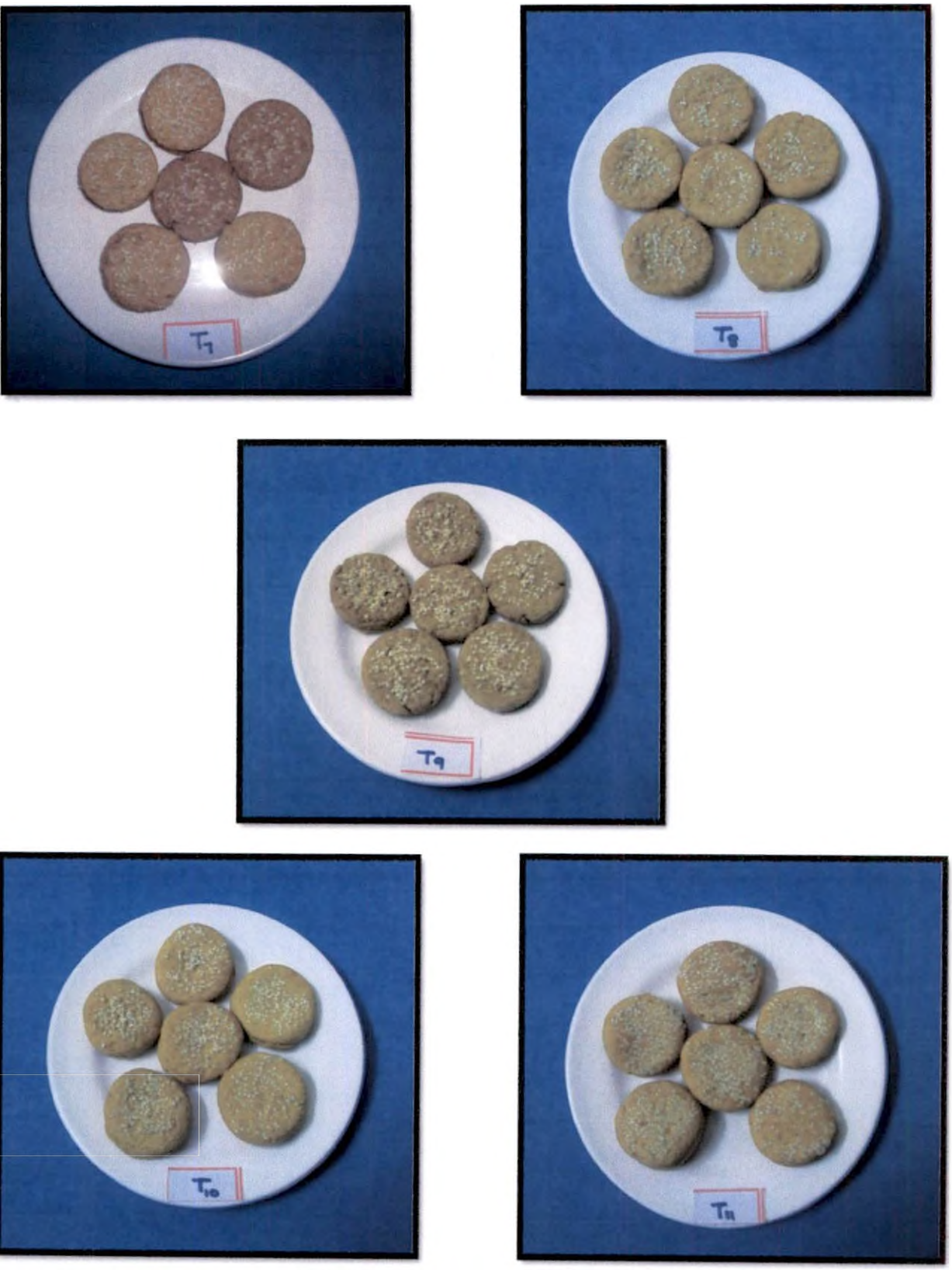


Plate 7. Wheat bran based savory cookies

Plate 8. Rice bran + wheat bran based cookies

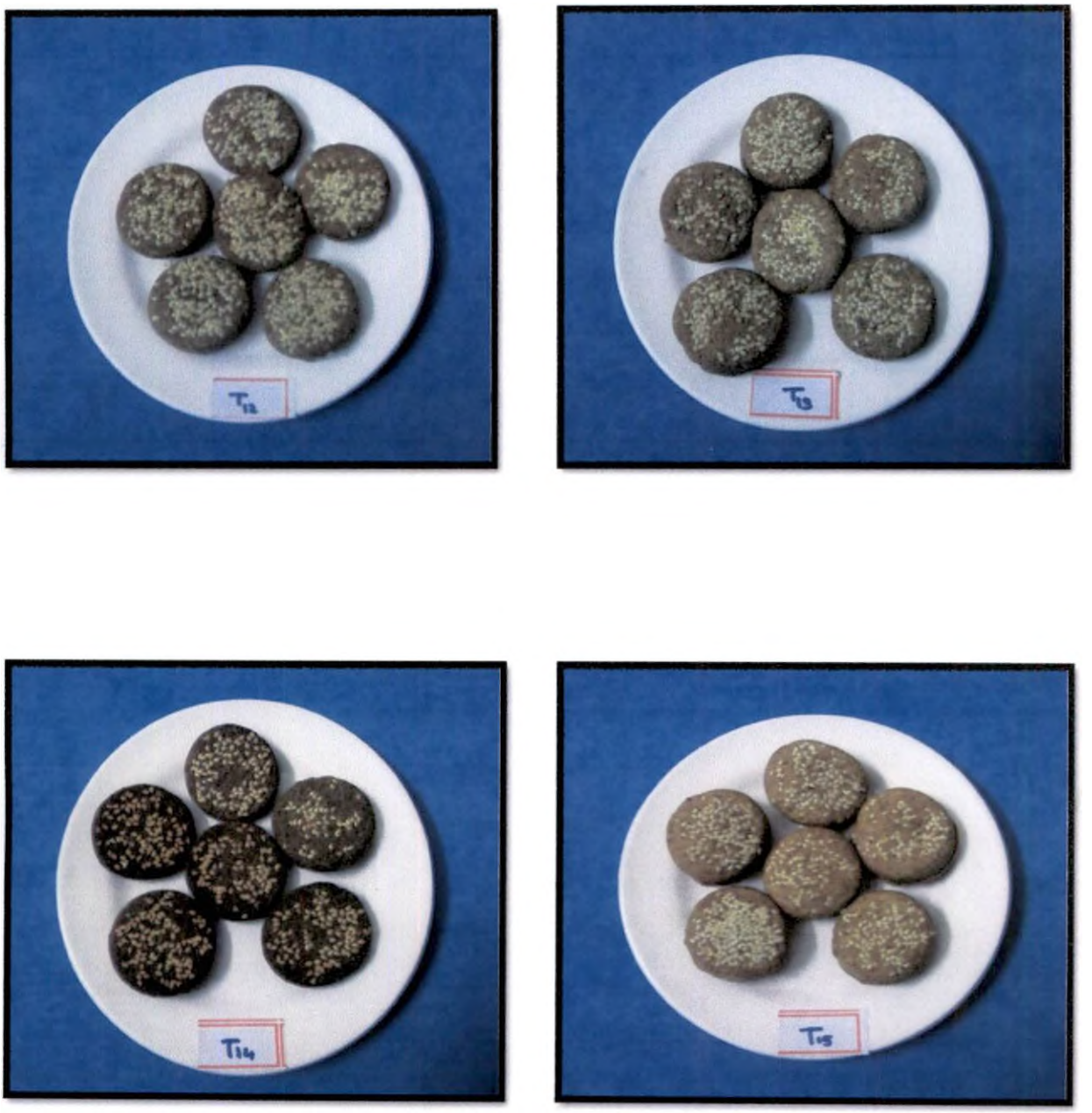


Plate 9. Rice bran + wheat bran based cookies

4.2 Sensory evaluation and selection of best treatments

Sensory evaluation is a scientific discipline that applies the principle of experimental design and statistical analysis to the use of human senses viz., sight, smell, taste, touch and hearing for the purpose of evaluating consumer products (IFT, 2005). The sensory parameters such as appearance, flavor, texture taste and overall acceptability of any food products depends to a great extent on the oxidation of fats and oils in the food due to the formation of peroxide, aldehydes and ketones (Gupta and Singh, 2005).

The fibre enriched cookies standardized under the present study were assessed organoleptically by a panel of 10 judges using a score card on a five point scale. Cookies supplemented with different levels of substitution of cereal bran (rice and wheat) were evaluated organoleptically and compared with control cookies (T_1) (cookies made with 100 per cent refined flour).

Colour

Colour is an important parameter in judging properly baked cookies that not only reflects the suitable raw material used for the preparation but also provides information about the formulation and quality of the product. Table 3 represents the mean scores for the quality attribute appearance of the fibre enriched cookies.

It was evident from the results that highest score was achieved by the cookies prepared from T_9 (4.10) followed by T_4 (4.00) and T_{14} (3.90) in the case of sweet cookies where as it was found highest in T_{14} (4.20) followed by T_4 (3.70) and T_9 (3.60) in the case of savory cookies. The judges dislike cookies prepared with T_2 and T_{11} with respect to colour when subjected under sensory evaluation. T_2, T_5,T_6, T_{11}, T_{12}, T_{13} and T_{15} were on par with T_1 in the case of sweet cookies. In the case of savory cookies, bran based cookies were on par with T_1 (Table.3).

Crispiness

Crispiness is the property of being pure and fresh and not stale or deteriorated.

Table 3 shows the quality scores for the crispiness of the cookies. It is revealed from the table that quality score for the crispiness of the sweet cookies ranged between 2.90 to 4.50. The highest (4.50) value was found for T_9 and lowest (2.90) was noticed in control cookies. In the case of savory cookies, the highest mean score 4.30 was observed in T_9 and T_{14} followed by T_4 (4.10). The lowest score (2.90)

and (2.20) was noticed in both control cookies (T_1) i.e. sweet and savory respectively. Statistical analysis of the above data revealed a significant difference between control and bran supplemented cookies. In sweet cookies, T_7, T_8 and T_{10} were on par with T_{11}.

Aroma

Aroma is the main criterion for a product to be liked or disliked. Odour preference is generalized by stimulation of the sensory cells by specific volatile compounds present in the food. Aroma is commonly defined as being the sensation arising from the integration or interplay of signals produced as a consequence of sensing smell, taste after initiating stimuli from a food or a beverage.

Mean score for the aroma of the cookies revealed that it was varied among different treatments. In sweet cookies, the highest score was shared by wheat bran based cookies (T_9) (4.70) and rice bran + wheat bran based cookies (T_{14}) (4.70). The lowest score was obtained for control sample (T_1) and T_2 (3.20). In the case of savory cookies, the values ranged between 3.20- 4.10. The wheat bran based cookies (T_9) (4.10) scored the highest score when compared with other cookies. Statistical analysis of the data revealed that treatments $T_1$and T_2 were on par with T_3 and treatment T_4 and T_5 were on par with T_6 in the case of savory cookies (Table 3).

Table 3. Sensory evaluation of the cookies

Cookies	Treatments	Average score for aroma											
		Colour		Aroma		Crispness		Mouth feel		Taste		Overall acceptability	
		Sweet	Savory	Sweet	Savory	Sweet	Savory	Sweet	Savory	Sweet	Savory	Sweet	Savory
Control	$T_{1\ (100\%)}$	3.00^{b}	3.10^{ab}	3.20^{c}	3.50^{a}	2.90^{b}	2.20^{c}	3.10^{a}	2.40^{bc}	2.40^{c}	2.50^{b}	2.92^{d}	2.74^{d}
Rice bran based cookies	$T_{2\ (50:50)}$	2.90^{b}	2.80^{a}	3.20^{c}	3.40^{a}	3.60^{a}	3.70^{ab}	3.10^{a}	2.80^{b}	2.70^{bc}	2.40^{b}	3.10^{b}	3.02^{c}
	$T_{3\ (60:40)}$	3.30^{c}	3.30^{c}	3.30^{bc}	3.50^{a}	3.40^{ab}	3.50^{b}	2.60^{b}	2.90^{ab}	2.60^{bc}	2.80^{a}	3.04^{bc}	3.20^{c}
	$T_{4\ (70:30)}$	4.00^{a}	3.70^{b}	3.90^{a}	3.90^{b}	4.00^{a}	4.10^{a}	3.20^{a}	3.40^{a}	3.40^{a}	3.10^{ab}	3.72^{a}	3.64^{a}
	$T_{5\ (80:20)}$	3.40^{b}	3.20^{ab}	3.80^{a}	3.60^{b}	3.50^{ab}	3.60^{ab}	3.00^{a}	2.90^{ab}	3.10^{ab}	2.80^{a}	3.36^{b}	3.22^{b}
	$T_{6\ (90:10)}$	3.40^{b}	3.00^{a}	3.70^{ab}	3.60^{b}	3.20^{b}	3.30^{b}	2.30^{c}	2.80^{b}	2.70^{bc}	2.80^{a}	3.06^{c}	3.10^{c}
	CD (0.05)	0.556	0.567	0.487	0.608	0.687	0.593	0.960	0.570	0.655	0.819	0.961	0.673
Wheat bran based cookies	$T_{7\ (50:50)}$	3.70^{ab}	3.50^{a}	3.70^{b}	3.20^{bc}	3.80^{b}	3.60^{b}	3.90^{a}	2.90^{bc}	3.50^{b}	3.00^{abc}	3.72^{b}	2.24^{c}
	$T_{8\ (60:40)}$	3.60^{c}	3.50^{a}	3.90^{b}	3.20^{bc}	3.70^{bc}	3.20^{c}	3.60^{b}	3.20^{b}	3.50^{b}	3.30^{ab}	3.66^{b}	3.28^{b}
	$T_{9\ (70:30)}$	4.10^{a}	3.60^{a}	4.70^{a}	4.10^{a}	4.50^{a}	4.30^{a}	4.20^{a}	3.80^{a}	4.30^{b}	3.70^{ab}	4.36^{a}	3.88^{a}
	$T_{10\ (80:20)}$	3.70^{ab}	3.30^{a}	4.10^{b}	3.20^{bc}	3.20^{cd}	3.60^{b}	3.80^{b}	3.30^{ab}	3.70^{ab}	3.60^{a}	3.70^{b}	3.42^{ab}
	$T_{11\ (90:10)}$	3.00^{b}	2.90^{b}	3.60^{b}	3.70^{ab}	3.30^{bcd}	3.10^{bc}	2.90^{ab}	3.10^{b}	3.60^{b}	2.90^{bc}	3.28^{c}	3.14^{bc}
	CD (0.05)	0.658	0.913	0.523	0.822	0.529	0.686	0.615	0.592	0.604	0.772	0.498	0.471
Rice bran + wheat bran based cookies	$T_{12\ (50:50)}$	3.60^{b}	3.20^{b}	3.50^{bc}	3.70^{a}	3.60^{b}	3.60^{b}	3.30^{b}	3.00^{a}	2.90^{bc}	2.90^{b}	3.38^{b}	3.28^{b}
	$T_{13\ (60:40)}$	3.40^{b}	3.00^{b}	4.00^{b}	4.00^{a}	3.40^{ab}	3.20^{c}	3.90^{ab}	2.80^{b}	3.40^{ab}	2.50^{a}	3.62^{ab}	3.36^{b}
	$T_{14\ (70:30)}$	3.90^{a}	4.20^{a}	4.70^{a}	3.50^{b}	4.00^{a}	4.30^{a}	4.40^{a}	3.70^{a}	3.60^{a}	3.80^{b}	4.12^{a}	3.64^{a}
	$T_{15\ (80:20)}$	3.50^{b}	3.10^{b}	3.80^{b}	3.50^{b}	3.50^{ab}	3.60^{b}	3.80^{ab}	2.60^{b}	2.70^{c}	2.70^{b}	3.46^{b}	3.10^{c}
	CD (0.05)	0.667	0.554	0.506	0.549	0.687	0.686	0.698	0.637	0.654	0.652	0.609	0.597

Mean values denoted by different letters in the same column are significantly different

Mouth feel

Mouth feel is the textural attribute of a food or beverage which are responsible for producing characteristic tactile sensational on the surfaces of the oral cavity. Mouth feel of the cookies depends mainly on the rate of development of the dough and the proportion of sugar used.

Table 3 depicts the mouth feel of the formulated cookies. The mean scores fell between 2.30-4.40 in the case of sweet cookies and 2.40-3.80 in the case of savory cookies. The highest score was obtained for rice bran +wheat bran supplemented cookies (T_{14}) (4.40) followed by wheat bran supplemented cookies (T_9) (4.20). In the case of savory cookies, the highest score was obtained by wheat bran supplemented cookies (T_9) (3.80) followed by rice bran + wheat bran supplemented cookies (T_{14}) (3.70). T_{12}, T_{15} were on par with T_{13} and T_{15} in the case of sweet cookies and T_8, T_9 andT_{11} were on par with T_{10} in the case of savory cookies.

Taste

Taste is also influenced by the quality of the raw materials used in the processing of cookies. Sharma et al (1993) stated that taste is the primary and most important quality among various attributes.

From the mean score obtained, the range of scores was found to be between 2.40-4.30 in the case of sweet cookies. The highest score was recorded for treatment T_9 (4.30). The lowest mean score (2.40) was achieved by control sample (T_1)

followed by treatment T_3 (2.60). Among savory cookies, the highest score of 3.80 was achieved by rice bran + wheat bran supplemented cookies (T_{14}) (3.80) followed by wheat bran supplemented cookies (T_9) (3.70). T_7, T_8 and T_9 were on par with T_{10} in sweet cookies and in savory T_7, T_8, T_9 and T_{11} were on par with T_7.

Overall acceptability

Overall acceptability is the most important parameter to evaluate the acceptability of a product. It was calculated by taking the total of mean score assigned by 10 judges for appearance, crispiness, aroma, mouth feel and taste.

It was obvious from the results that supplementation significantly affected the overall acceptability of the cookies. Wheat bran based cookies (T_9) was adjudged to be the best in overall acceptability (4.36) among sweet cookies. Control cookie got least score (2.92) with respect to overall acceptability. In the case of savory cookies, the highest score was obtained by wheat bran based cookies (T_9) (3.88) and lowest score was obtained by T_7 (2.24). In sweet cookies, T_2, T_5 and T_6 were on par with T_3 (Table 3).

The sensory evaluation of cookies revealed that the score for sensory parameters like colour (4.10), aroma (4.70), crispiness (4.50), taste (4.30) and overall acceptability (4.36) was found to be higher in wheat bran based sweet cookies (T_9) in the case of sweet ones where as the attribute of mouth feel was found to be highest for rice bran + wheat bran cookies (T_{14}) with a score of 4.40.

In the case of savory cookies, highest mean scores for colour (4.20) and taste (3.80) were bagged by rice bran + wheat bran based cookies (T_{14}) while quality attributes such as aroma (4.10), mouth feel (3.80), and overall acceptability (3.88) were found to be higher for wheat bran based cookies (T_9).

4.2.1 Selection of best treatments

Based on the maximum scores obtained for overall acceptability, six treatments- two bran rice bran based cookies (sweet and savory) (T_4), two from wheat bran (sweet and savory) (T_9) and two rice bran + wheat bran (sweet and savory) (T_{14}) based cookies were selected. Hence the treatments selected in the present study were T_4 (sweet and savory), T_9 (sweet and savory) and T_{14} (sweet and savory). The selected treatments were subjected to in-depth analysis such as physical parameters, chemical and nutrient composition, glycemic index and shelf life study (Plate 9).

