PREPARATION OF MALTODEXTRIN FROM SORGHUM AND ITS UTILIZATION IN BAKERY PRODUCT (COOKIES)

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B. Tech. (Food Technology)

MASTER OF TECHNOLOGY

IN

FOOD TECHNOLOGY

DEPARTMENT OF FOOD CHEMISTRY AND NUTRITION

COLLEGE OF FOOD TECHNOLOGY, PARBHANI

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PARBHANI - 431 402 (M.S.) INDIA

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A thesis submitted to
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani
in partial fulfilment of the requirements for the degree of

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IN
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COLLEGE OF FOOD TECHNOLOGY, PARBHANI
VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH
PARBHANI - 431 402 (M.S.) INDIA

2022

DECLARATION BY THE CANDIDATE

I hereby declare that the thesis entitled **"PREPARATION OF MALTODEXTRIN FROM SORGHUM AND ITS UTILIZATION IN BAKERY RRODUCT (COOKIES)"** submitted by me is based on the actual work carried out by me under the guidance and supervision of **Dr. K. S. Gadhe**. The extent of information derived from the exiting literature have been duly cited and referenced. The exiting research work or its any part is not submitted anywhere else for the award of any degree or diploma.

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Place : Parbhani

Date : 30 / 11 / 2022

Sadaf Tarannum Mohammad Ilyas

(Reg. No: 2020T12M)

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This is to certify that the thesis entitled, **"PREPARATION OF MALTODEXTRIN FROM SORGHUM AND ITS UTILIZATION IN BAKERY PRODUCT (COOKIES)"** submitted by **SADAF TARANNUM MOHAMMAD ILYAS (Reg. No. 2020T12M)** in partial fulfillment of the requirements for the award of the degree of **MASTER OF TECHNOLOGY** in the subject of **(Food Technology)** submitted to the Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani is a record of bonafide research work carried out by her under my guidance and supervision. The thesis or its any part has not previously formed the basis for the award of any degree, diploma or other similar title.

Place: Parbhani

Date : 30 / 11 / 2022

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CERTIFICATE - II

This is to certify that the thesis entitled **"PREPARATION OF MALTODEXTRIN FROM SORGHUM AND ITS UTILIZATION IN BAKERY PRODUCT (COOKIES)"** submitted by **SADAF TARANNUM MOHAMMAD ILYAS (Reg. No. 2020T12M)** in partial fulfillment of the requirements for the award of **MASTER OF TECHNOLOGY** in the subject of **(Food Technology)** to the Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani has been approved by the Students Advisory Committee after viva voce examination of the student in collaboration with the External Examiner.

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CHAPTER-I INTRODUCTION Sorghum (Sorghum bicolor L. Monech) is one among the five major cereals of the world. Sorghum also known as jawar or milo, is a major cereal crop in the semi-arid and arid regions of Africa and Asia where it is used in the preparation of several traditional foods. It is heat and drought resistant than most other cereals (Carcea et al., 1992). In India, it is third largest cultivated crop after rice and wheat and is fifth in the world after rice wheat, corn and barley. India has largest area (32.30 %) under sorghum cultivation in the world and ranks second in production after USA (Diats et al., 1997). The total area under sorghum cultivations is 11.57 million hectares and 5.69 million hectares in Maharashtra. The average yield was 958 kg and 1096 kg/hectare in the country and Maharashtra respectively (Rana et al., 1999). There are several reports available in scientific literature on proximate composition of sorghum grain, which revealed that they are rich in carbohydrates (85-89 %) out of which starch alone accounts 62 - 72 % depending on variety (Eggum et at., 1981). Sorghum is consumed by people for its carbohydrate content as energy source and starch is leading ones in it. Sorghum is being used as source for the isolation of starch. Starch plays an important role in physical, chemical and nutritional properties of the finished foods. It is extensively used for non food uses like textile. In food, starch adds a degree of nutritive value, but the main reason starches are incorporated in foods is the high functional value they provide. Sorghum is a gluten- free grain tolerated by patients with celiac disease, that has potential in the gluten- free food market. Despite considerable scientific progress in understanding celiac disease, to date, a strict gluten-free diet for life is the only treatment for patients with celiac disease. With an increasing number of people being diagnosed with celiac disease and with the market for gluten- free products growing, there is a great opportunity to create new products using sorghum flour. There are many sorghum hybrids that have not been characterized for grain, flour or end- product quality. Therefore, understanding the quality attributes of sorghum varieties is critical in translating to end- product use. The results have

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PLACE : PARBHANI

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ABBREVIATIONS USED

Abbreviation		Elaboration
%	:	Per cent
CD	:	Critical Difference
SE	:	Standard Error
Mm	:	Milli meter
Mg	:	Milli gram
G	:	Gram
Kg	:	Kilogram
RDA	:	Recommended Daily Allownces
et al.	:	et alibi (and associates)
hr.	:	Hour
i.e.	:	That is
Kcal	:	Kilo Calorie
Cp	:	Centi poise
viz.	:	Videelict (namely)
Etc	:	Etcetera
WHO	:	World Health Organization
AOAC	:	Association of Official Analytical Chemists
Min	:	Minute (s)
N	:	Normality
No.	:	Number
Sec	:	Seconds
Rs	:	Rupees
Deg	:	Degree
Ml	:	Milliliter
ºC	:	Degree Celcius
Psi	:	Pound per square inch
CFU	:	Colony forming unit
ANOVA	:	Analysis of variance

ABSTRACT

THESIS ABSTRACT

Title of the thesis	:	Preparation of Maltodextrin from Sorghum and its Utilization in Bakery Product (Cookies)
Name of candidate	:	Sadaf Tarannum Mohammad Ilyas
Research Guide	:	Dr. K.S. Gadhe
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ABSTRACT

In the present investigation, the technology was developed to standardize the process for preparation of maltodextrin from Sorghum variety (Parbhani Shakti) by acid hydrolysis and enzyme hydrolysis method and its utilization in preparation of cookies as a fat replacer. Maltodextrin used as fat replacer due its low calorie content as compare to hydrogenated fat. The yield of maltodextrin prepared by enzyme hydrolysis method was greater than the acid hydrolysis method. Demand for ready to eat processed foods with better shelf life, satisfying taste, ease of palatability high nutritional quality and low calories is increasing throughout the world because of growing urbanization, economy and increased employment in industrial and day to day changing life style of people. Bakery products like cookies are most important product due to less moisture and better shelf life. Cookies were prepared from wheat flour (maida), sugar, fat, maltodextrin, baking soda, ammonium bicarbonate and milk. Prepared cookies were analyzed for sensory properties. Sensory evaluation revealed that the T3 sample, which contained 30 per cent maltodextrin as a fat replacer was the best . The nutritional study revealed that the selected sample (T_3) has moisture, fat, carbohydrate, protein, ash and crude fibre content of 1.3%, 8.96%, 83.82%, 2.97%, 1.28%, and 2.061% respectively. The selected sample is superior in carbohydrate content and less in fat content than control sample (T_0). The energy value of the selected cookies sample is less than control sample. This was due to lower fat content in T_3 sample as compare to control sample.

(Key words : Sorghum, Maltodextrin, Fat replacer, Cookies)

CHAPTER -I

INTRODUCTION

CHAPTER - I

INTRODUCTION

Sorghum (Sorghum bicolor L. Monech) is one among the five major cereals of the world. Sorghum also known as jawar or milo, is a major cereal crop in the semi-arid and arid regions of Africa and Asia where it is used in the preparation of several traditional foods. It is heat and drought resistant than most other cereals (Carcea *et al.,* 1992).

In India, it is third largest cultivated crop after rice and wheat and is fifth in the world after rice wheat, corn and barley. India has largest area (32.30 %) under sorghum cultivation in the world and ranks second in production after USA (Dias *et al*., 1997).

There are several reports available in scientific literature on proximate composition of sorghum grain, which revealed that they are rich in carbohydrates (85-89 %) out of which starch alone accounts 62 - 72 % depending on variety (Eggum *et al*., 1981).

Sorghum is consumed by people for its carbohydrate content as energy source and starch is leading ones in it. Sorghum is being used as source for the isolation of starch. Starch plays an important role in physical, chemical and nutritional properties of the finished foods. It is extensively used for non food uses like textile. In food, starch adds a degree of nutritive value, but the main reason starches are incorporated in foods is the high functional value they provide.

Sorghum is a gluten free grain tolerated by patients with celiac disease, that has potential in the gluten free food market. Despite considerable scientific progress in understanding celiac disease, to date, a strict gluten free diet for life is the only treatment for patients with celiac disease. With an increasing number of people being diagnosed with celiac disease and with the market for gluten free products growing, there is a great opportunity to create new products using sorghum flour. There are many sorghum hybrids that have not been characterized for grain, flour or end-product quality. Therefore, understanding the quality attributes of sorghum varieties is critical in translating to end product use. The results have shown that sorghum hybrids

can differ in kernel and flour characteristics, which could help predict end- product quality and application in gluten free products.

Starch is a principle component in many fabricated / engineered food systems constituting a major source of energy. It also plays an important role in the finished food products with special reference to structure, texture consistency and also consumer appeal.

The principle functions that specially starch perform in food are adhesion, antistaling, binding, clouding, dusting, emulsification, flow aid, foam strengthening, gelling, glaze forming, moisture holding, processing aid, shaping, stabilizing, texturizing and thickening (Smith and Bell, 1986).

Fats have such a wide array of functions because the family of dietary fatty acids in the food supply is diverse and has a range of properties. Subtle differences in the particular mixture of fatty acids, which vary in chain length and degree of saturation, can markedly alter the sensory properties and nutritional implication of a food. Because these attributes generally reflect the collective influences of multiple fatty acids in a product, it is unlikely they will ever be replicated with a single natural or synthetic compound. Indeed, there is increasing awareness that product optimization will often requires blends of more than 100 compounds identified during the past decades as contributing specific “Fat like” functional properties to reduce fat in foods.

The preparation and use of variety of food ingredients known as fat replacers are making possible the production of many low fat or no fat foods. In recent years the food industry has developed wide variety of tow calorie, starch based material to reduce and replace fat in processed foods. These fat replacers are used to deliver finished food product with flavour, mouthfeel, color, texture and appearance of their full fat counterparts.

The fat in foods plays key role in determining texture and taste, and ultimately foods acceptability. But reducing fat in foods which preserve taste and texture has been major challenge and by using ingredients that minimize the functions of fat in food, lowering the risk of heart diseases. So fat replacer may provide an answer to this enigma by using carbohydrate-based mimetics. Dextrin is a generic term applied to a

variety of modified starches obtained by heating a starch in presence of small amounts of moisture and acid (Wankhede *et al*., 2005).

The FDA regulation 1983 described maltodextrin as a nutritive saccharide polymer that consists of D-glucose units linked primarily by α (1-4) bonds and that has DE less than 20. It is prepared as white powder or concentrated solutions by the partial hydrolysis of corn starch with safe and suitable acid and enzymes (Alexander, 1992).

Hydrolytic breakdown products from starch are often characterized by their dextrose equivalence (DE) which is the percentage of reducing power compared to anhydrous D-glucose (dextrose). The DE value is inversely related to molecular size, i.e. the degree of depolymerization (DP), and is, thus an indicator of the degree of hydrolysis. The DE value of anhydrous D-glucose is 100. The DE value of native starch is 0. (Bemiller, 1993).

Maltodextrin is a polysaccharide produced from the acidic or enzymatic hydrolysis of starch which has a nutritional contribution of only 4 calories per gram. It is considered a polymer of D-glucose chains linked by glycosidic α-(1-4) and α-(1-6) bonds, and is formed by linear (amylose) and branched (amylopectin) carbohydrates with different equivalents of dextrose (DE) (Valenzuela, and Aguilera, 2015).

Maltodextrin is the name given to those hydrolysates with DE values in the 3–20 range, while those with values higher than 20 are known as glucose syrups. In this sense, the physicochemical and functional properties of maltodextrin depend on the DE value i.e., powder may behave as a highly hygroscopic powder or as a concentrated liquid solutions (Udomrati, and Gohtani, 2015).

The dextrose-equivalent (DE) expresses the number of aldehyde groups with reduced ends in relation to pure glucose. Thus, high dextrose equivalent (DE) indicates high hydrolytic conversion and low molecular weight. Depending on the degree of hydrolysis of the starch molecule, the product obtained is classified as maltodextrin (if the DE value is less than 20) or syrup (DE equal to or greater than 20) (Silva, *et al.,* 2014).

Bakery industry is one of the major food industries in India. It has played a significant role in the economic development of the country. The two most important bakery products viz., bread and biscuits accounts about 81% of the whole bakery

products. The yearly manufacturing of bakery products which includes bread, biscuits, pastries, cakes, buns, etc. are from both the organized and unorganized sectors, which comprises 15 lakh tonnes most of which are in the organized sector is estimated to be around 31 Lakh tonnes. The production of bakery products in both is estimated to be around 15 lakh tones and 11 lakh tones respectively (Mohammed Asmatoddin *et al*., 2008).

Baking industry in India is considered as one of the major industries in food processing. Baking products are gaining popularity as processed foods because of their availability, ready to eat convenience and reasonably good shelf life. Wheat based baked products like bread, cookies, and cakes are popular among the baked products. Among the bakery products, cookies are most significant. Cookies are important food snacks for children and adults. However these are most commonly relished by school going children and adults. Cookies hold an important position in snack foods due to variety in taste, crispiness and digestibility. These are popular among all age groups especially in children's. Commercially available cookies are prepared from white flour that is nutritionally inferior to whole wheat flour (Hussain *et al.*, 2006).

"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 biscuit like products have been made, eaten by man for centuries.Cookies are ideal for nutrient availability, palatability, compactness and convenience. They differ from other bakery products like bread and cakes because of having low moisture content, comparatively free from microbial spoilage long shelf life of the product.

Apart from this cookies are having a good eating quality and quite long shelf life. Long shelf life makes large scale production and distribution possible (Rodge, 1991).

Bakery industry in India is the largest of the food industries with an annual turnover of about 3000 corers. 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 etc. Importance of bakery products has expanded

especially the use of whole and natural grains and other natural ingredients (Saranraj and Geetha, 2012).

Among the bakery products, cookies are most significant. Cookies are important food snacks for children and adults. Cookies hold an important position in snack foods due to variety in taste, crispiness and digestibility. These are popular among all age groups especially in children. Commercially available cookies are prepared from white flour that is nutritionally inferior. (Hussain *et al.*, 2006).

The word cookie is derived from the Dutch word "koekje" or (informal) "koekie" which means little cake, and arrived in the English language through the Dutch in North America, Cookies are made in a wide variety of styles using an array of ingredients including sugars, spices, chocolate, butter, peanut butter, nuts or dried fruits. The softness of the cookie may depend on how long it is baked. (Washeed *et al.,* 2010).

Cookies are characterized with quite long shelf life, which results in their availability almost everywhere at any time. Therefore, the alteration of composition of cookies directed to enhancement their nutritive and/or functional properties. The basic composition of cookies enables a variety of different possibilities for achievement of dietary properties of the products with respect to type, share and function of three main components for cookie dough production: flour, fat and sugar. There are different possibilities for development and production of dietary cookies, from sugar replacement or reduction, over alteration of fat shares, composition and properties to enrichment of cookies with different functional components. (Jovanka *et al.,* 2013).