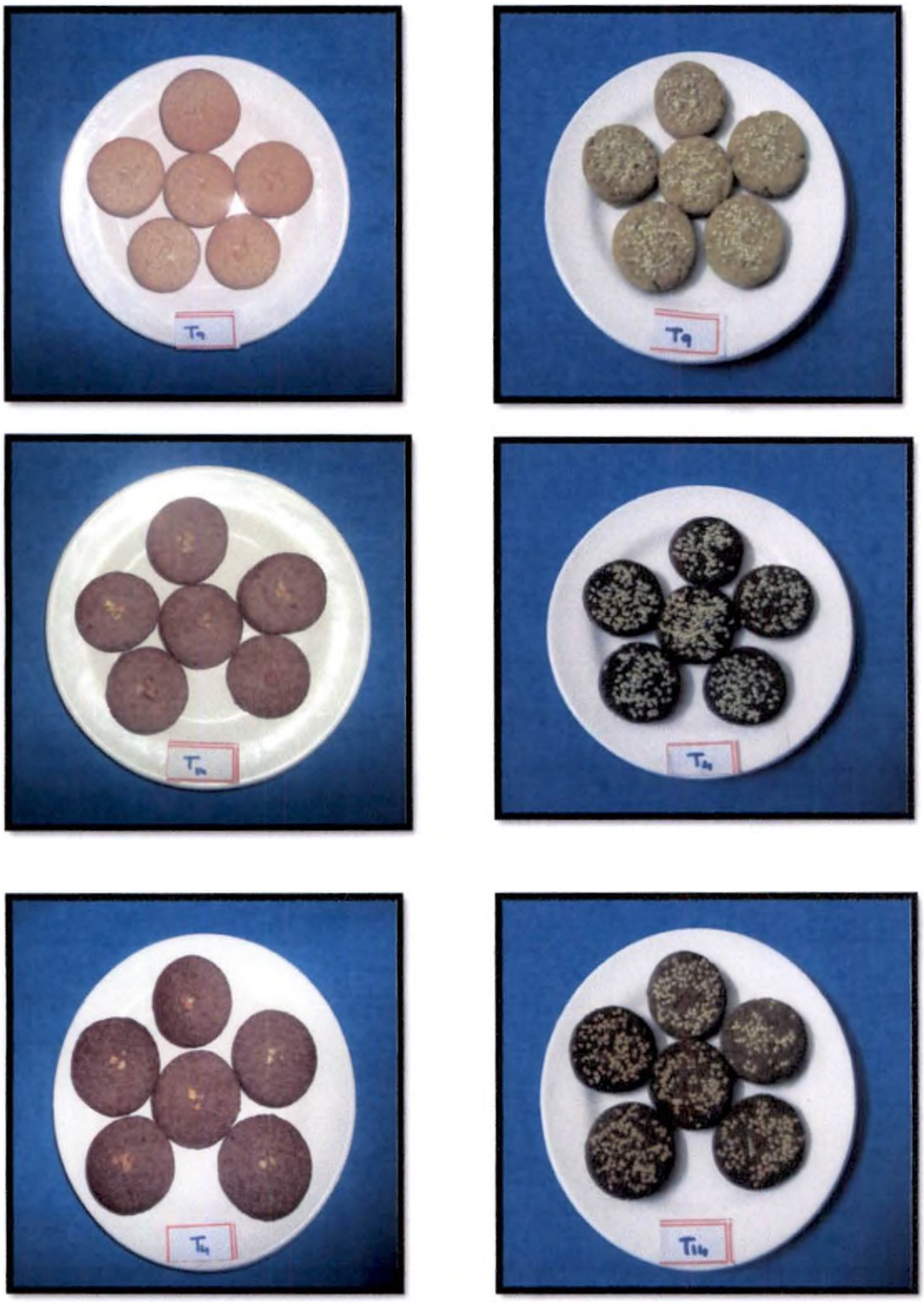


Plate 10. Selection of best treatments

4.3 Quality assessment of cookies

Quality is a very important parameter for judging the edible nature of any food products (Sharma, 2006). It is the ultimate criterion for the desirability of a food product. Among the various factors that influence the quality of a product, sensory attributes followed by chemical constituents are the major factors that determine the quality of a food product either before development or after the development of any food product. The results of the chemical and nutritional composition of selected six bran supplemented cookies (both sweet and savory) with control cookies (both sweet and savory) followed by organoleptic qualities of bran enriched cookies are detailed under quality assessment.

4.3.1 Physical parameters

The selected cookies were compared with their respective control (made with 100% refined flour) for the physical parameters such as weight, diameter/ width, thickness and spread ratio.

4.3.1.1 Weight

Weight of a substance is the measure of the intensity of the force imposed on this object by the local gravitational field or it is the quality of heaviness.

Table 4. Weight of the cookies

Treatments	Sweet(g)	Savory(g)
T1	13.67^{c}	13.33^{b}
T4	15.00^{b}	14.33^{ab}
T9	16.00^{a}	15.33^{a}
T14	15.33^{ab}	15.00^{a}
CD (0.05)	0.769	1.331

Mean values denoted by different letters in the same column are significantly different

The data revealed that weight of cookies ranged between 13.67-16.00g in the case of sweet cookies where as it ranged between 13.33- 15.33g in the case of savory cookies. It was observed that control cookie had the minimum weight both in the case of sweet and savory cookies (13.67g and 13.33g respectively). An increase in weight of cookies was observed with the addition of bran when compared to control. The mean value of weight revealed that cookies made with wheat bran were found to be heaviest (16.00g) among the samples (Table 4).

4.3.1.2 Diameter / width

The diameter of cookies is a line that passes through the center and starts and ends at two opposite points on its perimeter or edge.

Table 5. Diameter / width of the cookies

Treatments	Sweet(cm)	Savory(cm)
T1	3.77^{c}	3.67^{b}
T4	4.00^{b}	3.90^{ab}
T9	4.10^{ab}	4.13^{a}
T14	4.20^{a}	4.10^{a}
CD (0.05)	0.188	0.243

Mean values denoted by different letters in the same column are significantly different

The result of diameter of cookies revealed that it was found to be highest for cookies supplemented with wheat bran + rice bran incorporated ones (4.20mm) followed by wheat bran cookies (4.10mm). It was observed that sweet cookies exhibited higher diameter than control one. In the case of savory cookies, control sample (3.67) was on par with cookies made with rice bran (T_4) (3.90) but it differed significantly between control and bran supplemented treatments with respect to sweet cookies. The control sample exhibited less diameter both in the case of sweet (3.77mm) and savory cookies (3.67mm) (Table 5).

4.3.1.3 Thickness

Thickness of cookies is the measure of how thick a product is, as distinguished from the length or width of any of its surfaces.

Data on thickness of the cookies is presented in the Table 6.

Table 6. Thickness of the cookies

Treatments	Sweet(cm)	Savory(cm)
T1	1.13^{b}	1.18^{c}
T4	1.27^{a}	1.24^{b}
T9	1.28^{a}	1.29^{a}
T14	1.29^{a}	1.28^{ab}
CD (0.05)	0.041	0.036

Mean values denoted by different letters in the same column are significantly different

The result of ANOVA on thickness revealed that all the three bran incorporated cookies differ significantly with the control both in the case of sweet and savory cookies (Table 6). At the same time, the bran incorporated cookies were on par with each other in the case of sweet cookies where as in the case of savory cookies, the wheat bran + rice bran incorporated cookies (1.28) was on par with wheat bran incorporated cookies (1.29) and rice bran incorporated cookies (1.24). The maximum thickness was found in cookies supplemented with rice bran + wheat bran (1.29) in the case of sweet cookies where as it was found to be highest in cookies incorporated with wheat bran (1.29) in the case of savory cookies. The thickness was found to be minimum in the case of control samples both in sweet and savory cookies (1.13 cm and 1.18cm) (Table 6).

4.3.1.4. Spread ratio

Spread ratio represents the ratio of diameter to height.

Table 7. Spread ratio of the cookies

Treatments	Sweet	Savory
T1	3.83^{a}	3.58^{a}
T4	3.59^{b}	3.36^{b}
T9	3.57^{b}	3.48^{ab}
T14	3.56^{b}	3.41^{b}
CD (0.05)	0.133	0.134

Mean values denoted by different letters in the same column are significantly different

The spread ratio values depicted in Table 7 reveals that there was a significant difference in spread ratio between control and bran supplemented cookies. It was observed that control had maximum spread ratio both in the case of sweet and savory cookies (3.83 and 3.58 respectively). The results of ANOVA revealed that spread ratio of bran supplemented cookies were on par with each other. In the case of savor cookies, T_9 was on par with T_4 and T_{14}. The lowest spread ratio (3.56 and 3.36) was noticed in T_{14} and T_4 respectively.

Salient findings of physical parameters revealed that in the case of sweet cookies, the weight was found to be higher in wheat bran supplemented cookies (T_9). The diameter/width and thickness was found to be higher in rice bran + wheat bran supplemented cookies (T_{14}). The highest spread ratio was observed in control cookies (T_1). Whereas, in the case of savory cookies, weight (15.33), diameter (4.13), thickness (1.29) and spread ratio (3.48) was found to be highest in wheat bran supplemented cookies (T_9).

4.3.2 Chemical and nutrient composition.

Nutritional quality of food appears to be the major concern for the consumers. In recent years, there have been significant changes in the preference of consumers for foods that are healthier, higher nutritional quality and more exotic. Individual food manufactures are to respond rapidly to these changes in order to remain competitive within the food industry.

Saxena (2003) reported that laboratory analyses are one of the best methods to assess the quality of different constituents present in the product. Proximate composition of the cookies were ascertained with respect to moisture, carbohydrate, protein, fat, energy, fibre and total minerals.

4.3.2.1 Moisture

Moisture estimation is an important parameter for product development. Foods constitute a considerable amount of water rather than other ingredients. Moisture content of food material is an important factor as it affects the physical and chemical aspects of food which relates to the freshness and stability of food.

Table 8. Moisture content of the cookies

Treatments	Sweet (%)	Savory (%)	t values
T_1	2.78^c	2.53^c	9.714
T_4	3.98^a	3.85^a	7.201
T_9	3.50^b	3.50^b	3.464
T_{14}	3.30^b	3.39^b	3.779
CD (0.05)	0.342	0.228	NS

Mean values denoted by different letters in the same column are significantly different

The moisture content of the cookies is depicted in Table 8. From the table it was observed that there was no significant difference between wheat bran sweet cookies (3.50%) and rice bran +wheat bran sweet cookies (3.30%). The highest moisture content was found in rice bran sweet cookies (3.98%) followed by wheat bran sweet cookies (3.50%) and rice + wheat bran sweet cookies (3.30%). The lowest value of moisture content was recorded in control sample (2.78%). The moisture content ranged between 2.53-3.85 per cent in the case of savory cookies. The results revealed that there was no significant difference between sweet and savory cookies (Table 8).

4.3.2.2 Energy

All activities of the body require energy, and all needs are met by the cons umption of food containing energy in chemical form.

Table 9. Energy content of the cookies

Treatments	Sweet (Kcal)	Savory (Kcal)	t values
T_1	524^a	485^a	11.821
T_4	512^c	470^c	6.833
T_9	494^d	443^d	5.941
T_{14}	518^b	476^b	6.313
CD (0.05)	0.771	0.769	NS

Mean values denoted by different letters in the same column are significantly different

There was a significant difference between the control and bran supplemented cookies with respect to energy content. The energy content of sweet cookies fell between 494-524 Kcal/100g where as it ranged between 443-485 Kcal/100g in the case of savory cookies. The highest energy content was noticed for control sweet cookies (524 Kcal) followed by rice bran + wheat bran supplemented cookies (518 Kcal). In the case of savory cookies highest value was noticed again for control cookies (485 Kcal). The lowest energy content was

observed in wheat bran cookies i.e.443 Kcal in the case of sweet and 494 Kcal for savory cookies. There was no significance difference between sweet and savory cookies ($p>0.05$) (Table 9).

4.3.2.3 Fibre

Fibre is the indigestible portion of food derived from plants. Fibres can act by altering the nature or the contents of the gastrointestinal tract and by changing the rate of absorption of nutrients and chemicals.

Data on fibre content of cookies is depicted in Table 10

Table 10. Fibre content of the cookies

Treatments	Sweet (g/100g)	Savory (g/100g)	t value
T_1	1.40^{d}	1.43^{c}	8.010
T_4	2.50^{c}	2.63^{b}	1.615
T_9	3.03^{b}	3.26^{a}	4.666
T_{14}	3.40^{a}	3.50^{a}	2.333
CD (0.05)	0.317	0.461	NS

Mean values denoted by different letters in the same column are significantly different

In the case of sweet cookies, the highest fibre content was found in rice + wheat bran cookies (3.40g). The lowest fibre content was observed for control sample (1.40g). Significant differences were noticed in fibre content of all the bran supplemented sweet cookies. Wheat bran supplemented cookies were seen to be on par with wheat + rice bran supplemented cookies but other treatments were significantly different in the case of savory cookies. The highest and lowest fibre content was noticed in rice bran + wheat bran supplemented cookies (3.50g) and control sample (1.43g) respectively with respect to savory cookies. There was no significant difference between sweet and savory cookies.

4.3.2.4 Fat

Fat is an essential nutrient as it provides energy, absorbs certain nutrients and maintain core body temperature. Fats are the most concentrated source of energy (calories) in the diet, providing nine calories per gram compared to four calories per gram for either protein or carbohydrates.

Data on fat content of the cookies is depicted in Table 11.

Table 11. Fat content of the cookies

Treatments	Sweet (g/100g)	Savory (g/100g)	t value
T_1	11.13^d	10.76^d	17.428
T_4	16.19^b	16.23^b	9.231
T_9	14.16^c	13.53^c	4.101
T_{14}	17.51^a	17.63^a	1.470
CD (0.05)	1.384	1.115	NS

Mean values denoted by different letters in the same column are significantly different

From the above table it could be noted that high fat content was noticed in rice bran + wheat bran supplemented sweet cookies (17.51g). The lowest fat content was observed in control cookies (11.13/100g). The rice bran supplemented sweet cookies had 16.19 g and wheat bran supplemented sweet cookies had 14.16g fat content/100g . The results proved that there was significant difference in fat content between treatments.

The fat content present in the savory cookies ranged from 10.76 to 17.63g. The highest amount of fat was present in rice bran + wheat bran supplemented savory cookies (17.63g). The least fat content was noticed in control sample (100% refined flour) when compared with other bran supplemented cookies (10.76). Statistical analysis of data revealed significant differences between the

cookies. The results revealed that there was no significant difference between sweet and savory cookies at 5 % level.

4.3.2.5 Protein

Protein is one of the most important nutrients required by the body to carry out wide range of function essential for the maintenance of life. Protein are essential components of tissues and cells of the body (Gopalan et al.,2009).

Table 12. Protein content of the cookies

Treatments	Sweet (g/100g)	Savory (g/100g)	t values
T_1	5.00^c	5.36^c	5.281
T_4	6.79^b	7.01^b	5.800
T_9	8.46^a	8.60^a	19.00
T_{14}	8.49^d	8.84^d	13.333
CD (0.05)	0.672	0.838	NS

Mean values denoted by different letters in the same column are significantly different

The protein content of the developed cookies are depicted in Table 12. From the above table it was observed that there was no significant difference in the protein content of the sweet cookies and it ranged between 5.00-8.49g. The protein content was found to be higher for rice bran +wheat bran based sweet cookies (8.49g/100gm). The lowest protein content was noted in control samples for both sweet and savory cookies (5.00 and 5.36g/100g). The wheat bran sweet cookies (T_9) and rice bran sweet cookies (T_4) contained 8.46g and 6.79g respectively.

In the case of savory cookies, the protein content was found to be highest in rice bran + wheat bran cookies (8.84g) while the least in control sample (5.36g) when compared with wheat bran cookies (8.60g) and rice bran cookies (7.01g). In protein content also there was no significant difference between sweet and savory cookies (Table 12).

4.3.2.6 Total Ash

Total ash content or total minerals is the measure of the total amount of minerals present within a food, whereas the mineral content is a measure of the amount of specific inorganic components present within a food.

Table 13. Ash content of the cookies

Treatments	Sweet (g)	Savory (g)	t value
T_1	0.83[b]	0.99[b]	2.253
T_4	2.06[a]	2.26[a]	1.913
T_9	2.12[a]	2.22[a]	1.105
T_{14}	2.33[a]	2.23[a]	5.400
CD (0.05)	0.301	0.405	NS

Mean values denoted by different letters in the same column are significantly different

The ash content of the selected cookies are shown in Table 13. Their levels ranged from 0.83-2.33g/100g in the case of sweet cookies. The highest ash content was noticed for rice + wheat bran sweet cookies (2.33g/100g) and lowest in control sample (0.83g/100g). The ash content of all the three bran supplemented cookies differ significantly with the control sample but were on par with each other. In savory cookies, higher ash content was recorded for rice bran savory cookies (2.26g/100g) followed by rice bran + wheat bran cookies (2.23g/100g). The control sample exhibited lowest ash content (0.99g/100g). Significant differences were observed between bran supplemented cookies and control sample with respect to ash content. In both control and bran cookies there was no significant difference between sweet and savory cookies.

4.3.2.7 Calcium

Calcium is essential for all living organisms, in particular for the cell physiology. As a major material used in mineralization of bone, teeth and shells. Calcium is the most abundant mineral by mass in most animals.

Table 14. Calcium content of the cookies

Treatments	Sweet (mg/100g)	Savory (mg/100g)	t values
T_1	20.50^c	24.73^c	8.03
T_4	61.36^a	62.10^a	15.00
T_9	50.43b	51.10^b	11.50
T_{14}	62.70^a	62.66^a	13.83
CD (0.05)	2.724	4.010	NS

Mean values denoted by different letters in the same column are significantly different

The calcium content of the developed cookies is depicted in Table 14. From the table it may be noted that the calcium content ranged from 20.50-62.70 mg in the case of sweet cookies and minimum level were noted in control sample (20.50). Statistically significant differences were noted between control sample and bran supplemented cookies. At the same time, the calcium content of rice + wheat bran supplemented cookies were observed to be high as 62.70mg/100g followed by rice bran supplemented cookies 61.36 mg/100g respectively. The differences between these values were statistically significant.

In the case of savory cookies also, highest calcium content was observed in rice bran + wheat bran supplemented cookies (62.66g) followed by rice bran supplemented cookies (62.10g). There was no significant difference between sweet and savory cookies in both control and bran cookies.

4.3.2.8 Potassium

Potassium is an essential macro-mineral in human nutrition. It is the major cation in animal cells and is important in maintaining fluid and electrolyte balance in the body. Potassium is also important in conducting muscle contraction and in the sending of all nerve impulses through action potential.

Table 15. Potassium content of the cookies

Treatments	Sweet (mg/100g)	Savory (mg/100)	t value
T_1	160.16^b	162.30^d	61.77
T_4	240.86^a	271.06^a	30.19
T_9	175.80^b	174.53^c	28.95
T_{14}	249.40^a	248.16^b	79.03
CD (0.05)	32.852	9.625	NS

Mean values denoted by different letters in the same column are significantly different

The potassium content of the developed cookies is depicted in Table 15. The data revealed that the potassium content was found to be highest in rice + wheat bran sweet cookies (249.40 mg) and lowest in control (160.16 mg) sample. The level of potassium in rice bran sweet cookies (T_4) and rice +wheat bran sweet cookies (T_{14}) were on par with each other.

In the case of savory cookies, there was significant difference between the calcium content of the developed cookies. The highest content of potassium was found in rice bran savory cookies (271.06 mg) followed by rice +wheat bran cookies (248.16 mg). Control sample exhibited the lowest amount of potassium (162.30 mg). Significant difference was not observed between sweet and savory cookies at 5% level.

4.3.2.9 Sodium

Sodium is possibly the most important mineral in the body. Sodium is a mineral that exists in the body as the Na ion. Sodium is acquired through diet, mainly in the form of salt (sodium chloride).