Meal can be made healthier by eating high-fiber whole grain cereals that has low sugar. Also, eating a variety of cereals is helpful to health rather than just feeding on one item. All cereal grains have high energy values, mainly from the starch fraction, but, also from the fat and protein portions. Cereal grains contain carbohydrates- mainly starches (comprising 65 to 75% of their total weight), as well as proteins (6 to 12%) and fat (1 to 5%) along with traces of minerals and vitamins. Cereals and wholegrain foods can reduce the risk of developing certain diseases including coronary heart disease, colon cancer, diabetes and diverticular disease. (Sarwar *et al.*, 2013).

Wheat is considered a good source of protein, minerals, vitamins and dietary fiber that is an excellent health-building food. Thus, it has become the principal cereal, being more widely used than any other cereal because of the quality and quantity of its characteristic protein called gluten. The whole wheat, which includes bran and wheat germ, therefore, provides protection against diseases such as constipation, heart disease, disease of the colon called diverticulitis, appendicitis, obesity and diabetes (Kumar *et al*., 2011).

Cookies hold an important position in snack foods due to varieties in taste, crispiness and digestibility. At present cookies are prepared from white flour which is inferior in quality and low in fiber content. Low levels of dietary fibers cause certain non infectious diseases such as diverticulitis and colonic cancer. (Burkitt, 1971).

Reducing dietary fat is the primary dietary goal for many consumers. Fat replacers are compounds incorporated into food products to provide them with some qualities of fat. Consequently, health conscious individuals are modifying their dietary habits and eating less fat. Consumer acceptance of any food product depends upon taste which is the most important sensory attribute. Although consumers want foods with minimal to no fat or calories, they also want the foods to taste good. The development of reduced-fat foods with the same desirable attributes as the corresponding full-fat foods has created a distinct challenge to food manufacturers. (Ognean *et al.*, 2006).

The prevalence of obesity nowadays is alarming. Hence consumers show growing preference to low calorie products, so as to prevent obesity and overweight. Maltodextrins are hydrolysis products of starches with Dextrose equivalence lower than 20 and substituted on an equal-weight basis provide 4 kcal or 16.8 kJ/g. they have received considerable attention for developing fat- and calorie-reduced products. Some of their important functional properties include bulking, gelling, crystallization prevention, promotion of dispersibility, freezing control, and binding (Loannis, 1998).

Fat is one of the important ingredients influencing the sensory characteristics of baked products. Attempts have been made to replace the fat with other food components in baked products to reduce the total calories as well as to enhance nutritional properties. Among the substituting materials, carbohydrates are widely used in baked products, partly because they have economical advantages over many

other fat substitutes. Maltodextrin is widely used for partial replacements of fats in a variety of processed foods because of its ability to form a particle gel cream in food systems (Hye *et al*., 2001).

Maltodextrins are non-sweet polysaccharides that can be derived from various botanical sources such as com, oat, potato, rice, tapioca or wheat starches. Maltodextrin is produced by partial hydrolysis of starch through enzymatic process or acid-conversion. Maltodextrin with low Dextrose equivalence is commonly used as stabilizer, thickener, texture modifier, fat or flavour binder (Sze and Lai, 2013).

Maltodextrins are partially hydrolyzed starch products. Starch and maltodextrin are commonly added to many food products, because they give specific characteristics to the final product (Joanna *et al.*, 2012).

Consumers now days are really concerns about the adverse health effect of overconsumption of certain types of lipids, this has resulted in some development of reduced-fat food to solve the issue. As a food component, fat contributes to the flavor, appearance, texture, and shelf life of food products (Abbas *et al*., 2010).

The food industry is primarily driven by consumer health trends. At present day dietary concern is the consumption of a large amount of fat and sugar. With the growing incidence of obesity and diabetes, low calorie foods have gained immense popularity. (Chugh *et al.*, 2013).

The present investigation has been planned to develop the technology for preparation of maltodextrin from Sorghum grains and this prepared maltodextrin used as a fat replacer in the preparation of low calorie cookies with following objectives:

OBJECTIVES:

1. To study the physicochemical properties of Sorghum.
2. To study the methods of preparation of maltodextrin and its analysis for nutritional composition.
3. To standardize the recipe of bakery product (Cookies).
4. To evaluate the Cookies for sensory quality.
5. To study the physicochemical properties of Cookies.
6. To study the product for storage life , microbial quality and packaging.
7. To study the technoeconomical feasibility of Cookies.

CHAPTER -II

REVIEW OF LITERATURE

CHAPTER - II

REVIEW OF LITERATURE

A review of literature is a necessary and crucial part of scientific investigations. Its major purpose is to know the previous works done and to assist the delineation of objectives, hypothesis and research procedure to be followed. This chapter deals with the comprehensive review of literature. The bakery product (cookies) has wide consumer acceptance because it acts as the combination of nutrition and healthy food. As per the preparation and analysis of product is concerned, the literature pertaining to different objectives and aspects of present study has been reviewed under suitable captions:

2.1 Physicochemical properties of Sorghum
2.2 Methods of preparation of maltodextrin and its analysis for nutritional composition
2.3 Standardization of recipe for preparation of bakery product (Cookies)
2.4 Sensory evaluation of prepared Cookies
2.5 Physicochemical properties of Cookies
2.6 Study of storage life, microbial quality and packaging of Cookies
2.7 Study of technoeconomical feasibility of Cookies

2.1 Physicochemical properties of Sorghum

Dev *et al*., (1982) reported that the kernel dimensions, size and shape of grains are the important parameters for studying the behaviour of the grains during handling, storage and processing.

Waniska R.D.(1976) showed several groups of workers found variations in physical properties of different sorghum grains that would predict the quality of sorghum varieties for use in food. Variations in the kernel weight (18.49- 37.40 g/l000) and kernel density (1.18-1.43 g/cc.) were noticed among different varieties of sorghum.

Loya (1983) reported that the values for length varied from 4.20 to 5.03 mm., for breadth from 3,78 to 4.68 mm and for thickness from 2.45 to 3.35 mm among 7 the three varieties of sorghum studied. The size of all the three varieties ranged from 3.392 to 4.288 mm, while sphericity varied from 0.807 to 0.893. Density of all the varieties studied varied from 1.26 to 1.35 g/cc., while bulk density varied from 0.784

to 0.815 g/cc, and porosity from 35.1 to 39.3 per cent. The weight of the sorghum varieties also varied from 24.7 to 32.3 g/l000 kernels. From the results of the study he pointed out that the varieties of sorghum having small size grains had more density and the bulk density was inversely related to porosity.

Kulkarni *et, al.* (1986) evaluated the physical properties of 11 sorghum varieties. Varietal differences in length (2.7-5.0 mm), breadth (2.1-4.4 mm), thickness (1.7-2.9 mm), size (2.154-3.893 mm), bulk density (0.80-1.00 g/ml.), and weight of 1000 kernels (17.34-28.08 g) were noticed. They found that grain weight was positively associated with the grain-length, grain-breadth and grain-thickness. Nutritional quality of sorghum is another important characteristic of determining the quality of sorghum varieties. Sorghum forms a major source of protein, energy and iron in the diets of large segments of population subsisting on it. Nutritive value of sorghum is, therefore, one of the most important determinants of the grain quality of the sorghum. In general, the protein and starch contents of sorghum are as high as in other cereals. But the availability of these nutrients is limited due to the presence of high tannin content, imbalance of amino acids, high gelatinization temperature of starch and high viscosity of the cooked product.

Fabre *et al*., (1981) analyzed the proximate composition of 4 different sorghum varieties. They noted mean values of various grain constituents for moisture 13.6 per cent, ash 1.75 per cent, crude fat 3.34 per cent, crude fibre 3.47 per cent, protein 11.59 per cent, starch 68.42 and tannins 1.35 per cent.

Jambunathan and Subramanian, (1988) reported that the major carbohydrate portion of sorghum and millets is starch. It is having amylopectin (branched-chain polymer of glucose) and amylose (a straight- chain polymer) and their values ranging from 56-73 per cent, the average starch content of sorghum is 69.5 per cent.

Osman *et al*., (2000) depicted that the range of oil content in sorghum kernel is 2.1- 5.9 per cent where about 76 per cent, 13 per cent and 11 per cent of the total oil is situated in the germ, endosperm and pericarp respectively. Fatty acid composition found to be dominated by the unsaturated linoleic, oleic and palmitic acids.

Gopalan *et al*., (2000) reported that protein quality and essential amino acid profile of sorghum is superior than many of the cereals and millets. Sorghum in general shoes richness in amounts of fibre and B- complexvitamins.

Chavan and Patil, (2010) depicted that the grain sorghum contains high amounts of fibre and minerals apart from having a sufficient quantity of carbohydrates (72 per cent), proteins (11.6 per cent) and fat (1.9 per cent). Starch comprises major part of the grain. The protein of grain sorghum contains albumin globulin (15 per cent), prolamin (26 per cent) and glutelin (44 per cent). Sorghum is gluten free and due to that dough does not have stickiness, to roll with the chapatti roller. It is a safe energy source for people who are allergic to gluten. Low amounts of flavan-4-ols and phytic acid are present in white sorghum.

Longvah *et al.*,(2017) reported that average carbohydrates content of millets and sorghum ranges from 56.88 to 72.97 g/100 g, protein content of 7.5 to 12.5% and lipid content varies from 1.3 to 6 g/100 g. They are richest source of fibres, i.e. crude fibre as well as dietary fibre and they are also rich in vitamins, minerals.

Kurien *et al.,* (1960) studied the chemical composition and nutritive value of jowar. They found that jowar was a richer source of protein than rice or ragi and fairly good source of B-complex vitamins,

Jalja (1965) observed that the protein content of the local strain was higher than the hybrid strains analyzed. Wide variations were found in the protein content (8.17-10.40 g. %), iron content (3.5-5.0 mg. %) and calorie content (340-386 KCal) of different sorghum samples.

Gopalan and Srikantia, (1960) reported that like other plant proteins, protein quality of sorghum is poor. Poor nutritional quality of sorghum grains had been attributed to the excessive content of leucine.

Solunke *et al.*,(1977) observed low levels of certain essential amino acids especially lysine, threonine and tryptophan.

Miller and Burns (1970) reported the starch content of 17 varieties of grain sorghum to range between 64.2 and 70.6 per cent and that of amylose of total starch ranged between 0.79 and 34.8 per cent. They observed a direct relationship between amylose and starch content.

Sullins and Rooney (1974) reported the starch content as 66.7-75.2 per cent and amylose content as 0.22-0.29 per cent on analysis of 4 sorghum lines.

According to Hulse *et al.* (1980) starch, cellulose, simple sugars and pentosans comprise approximately 80 per cent of the dry weight of the kernel with starch usually 70-75 percent.

Okoh *et al.* (1982) observed comparatively little differences among the varieties of Nigerian sorghums in ash, crude fiber, fat and carbohydrate contents. In contrast, the crude protein and tannin contents showed considerable variation.

2.2 Methods of preparation of maltodextrin and its analysis for nutritional composition

Alexander (1992) discussed the maltodextrin production, properties and applications. The single stage and dual stage process of production of maltodextrin was described excellently. Properties of maltodextrin such as Dextrose Equivalent (DE), viscosity, browning reaction, cohesiveness, freezing point depression, hygroscopicity, osmolality, solubility and sweetness in the relation of DE were discussed. The maltodextrins have wide applications viz., flavour encapsulation, bulking agents; salt substitutes, fat replacers etc. are discussed briefly. Regarding stability of maltodextrins during storage, it has been found that at temperature 55 - 90 °C and pH 2 - 4, the product was stable for several months.

Jane (1992) studied preparation and food applications of physically modified starches. Cold water soluble starches are of commercial interest for use in instant foods such as puddings and microwave cooked foods, and a small crystallite starches have applications as fat substitutes. Various methods have been developed to produce a range of modified starch preparations with a variety of physical characteristics and applications. Study of such modified starches may also aid in understanding of structure of starch granules.

BeMiller (1993) stated that maltodextrins were produced from starch by hydrolysis only i.e. without molecular rearrangement. A various types of maltodextrins can be produced with variability in starch source, the means of conversion (i.e. the use of acid and /or an enzyme preparation) and the extent of breakdown (i.e. the DE value of the product). In general, the DE values of the maltodextrins range from 5 to 19, the amount of D-glucose ranges from 0.5 to 3 per cent and moisture level 4 to 6 per cent.

Kiriluva *et al.,* (1993) studied the production of maltodextrin based on partial hydrolysis of starch solution using amylase in the presence of calcium ions. According to him, a production kinetics and quality of maltodextrin were found to influence pH, temperature, enzyme concentration and reaction time.

Antwal (1999) in his studies on an assessment of sorghum starch based far replacers in low calorie foodstuffs, attempted to explore the potential of sorghum grains (var. PVK-801) for the production of starch using wet milling process. The starch so prepared was further utilized for production of maltodextrin. The maltodextrin was extracted by using 0.25 per cent HCL, which was found to have DE of 14. This maltodextrin was used as fat replacer in low calorie foodstuffs i.e. cookies and toffees. He had been successful in replacing 35 per cent fat and 25 per cent fat in cookies and papaya toffees, respectively without affecting quality attributes He further recommended the production of maltodextrin for commercial exploitation in different food products as fat replacer.

More *et al.,* (2005) studied the production of maltodextrin from cassava and corn starch by enzymatic hydrolysis with a - amylase. They reported that the cassava starch hydrolysis rate was higher than that of corn starches in maltodextrin production with shorter dextrose equivalent (DE). According to them, maltodextrin production differs according to the source of the starch.

Wankhede *et al.,* (2005) described the production kinetics of maltodextrin using acid hydrolysis. They found that the maximum amount of maltodextrin was liberated at 4.5 per cent concentration of hydrochloric acid at 120 minute, interval i.e. 95 per cent and 92 per cent for sorghum varieties PVK-801 and CSH-9 and their dextrose equivalents were 9 and 8 respectively. They reported that, the maltodextrin contained 98 and 97 per cent total carbohydrate in PVK-801 and CSH-9, respectively. They investigated the rheological attributes particularly the pasting behavior of maltodextrin. They revealed that the viscosity at 40 ^{0}C was found to be maximum and then decreases as the temperature increased.

Freeman (1982) described polydextrose for reduced calorie foods. It has potential as non-caloric or reduced calorie replacements for sugar and as partial replacement for fat, flour and starch. FDA status of polydextrose was also reviewed.

Various formulations of cake, cookies, brownies, chocolate and puddings with polydextrose were discussed.

2.3 Standardization of recipe for preparation of bakery product (Cookies)

Standardization of recipes is necessary for many reasons. Product will be consistent in quality each time they are prepared using the standard recipes. By using standardized recipe the planned number of serving will be produced. Nutritional values per serving will be consistent in standardized recipes. For the food cost control standardized recipes provide consistent information because of the same ingredients and quantities of ingredients used each time the recipe is made. It is useful for purchasing as the quantity & quality of food required for production is easily calculated from standardized recipe. Exact number of labor requirement can be predicted & even maximum use of their time can be utilized for the particular day. An instruction given for preparation of products helps the new joiner & training cost of the employer is saved. Standardized recipes eliminate guesswork, reduces the chances of producing poor food products which increases chefs confident & feel more satisfied in their jobs.

Bakery products are the integral part of meals in some countries. In India, it is not a staple food but generally eaten at the time of breakfast or tea and used for making bakery based products. Bakery products are generally made from the flour, yeast, salt & water. Other kind of bread contains additional ingredients, including sugar, shortening, milk, eggs, and flavorings. Sliced bread, cookies, khari and toast are very commonly made in most of the bakeries. These products are always made in bulk quantities. It is very challenging task for bakers to make good quality product every time & avoid excess of production since most of the items are perishable. Moreover minimize the wastage & reduce food cost.