Table 16. Sodium content of the cookies

Treatments	Sweet (mg/100g)	Savory (mg/100g)	t value
T_1	118.10^{d}	115.63^{d}	14.70
T_4	132.19^{c}	133.80^{c}	15.71
T_9	215.90^{a}	226.40^{a}	16.79
T_{14}	166.10^{b}	163.83^{b}	11.93
CD (0.05)	12.202	10.33	NS

Mean values denoted by different letters in the same column are significantly different

Table 16 depicts the sodium content of the developed cookies. The statistical analysis of data revealed that, there was a significant difference between the cookies. The sodium content was found to be 215.90 mg in wheat bran sweet cookies. Rice + wheat bran sweet cookies exhibited a sodium content of 166.10 mg and rice bran cookies showed 132.19 mg. Sodium content was found to be lowest in control sample (118.10 mg).

The data also revealed that there was a significant difference between the sodium content of the savory cookies. The sodium content ranged between 115.63 mg to 226.40 mg / 100g. Highest sodium content was again noticed in wheat bran supplemented cookies (226.40 mg) followed by rice + wheat bran supplemented cookies (163.83 mg). There is no significant difference between sweet and savory cookies.

Major findings of chemical and nutrient composition revealed that moisture content was highest in rice bran supplemented sweet cookies (T_4) (3.98). The control cookies (T_1) had higher amount of energy (524kcal). Fat (17.63g), protein (8.84g) and ash (2.33%) contents were found to be highest in rice bran + wheat bran supplemented cookies (T_{14}). Minerals like calcium (62.70mg in sweet cookies) and potassium (271.06 mg in savory cookies) was found to be higher in rice bran supplemented cookies (T_4).

4.4 Shelf life of the cookies

Assessment of shelf life quality is important since it determines the suitability of a particular ingredient for the product development. Shelf life is the recommendation of time that the products can be stored, during which the defined quality of a specified proportion of goods remains acceptable under expected conditions of distribution, storage and display (Azanha and Faria, 2005). Shelf life is the period between the manufacture and the retail purchase of a food product, during which time the products is of satisfactory quality in terms of nutritional value, sensory quality etc. The shelf life quality of the developed cookies was analyzed by assessing the moisture content, peroxide value and sensory qualities up to a period of three months.

4.4.1 Moisture

Moisture content is one of the most commonly measured properties of food materials. Knowledge of the moisture content is often necessary to predict the behavior of foods during processing. The moisture content of the stored cookies packed in laminated pouches was analyzed.

Moisture content of the cookies is depicted in Table 17.

Table 17. Moisture content of the stored cookies (percentage)

Storage period	Sweet				Savory			
	T_1	T_4	T_9	T_{14}	T_1	T_4	T_9	T_{14}
Initial month (0 day)	2.78	3.98	3.50	3.30	2.53	3.85	3.50	3.39
I^{st} month	2.82	4.07	3.60	3.35	2.63	3.91	3.59	3.47
II^{nd} month	2.85	4.15	3.64	3.40	2.64	3.99	3.64	3.50
III^{rd} month	2.90	4.20	3.69	3.47	2.67	4.09	3.71	3.59
% Increase	0.12	0.22	0.19	0.17	0.14	0.24	0.21	0.20

Table.17 indicate that the moisture content of the stored cookies. The moisture content of the stored cookies gradually increased during storage period. The percentage increase was ranged between 0.12 to 0.22 in the case of sweet cookies. The highest percentage increase was found in cookies incorporated with rice bran (0.22) were followed by wheat bran cookies (0.19) and rice bran + wheat bran cookies (0.17) whereas in the case of savory cookies, the percentage increase ranges from 0.14 to 0.24. In savory cookies also rice based cookies (0.24) showed highest increase moisture percentage during storage period.

As per the BIS Specification (IS:1011-2002), the estimated value of the moisture was below the BIS specification. The BIS specification for moisture content of cookies was maximum 6.00 per cent, where as in the developed cookies the moisture content ranges between 2.78-4.20 % for sweet cookies and 2.53-4.09% savory cookies respectively.

4.4.2 Peroxide value of the stored cookies

Peroxide value gives an indication about the extent of peroxidation taking place in stored food materials. The acceptability of a food product depends on the extent to which deterioration has occurred and oxidative rancidity is a major cause of food deterioration. This in turn represents a major cause of loss of nutritional quality as well as cause of concern for food safety, as the oxidized fats in a very high dosage have been shown to have toxic effects (Sen and Sen,2009). The peroxide value was recorded for a period of 3 months.

Table 18. Peroxide value of the stored cookies (meq/kg)

Storage period	Sweet				Savory			
	T_1	T_4	T_9	T_{14}	T_1	T_4	T_9	T_{14}
Initial month (0 day)	0	0	0	0	0	0	0	0
I^{st} month	0	0	0	0	0	0	0	0
II^{nd} month	0	0	0	0	0	0	0	0
III^{rd} month	0.19	0.21	0.20	0.20	0.19	0.23	0.21	0.23
Mean	0.04	0.05	0.05	0.05	0.04	0.05	0.05	0.05

The changes in peroxide value of cookies are depicted in Table 18. The peroxide value was not observed upto a period of 60 days of storage. There after negligible values were noticed in stored cookies. It was also observed that there was a linear relationship between peroxide value and storage period. As the storage period increases, the peroxide value also increases. In sweet cookies, the mean value of the peroxide value ranges from 0.04 to 0.05 meq/kg. Whereas in the case of savory cookies it ranges between 0.04-0.05meq/kg.

4.4.3. Sensory evaluation of the stored cookies

Sensory evaluation of the food products plays an important role in determining the acceptability and shelf stability of products. Chemical indices of deterioration alone will not decide the quality changes and it should be correlated with sensory evaluation of stored products. Hence, periodical evaluation of the cookies were carried out with respect to the sensory parameters using a score card by a selected panel of judges to understand the deteriorative changes occurring in the cookies. The cookies were evaluated at monthly interval for color, crispiness, aroma, mouth feel and taste during the period of storage.

4.4.3.1 Color

Colour is the criterion for the desirability of any food product. The color of the food product is contributed by surface characteristics i.e. size, shape, transparency, opaqueness, turbidity and doneness (Srilakshmi, 2003). The changes in the color of cookies is presented in Table 19.

Table 19. Influence of storage on the colour of cookies (mean score)

Storage period	Sweet				Savory			
	T_1	T_4	T_9	T_{14}	T_1	T_4	T_9	T_{14}
Initial month (0 day)	3.00[b]	4.00[a]	4.10	3.90	3.10	3.70	3.60	4.20
I[st] month	3.00[ab]	3.70[a]	3.90	3.60	3.00	3.40	3.40	3.40
II[nd] month	2.90[b]	3.20[a]	3.50	3.40	2.80	3.00	3.30	2.90
III[rd] month	2.50[b]	2.70[b]	3.20	2.30	2.60	2.60	2.90	2.60
CD (0.05)	0.603	0.567	0.497	0.420	0.572	0.522	0.452	0.422

Mean values denoted by different letters in the same column are significantly different

The mean scores obtained for color of stored cookies were decreased gradually during the storage period. Statistically significant difference was observed in the quality attribute color during storage. A linear relationship was observed between quality attribute color and storage period. As the storage period increases, the mean score for appearance decreases. No significant difference was observed in the mean score of treatments during the storage period with respect to colour. The highest score for colour was obtained by T_9 during initial day which was gradually decreased to 3.20 at the end of 90[th] day in the case of sweet cookies. In the case of savory cookies the highest value (4.20) was noticed in T_{14} (rice bran + wheat bran cookies) which was decreased to 2.60 at the end of 90[th] day.

4.4.3.2 Crispiness

Crispiness of the cookies was ascertained by pressing the crumb with fingers to see whether they were sticky or not. Data on crispiness of cookies is depicted in Table 20.

Table 20. Influence of storage on the crispness of cookies (mean score)

Storage period	Sweet				Savory			
	T_1	T_4	T_9	T_{14}	T_1	T_4	T_9	T_{14}
Initial month (0 day)	2.90^{b}	4.00^{a}	4.50^{a}	4.00^{a}	2.60^{c}	4.10^{ab}	4.30^{a}	4.30^{b}
I^{st} month	2.80^{b}	3.70^{bc}	4.30^{a}	3.50^{ab}	2.20^{b}	3.50^{b}	4.00^{a}	3.60^{b}
II^{nd} month	2.20^{c}	3.30^{bd}	3.80^{b}	3.40^{ab}	2.20^{a}	3.10^{a}	3.60^{b}	3.20^{b}
III^{rd} month	2.10^{a}	2.80^{a}	3.00^{b}	2.90^{ab}	2.10^{b}	2.60^{a}	2.90^{ab}	2.20^{c}
CD (0.05)	0.645	0.627	0.518	0.487	0.623	0.583	0.496	0.476

Mean values denoted by different letters in the same column are significantly different

It was observed that the crispiness of cookies decreases as storage period increases. The decrease in crispiness was more among bran supplemented cookies when compared to control cookies both in the case of sweet and savory cookies. The decrease in mean score was maximum found in wheat bran supplemented both sweet (4.50 to 3.00) and savory (4.30 to 2.90) cookies. The least score for crispiness was obtained in T_1 (control) 2.90 and 2.10 during the storage period. In the case of savory, the highest score was fond in T_9 (4.30) on the initial day which was decreased to 2.90at the end of 90^{th} day.

4.4.3.3 Aroma

The aroma of a food is not recognized by a single component, but rather as a series of events experienced as the food is consumed (Piggot,2000). Aroma is the combination of taste and smell. Taste includes sweet, salty and sour characters in food products, while smell is identified as fragrant, acidic, burnt etc. The score for aroma changes of the stored cookies are given in Table 21.

Table 21. Influence of storage on the aroma of cookies (mean score)

Storage period	Sweet				Savory			
	T_1	T_4	T_9	T_{14}	T_1	T_4	T_9	T_{14}
Initial month (0 day)	3.20^{b}	3.90^{b}	4.70^{a}	4.70^{a}	3.50^{b}	3.90^{ab}	4.10^{a}	3.50^{a}
I^{st} month	3.00^{b}	3.80^{a}	4.10^{b}	4.00^{b}	3.20^{c}	3.80^{a}	3.70^{ab}	3.50^{a}
II^{nd} month	3.00^{a}	3.60^{a}	3.90^{b}	3.80^{b}	3.00^{b}	3.40^{a}	3.20^{bc}	3.00^{b}
III^{rd} month	2.90^{b}	3.40^{a}	3.60^{b}	3.00^{b}	2.50^{a}	3.20^{b}	3.20^{bc}	2.70^{a}
CD (0.05)	0.593	0.57	0.566	0.461	0.684	0.582	0.55	0.471

Mean values denoted by different letters in the same column are significantly different

Aroma of cookies disclosed that highest mean score was obtained by T_9 which was on par with T_{14} (0^{th} day) gradually decreased with storage. The range between 0^{th} day and 60^{th} day was 4.70 to 3.90. Whereas in the case of savory cookies the range was between 4.10 to 3.20. The resulted revealed that, the cookies incorporated with wheat bran showed the highest mean score during initial (4.70) and third month (3.60) of storage period in the case of sweet cookies, whereas in the case of savory cookies also T_9 (4.10) shows the highest score during the initial which was gradually decreased to 3.20 at the end of third month.

4.4.3.4 Mouth feel

Mouth feel is described as a texture or kinesthetic factor evaluated by the skin or muscles in the mouth

Table 22. Influence of storage on the mouth feel of cookies (mean score)

Storage period	Sweet				Savory			
	T_1	T_4	T_9	T_{14}	T_1	T_4	T_9	T_{14}
Initial month (0 day)	3.10^{c}	3.20^{bc}	4.20^{a}	4.40^{ab}	2.50^{c}	3.40^{ab}	3.80^{a}	3.70^{bc}
I^{st} month	3.00^{a}	3.10^{a}	4.00^{b}	4.20^{a}	2.40^{b}	3.20^{a}	3.40^{a}	3.60^{b}
II^{nd} month	2.60^{a}	3.00^{b}	3.90^{b}	3.90^{ab}	2.30^{a}	3.10^{b}	3.10^{b}	3.30^{ab}
III^{rd} month	2.40^{b}	3.00^{a}	3.80^{ab}	3.80^{ab}	2.10^{a}	3.00^{b}	2.80^{b}	2.80^{b}
CD (0.05)	0.686	0.586	0.57	0.688	0.636	0.56	0.552	0.627

Mean values denoted by different letters in the same column are significantly different

Significant difference was observed between control and bran supplemented cookies for mouth feel during storage. The quality mean score in response to mouth feel of the cookies depicted that highest score (4.40) was obtained by T_{14} fresh cookies (0^{th} day) which was decreased significantly as the storage period increased. In the case of savory cookies the highest score was found to be in T_9 (3.80) during initial which was decreased gradually to 2.80.

4.4.3.5 Taste

The taste can be defined as the sensation of flavor perceived in the mouth and throat on contact with a substance.

Table 23. Influence of storage on the taste of cookies (mean score)

Storage period	Sweet				Savory			
	T_1	T_4	T_9	T_{14}	T_1	T_4	T_9	T_{14}
Initial month (0 day)	2.40^{c}	3.40^{b}	4.30^{a}	3.60^{ab}	2.50^{b}	3.10^{ab}	3.60^{a}	2.70^{b}
I^{st} month	2.40^{c}	3.20^{ab}	3.50^{b}	3.40^{b}	2.20^{b}	3.00^{b}	3.30^{ab}	2.50^{b}
II^{nd} month	2.10^{a}	3.10^{a}	3.00^{b}	2.90^{bc}	2.10^{a}	2.80^{a}	2.90^{b}	2.50^{ab}
III^{rd} month	2.00^{b}	2.60^{ab}	2.70^{b}	2.90^{bc}	2.00^{b}	2.40^{a}	2.40^{a}	2.20^{c}
CD (0.05)	0.737	0.659	0.624	0.554	0.775	0.604	0.519	0.525

Mean values denoted by different letters in the same column are significantly different

The results concerning with the taste of cookies disclosed highest score (4.30) for T_9 (0^{th} day) which was gradually decreased with storage days. The range between 0^{th} day and 90^{th} day was 4.30 to 2.00 in the case of sweet cookies whereas in the case of savory cookies it ranged between 3.60 to 2.00. The least change in score was shared by T_1 (control) both in the case of sweet (2.40 to 2.22) and savory cookies i.e. 2.50 to 2.00. There was a slight decrease in mean score of the cookies after second months of storage in all treatments.

4.4.3.6 Overall acceptability

Data on overall acceptability of the stored cookies are shown in Table 24.

Table 24. Influence of storage on the overall acceptability of cookies (mean score)

Storage period	Sweet				Savory			
	T_1	T_4	T_9	T_{14}	T_1	T_4	T_9	T_{14}
Initial month (0 day)	2.92^c	3.72^b	4.36^a	4.12^a	2.84^b	3.64^a	3.88^a	3.68^a
Ist month	2.84^b	3.50^b	3.96^b	3.74^{ab}	2.60^a	3.38^b	3.50^b	3.32^c
IInd month	2.56^a	3.24^a	3.62^b	3.52^b	2.48^a	3.08^a	3.22^b	2.98^a
IIIrd month	2.38^a	2.70^b	3.26^a	2.98^a	2.26^a	2.76^a	2.84^b	2.50^a
CD (0.05)	0.593	0.526	0.492	0.479	0.634	0.683	0.584	0.482

Mean values denoted by different letters in the same column are significantly different

Analysis of variance disclosed a highly significant effect of storage on overall acceptability of cookies. The overall acceptability (mean score) was found to be higher in wheat bran supplemented cookies (T_9) (4.36 and 3.88 in the case of sweet and savory cookies). A significant difference was noticed between control and bran supplemented cookie with respect to overall acceptability during storage.

From the above data, it can be concluded that, among all the sensory parameters except mouth feel and aroma the wheat bran supplemented cookies scored higher value for sweet and savory cookies.

4.5 Glycemic index of the formulated cookies

The Glycemic Index (GI) is a scale that ranks carbohydrate-rich foods by how much they raise blood glucose levels compared to a standard food. The standard food is glucose or white bread.

To find out the glycemic index of the selected cookies, ten students were selected from the College of Agriculture, Vellayani. The subjects were in the age between 20-25 years and having a weight between 45-60kg and height between 150-165cm. There BMI ranged from 17.9 to 23.5. Out of ten subjects, nine were having normal BMI and the remaining one was under weight. Among the selected subjects, two of them were vegetarians and the remaining were non-vegetarians.

All the selected subjects were administered with 50g of glucose. Among these ten subjects five of them were provided with sweet cookies and the remaining five were provided with savory cookies. Blood sugar level were monitored before (fasting glucose level) and after supplementation of reference food (glucose) and test food (cookies).

Table 25 shows mean area under plasma glucose responses curve (AUC) for test food (cookies) and reference food (glucose). As indicated in Table 25 glucose had an AUC of 298 mm^2.

Table 25. Mean area under the curve of test food and reference food

Food		Cookies	
		Sweet	Savory
		Area under the curve (mm^2) (mean values)	
Glucose (Reference food)		298	
Test food	**Control**	167	145
	T_4 (Rice bran cookies)	181	128
	T_9 (Wheat bran cookies)	163	127
	T_{14} (Rice +Wheat bran cookies)	156	126

Figures indicate mean values of 5 subjects

Based on AUC, the glycemic index of the test food (cookies) was determined which is depicted in Table 25. Compared with cookies glucose covered more area under the curve. Among test foods control cookies had highest area than bran supplemented cookies.

Table 26. Glycemic Index of test food

Food		Cookies	
		Sweet	Savory
Glucose (Reference food)		100	100
Test food	Control	56	49
	T_4 (rice bran cookies)	54	43
	T_9 (wheat bran cookies)	52	42
	T_{14} (rice +wheat bran cookies)	53	43

The above table revealed that lowest glycemic index was noticed in T_9 (52) followed by T_{14} and T_4 (54). The highest glycemic index (56) was found in control cookies. It was evident from the above table that the GI was found to be less in savory cookies when compared to sweet cookies. Among the savory cookies, the lowest GI was noticed in T_9 (42) followed by T_{14} and T_4 (43). The glycemic index of control cookies was higher than the bran supplemented both in the case of sweet and savory cookies ie. 56 and 49 respectively.

4.6 Consumer acceptance of the cookies

Today consumers are more conscious of food products available in the market. New foods/ novel foods are rapidly increasing in number in the markets. Consumer acceptance of a new product is based largely on its convenience, appearance, sensory value and economic value and health benefits. T_4, T_9 and T_{14} sweet and savory cookies which maintained highest organoleptic scores were selected for the study. In the present study, consumer acceptance was conducted among technical experts, college students and school children and the data was rated using hedonic scoring.

Hedonic scoring is used to measure the degree of pleasurable and unpleasurable experience of the food product on a scale of 9 points from "like extremely" to "dislike extremely" (Kalia and Sood, 2000). Since none of the developed cookies were rated as dislike very much and dislike extremely these two characters were deleted while discussing the data.

The respondents were selected at random and the freshly prepared cookies were distributed among consumers along with the schedule to record their acceptance. The results of the study are consolidated and presented in Table 27.

The results revealed that the percent score ranged between 66 to 90. The highest per cent score was achieved by wheat bran supplemented sweet cookies (90) followed by rice bran + wheat bran supplemented sweet cookies (81) and wheat bran supplemented savory cookies (81). The least score was obtained for rice bran supplemented savory cookies (66).