Finney *et al.,* (1950) studied the effect of varying levels of sugar, shortening and ammonium or sodium bicarbonate on the spreading and top grain of sugar-snap cookies. Shortening was varied in the cookies formula from 25 to 35 per cent, sugar from 50 to 80 per cent and ammonium bicarbonate from 0 to 3.25 per cent. Varying the quantity of shortening did not materially affect cookies diameter but did alter top grain in certain circumstances. Spreading of cookies during baking was directly proportional to the quantity of sugar added within each ammonium bicarbonate

concentration. Increase in ammonium bicarbonate also produced proportional increase in diameter within each sugar level. When the quantity of sugar was less than 55 per cent, inferior top grain was obtained. An addition of 0.5 per cent ammonium bicarbonate produced as much increase in cookies diameter and change in top grain as an increase of 7.6 per cent sugar.

Kissell *et al.*, (1971) studied the effects of flour lipids on cookie quality and reported that flours of wheat varieties, defatted with petroleum ether, produced smaller cookies with reduced top grain than parent flours. Return of unfractionated free lipids to defatted flours at normal concentration restored original spread and top grain quality. Polar and non polar lipid fractions alone were only partially effective in improving defatted flour both were required for full restoration of quality.

Tsen (1976) observed the effect of shortening levels and SSL on the spread ratio of regular (wheat flour only) and 12 per cent defatted soy flour fortified cookies. With the increase in level of shortening from 16 to 32 per cent, the spread ratio of regular cookies, without SSL and with 0.5 per cent SSL, increased from 6.18 to 8.07 and 6.93 to 8.63, respectively. With the same increase in shortening level, the spread ratio of soy fortified cookies, with no SSL and with 0.5 per cent SSL, increased from 5.91 to 7.11 and 5.31 to 7.56 respectively.

McWatters (1978) studied the effect of water adjustment on spread characteristics and sensory quality of sugar cookies containing soy flour. With the increase in the ratio of added water, dough consistency changed from dry crumbly to wet sticky, the diameter and spread ratio increased and the height of cookies decreased significantly. The sensory parameters viz., appearance, colour, aroma, texture and flavour were changed but not very significantly.

El-Warraky *et al*., (1980) evaluated the effect of sugar, fats and oils on cookies quality and reported that stack height and cookies weights were decreased the level increased. The diameter of cookies was unaffected by sugar level. Stack height and cookies weights were decreased as the fat level increased thus increasing the spread ratio of cookies.

Khovanskaya and Shathyuk (1983) determined effect of substitution of 10-50 per cent of sugar in cookies premix containing 0.4-0.7 per cent sodium bicarbonate and 0.2-0.5 per cent citric acid. Effect of dough treatment on quality of the final

product indicated that at high level of ingredients, the quality and sensory properties deteriorated. The authors suggested 20-25 percent level of sugar and 0.7 percent sodium bicarbonate as an optimum level for cookies preparation.

Abboud *et al.*, (1985) determined the effects of variations in fat and sugar on cookie spread. They reported that although the type of fat was not important, the amount of fat affected the cookie spread. Increasing the fat from 30 per cent (based on flour weight) to 35 per cent did not affect cookie spread, but gave a finer top grain. On the other hard, decreasing the fat to 25 per cent gave irregularly shaped cookies with coarse top grains. Increasing or decreasing the sugar level by 10 per cent from the control of 60 per cent (based on flour weight) made no difference in cookie diameter using the creamed procedure. However, finer top grains were obtained with the lowest sugar percentage. Using the non creamed procedure, cookie spread increased as the sugar level was increased from 50 to 70 per cent on the flour weight basis.

Gandhi *et al.,* (1985) studied that cookies have been man's food since a long time. It is a processed convenience food ever produced and in most widely acceptable. It is one of the few universal staples, which is complete in it and requires no additional preparation. Thus, for many, cookie becomes an important source of high molecular carbohydrates, vegetable proteins and some vitamins and minerals. But it is important to know that, as compared to refined wheat flour which is deficient in certain essential amino acids thus has a lost nutritional value. The nutritional value of cookie can be enhanced by fortification and supplementation with a wide variety of protein. Soya bean is the most efficient protein source of vegetable origin containing about 40% protein besides other nutrients like (carbohydrate about 22%), fat about (19.01%) and reasonable quantity of minerals and vitamins.

Berglund and Hertsgaard (1986) used vegetable oils at reduced levels of low gluten in cookies. Muffins and concluded that drop sugar cookies made from oils were similar in flavour to those made with shortening but were less liked for appearance, crispness and overall preference.

Prasad (1988) prepared a coperecipitate from low gluten cookies. Products were evaluated for nutritional quality, organoleptic acceptability and storage life. The

products were acceptable, had about 5 per cent more protein, were equally shelf stable and were cheaper to produce than controls (made with conventional skim milk).

Akpapunam M.A. and Darbe J.W. (1994) studied that the basic formulation was 49.5% wheat flour, 20% margarine, 10% beaten whole egg, 20% sucrose and 0.5% baking powder. The dry ingredients were weighted and mixed manually. Margarine was added and rubbed thoroughly for uniformity in blending. Egg was added and the dough was thoroughly kneaded manually in a clean stainless steel bowl for 5 min. The dough was rolled on a sheathing board to uniform thickness (3.5 cm) and cut out using a round scorn cutter to a diameter of 2.5 cm. The cut dough were baked in greased pans at 160°C for 15 min in an oven and cooled at room temperature for 1 hour, and packedin HDPE.

O'Brien *et al.*, (2003) cookies constitute major component of human snacks in most part of the world. It is an unleavened crisp, sweet pastry made from wheat flour, shortening (hydrogenated fat) and sugar, and is usually made light by the addition of baking powder (a mixture of sodium carbonate, sodium bi phosphate and cereal flour).

Patel and Venkateswara Rao (1996) studied the effect of sugar, fat and emulsifier on the cookies prepared from blends of wheat and black gram flour. They also observed that spread ratio of cookies increased with increasing level of sugar and fat and on addition of 0.5 per cent emulsifiers.

Chugh *et al.* (2013) conducted an experiment to develop low fat soft dough biscuits using carbohydrate based fat replacers maltodextrin and guar gum. The optimum level of ingredients obtained for low fat biscuits was sugar 31.7g, fat 13.55g, maltodextrin 21.15g, guar gum 0.3g, ammonium bicarbonate 2.21g, and water 21ml based on l00g wheat flour. The optimized product had 62.5% replacement of fat with carbohydrate based fat replacers and guar gum. The fat level in the optimized low fat biscuit formulation was found to be 8.48% as compare to 22.65% in control. Therefore the reduction in the fat was 62.5%. Results indicated that hardness increased with increase in the level offat replacers and decrease in the fat level.

Wankhede *et al*., (1990) studied isolation and characterization of starch from pearl millet [Pennisetum americanum (L) Leeke] grains. The yield of starch was approximately 60.2 per cent on whole grain basis. The starch exhibited two stage

swelling and moderate solubility patterns in an aqueous media. The starch contained 22.8 per cent amylose. The gelatinization temperature range of the starch was 69.5 - 74.0 - 77.5 °C. The viscoamylographic examination of starch paste (8 per cent w/v) showed a peak viscosity 640 B.U. but it reduced considerably during holding at 93 °C for 30 minutes. However, the viscosity of the starch paste increased abruptly (885.0 B.U.) during cooling (50 °C) probably due to retrogradation of amylose The extent and modes of attack by glucoamylase and human salivary a-amylase on the native starch granules as viewed by scanning electron microscopy were investigated.

Katz (1986) has excellently reviewed the manufacture of maltodextrins, GRAS regulations applied to them, characteristics of maltodextrin and their quality control.

Rogols (1986) reviewed the application of chemical and physical modification of starch for foods, and the rote of starch in the technology of extrusion was described. Oxidation / acid thinning of starches, use of polyfunctional reagents to impart a cross linking effects on starch, use of monofunctional reagents, complexing pregels and gum extension were discussed.

Smith *et al.,* (1986) discussed the new starches for food applications. Principle function of starch and modified food starches, types of modified starches were discussed.

La-Barge (1988) summarized various approaches and products that have been suggested for replacement or reduction of the fat content of foods. Different water soluble compounds such as polydextrose, N- oil, maltodextrin, variety of triglyceride modifications including polycarboxylic esters and sterically hindered esters were described. Waring (1988) described the shortening replacement in cakes. A new matrix of emulsifiers, modified food starch, guar gum and non fat dry milk had found application as a replacement for shortening in cakes and other baked goods. This article discussed the functions of shortening in cakes and described the formulation and application of shortening replacer i.e. N -flate.

Altschum (1989) summarized the low calorie foods along with their nutritional significance as nutrition was one of the key target area of Health and Human Services agenda for health promotion and disease prevention, the food industry had an especially important role to play in the development and implementation of the health

objectives. Technological developments created low calorie foods; beverages and other dietary items have been focused in this article.

Daziezak (1989) summarized fats, oils and fat substitutes as nutrients, texturizers and energy sources. Fats and oils play an integral role in foods. This report reviewed of these ingredients and several fat substitutes.

Best (1991) reviewed the challenges of fat substitution, which lies in providing fat reduced products that offer little or no sacrifice in quality or values to consumer. Various key factors for success in such product development were discussed.

Inglette *et al.*, (1991) described the role of maltodextrin fat substitutes in lowering cholesterol. Oatrim: a maltodextrin prepared from oat, lowers blood cholesterol. The preparation and properties of Oatrim are discussed.

Pszozola (1991) described carbohydrate fat replacers. Stellar fat R, a modified food starch derived from corn was described which can reduce the fat content of such food application as margarine, cheese spread and baked goods. It enables food manufactures to replace fat with a fully digestible complex carbohydrate in a broad range of application. Headings include technical benefits (performance, versatility, temperature stability, self stability, case of use regulatory status) preparation availability

Singhal *et al.,* (1991) reviewed low calorie fat substitutes. The population of most developed countries had been advised by nutritionist and medical practitioners to loose their fat intake of total fat and saturated fat as measure towards reducing the incidences of cardiovascular diseases and obesity. As a consequence, the numbers of low calorie and calorie free foods have been increasing steadily over the past two years. Recently, a variety of low calorie fat substitutes have been developed for food use. The article briefly described and compared the measure of fat substitutes that had been developed to date.

Sobczynska and Sester (1991) studied the replacement of shortening by maltodextrin emulsifier combination in chocolate layer cakes. All gels made from maltodextrin and emulsifiers were softer than gels made from maltodextrin alone. A chocolate layer cake was selected as a test product and either 50 or 100 per cent of the shortening was replaced with maltodextrin and emulsifier combinations. Most cakes made with a potato maltodextrin and emulsifiers at either level of replacement were

comparable to the control 100 per cent shortening cakes. Cakes made with sucrose ester tended to have higher volumes than cakes made with other emuisifiers, in general, the sorbitan monostearate performed least well. Incorporation of prehydrated emulsifier and dry maltodextrin generally provided highest volumes.

Bruhn *et al.,* (1992) reviewed consumer attitudes and market potential for foods with fat substitutes. Low fat diets appeared to be one of the controllable components in the etiology of life threatening diseases. The article elicits information on consumer's perceptions of high fat foods and their attitudes towards lower fat foods, which incorporate fat substitutes such as Simplesse and Olestra.

Lucca and Teper (1992) studied fat replacers and the functionality of fat in foods. Developing no and low fat products is a high priority for the food industry given the variety of fat replacers available, how does a product developer decide which to use. Fat replacers can be divided into three classes on the basis of their composition, protein based, carbohydrate based and fat based. Each has different functional properties that provide both advantages and limitations in specific applications. Presently there is no "Silver bullet, no single fat replacers that contributes all of the desired sensory and functional qualities to all products. A system approach, one that makes use of a combination of two or more widely chosen fat replacers coupled with formula and procedural changes appears to be the best current strategy.

2.4 Sensory evaluation of prepared Cookies

Khovanskaya and shathyuk (1983) reported that at high level of ingredients, the quality and sensory properties of cookies are deteriorated. The author suggested 20-25 % level of sugar and 0.7% sodium bicarbonate as an optimum level for cookie preparation.

Rao *et al*.,(1984) reported Use of baking soda at 0.5 and 1.0 % respectively improved cookie texture. The increase in fat percent of cookies also improved the texture of cookie.

Srivastava and Rao (1993) studies on reduction in fat from 20 to 7.5% in soft dough cookies. In addition, the overall quality score decreased from 48.5 to 30.0. Further reduction in fat adversely affected mechinability of the dough. The adverse effects were considerably lower with bakery shortening as compared to other fat or

oil. Lecithin at 0.5% was found to be most effective for improving the overall quality of low- fat cookies.

Singh *et al.,* (1997) evaluated soy-fortified the cookies the results of sensory evaluation revealed that the scores for texture and overall acceptability in control as well as in soy cookies improved up to 30% fat level and thereafter decreased. However, the effect of increasing levels of sugar on the texture and overall acceptability scores increased up to 37% in control cookies and thereafter decreased, whereas in soy cookies improving effects were observed up to maximum level of sugar.

2.5 Physicochemical properties of Cookies

Jissy Jacob and Leelavathi (2006) studied on Effect of fat-type on cookie dough and cookie quality. They were used sun flower oil and bakery fat in cookies observed that The dough containing sunflower oil had the least initial farinograph consistency while that containing the bakery fat ('marvo') had the most consistency.

Foda *et al.,* (1984) evaluated the quality of biscuits supplemented with low-fat soy flour at 0, 10, 20 and 30 per cent levels. The chemical composition of biscuits was observed as follows: moisture 2.24-6.97, fat 9.43- 10.45, proteinl 1.43-17.14 and ash 0:49-1.90 per cent.

Singh *et al.,* (1997) evaluated soy-fortified the cookies compared for the effects of various levels of fat (20, 25, 30 and 35%) and sugar (28, 31, 34, 40 and 43%), using the traditional creaming method. With increasing levels of fat and sugar in the formulation, attributes such as weight, diameter spread ratio and percent spread factor of cookies increased, whereas thickness and hardness of the product decreased irrespective of soy flour incorporation.

Gajera *et al.,* (2008) reported there was an increase in the protein content with a decrease in total fat content when the proportion of peanut butter increased in the biscuits.

Sweta *et al.,* (2011) the present investigation was undertaken on the utilization of alternate flours/meals (rice (Oryza sativa), maize (Zea mays), sorghum (Sorghum vulgare) and pearl millet (Pennisetum glaucum) for the preparation of gluten free cookies as compared to conventional wheat (Triticum aestivum) flour cookies. The physicochemical parameters, sensory qualities and functional properties of flours/cookies were studied and compared with control cookies. The blend of maize

and pearl millet had best pasting qualities followed by blend of pearl millet and sorghum flour. The control cookies showed a higher yield (186.8%) but stronger peak force (2.69 kg). The cookies prepared from rice and maize combination had highest spread ratio whereas, the lowest spread ratio was observed in rice and sorghum combination. The cookies with pearl millet and sorghum flour combination had higher fat, protein, ash and calorific values as compared to control cookies. The maximum sensory overall acceptability scores were found for cookies prepared from combination of pearl millet and sorghum flour followed by rice and sorghum, maize and sorghum, rice and maize, maize and pearl millet, rice and pearl millet and control cookies. All gluten free cookies had higher nutritional value as compared to control cookies and were acceptable by panelists.