Table 27.Hedonic rating of bran based cookies

Rating scale	Scores	Scores of the cookies					
		Rice bran cookies (T_4)		Wheat bran cookies (T_9)		Rice bran + wheat bran cookies (T_{14})	
		Sweet	Savory	Sweet	Savory	Sweet	Savory
Like extremely	9	-	-	**126(14)**	36(4)	54(6)	18(2)
Like very much	8	48(6)	8(1)	88(11)	**96(12)**	**80(10)**	**88(10)**
Like moderately	7	**77(11)**	56(8)	14(2)	56(8)	35(5)	21(3)
Like slightly	6	36(6)	**66(11)**	-	24(4)	42(7)	12(2)
Neither like or dislike	5	25(5)	50(10)	15(3)	-	10(2)	50(10)
Dislike slightly	4	-	-	-	8(2)	-	8(2)
Dislike moderately	3	6(2)	-	-	-	-	-
Dislike very much	2	-	-	-	-	-	-
Dislike extremely	1	-	-	-	-	-	-
Max score	270	192	180	243	220	221	197
Mean preference score		0.71	0.66	0.90	0.81	0.81	0.72
Percent score		71	66	90	81	81	72

(Figures in parenthesis indicate number of judges); n=Number of judges=10)

4.5.1 Ranking of the cookies.

Table 28. Ranking of the cookies based on percent score

Cookies		Percent score	Rank
Rice bran cookies (T_4)	Sweet	71	**5**
	Savory	66	**6**
Wheat bran cookies (T_9)	Sweet	90	**1**
	Savory	81	**3**
Rice bran + wheat bran cookies (T_{14})	Sweet	81	**2**
	Savory	72	**4**

Table 28 reveals the ranking of cookies based on consumer acceptance. The results revealed that higher proportion of respondents accepted and preferred wheat bran sweet cookies (T_9) followed by rice bran + wheat bran sweet (T_{14}) cookies and wheat bran supplemented savory cookies. Among the sweet and savory cookies distributed the first two ranks were bagged by sweet cookies. Cookies formulated with rice bran were preferred least by consumers.

4.7 Cost of the developed cookies

In order to realize the economic feasibility of the developed cookies the cost was calculated by taking individual cost of the ingredients used with 10 percent over head charges. The cost of 100g packets of developed cookies were thus calculated on the basis of the market value of ingredients used for the formulation of cookies.

Table 29. Cost of the developed cookies

Cookies	Sweet (Rs/100g)	Savory (Rs/100g)	Proprietary product (100g)		
			1	2	3
T_1	10.87	12.82	20.00	36.00	40.00
T_4	9.50	11.34			
T_9	9.54	11.43			
T_{14}	9.50	11.41			

The cost of the developed cookies ranged from Rs.9.50-10.87 for sweet cookies and Rs.11.34-11.43 for savory cookies per100g. While comparing the cost, the control cookies had higher cost than the bran supplemented cookies. Wheat bran supplemented cookies had high cost (9.54) among the bran supplemented cookies. It was found that the cost of developed bran based cookie was less when compared to fiber enriched proprietary cookies available in the market.

4.7.1 Yield ratio

Drying removes moisture, the food shrinks and decreases in size and weight, thus requiring less space for storage. Yield of dried products are directly related to how much water is in the original product. The yield of formulated cookies are given in Table 30.

Table 30. Yield ratio of the formulated cookies

Cookies	Sweet	Savory
T_1	0.40	0.39
T_4	0.45	0.52
T_9	0.48	0.56
T_{14}	0.46	0.54

The yield ratio of cookies ranged from 0.40-0.48 in the case of sweet cookies and 0.39-0.56 in the case of savory cookies for 100g of cookies. The data further revealed that compared with control cookies (T_1) the yield ratio of bran supplemented cookies were more. Among bran supplemented cookies wheat bran supplemented cookies, yield more for both sweet and savory cookies (0.48 and 0.56).

Discussion

5.0 DISCUSSION

The result of the present investigation entitled "Development and quality evaluation of fibre enriched cookies" are discussed below.

5.1 Standardization of cookies

5.2 Sensory evaluation and selection of best treatments

5.3 Quality evaluation of cookies

5.4 Shelf stability of the cookies

5.5 Glycemic index

5.6 Consumer acceptance of the cookies

5.7 Cost of the product

5.1 Standardization of cookies.

Standardization plays a key role in product development which facilitates growth of food industries. According to Poduval (2002), one of the fore most purpose of standardization is to facilitate the movement of materials and products through all stages of production in any industrial activity starting from the raw material to the finished products then to the dealer and finally to the retailers and consumers.

Laiqeit and Mohammad (2009) observed that the recipe standardization is important to achieve optimal accuracy in determining the nutrient estimation.

Standardization is a prerequisite of any food based industry. Singh and Gopala krishnan (2002) have opined that product diversification is the need of the hour due to rapid changes in socio-economic and living styles of the people dwelling in the rural and urban area and as a the result more and more convenient foods are entering in the market.

Cookies have become one of the most desirable snacks for both youth and elderly people due to their low manufacturing cost, more convenience, long shelf-life and ability to serve as a vehicle for important nutrients (Akubor, 2003; Honda and Jood, 2005).

In the present study 15 treatments were selected for the formulation of cookies. The cookies were standardized using different combinations and proportions of refined flour, cereal bran (rice bran, wheat bran, rice bran + wheat bran) butter and other adjuncts. The formulated cookies were compared with control (T_1) (100% refined flour).

5.2. Sensory evaluation

Sensory evaluation is defined as a scientific discipline used to evoke measure, analyse and interpret those response to products that are perceived by the sense of sight, smell, touch, taste and hearing (Stone and Sidel, 2003).

Starting from product development, products are evaluated in terms of their sensory attributes to get their profile and to know if their target consumer would prefer to buy it. So sensory evaluation is necessary for the quality assessment of foods (Akharali and Maharaj, 2014).

5.2.1. Colour

Colour of food serves as a useful criterion for the measurement of quality. Colour is a very important parameter in judging the properly baked cookies that not only reflects the suitable raw materials used for the preparation but also provides information about the formulation and quality of the products (Abusalem and Abouarab, 2011).

Dorko and Penfeild (1993) are of the opinion that aesthetic, safety, sensory characteristics and acceptability of foods are all affected by colour.

In baking, colour serves as a cue for the doness of the food and is correlated with changes in aroma or flavour. Colour, one of the visual attributes has been used to judge the overall quality of foods for a very long time. If the colour is unattractive, a potential consumer may not be impressed by any other attributes.

The first impression of a food is usually visual, and major part of our willingness to accept a food depends on its colour (Manay and Swami, 2002).

The results pertaining to mean score for the colour of bran supplemented cookies revealed that wheat bran supplemented cookies (T_9) ranked at the top (4.10) due to excellent colour and appearance followed by rice bran

supplemented cookies (T_4) (4.00) as compared to control cookies (3.00) in the case of sweet cookies.

Cookies prepared with 30 per cent supplementation were acceptable by the judges to the trait. By the progressive increase in supplementation colour of cookies turned towards darker leading to lower acceptance. Similar findings were also observed by Sudha et al. (2007).

Darkening of colour of the biscuits/ cookies was increased with increased proportion of millet flour (Mridula et al., 2007).

Sharif et al. (2009) reported that the mean score for the colour of the cookies developed from 70:30 ratio of defatted rice bran flour was found to be 7.48 compared to control cookies (6.65).

Cookies prepared from soya flour and rice bran by Mishra and Chandra (2012) reported that control cookies bagged higher scores (7.26) for colour due to its excellent in appearance.

5.2.2 Crispiness

Deterioration during storage can manifested itself by changes in physical and chemical characteristics, referred to as spoilage mechanism. In the case of physical changes, loss of crispiness occurs due to moisture uptake as biscuits are hygroscopic in nature (Manley, 2002).

It was obvious from the findings that the quality mean score for the crispiness of the cookies ranged from 2.90-4.50 in the case of sweet cookies and 2.20-4.30 in the case of savory cookies. The study is in accordance with the findings of Hussain (2006) who had reported that the crispiness of the cookies formulated with flaxseed flour ranged from 4.41-8.00.

The highest score for the crispiness was bagged by wheat bran supplemented cookies (T_9) (4.50) followed by T_4 and T_{14} (4.00) in the case of

sweet cookies while it was highest in T_9 and T_{14} (4.30) in the case of savory cookies.

In a study conducted by Nooraziah et al, (2012) a value of 27.48 was reported for cookies prepared with chickpea flour.

Singh et al (2000) remarked that since cookies in general have low moisture and significant amount of fat and they are prone to lose the crispiness by absorption of moisture and develop rancidity due to oxidation.

5.2.3 Aroma

Aroma preference is generated by stimulation of the sensory cells by specific volatile compounds present in the food. Abusalem and Abouarab, (2011) stated that aroma is the main criteria that makes the product to be liked or disliked.

Aroma is defined as the combination of taste and odour and is influenced by sensation of heat, cold and by tactile sensation. Aroma is total or unitary experience that arises from stimulation of the sense of taste, the sense of smell and other senses.

Aroma is a perceived attribute that results from over integrated response to complex mixtures of stimuli on several senses including smell, taste, sight, touch etc.

Appearance of a food is important, but it is the flavour that ultimately determines the quality and acceptability of foods. Manay and Swami (2002) defined flavour as sensory phenomenon depending upon taste, odour or aroma, appearance and temperature. Sensation of heat, cold and texture or mouth feel affects the sense of touch. Sensory evaluation of flavour for analytical purpose is limited to the sensations of taste and smell.

The present study revealed that supplementation of cereal bran increased the aroma of the cookies significantly. Among the bran supplemented sweet

cookies highest scores were obtained by rice bran + wheat bran supplemented cookies (T_{14}) (4.70) and wheat bran supplemented cookies (T_9) (4.70) when compared to control cookies (3.20). In savory cookies the wheat bran based cookies (T_9) (4.10) scored the highest score when compared with other cookies. Similar findings were reported by Anis et al. (2014). But aroma of the cookies formulated from soya flour and rice bran decreased from 7.19 -5.7 with increasing level of substitution of rice ban and soya flour (Mishra and Chandra, 2012).

Shakuntala et al. (2008) reported that with increase in the level of bengal gram flour, the sensory scores for the quality attributes for aroma of cookies increased at 25 per cent level.

Flavour of cookies was observed to be maximum at 20 per cent supplementation of bran (corn/ wheat/ rice/ psyllium husk) (Pasha et al., 2008).

5.2.4 Mouth feel

Mouth feel is a term used to refer to the tactile aspects of texture perception during consumption. Mouth feel encompasses all of the tactile (feel) properties perceived from the time at which solid, semi-solid or liquid foods or beverages are placed in the mouth until they swallowed.

The study disclosed no significant difference between control and bran supplemented cookies with respect to mouth feel. The highest mean score for mouth feel (4.40) was observed in rice + wheat bran cookies (T_{14}) and lowest (2.30) for rice bran supplemented sweet cookies (T_6).

Cookies developed with addition of inulin and oilgofructose were assessed as the best regarding the mouth feel (Jovanka et al., 2013).

Cookies/ biscuits prepared with wheat bran and date powder had better mouth feel at level of 40 per cent reported by Gamal et al. (2012).

5.2.5 Taste

Taste is a major attribute which determines the acceptability of food. It is not only a sensory response to soluble materials but also aesthetic appreciation of mouth. The sense of taste affects ingestion and uptake into the body (Iwe and Ngoddy, 2007).

The results of the present study revealed that the mean score of the quality attribute taste ranged between 2.40-4.30 and 2.50-3.80 in the case of sweet and savory cookies respectively.

The highest score for taste was found in wheat bran cookies (T_9) (4.30 and 3.70) in the case of sweet and savory cookies respectively. It was noticed that the taste of bran supplemented cookies was better than the control cookies both in the case of sweet and savory. Similar findings were recorded by Atuonwu and Akobundu. (2010) for cookies made with pumpkin seed flour.

Cookies supplemented with 30 per cent flaxseed flour were found to be acceptable in terms of the quality attribute taste (Preethi and Renu, 2013). The results are in agreement with those of Sudha et al. (2007).

A study conducted by Zlatica et al. (2011) on "Effect of the addition of commercial apple fibre powder on the baking and sensory properties of the cookies" had reported that addition of apple fibre powder significantly increased the sweet taste of the cookies.

Ojinnaka et al. (2014) found that cookies supplemented with African bread fruit in the ratio of 90:10 were better in taste with a value of 6.10.

Cookies incorporated with wheat bran and date powder mixture at 30 and 40 per cent level were having better taste when compared to other treatments (Gamal et al., 2012).

5.2.6 Overall acceptability

According to Savithri et al. (1990), the overall acceptability depends on the concentration or amount of particular components, the nutritional and other hidden attributes of the food and also its palatability or sensory quality.

The results of the present study unveiled that supplementation of bran significantly affected the overall acceptability of the cookies. The overall acceptability scores ranged between 2.92-4.36 and 2.24-3.88 in the case of sweet and savory cookies respectively. The overall acceptability of the bran supplemented cookies was highly acceptable in the ratio of 70:30 when compared to control and other bran supplemented cookies (Fig 3 and 4). The study is in line with findings of Preethi and Renu (2013) who had reported that biscuits supplemented with 30 per cent flaxseed flour had good acceptance.

The overall acceptability of the biscuits formulated from flaxseed flour ranged between 6.4-8.6 reported by Preethi and Renu (2013). When the level of flaxseed flour was increased to 40 per cent, decreases in all sensory attributes were noticed. Similar findings were reported by Hussain et al. (2006) and Preethi et al, (2009) who had observed that cookies supplemented with 30 percent or lower level of flaxseed flour were highly acceptable.

Cookies with high sensory rating have been produced from blends of wheat flour and rice bran (Sharif, 2009).

Pasha et al. (2008) reported that quality of biscuits were acceptable at 20 percentage incorporation with wheat, corn, rice bran and 10 percentage for psyllium husk.

Sharif et al. (2009) found that the total score for all the attributes was relatively high at 10 per cent rice bran supplemented cookies.

The results of the sensory evaluation of the cookies prepared from the different treatments of the composite flour were in accordance with the findings of Gambus et al. (2003); Shearer (2002) and Sharma et al. (1993) who had reported

Fig 3. Selection of best treatments (Sweet)

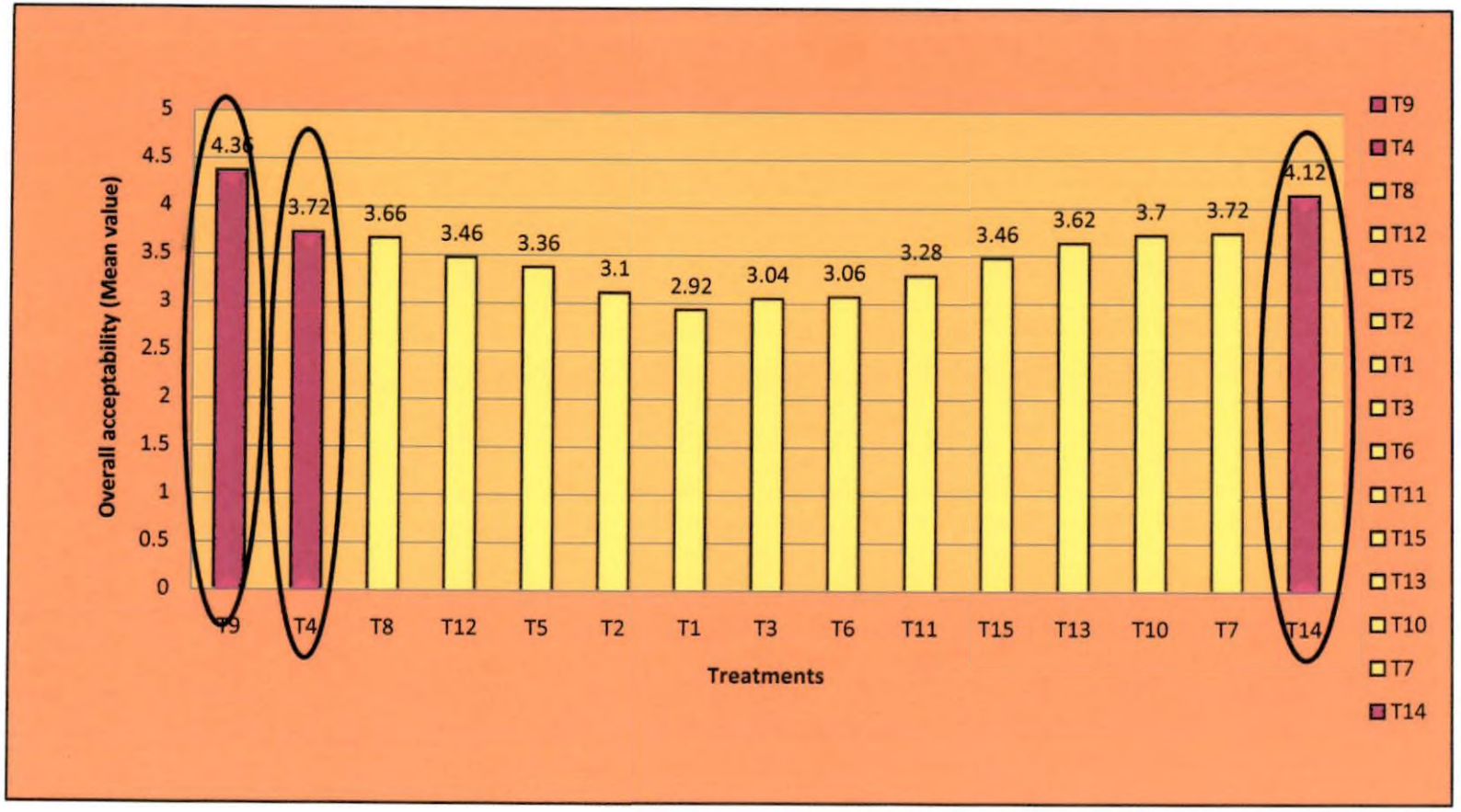
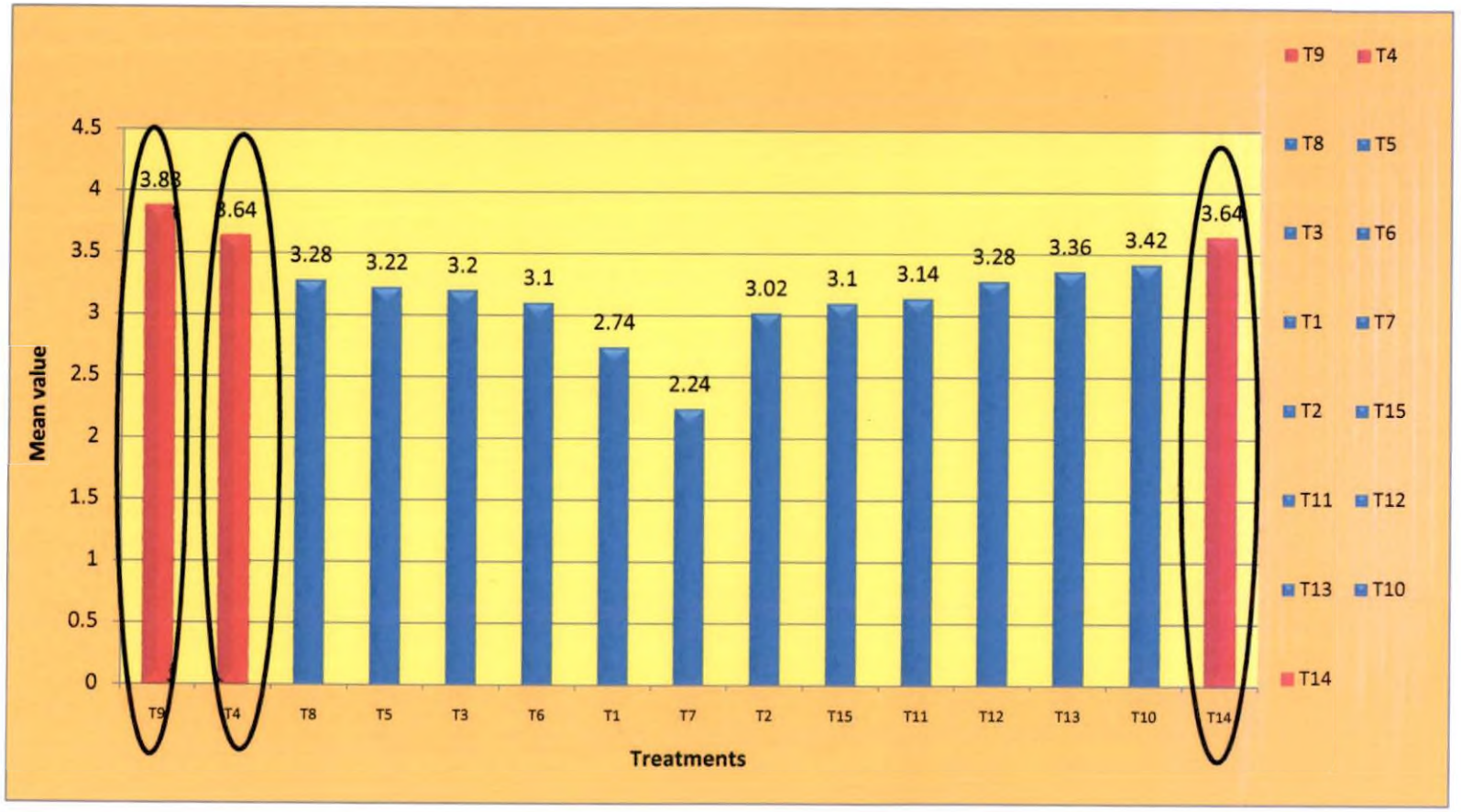


Fig 4. Selection of best treatments (Savory)



that increasing the level of flaxseed flour and, cowpea flour in the cookies resulted in the significant decrease in the sensory attributes of the cookies.

Sensory evaluation of the addition of commercial apple fibre powder on the baking and sensory properties of cookies showed that cookies with apple fibre powder were characterised by fruity and sweet taste and were firmer than sample without apple fibre (Zlatica et al., 2011).

Supplementation of wheat biscuits with bengal gram flour was tried by Shakuntala et al. (2008) and found that sensory attributes of biscuits improved on supplementation of gram flour at 15-20 per cent level.

Sunday et al. (2005) investigated the quality and sensory attributes of cookies supplemented with pumpkin seed flour found that substitution upto 50 per cent had produced acceptable cookies.

5.3 Quality evaluation of cookies

Food quality is a complex concept that is frequently measured using objective indices related to the nutritional, microbiological or physicochemical characteristics of the food or in terms of the opines of designated experts. The quality of food is a combination of the attributes that determine the degree of acceptability of the product. These include nutritional value, microbiological safety, cost, convenience and organoleptic qualities.

Nambiar and Parnami (2008) reported that development of nutritious and organoleptically acceptable recipes with locally available foods is a challenge for the food scientists and the benefits of such food- based strategies to prevent micronutrient malnutrition are manifold.

In the present investigation, the bran supplemented cookies were assessed for sensory qualities, physical parameters, chemical/ nutrient composition and shelf life study.

5.3.1 Physical Characteristics

The physical characteristics are important criteria for product acceptance. The physical properties of cookies are more important when evaluating the quality attributes from the point of view of consumer acceptance.

Weight, thickness, diameter and spread ratio were analysed to assess the physical characteristics of cookies.

5.3.1.1 Weight

Weight is a measurement of the gravitational force acting on an object. It is a unit or system of units used for expressing how much an object or quantity of matter.

The results of the present study revealed that there were no significant difference between the control and bran supplemented cookies in terms of weight. The maximum weight was observed in wheat bran supplemented sweet cookies (T_4) (16.00g).

A study conducted by Nooraziah et al. (2012) on "Physico-chemical and organoleptic property of cookies incorporated with legume flour" revealed significant difference between samples in terms of weight, thickness and diameter. The authors also reported that lowest weight was indicated in chickpea cookies (7.36). The results also suggested that the chickpea cookies have high water holding capacity as compared to mung bean and control cookies due to the high protein content.

5.3.1.2 Thickness

Thickness is an important variable that play a role in product quality. It is the distance between the top and bottom or front and back surface of food material.

The results revealed that there was an increase in thickness with the supplementation of bran when compared to control cookies. The rice bran + wheat bran supplemented cookies exhibited the highest thickness (1.29cm) in the case of sweet cookies. The lowest thickness was noticed in control cookies both in sweet (1.13cm) and savory (1.18cm) respectively. The results are in accordance with observations of Hussain (2006) who had reported an increase in the thickness of cookies with supplementation of flaxseed flour. The study is in close agreement with the findings of Pasha et al (2008) and Sharif et al. (2009).

Contrary to this, Zlatica et al. (2011) in a study on "Effect of the addition of commercial apple fibre powder on the baking and sensory properties of cookies "observed a reduction in thickness of cookies. Similar reduction in cookie thickness was also reported by Ajila et al. (2008) after addition of mango peel powder

A study conducted by Mishra and Chandra (2012) reported that the thickness of biscuit increases with increase in the level of substitution of soya flour and rice bran. Grover and Singh (1994) observed that increasing levels of defatted soya flour reduced diameter and increased the thickness of cookies.

Pasha et al. (2008) are of the opinion that biscuits containing unextracted wheat bran were having more thickness than biscuits containing extracted wheat bran. Contrary to this Srivastva et al. (2012) found that increase in level of sweet potato flour resulted in linear decrease of thickness in cookies. A decrease in cookie thickness was reported by Bunde et al. (2010) with increasing the level of substitution of rice bran.

5.3.1.3 Diameter / Width

The diameter of the cookie is a line that divides the cookie into two equal halves, through the centre of the cookie.

Singh and Chauhan (2000) observed that physical properties of cookies like width, thickness and spread factor were affected significantly with increase in the level of bran and also by the method of stabilization.

Data on diameter/ width of cookies revealed an increase in diameter with the supplementation of bran cookies.

The study revealed that rice bran + wheat bran supplemented cookies exhibited highest diameter (4.20cm and 4.13cm) in the case of sweet and savory cookies respectively when compared to control cookies. The results are in tune with the findings of Haque and Shams (2002) who observed that diameter of bran supplemented cookies increased with increase in fibre. The study coincides with the findings of Hussain (2006) who had reported that the mean diameter of cookies prepared from the different treatments of the composite flour and flaxseed flour prepared in the ratio of 70:30 had the highest diameter (291mm) when compared to other treatments. But a reduction in cookie diameter was observed by Sievert et al. (1990).

Pasha et al. (2008) reported that biscuits containing unextracted wheat bran were having larger diameter than biscuits containing extracted wheat bran. A study conducted by Mishra and Chandra (2012) on "Development of functional biscuit from soya flour and rice bran" revealed that the diameter of biscuit decrease with increase in level of substitution of composite flour of rice bran and soya.

A decrease in width of cookies was also reported by Nassar et al. (2008) in apple fibre and citrus by-products incorporated biscuits

A study conducted by Bunde et al. (2010) on "Supplementation of biscuits using rice bran and soya bean flour reported that the width/diameter of biscuit sample ranged between 36.75-43.30 mm. Increase in width was noticed with increase in level of substitution of rice bran.

5.3.1.4 Spread ratio

Spread ratio is an indication of ability of the cookies to raise. It is a physical property of measuring of cooking quality. Cookies with higher spread are considered better in quality.

There is a relationship between the spread ability height and the breaking strength. The thinner the biscuit, the lesser its ability to withstand stress/load.

Pasha et al. (2008) prepared cookies with 0%, 10%, 20% and 30% addition of fibre and were evaluated for physical choice. The results revealed that incorporation of wheat bran decreased the spread of the cookies from 41.79 to 41.30 mm. Sudha et al. (2007) also showed that incorporation of different types of bran decreased the spread factor of cookies.

According to Neha and Ramesh (2012) the spread factor of biscuits decreased from 47.8 to 34.1 with increase in the supplementation. Spread ratio of biscuit decreased with increase in supplementation of soy flour and rice bran (Van et al, 2006).

In the present study, the control cookie sample (100% refined flour) had the lowest spread ratio when compared to bran supplemented cookies. The spread ratio values of the control sample showed that starch polymer molecules are highly bound with the granules and the swelling was limited when heated.

Cookies with higher value of spread ratio are more desirable (Eissa et al., 2007; Hussain, 2006). Increased spread factor in bran supplemented cookies was due to the difference in particle size between the wheat flour and bran. Wheat flour has gelatinization temperature between 56-62 ^{0}C, but this temperature is markedly altered and increased by physical or chemical modification which affects the strong intermolecular bonds in the granules structure. A study conducted by Kaur et al. (2012) on "Physico-chemical and sensory quality of cereal bran enriched biscuits" reported that cereal bran substitution affected the

spread ratio of cookies and the highest spread ratio was observed in oat bran supplemented biscuits.

But contrary to this, Gamal et al. (2012) observed that incorporation of wheat bran and date powder mixture decreased the spread of biscuits from 55.66 to 52.82mm without larger changes in the thickness.

Decreasing trends in the spread ratio of cookies with the proportionate increase of rice bran supplementation was reported by Sharif et al. (2009). The results are in close agreement with those of Sekhon et al. (1997).

5.3.2 Chemical and Nutrient composition

Kalia and Sood (2000) defined nutritional quality as the combination of chemicals that has significance in determining the degree of acceptability of the product to a user based on its quality and sensory attributes. Nutrients are invisible chemicals in the foods which are necessary for keeping the body healthy. Stability of the original quality of any product is of paramount importance during storage and it should be checked to detect the acceptability of the product.

Sharma (2006) has viewed that chemical estimation of food products is a useful criterion to judge the quality. Lesser or higher amount of certain chemicals in food makes them acceptable or non-acceptable.

5.3.2.1 Moisture

Moisture content of food material is an important factor as it affects the physical and chemical aspects of food which relates with freshness and stability of food. Cookies differ from other baked products like bread and cakes because of having low moisture content, comparatively free from microbial spoilage and longer shelf life of the product.

The moisture content of different cookies varied according to the type of cookies produced. Various researchers have observed that moisture content of cookies varied from 8.19-11.9 per cent.

Sudha et al. (2007) reported that the moisture content of rice bran cookies was 10.56 per cent and that of other bran samples ranged between 4.92 to 7.68 per cent.

Ollerros et al. (1999) also observed a similar range after analysing psylliumfibre and found to have moisture content between 7.88-8.96 per cent. The results corroborates with the findings of Shafiq (1999) who had reported a moisture content of 10.36 per cent in wheat flour.

In the present study, it was observed that there was an increase in moisture content in the case of bran supplemented cookies. The lowest moisture content was noticed in control sample (2.78 and 2.53 % in sweet and savory cookies respectively) followed by rice bran+ wheat bran cookies (3.30 and 3. 39 % in sweet and savory cookies respectively). The low moisture content values observed in this study will also increase the shelf life of the product. The study is in agreement with the findings of Alozie et al. (2009). A high level of moisture content may indicate short shelf life of cookies as they encourage microbial growth which leads to spoilage (Mushtaq et al., 2010).

A study conducted in KAU by Shruthy (2005) reported that the moisture content of the cookies made with jackfruit seed flour was found to be 6.01 per cent. Another study conducted in KAU by Neelofer (2004) had reported a moisture content of 10 per cent in the cookies formulated from coconut.

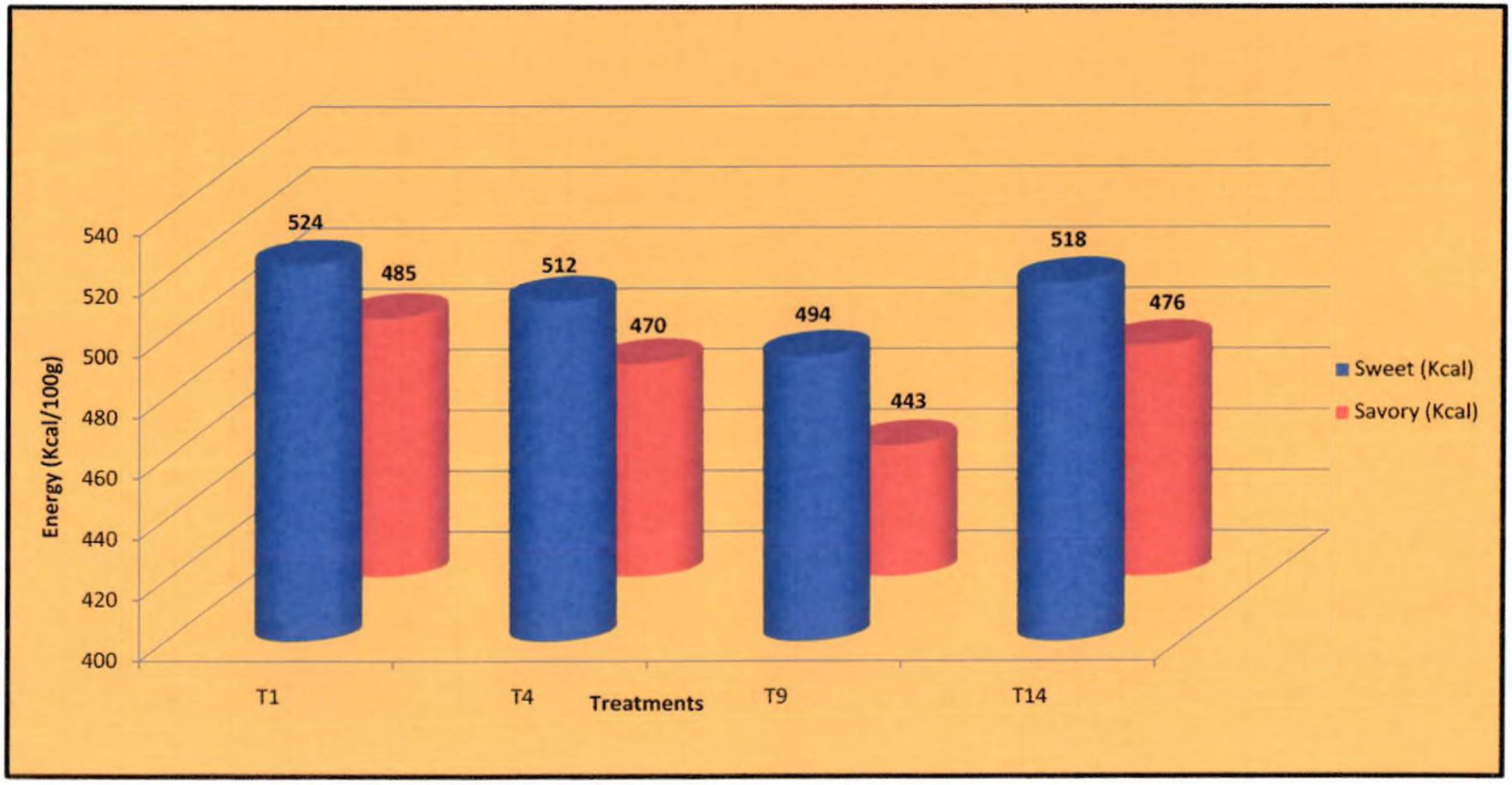
5.3.2.2 Energy

Energy is essential for normal growth, rest, activity, maintenance of sound health and functioning of body

Cookie is an energy dense food which is taken mostly in between meals by both young and old (Chikwendu, 2007; Yusuf et al., 2008 and Giwa and Abiodun, 2010).

In the present study, there was a significant difference between the control and bran supplemented cookies with respect to energy content. It was observed

Fig 5. Energy content of the cookies



that the energy content of cookie was lower on with supplementation with bran. When the energy value of cookie was determined it was observed that energy value was found to be highest (524Kcal/100g) for control sweet cookies (T_1) and lowest (443Kcal/100g) in wheat bran savory cookies (Fig 5)

The results of the study conducted by Pasha et al. (2008) indicated that the energy values were reduced with addition of fibre. The results are also in close agreement with the findings of Anjum et al (2006) who had reported that increasing levels of bran in baked products progressively decreased the energy value of the products.

Anjum et al. (2006) reported that increasing the levels of bran in baked products progressively decreased the calorific value of the product.

In a study conducted by Neelofer (2004) in KAU on coconut based bakery products observed a calorific value of 356 and 390 Kcal/100g in cookies and biscuits respectively.

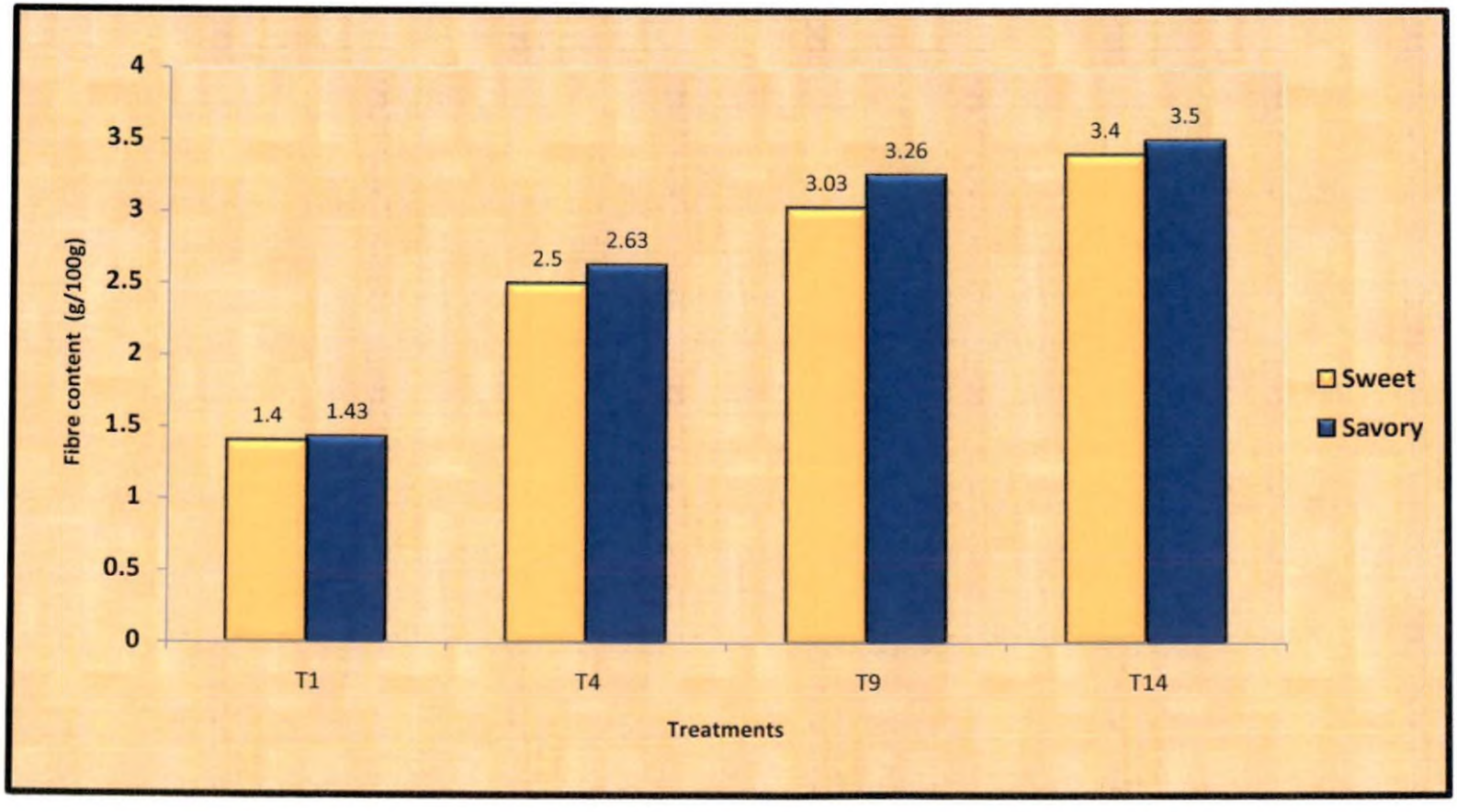
Hanan et al. (2012) in their study on wheat biscuits with citrus peel powder were found to have energy value of 472.27 Kcal per 100g. The data are in good agreement with those previously reported by Donalson (2004), Archibald (2005) and Gonzalez et al. (2010).