Suyong and Geroge,(2005) this investigation is studied rheological and physical characteristics of cookies made from fortified Oat bran in low calorie cookies. Different levels of shortening in cookies (10%, 20% and 30% by weight) were replaced with 20% jet-cooked oat bran, also called Nutrim oat bran (OB), to prepare cookies with fewer calories. The cookies containing Nutrim OB were investigated in terms of rheological and physical properties and compared with a control. As more shortening was replaced with Nutrim OB, a decrease in the diameter and an increase in the height of cookies were observed. The increased moisture content from Nutrim OB caused a decrease in the dynamic viscoelastic properties of cookie dough.

Tyagi *et al.,* (2006) studied nutritional, sensory and textural characteristics of defatted mustard flour fortified biscuits, to optimize the mustard flour supplement in the blend for making biscuits. The wheat flour was replaced by defatted mustard flour at 5, 10, 15 and 20 per cent incorporation levels in biscuit preparation. The protein content of mustard flour biscuit increased nearly 2.5 times as a result of mustard flour incorporation coupled with reduction in fat and an increase in fibre content.

Sudha *et al.,* (2005) studied on Influence of fibre from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. Consumption of high fibre products consisting of indigestible cellulose, hemicellulose, lignin and gums have several health benefits and to over com health problems such as hypertension, diabetes, and colon cancer, among others. Apart from these benefits, b-glucan-rich fibres have the benefit of reducing the absorption of glucose. Fibre

sources from wheat, rice, oat and barley were used to study their influence on rheological characteristics of wheat flour dough and biscuit making quality.

2.6 Study of storage life , microbial quality and packaging of Cookies

Leelavathi and Rao (1993) stated that cookies had a shelf life of approximately 90 days when wrapped in 100 gauge polypropylene pouches and stored at 27 ^{0}C and 60 % RH.

Singh *et al.,* (2000) stated that during storage moisture content, peroxide value and free fatty acid contents of cookie increased whereas hardness, crispiness and overall sensory acceptability scores of cookie decreased gradually. They also suggested that polypropylene proved to be a better packaging material for cookie then the laminated one and cookie packed in it could be stored for 45 days under ambient conditions whereas, in laminated packaging, the shelf life of cookie was 30 days.

Selvaraj *et al.,*.(2002) studied on biscuits containing finger millet flour indicated that a moisture content of 5% equilibrating to 32% Rh was critical with respect to storage stability of the product. Shelf life periods of biscuits were 75 and 50 days at 90% Rh, 380C, when packed in double pack of polypropylene and metalized polyester/poly laminate pack, respectively and over 120 days at 60% Rh, 27 ^{0}C in both types of packs. Their sorption characteristics and shelf life were comparable to that of conventional glucose cookies.

Nagi *et al.,* (2012) studied on a effect of storage period and packaging on the shelf life of cereal bran incorporated biscuits. Biscuits were prepared by using full fat and defatted cereal brans. Study revealed that 20 per cent level was selected best. In case of storage study biscuits were stored in two packaging material i,e, HDPE and aluminium laminate. The high acceptability range was remained upto 3 months. Free fatty acids content of biscuits were within permissible limits after three months of storage except full fat biscuits.

Raljic *et al.,* (2013) developed a dietary cookies prepared by using different dietary fibre sources like inulin and oligo fructose, oat flakes mixture of oat flake and whole meal flour and mixture of whole meal flour and carob flour. Cookies were measured in terms of upper and lower surfaces, after storage at temperature of 18-20˚C for 180 days. The result showed that after storage there is a lower score for sensory evaluation, increased crumbling of the products, and appearance of surface / breakages and there is a color changes in dietary cookies.

Amin *et al.,* (2016) studied on shelf life of high protein and sugar free cookies fortified with pea flour, soy bean flour and oat flakes at different level (0-15 %). These cookies were packed in polyethylene pouches and stored in airtight container at ambient temperature and analyzed at an interval of 1 month. The result showed that the cookies were stable both in terms of peroxide and acid values during two months of storage period as both the values were within the permissible limits prescribed by Bureau of Indian Standards (BIS).

Satyanarayana Rao *et al*., (1995) studied storage properties of whole egg powder incorporated biscuits. The results indicated that the changes in moisture, peroxide value, free fatty acids during storage at different temperatures in different packaging materials were insignificant, as compared to those in freshly made biscuits. The biscuits with vanillin plus orange and vanillin plus pineapple flavors were found to be more stable at different temperatures, and were highly acceptable for a period of 6 months at 37°C, ambient temperature and 4°C, as compared to those with orange flavor alone. Among the packaging materials used, paper-aluminium foil-polyethylene laminate pouch packed samples were more stable and acceptable, when compared to other packaging materials like metalized polyester and biaxially oriented polypropylene.

Seevaratnam *et al.,* (2012) who studied biscuits incorporated with potato flour that no fungus growth observed in cookies during 60 days of storage.

Mehta (2013) did not found any bacteria and fungi count in the biscuits with Ayurvedic formations of 3 week storage period.

Joshaline *et al.,* (2013) studied that in sprouted green gram flour used with refined wheat flour for biscuit preparation, the result showing bacteria and fungi count was below detectable level till 15th day of storage.

CHAPTER -III

MATERIAL AND METHODS

CHAPTER - III

MATERIALS AND METHODS

The present investigation entitled "Preparation of maltodextrin from Sorghum and its utilization in bakery product (Cookies)" was carried out in the Department of Food Chemistry and Nutrition with collaboration of Department of Food Microbiology and Safety, Department of Food Process Technology and Department of Food Engineering, College of Food Technology and Department of Soil Science, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth., Parbhani (MS) India during the year 2020-2022.

The experimental techniques and procedures used to carry out the experiments towards fulfilling the different objectives of this investigation are briefed here. During the research, different chemicals, microbial and sensory characteristics of selected raw materials and prepared Cookies were studied and the statistical analysis was also done in order to check economical feasibility of the product. The materials required and methods followed during study are given below under suitable headings and subheadings.

3.1 Materials

3.1.1 Raw Materials

The raw materials include Sorghum grains (Parbhani Shakti), Wheat Flour (Maida), Sugar, Fat, Baking soda, Ammonium Bicarbonate and Milk were procured from local market.

3.1.2 Chemicals and glasswares

Chemicals of analytical grade and sufficient glasswares required were available in the college laboratories.(Department of Food Chemistry and Nutrition, Department of Food Process Technology, Department of Food Microbiology & Safety and Department of Food Engineering, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani.)

3.1.3 Packaging Materials

Packaging materials i.e. LDPE (low density polyethylene), HDPE (high density polyethylene), PET jars, and Aluminum foils were used for packaging of

cookies.

3.1.4 Equipments and Intruments

Various equipments and instruments which were required for the preparation of Maltodextrin and Cookies were Electronic weighing balance, Sieves, Water bath, glasswares, mixer, baking oven etc. These were made available from the Department of Food Chemistry and Nutrition, Department of Food Process Technology, Department of Food Engineering, Bakery pilot plant and other departments of College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani.

3.2 Methodology

3.2.1 Preparation of sample

Sorghum grains were cleaned and stored properly in airtight container at room temperature prior to their use in actual experiment.

3.2.2 Physical Properties:

3.2.2.1 Thousand kernel weight:

Neat, clean and sorted 1000 thousand grains weight was measured by electronic balance and average weight was calculated.

3.2.2.2 Thousand kernel volume:

Volume of thousand grams of dry seeds was measured by water displacement in milliliters.

3.2.2.3 Bulk Density:

25g of sound grains weighted on the digital weighing balance and filled into the measuring cylinder earlier filled with reference solution of kerosene or toluene. The increase in the level of liquid will be measured after adding the grains. It is bulk density represented in g/L.