5.3.2.3 Fibre

Dietary fibres are the edible part of plants or are the analogous carbohydrates that are resistant to digestion and absorption in the human intestine with partial fermentation in the large intestine.

The importance of consuming dietary fibre has increased owing to its relation with reduction of blood cholesterol levels and incidence of colon cancer. Mean values for fibre content of bran supplemented cookies revealed significant variation due to supplementation of bran. In bran supplemented cookies maximum fibre content (3.40g) was observed in rice bran +wheat bran cookies

Fig 6. Fibre content of the cookies (g/100g)



followed by wheat bran cookies (3.03g) were as lowest fibre content (1.40g) was noticed in control cookies (Fig 6).

Dietary fibre components exert beneficial effects mostly by way of their swelling properties and by increasing transit time in the small intestine. Consequently, they reduce the rate of release of glucose and its absorption, thus helping in the management of diabetes.

Dietary fibre components bind with bile salts, thereby promoting cholesterol excretion from the body and thus reducing blood cholesterol levels (Gopalan, 2009).

Abete et al. (2010) reported that a diet high in fibre, low in energy density, glycemic load and moderate protein is important for disease management. There is a positive relation between reduction of risk of CHD and fibre consumption.

According to a survey conducted in 1999, women consuming fibre rich food had 34 per cent lower risk of CHD than those consuming in a low amount. In another study, it was proved that if 3g fibre is consumed daily, it will decrease the risk of CHD mortality by 27 per cent (Vander et al., 2004).

Fibre supplementation has been used to enhance the fibre content of an array of foods. Rice bran fibre comprised of a relatively low proportion of soluble fibre (7 to 13 %) and the rest is comprised of insoluble fibre (Anderson et al., 1990).

Pereira and Ludwig (2001) reported that high fibre diet is associated with lower food intake there by triggering maximal sensory stimulation in the mouth and increased need for chewing. High fibre diet also leads to slower gastric emptying and a slower rate of nutrient absorption thus reduce the energy density of the overall diet.

The WHO recommendation for dietary fibre intake is above 24g /day (WHO, 2003).

5.3.2.4 Fat

Fat in bakery products provide tenderness. Fat plays a significant role in determining the shelf life of food products and as such relatively high fat content could be undesirable in baked products. This is because; fat can promote rancidity in food leading to development of unpleasant and odorous compounds. Diet high in fat predisposes consumers to different illnesses such as obesity and CHD (Okpala and Chinyelu, 2011).

It has been reported that the yield of fat from tropical crops depends on a number of factors; while the storage stability of fat largely is affected by the type of fatty acids present (Min and Boff, 2003).

In the present study, the fat content values ranged between 11.13-17.51g/100g in sweet cookies and 10.76-19.17.63g/ 100g in savory cookies. The lowest value (11.13g and 10.76g/100g) was reported in the case of control sample (sweet and savory respectively) (Fig 7).

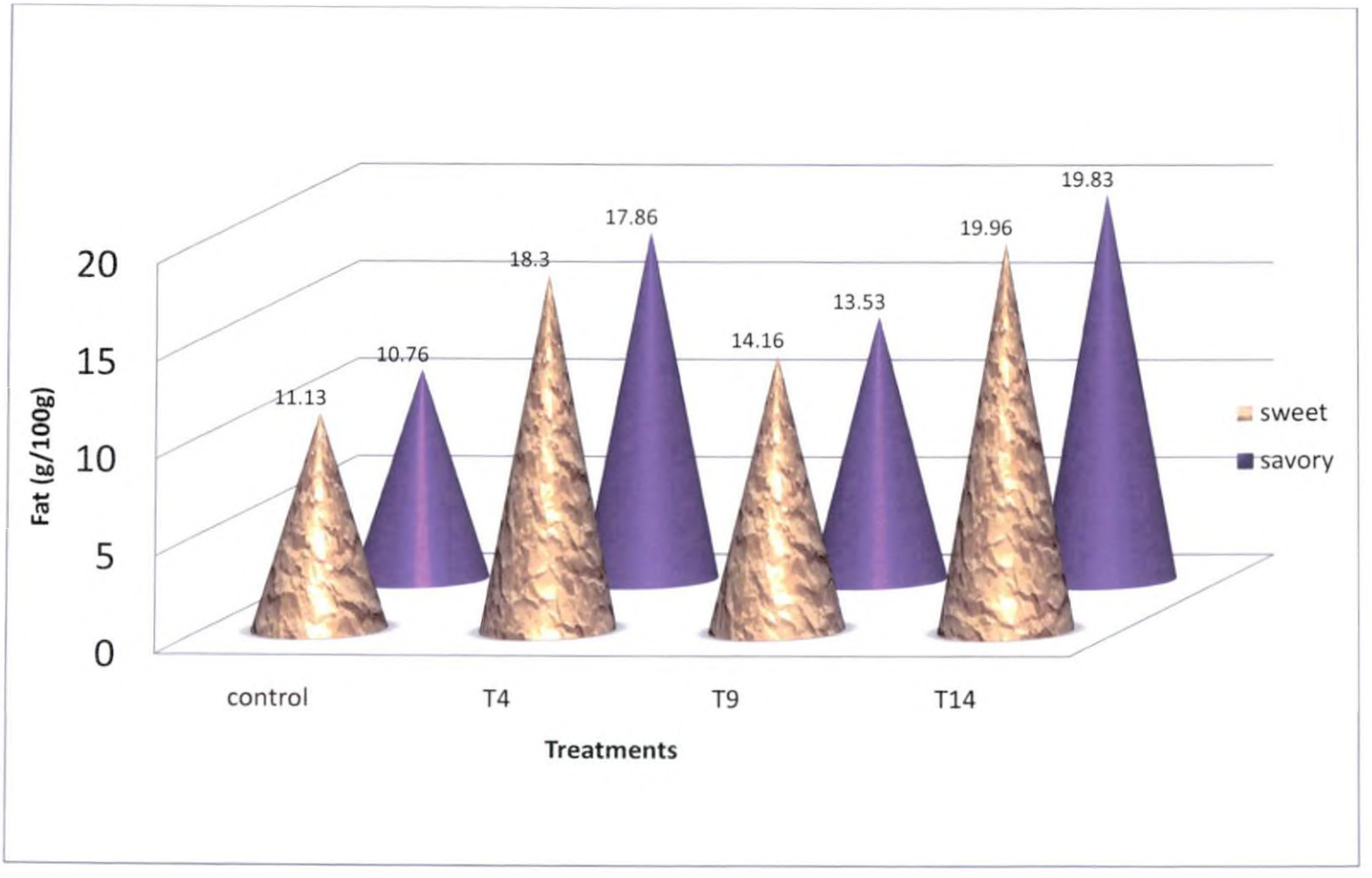
According to Ojinnaka and Agubolum (2013), the fat content of cashew nut and wheat based cookies ranged from 11.41- 44.34 per cent.

In a study on "Quality characteristics of biscuits made from wheat and African bread fruit" had a fat content of 9.02 – 19.78 per cent. In agreement with the above study, fat percentage in sorghum biscuit fortified with soya was 20.5 per cent (Serrem et al., 2011). The above values were slightly high as fat content in cookies / biscuits usually range between 5 and 20 per cent.

Hanan et al. (2012) reported a fat content of 16.99 percent in wheat biscuits with citrus peel powder. Therefore, a relatively low fat content in cookie is desirable to both the processor and health conscious individuals.

According to Anis et al. (2014), wheat flour substitution with young corn powder had significantly decreased the fat content of the biscuits ranging between 20.69 and 21.01 per cent.

Fig 7. Fat content of the cookies



In a study conducted in KAU by Neelofer (2004) reported that the fat content was 20.55g in cookies formulated with coconut whereas, fat content of 19.88g was observed in cookies formulated with jackfruit seed flour (Shruthy, 2005).

Singh et al. (2000) reported a fat content of 17.70 per cent in soya fortified biscuit whereas Devi et al. (2000) observed a fat content of 39.79 per cent in green gram supplemented biscuits.

5.3.2.5 Protein

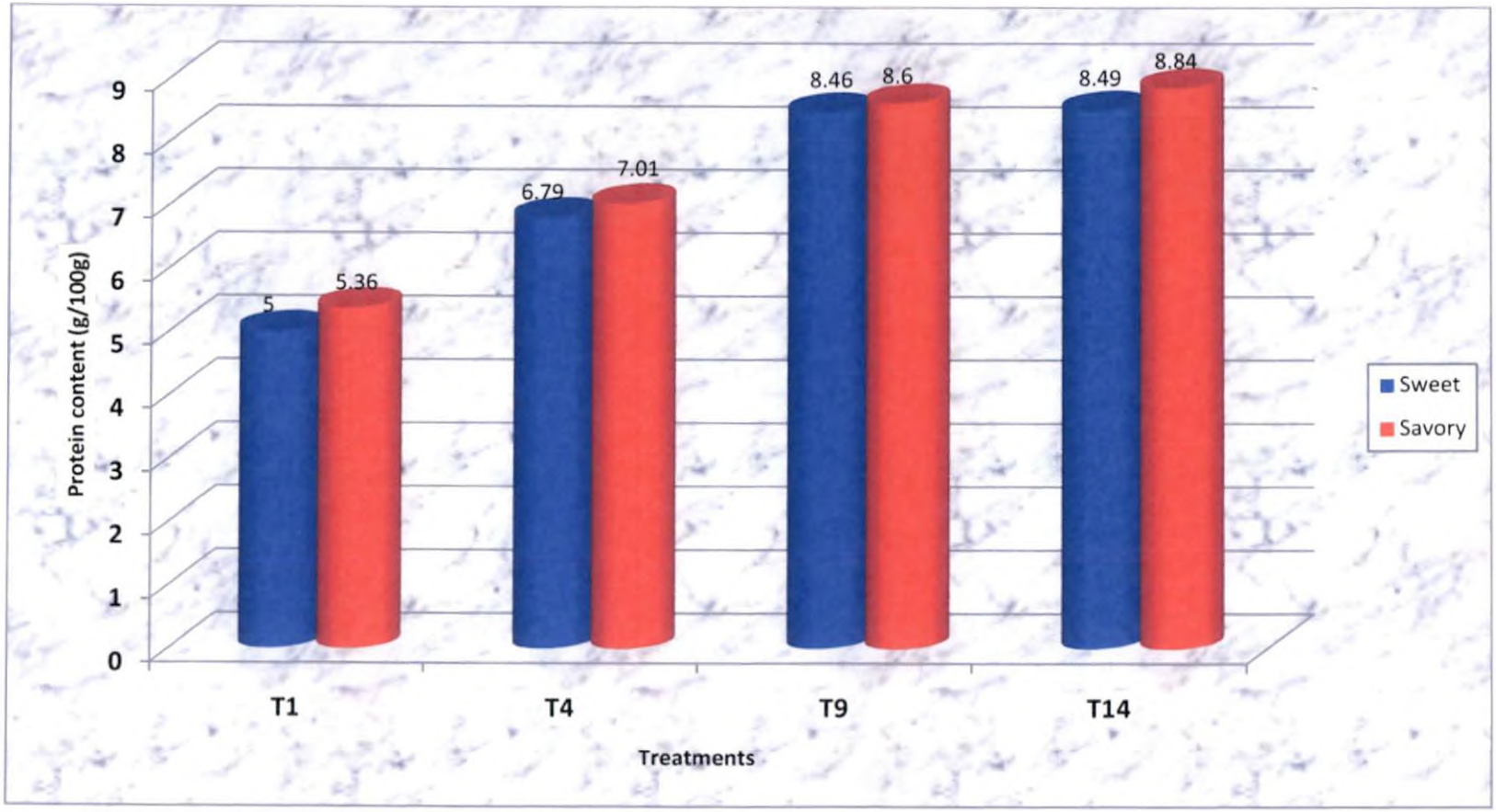
Protein is one of the most important nutrients required by the body to carry out a wide range of functions essential for the maintenance of life. Proteins are essential for tissues and cells of the body (Gopalan et al., 2009).

The protein content of cookies ranged between 5.00g -8.49g in sweet cookies and 5.36g-8.84g in savory (Fig 8). Control cookie (100 % refined flour) had the lowest percentage of protein content (5.00g and 5.36g in sweet and savory respectively) while the highest value was recorded in rice bran + wheat bran supplemented cookies (8.49g and 8.84g in sweet and savory respectively). The study is in line with the findings of Asumugha and Uwalakha (2000) who had reported that the protein content of cookies prepared from wheat flour and cocoyam flour ranged from 5.92- 12.25 per cent. It was noticed that the protein content was increased with the addition of bran. The result implies that the cookies were high in protein content and could be used as an alternative protein sources in protein deficiency.

Bran is an excellent source of protein and complements lysine the limiting amino acid in cereal protein. Addition of bran improves the quantity and quality of the protein content of the cookies, thereby serve as a great potential in combating with PEM.

The increase in protein content in the different supplemented cookies agrees with the findings of many researches who supplemented cereal based food

Fig 8. Protein content of the cookies (g/100g)



with bran or legume. In a study by Anis et al. (2014) on "Physio-chemical and sensorial evaluation of biscuit and muffins incorporated with young corn powder" has been reported an increase in protein content of biscuit from 6.77 to 9.94 per cent.

The protein content of all most all the composite flour was higher (15.57g) than the control (9.43g). Similar findings were also reported by Figoni (2011). Singh et al. (2000) reported that protein content of cookies formulated from sweet potato flour was found to be 9.66g whereas Devi et al. (2000) found a protein content of 14.42 g in cookies formulated with green gram dhal.

In a study conducted at KAU by Shruthy (2005) observed that the protein content of cookies formulated with from jackfruit seed flour was 8.01g/100g. Similar findings were also reported by Sulieman et al. (2008) in cookies made with cowpea seed flour.

5.3.2.6 Total minerals

Ash refers to inorganic residue that is left following removal of water and organic matter by heat in the presence of oxidising agents (McClements, 2003). Therefore, content of ash will reflect total amount of minerals in food.

Ash is a nonorganic compound containing mineral content of food and nutritionally aid in the metabolism of other organic compounds such as fat and carbohydrate. Ash content is an indication of mineral content; hence samples with higher ash content are expected to have a relatively higher mineral content

The highest amount of ash content (2.33) was noticed in rice bran + wheat bran sweet cookies whereas in savory cookies it was found to be highest (2.26) in rice bran cookies (Fig 9).

The results are in tune with findings of Sharif et al. (2009) who reported that blending of rice bran significantly improved the mineral content of the cookies.

Fig 9(a). Mineral contents in the sweet cookies

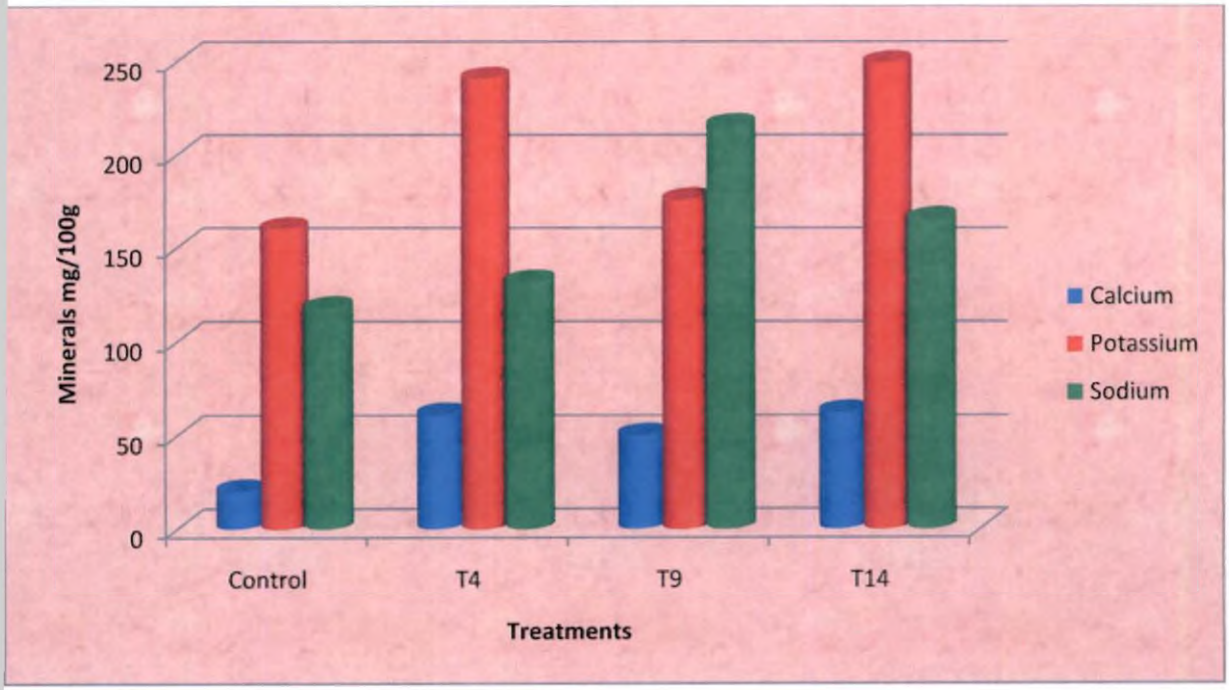
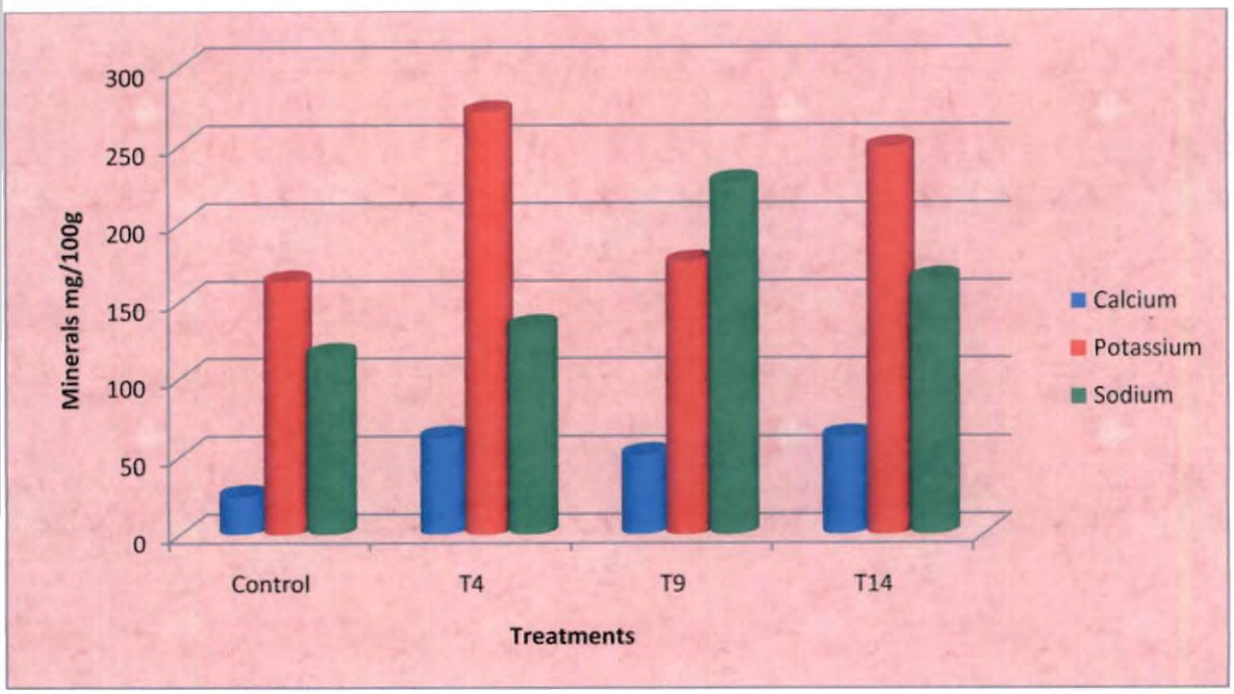


Fig 9 (b). Mineral contents in the savory cookies



It was observed that there was a significant difference between the total mineral content of the control and bran supplemented cookies

Addition of wheat bran and date powder mixture improved the mineral quality of biscuit reported by Gamal et al. (2012).

The mineral content was found to be increased in all the fibre supplemented cookies and this was probably due to the increase of the mineral content as a result of the incorporation of bran which are rich in minerals (Singh et al., 2000).

The ash content of biscuit made from wheat and African breadfruit ranged from 0.99 to 1.13 per cent (Agu et al., 2007). The biscuit produced from 60:40 per cent bread fruit and wheat had the highest mineral content. Nutritionally, this means that when used as composite flour will improve the ash content of the product.

5.3.2.6.1 Calcium

Calcium is essential for teeth formation and also helps in muscle contraction, maintenance of cell membrane, clotting of blood and normal functioning of nerve muscle and heart. It participates in the activation of many enzymes.

Calcium content was found to be more in bran supplemented cookies when compared to control cookies. The highest calcium content was noticed in rice bran + wheat bran cookies (T_{14}) (62.70 mg and 62.66mg/100g in the case of sweet and savory cookies respectively).

The calcium content ranged between 54.95-190.60mg / 100gm in cookies with 50 per cent defatted rice bran (Sharif et al., 2009).

A study conducted in KAU by Neelofer (2004) found that the calcium content of the cookies formulated with coconut was found to be 60.33mg/100g.

In a study conducted at KAU by Shruthy (2005) it was observed that calcium content was 58.5mg/100g in cookies formulated with jack fruit seed flour.

Soya fortified biscuits standardized by Singh et al. (2000) was also found to contain good amount of calcium.

5.3.2.6.2 Potassium

Potassium participates in certain enzyme systems in the body and controls acid base along with sodium to maintain fluid balance.

The potassium content of cookies ranged between 160.16-271.06mg/100g. It was found that bran supplementation increased the potassium content of cookies. The study is in tune with the findings of Sharif et al. (2009) who had found a potassium content in the range of 44.55 to 407.01 mg/100gm in cookies supplemented with defatted rice bran.

5.3.2.6.3 Sodium

The study revealed that bran supplemented cookies were having higher sodium content when compared to control cookies. The value ranged between 118.0 to 215.90mg and 115.63 to 226.40mg in sweet and savory cookies respectively. The highest sodium content was observed in wheat bran supplemented savory cookies (T_9) (226.40mg/100g).

Sharif et al. (2009) reported that the sodium content of defatted rice bran cookies ranged between 100.44 to 196.51mg/100g.

5.4 Shelf life of the cookies

The consumer demands foods which will remain fresh for long time, easy in handling, safe, healthy and having eco-friendly packaging (Pandey et al., 2005).

Assessment of shelf life quality is important since it determines the suitability of a particular ingredient for the product development. Shelf life

depends on a multiplicity of variables and their changes, including the product, the environmental conditions and the packaging (Brody, 2003).

Shelf life is the recommendation of the time that products can be stored, during which the defined quality of a specified proportion of the goods remains acceptable under expected conditions of distribution, storage and display (Azanha and Faria, 2005).

In sensory shelf life studies, food samples at different times of storage are presented to consumers (Hough et al., 2003).

5.4.1 Moisture content of the stored cookies

Moisture is one of the most important parameters which determine the shelf life quality of food products. Low moisture is highly important for longer storage period (Shankar, 2003).

Pande (2002) reported that most of the stored products are considered to be safe when stored at particular moisture content.

Considering the moisture content of the developed cookies, it could be observed that there was an increase in moisture content throughout the storage period. The moisture content observed in rice bran cookies was 4.07 % after 3 months. Prescribed moisture level of baked products is less than 6 per cent (Fig 10).

A study conducted in KAU by Shruthy (2005) observed that moisture content of cookies formulated from jackfruit seed flour increased with storage and the increase was found to be significant after 15 days of storage.

5.4.2 Peroxide value of the stored cookies

Afokowa et al. (2004) stated that peroxide value is an indicator of the keeping quality of food. Sharma (2006) reported that the primary products of lipids oxidations are generally present as peroxide. Thus it seemed reasonable to determine the concentration of peroxide as a measure of extent of oxidation and

Fig 10(a). Moisture content of the stored cookies (Sweet)

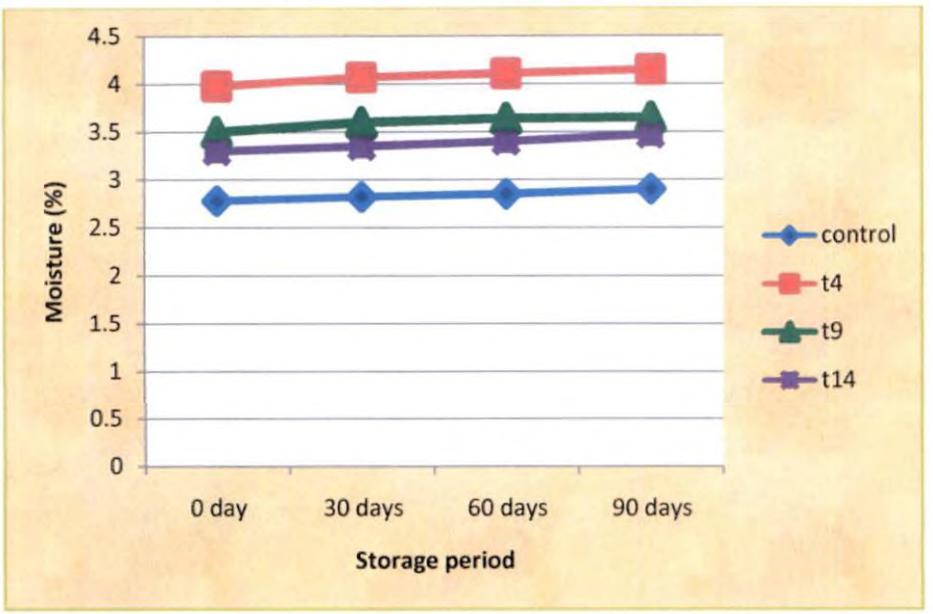
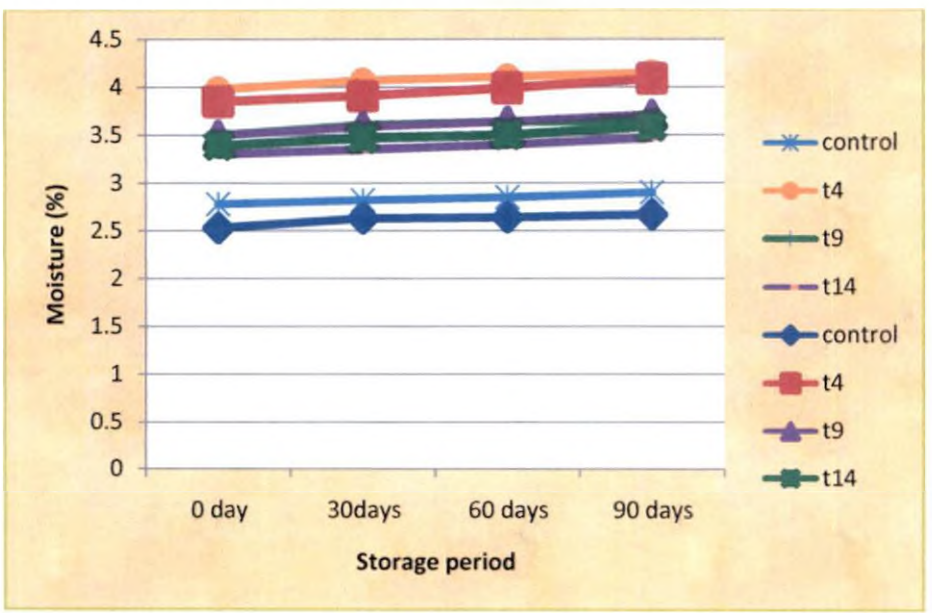


Fig 10(b). Moisture content of the stored cookies (Savory)



thus rancidity. The nature of auto oxidation degradation depends on the extent of unsaturation of lipids.

In the present study, the peroxidation occurs slightly after 60 days from the initial month. The peroxide value was found to be high in bran based cookies (0.05meq/kg and 0.05meq/kg in sweet and savory cookies respectively).

Peroxide value should not exceed 0.05 meq/Kg in finished products and the cookies were compared with the available BIS standards and were found to be in accordance with standard prescribed.

Krokida (2001) reported that the peroxide value was found to increase during storage. The study is in line with the findings of Pasha et al. (2008) who had reported an increase in peroxide value and free fatty acids contents in biscuits during storage.

A study by Neelofer (2004) in KAU also reported an increase in peroxide value in coconut cookies when stored. In the present study the cookies developed were not found to become rancid during the entire storage of 90 days and were crisp during the storage period.

5.4.3 Sensory evaluation of stored cookies

The sensory parameters such as colour, appearance, flavour, texture, taste and overall acceptability of any food product depends on the extent of oxidation of fats and oils in the food due to the formation of peroxide, aldehydes and ketones (Gupta, 2005). Evaluation of snack foods packed in laminated pouches and stored for 90 days was established to have acceptable colour, taste, texture, flavour and crispiness to the panel members (Shukla et al., 2013).

5.4.3.1 Colour

The colour of cookies depends on appearance of wheat flour and other ingredients used and on processing technique (Alam et al., 2014).

The present study indicated that the colour of the cookies decreased gradually as the storage period increased. Mean score of colour decreased in the case of rice bran + wheat bran based sweet cookies (T_{14}) (3.90 to 2.30) whereas it also decreased from (4.20 to 2.60) in case of rice bran + wheat bran (T_{14}) savory cookies. Minimum decrease in colour was noted in control sample 3.00 to 2.85 and 3.10 to 2.60 in sweet and savory cookies respectively. The results are in accordance with the findings of Elahi (1997) who observed a gradual decrease in colour of biscuits made from composite flour during storage.

A decrease in colour scores during storage was also reported by Neelofer (2004) in coconut cookies. The score for colour of the cookies formulated from Zylitol decreased from 6.80 to 5.10 as the storage period increased. The results are in tune with the findings of Iftikhar (2002) and Mushtaq et al. (2010). Manley (2002) reported that the natural trend of colour fading with progressive storage affects the appearance of cookies.

5.4.3.2 Crispiness

Crispiness is the gustatory sensation of brittleness in the mouth, such that the food item shatters immediately upon mastication. In the present study, the crispiness gradually decreased after three months of storage period. The mean score was found to be higher in wheat bran cookies during initial. The mean score was gradually decreased at the end of third month both in the case of sweet (4.50 to 3.00) and savory cookies (4.30 to 2.90).

Sharif et al. (2009) stated that the mean score of the fresh cookies formulated from defatted rice bran supplemented gradually decreased from 7.27 to 6.45 after 60 days of storage.

The crispiness of the cookies formulated with Xylitol gradually decreased with storage of 60 days (6.73-4.33). Winkelhausen et al. (2007) also found significant effect of storage on texture of cookies made with xylitol.

Loss of crispiness occurs due to moisture uptake as biscuits are hygroscopic in nature (Manley, 2002).

5.4.3.3 Aroma

Aroma is the property of a substance that causes a simultaneous reaction or sensation of taste on the tongue and odour in the olfactory centre in nose.

Aroma has been defined as "a memory" and "an experience" and it is indeed both of these. The sensation of taste and smell are functions of flavour which is a complex of sensation (Iwe, 2007).

During storage, the highest mean score for aroma (4.70) of wheat bran supplemented fresh cookies (0 day) gradually decreased to 3.90 and 3.60 after 60 days and 90 days of storage. Control cookies retained maximum score during storage period (i.e. 3.20, 3.00, 3.00 and 2.90 at 0^{th} day, 30^{th}, 60^{th} and 90^{th} day respectively). The findings are in agreement with the observation made by Neelofer (2004) in KAU who had reported that aroma scores in the coconut biscuits decreased with storage.

It has been observed that during storage of cookies, moisture absorption results in deterioration of aroma / flavour due to oxidation of fat (Sharif et al., 2009: Setser, 1996). The off flavour as a result of oxidation of fats is particularly related to the presence of moisture, further accelerated by metal ions and light (Manley, 2002).

Flavour of cookies formulated from xylitol gradually decreased with storage for 60 days (7.20 to 5.40). The loss in flavour might be attributed to absorption of water that resulted in fat oxidation.

5.4.3.4 Mouth feel

Mouth feel is a sensation perceived by the nerves in the skin of the mouth cavity resulting from thermal or chemical reaction.

Storing of cookies for 180 days had an effect on the mouth sensation of the products with respect to chewiness and crispiness (Jovanka et al., 2013).

The quality score in response to mouth feel of the cookies depicted that highest mean score (4.40) was obtained by T_{14} fresh cookies (0 day) which was decreased significantly with storage. The least score of (2.10) was obtained for control cookies after 90 days.

Jovanka et al. (2013) observed that average evaluation for mouth feel dropped by 0.4 and 0.5 points in the case of oat flakes and mixture of wheat flour and carob flour as dietary fibre sources.

The quality score in response to mouth feel of the cookies formulated from xylitol depicted that maximum score of 7.33 decreased to 5.60 significantly as the storage period increased.

5.4.3.5 Taste

Grige et al. (2009) opined that as far as a food is concerned taste is an imperative parameter that consumers used to judge the quality of food.

As far as taste attributes is concerned a significant decrease in taste scores was noticed after a period of 30 days. The taste of the developed cookies gradually decreased during the storage period. Mean score of taste decreased in the case of sweet cookies cookies supplemented with wheat bran (T_3) from (4.30 to 2.70) whereas it decreased from 3.60 to 2.90 in the case of rice bran + wheat bran (T_{14}). Minimum decrease in taste was noted in control sample (2.40 to 2.00 and 2.50 to 2.00 in sweet and savory cookies respectively).

Neelofer (2004) also reported similar decrease in taste score with storage in baked products from coconut during storage.

Sharif et al. (2009) reviewed that, the taste of the cookies formulated from defatted rice bran supplemented flour was gradually decreased from 7.16 to 6.53 after 60 days of storage. The decrease in cookie score might be due to the

rancidity of fats during storage. Mushtaq et al (2010) observed that the score for taste was 6.60 which gradually decreased 4.66 with storage after 60 days.

5.4.3.6 Overall acceptability

It was evident from the results that fresh cookies with wheat bran supplementation (4.36) were more appealing to judges at when prepared fresh. The overall acceptability score range between 4.36 to 3.26 between 0 day and 90 days.

Analysis of variance disclosed a highly significant effect of storage on overall acceptability of cookies prepared by replacement of xylitol on physico-chemical, sensory and microbial quality. The maximum score which was obtained by fresh cookies from 0 day gradually decreased with storage. The range between 0^{th} day and 60^{th} day was 6.20 to 4.53 (Mushtaq et al., 2010).

In earlier studies, a gradual decrease in overall acceptability of biscuits during storage was reported by Pasha et al (2002) who attributed it to moisture absorption and resulted in increased peroxide value and free fatty acid content in biscuits.

Sharif et al. (2009) found that the maximum score were obtained by fresh cookies formulated from defatted rice bran supplemented flour which gradually decreased from 7.15 to 6.40 during 60 days storage.

The decrease in overall acceptability was due to increase in colour, aroma, taste, texture and crispiness scores. The results were in close agreement with those of observed in earlier studies conducted by Butt et al. (2004).

In this study, the overall acceptability of the stored cookies gradually decreased during storage period. The initial value for wheat bran sweet cookies was 4.36. It was gradually decreased to 2.70 at the end of third month. The least mean score was obtained for control cookies during the initial and gradually decreased after third month both in the case of sweet and savory cookies.

5.5 Glycemic index of the cookies

GI of the food is defined as the incremental area under the two hour blood glucose response curve (AUC) following a 12hr. fasting and ingestion of a food with a certain quantity of available carbohydrate (usually 50g) (Jenkins, 2004). Glucose has a glycemic index of 100 and other foods have a lower glycemic index. Glycemic index is defined for each type of food, independent of the amount of food consumed.

The glycemic index of food is affected by various factors. Viscous and soluble fibres increase the viscosity of the intestinal contents and slow the interaction between the starch and the enzymes which can be the main factors affecting GI (Alison et al., 2014).

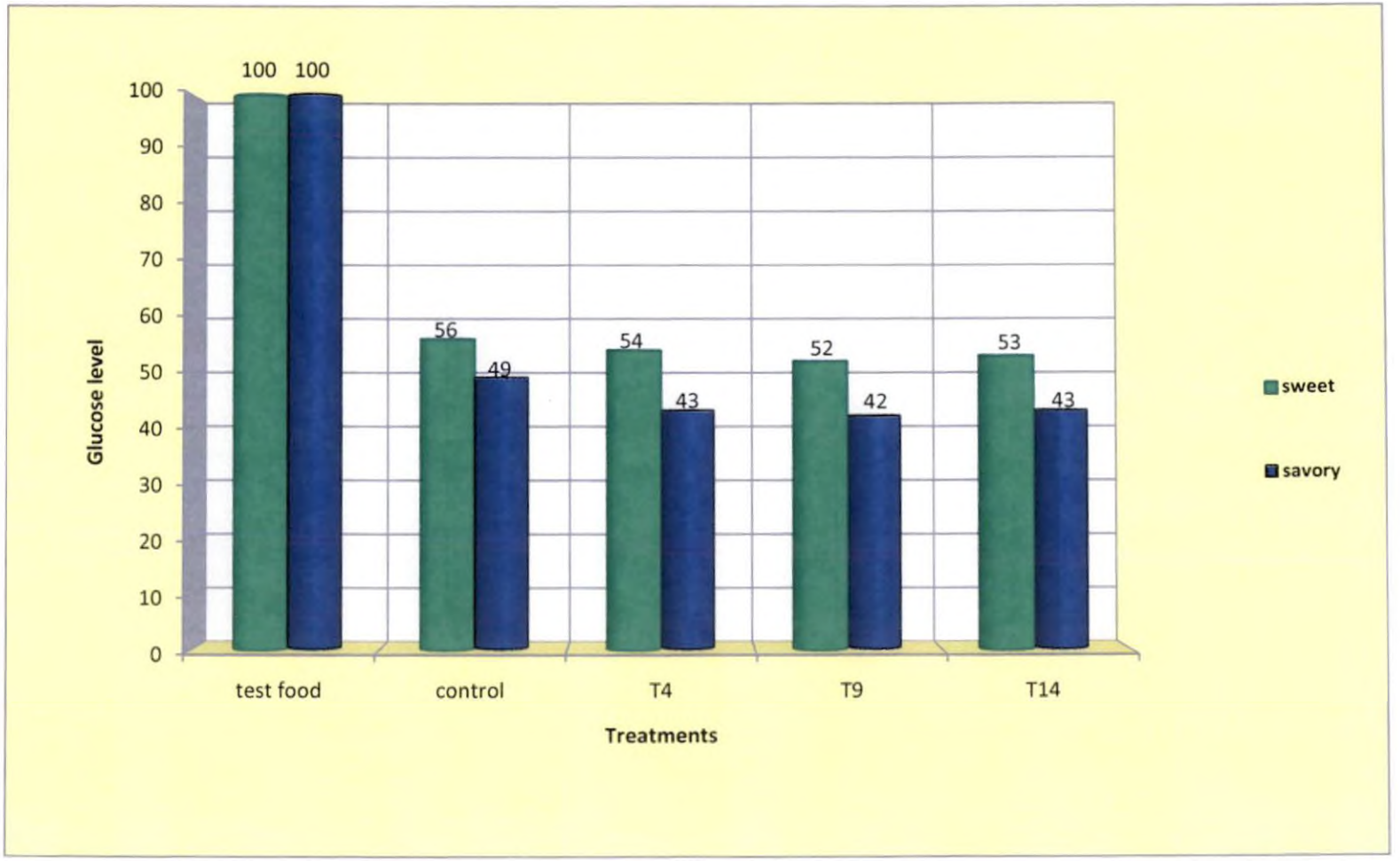
According to Wolever et al. (1990) the area under the glycemic index curve for each food taken by the same subjects and the resulting values were arranged to obtain the glycemic index value of the food.

In the present study, the glycemic index of the cookies were determined and compared with reference food (glucose). The glycemic index was observed in control cookies to be 56 and 49 in sweet and savory cookies respectively. The lowest glycemic index was observed in wheat bran based sweet cookies (52) and savory cookies (42) (Fig 11).

The study was in tune with the findings of Sharma et al. (2013) who had found a mean IAUC of 80.6mg/dl in cookies formulated with bottle gourd pulp fibre which was significantly lower than that of glucose (357.5 mg/dl) and wheat flour biscuits (106.3mg/dl).

Che et al (2014) in their study on "Effect of biscuits and muffins added with cornlettes powder on the Glycemic responses of healthy individuals" observed that the GI value of the biscuits formulated with cornlettes powder (46mg/dl) was less than the control biscuits (61mg/dl) and glucose (154 mg/dl).

Fig 11.Glyemic index of the cookies



5.6 Consumer acceptance and preference of cookies.

Consumer awareness and preference decide the success of food products standardized. Acceptance and preference are consumer oriented tests. The factors that motivates, consumer's consumption of food products include exceptional taste experience, good mouth feel, premium quality, enjoyment, wellness and naturalness.

The choice of foods depends on consumer beliefs and attitudes. Consumer uses numerous product criteria to evaluate whether a food product satisfies their expectations and requirements (Gellynck et al., 2008).

Consumer acceptance study was carried out in 30 subjects using hedonic rating scale. The highest score was obtained for wheat bran sweet cookies and the lowest score for rice bran sweet cookies (Fig 12).

Today, consumers have increased concern regarding food safety and qualities. Consumers measure food quality using visible features such as pleasant attributes of the product and also their awareness of invisible qualities such as microbial and toxicological safety and nutritive value (Taemans, 2000).

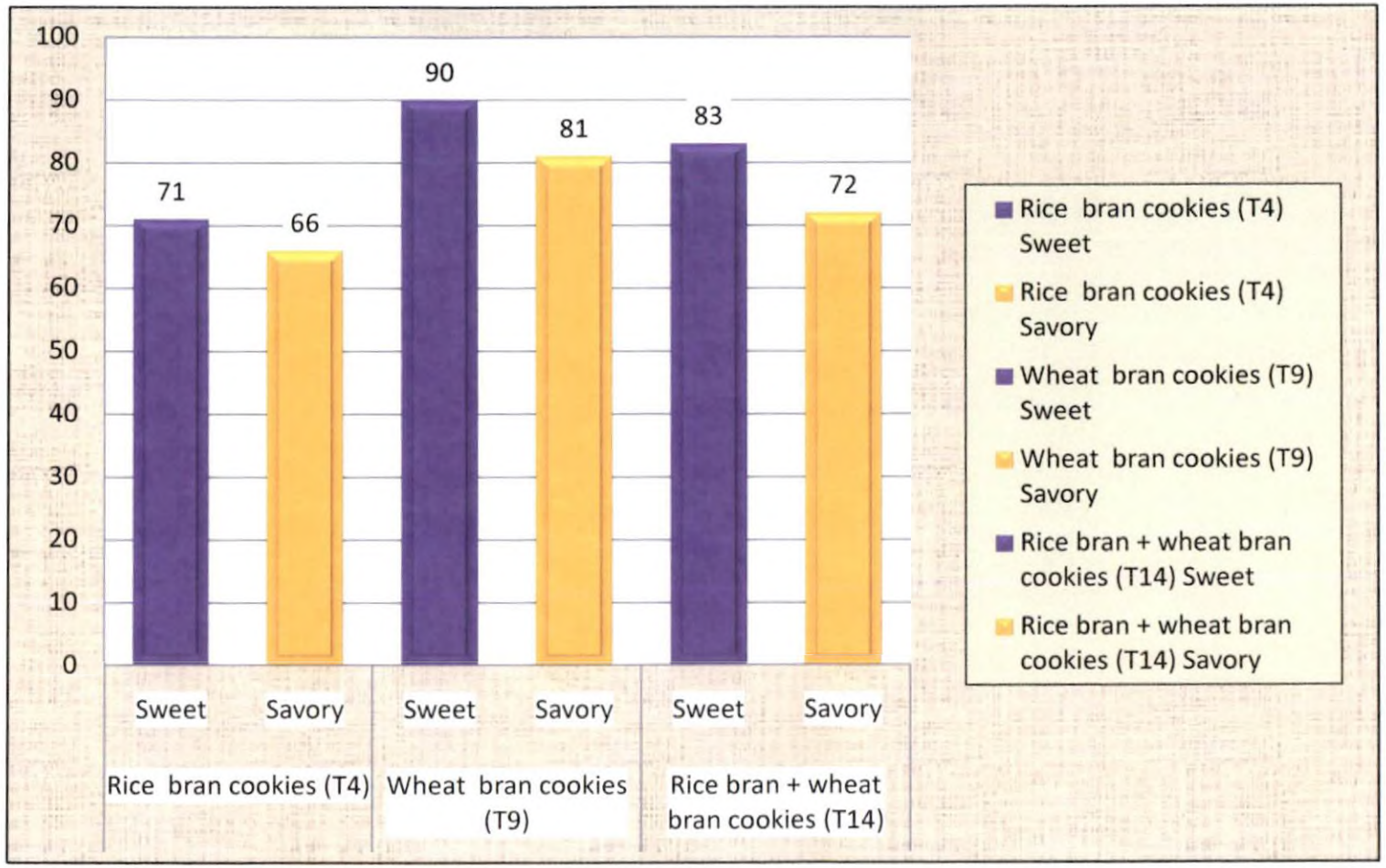
5.7 Cost of Production

Cost can be defined as the process of determining how much it cost to produce and sell a product. Costing is very important as the cost of a product can decide its profit or loss (Awasthi, 2006).

The factor that determines the cost of the finished product is the turnover of the finished product obtained from the raw materials used. Knowledge of the yield of products developed is essential in deciding the economic feasibility of the product. Hence, the cost of the formulated cookies were calculated.

Cost analysis was carried out to assess the expenses incurred for obtaining different finished products.

Fig 12. Consumer acceptance of the cookies



The cost of production of 100g cookies developed was found to be ranged between Rs 9.50 to 9.54 for sweet cookies and Rs 11.34 to 11.43 for savory cookies.

According to Srivastava et al. (2012) the cost of the developed cookies from sweet potato was found to be Rs. 32/ kg.

According to Kumbhar and Singh (1991), cost of production depends on the cost of the raw materials; cost involved in processing, packaging and marketing and profit margin setup by the industry.

One the health point of view, the rate of bran supplemented cookies is much less compared to the proprietary products available in the market. So sweet and savory bran cookies are justified as good products economically and also with respect to health.

Summary

6. SUMMARY

The present study entitled "Development and quality evaluation fiber enriched cookies" was under taken with the objective to develop wheat based cookies enriched with cereal bran and to assess its quality parameters and glycemic index. Consumer acceptance, cost, yield ratio were also ascertained. The raw materials selected for the study were refined flour, wheat bran, rice bran, sugar and other adjuncts. Composite flour was prepared by substituting refined flour with rice bran/ wheat bran/ rice bran + wheat bran upto maximum 50 per cent in different combinations and proportions. Altogether fifteen treatments / combinations were selected and the cookies were prepared based on standard recipe. The cookies were subjected to organoleptic evaluation by a panel of ten judges using a score card and were compared with control cookies to select the best treatment.

The organoleptic evaluation of cookies revealed that the mean scores for colour of the developed cookies ranged between 2.80 to 4.20 in the case of bran based cookies. The highest score (4.20) was assigned to rice bran + wheat bran based savory cookies (T_{14}) followed by wheat bran based sweet cookies (4.10) (T_9) and lowest score (2.80) to rice bran based savory cookies (T_2). The score for crispiness of the cookies ranged from 2.20 to 4.50 and the highest value (4.50) was obtained for wheat bran sweet cookies T_9. Mean score of aroma of the cookies revealed that it varied among different treatments. The highest score (4.70) was obtained for T_9 and T_{14}. The mean value fell between 2.30 to 4.40 in the case of sweet cookies and 2.40 to 3.80 in the case of savory cookies with respect to mouth feel. The highest mean score for taste was bagged by wheat bran based sweet cookies (T_9) (4.30). The overall acceptability of the mean score of the cookies ranged between 2.74 to 4.36. Wheat bran based cookies (T_9) was adjudged to be the best with respect to overall acceptability among sweet (4.36) and savory cookies (3.88).

Based on the maximum score obtained for overall acceptability, six treatments i.e. two from rice bran (sweet and savory), two from wheat bran (sweet and savory), and two from rice bran + wheat bran (sweet and savory) based cookies were selected. Hence, the best treatments selected in the present study were T_4 (sweet and savory), T_9 (sweet and savory), T_{14} (sweet and savory) along with T_1 (control). The selected treatments were subjected to in-depth analysis such as physical parameters, chemical/ nutrient composition and shelf life studies. The yield ratio cost of the product and glycemic index of the cookies were also worked out.

The physical parameters such as weight, diameter, thickness and spread ratio were studied. The data revealed that weight of cookies ranged between 13.33 to 16.00g. It was observed that control cookies had the minimum weight both in the case of sweet and savory cookies (13.67g and 13.33g respectively). An increase in weight of cookies was observed with addition of bran. The control sample exhibited less diameter both in the case of sweet (3.77cm) and savory cookies (3.67cm) with respect to diameter. It was found that highest diameter was observed in rice bran + wheat bran based cookies (4.20cm). Thickness of the cookies revealed that all the bran based cookies differed significantly with the control both in the case of sweet and savory cookies. The maximum thickness was found in cookies based with rice bran + wheat bran cookies (1.29cm) in the case of sweet cookies, where as it was found to be highest in cookies based with wheat bran (1.29cm) in the case of savory cookies. The spread ratio revealed that, there was significant difference between control and bran based cookies. The control cookies had maximum spread ratio both in the case of sweet and savory cookies (3.83 and 3.58 respectively).

The chemical and nutrient composition of the cookies was ascertained with respect to moisture, protein, fat, energy, fiber and total minerals. The moisture content of cookies ranged between 2.53 to 3.98 per cent. It was found that control cookies had less moisture when compared to bran based cookies. There was a significant difference between control and bran based cookies with

respect to energy content. The energy content ranged between 443 to 524 Kcal / 100g. The highest energy content was observed in control cookies i.e.524 Kcal in the case of sweet and 485 Kcal in the case of savory cookies. In the case of fiber content, it was found that the highest fibre content was noticed in rice bran + wheat bran savory cookies (3.50g/100g) and lowest (1.40g/100g) in the case of control cookies. Higher fat content was observed in bran based cookies when compared to control cookies. The highest fat content was observed in rice bran + wheat bran sweet cookies (T_{14}) being 17.51g and 17.63g/100g for savory cookies. The protein content was found to be highest in rice bran + wheat bran cookies (T_{14}) both in the case of sweet and savory (8.49g and 8.84g/ 100g). The control cookies exhibited less protein content compared to bran based cookies. The total mineral contents of the three bran based cookies differed significantly with the control sample but were on par with each other. The total mineral content was found to be highest in rice bran + wheat bran cookies in the case of sweet and savory cookies (2.33g and 2.22g/100g). Statistically significant differences were noted between control sample and bran based cookies with respect to calcium content and it ranged between 20.50 mg to 62.70mg/100g. The calcium content was found to be lowest in control cookies (20.50mg/100g in sweet cookies). The potassium content of the cookies ranged between 160.16 mg to 271.06mg/100g. In the case of potassium also, control cookies exhibited lower amount when compared to bran based cookies (160.16mg/100g in sweet cookies). There was a significant difference between sodium content of the control and bran based cookies.

The developed cookies were stored in laminated pouches at ambient conditions. The shelf life of the cookies were ascertained periodically for a period of three months in terms of organoleptic qualities, moisture and peroxide value. The study revealed that, there was an increase in the moisture content throughout the storage period. In the present study, the peroxidation occurred only after 60 days of storage. There after negligible values were noticed in stored cookies but within the permissible limit.

Organoleptic assessment of the cookies during storage period of three months showed a decreasing trend in the mean score of quality attribute colour. The decrease in colour score was more in the case of bran based cookies when compared to control cookies. The crispiness of the cookies gradually decreased after three months of storage period. In the case of aroma, control cookies retained maximum aroma during storage when compared to bran based cookies. It was observed that the score for taste of the cookies gradually decreased during the storage period. Minimum decrease in taste was noted in control sample (2.40 to 2.00 and 2.50 to 2.00 in sweet and savory cookies respectively).

The score in response to mouth feel of the cookies during storage depicted that mean score of 4.40 obtained by T_{14} fresh cookies (0^{th} day) decreased significantly during storage. The overall acceptability scores ranged between 4.36 to 2.26 from 0^{th} day to 90^{th} day.

The glycemic index of the cookies revealed that, bran based cookies had lesser glycemic index when compared to control cookies. The highest glycemic index was noticed in control cookies. (46 and 29 in the case of sweet and savory cookies respectively) whereas the lowest glycemic index was found in wheat bran based sweet (42) and savory (22) cookies respectively.

One cookie each from rice bran, wheat bran, rice bran + wheat bran which maintained highest organoleptic scores was selected for the consumer acceptance study. The test was conducted among technical experts, college students and school children using hedonic rating scale and the per cent score was calculated followed by assigning ranks. Wheat bran sweet cookies obtained the highest score (90) followed by rice bran sweet cookie (81).

The cost of the cookie was worked out and was found to be range between Rs. 9.50 to 12.82 / 100g cookies. It was found that the cost of bran based cookie was less when compared to fiber enriched proprietary cookies available in the market. The yield ratio of cookies ranged between0.40 to 0.48 in the case of sweet

cookies and 0.39 to 0.56 in savory cookies. The yield ratio was found to be more in bran based cookies when compared to control cookies.

From the present research work, it can be concluded that replacement of wheat flour with cereal bran up to 30 per cent is possible without adversely affecting physical and sensory characteristics of cookies. Cereal bran supplementation significantly improved the energy value, dietary fibre, minerals and protein content of the cookies. Moreover, cost of production was also viable when compared to proprietary products available in the market. Consumers preferred wheat bran based (T_9) sweet cookies with incorporation of bran at 30% level.

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Appendices

APPENDIX- I

Score card for the sensory evaluation of cookies

Product : **Date :**

Sl no:	Quality parameters	Score	Ctrl	A	B	C	E
1	Appearance						
	Excellent	5					
	Very good	4					
	Good	3					
	Fair	2					
	Poor	1					
2	Crispness						
	Highly crisp	5					
	Crisp	4					
	Tender	3					
	Soft	2					
	Moist	1					
3	Aroma						
	High	5					
	Moderate	4					
	Pleasing	3					
	Mild	2					
	Rancid(off flavor)	1					
4	Taste						
	Excellent	5					
	Very good	4					
	Good	3					
	Fair	2					
	Poor	1					
5	Mouth feel						
	Excellent	5					
	Very good	4					
	Good	3					
	Fair	2					
	Poor	1					

Name & Signature :

APPENDIX- II

Score card for consumer acceptance

Product : Date :

Sl no:	Criteria for acceptability	Rating	A	B	C	D	E
1	Like extremely	9					
2	Like very much	8					
3	Like moderately	7					
4	Like slightly	6					
5	Neither like or dislike	5					
6	Dislike slightly	4					
7	Dislike moderately	3					
8	Dislike very much	2					
9	Dislike extremely	1					

Name :

Signature :

Abstract

DEVELOPMENT AND QUALITY EVALUATION OF FIBRE ENRICHED COOKIES

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Abstract of the
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for the degree of

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ABSTRACT

The present study entitled "Development and quality evaluation of fibre enriched cookies" was conducted at the Dept of Home Science, College of Agriculture, Vellayani with the objective to develop wheat based cookies enriched with cereal bran and to assess its quality parameters and glycemic index. Consumer acceptance, cost, yield ratio were also ascertained. Sweet and savory cookies were standardized by trial and error method substituting wheat flour with cereal bran @ 10 to 50% along with other adjuncts. Fifteen experimental treatments viz. T_1 -control (100% refined flour), T_2 to T_6 rice bran cookies, T_7 to T_{11}- wheat bran cookies and T_{12} to T_{15} combination of rice bran + wheat bran were selected. Each treatment was replicated thrice.

Sensory evaluation of the 15 treatments was carried out by a panel of judges and on the basis of overall acceptability scores, best treatment from each category ie.T_4, T_9 and T_{14} @ 70:30 along with control (T_1) (100% refined flour)were selected for in-depth analysis such as physical parameters, nutrient composition, storage stability and glycemic index.

Results of physical parameters revealed an increase in weight of cookies with addition of bran. The weight of cookies ranged between 13.33 to 16.00g. The control cookies (T_1) exhibited less diameter (3.67cm). The maximum thickness was found in T_{14} cookies (1.29cm). The spread ratio revealed a significant difference between control and bran based cookies.

The nutrient composition of cookies revealed that the moisture content of cookies ranged between 2.53 to 3.98 per cent. There was a significant difference between control and bran based cookies with respect to energy content. The highest energy content was observed in control cookies i.e.524 Kcal /100g (sweet) and 485 Kcal/100g (savory). Fiber content was found to be highest in T_{14} (3.50g/100g) and lowest (1.40/100g) in T_1. Higher fat content was obtained in rice bran + wheat bran

sweet cookies (T_{14}) being 17.51g and 17.63g/ 100g for savory cookies. The protein content was found to be higher in T_{14} both in the case of sweet and savory (8.49g and 8.84g/100g) cookies. The total mineral content was found to be highest in rice bran + wheat bran cookies both in the case of sweet and savory cookies (2.33g and 2.22g/100g).

The shelf stability of the cookies was assessed by storing the cookies in laminated pouches at ambient condition for a period of three months. The organoleptic qualities, moisture and peroxide value was determined initially and at the end of each month. A slight increase in moisture content was observed during the storage period. FSSAI type tests were administered to the cookies and found that moisture content was within the prescribed limits. Peroxide value was not detected up to three months. Analysis of organoleptic scores indicated that overall acceptability scores did not vary significantly over the storage period.

The yield ratio was found to be more in bran based cookies. The cost of bran based cookies was found to be less (Rs 9.50 to 12.82/ 100g) when compared to fibre enriched proprietary cookies (Rs.20.00, 36.00 and 40.00/100g) available in the market.

Consumer acceptance study unveiled that T_9 (wheat bran sweet cookies) ranked the best having a score of 90. Lowest GI was noticed in T_9 followed by T_{14}(savory cookies). It can be concluded that replacement of wheat flour with cereal bran up to 30 per cent level is possible without adversely affecting physical parameters, sensory qualities and nutrient composition.