3.2.2.4 True Density:

25g of grains filled into the measuring cylinder and volume occupied by them will be measured. (Rooney et al., 1982).

3.2.2.5 Angle of repose:

The angle of repose is the angle between the base and the slope of the cone formed on a free vertical fall of the grain mass to a horizontal plane when material is free falling or sliding. It was determined by making a circular pile of the grains freely falling. The height of pile was taken (h) and its radius (r) was also taken. Angle of repose was then calculated by following formula

$$\text{Angle of Repose } (\Theta) = \tan (h/r)$$

3.2.3 Proximate composition of sorghum grain

3.2.3.1 Moisture

Moisture content from ground sample was estimated by hot air oven method (A.O.A.C; 1975). 5g of sample was weighed in previously weighed moisture box and dried in hot air oven at 105°C till constant weight was obtained. Loss in weight is calculated and expressed in per cent.

$$\% \text{ Moisture} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

3.2.3.2 Protein content

Protein was estimated by micro-kjeldhals method (A.O.A.C; 1975). 500 mg sample was accurately weighed by top pan digital electronic balance into digestion flask and 1 g catalyst mixture was added to it, followed by addition of 5 ml concentrated H_2SO_4 . It was subjected to digestion for 30-40 min. then cooled and transferred the content to 50 ml volumetric flask and volume was made up with distilled water. 10 ml boric acid was taken separately in 100 ml volumetric flask containing methyl red and bromo cresol green indicator (l:5v/v) under the condenser whose tip extends below the surface of solution 5 ml of digest was added in the funnel of distillation apparatus followed by 5 ml of 40 per cent sodium hydroxide solution and 5 ml distilled water and some was steam distilled until 75 ml of distilled was collected till it was totally free from NH_4 tested by red litmus, some was titrated with standard HC1 and the proteins content was calculated by multiplying total nitrogen with 6.25.

$$\% N = \frac{(\text{Sample - blank}) \times N \text{ of HCl} \times \text{Vol. of digest made} \times 0.014}{\text{Aliquot taken} \times \text{Wt. of sample (g)}} \times 100$$

% Protein = % Nitrogen X 6.25

3.2.3.3 Fat content

Fat was estimated by using soxhlet apparatus (A.O.A.C. 1975). The dried sample remained after moisture determination was used for the determination of fat. Petroleum ether was used for the extraction of fat. Extraction was done for 6-8 hrs. on thermostat at 80 °C. Solvent was evaporated in water bath, then cooled and weighed. The difference in weight give the quantity of fat extracted.

$$\% Fat = \frac{\text{Weight of ether extract}}{\text{Weight of Sample}} \times 100$$

3.2.3.4 Total Ash

Total ash was determined by using A.O.A.C. method (1975) 5 g of sample was taken in previously weighed and dried silica crucible and the sample was ignited on slow flame. It was then heated in muffle furnace at 600 °C for 5 to 6 hours.

$$\% Ash = \frac{\text{Weight before heating - Weight after heating}}{\text{Weight of sample (g)}} \times 100$$

3.2.3.5 Total carbohydrate

Total carbohydrate was determined by the procedure of Wankhede and Tharanathan (1979). 500 mg of sample was accurately weighed in a big test tube and kept in a ice bath, 2 ml of 72 per cent H_2SO_4 was added to it with gentle stirring for 5 minutes at ice bath temperature to avoid the burning of the sample. Then the volume of the solution was made to 2N H_2SO_4 with distilled water (23 ml). The sample was refluxed in water bath at 90 ± 5 °C for 3 hours using air condenser. It was then filtered through the Whattman No.l. Paper and filtered was made upto 50 ml volume with deionised water. From the filterate, total carbohydrate was estimated by phenol H_2SO_4 method. Intensity of colour was measured at 480 nm on spectrophotometer. From the calibrated curve, the concentration of total carbohydrates was calculated as

per modified procedure of Wankhede and Tharanathan (1976).

3.2.3.6 Crude Fibre

Crude fibre of sorghum grains was determined by method of AOAC. (1975). Weigh 10 gm sample in a 250 ml beaker. Add 200 ml of H_2S0_4 (1.25 %). Boil for 30 minutes and during boiling adjust the volume 200 ml constantly with hot water. After 30 minutes, filter the residue. Wash residue with hot water. Again take residue in 250 ml beaker. Add 200 ml of NaOH (1.25 %). Boil for 30 minutes, adjust volume 200 ml with hot water. Filter the residue and wash with hot water until the clear water comes. Wash with ethanol. Allow to dry and weigh in silica crucible. It was then heated in muffle furnace at 600 °C for 5-6 hours.

$$\% \text{ Crude fibre} = \frac{\text{Weight before heating - Weight after heating}}{\text{Weight of sample (g)}} \times 100$$

3.2.3.7 Starch content

Starch content was estimated as per the method of Wankhede *et al.*, (1977). 0.1 g ground sample was weighed accurately and suspended in distilled water and heated at 98 ^{0}C for 15 minute to gelatinize the starch followed by the addition of 0.5 M Sodium acetate buffer (pH 4.8) to attain the final concentration of 0.05 M. It was then equilibrated at 60 ^{0}C for 10 minute followed by the addition of glucoamylase (250 units) and incubated for 4-5 hours. The liberated glucose was estimated by glucose-oxidase procedure. The starch content was estimated by multiplying the factor 0.9.

3.2.4 Mineral Analysis

3.2.4.1 Preparation of mineral solution

The triple acid digestion method of (Sahrawat *et al.*, 2002) was employed. 2 g of sample was weighed into a Micro-Kjeldahl digestion flask to which 24 ml of mixture of concentrated HNO_3, H_2SO_4 and 60 per cent $HClO_4$ (9:2:1 v/v) were added. The sample was digested to a clear solution and diluted to 50 ml with distilled water. The solution was used for determination of mineral elements; copper, iron, zinc and manganese.

3.2.4.2 Mineral analysis using atomic absorption spectrometry (AAS)

Copper, iron, zinc and manganese were analysed using atomic absorption spectrometry (Model no. A-Annalyst 200, PerkinElmer, Inc.,U.S.A.)**.** The principle of method is based on nebulising a sample solution into an air acetylene flame whereit is vaporized. Elemental ions were then atomized and the atoms then absorb radiation of a characteristic wavelength from a hallow-cathode lamp. The absorbance measured, is proportional to the amount of analyte in the sample solution. As mentioned already, the level of each element in the sample solution was determined by reference to a calibration curve.

3.2.4.3 Determination of calcium

Minerals like calcium and phosphorus were determined by using titration and spectrophotometric method (AOAC, 1990).

3.2.4.3.1Mineral solution preparation

The ash obtained by above procedure was made moist with glass distilled water (0.5-1 ml) and concentrated HCl was added and evaporated to dryness on a boiling water bath. Again 5 ml concentrated HCl was added and evaporated to dryness as before. Lastly 4 ml of HCl and 5 ml of distilled water were added. This solution was warmed over a boiling water bath and filtered into the 100 ml of volumetric flask using whatman no.4 filter paper. After cooling the volume was made to 100 ml using distilled water and suitable aliquot was used for the estimation of calcium.

3.2.4.4 Determination of calcium

25 ml mineral solution was diluted to 150 ml with distilled water and neutralized with ammonia solution using methyl red as indicator till pink colour changes to yellow. Further the solution was boiled and 10 ml of 6 per cent ammonium oxalate was added. This mixture was boiled for few minutes and added with concentrated glacial acetic acid (99.9 per cent) till the colour change was distinctly pink. The mixture was kept aside in warm place (overnight) and when precipitate settled down, the supernatant was tested with a drop of ammonium oxalate to ensure the completion of precipitation. The contents were filtered through what man No.4 filter paper and given washings of warm distilled water. The precipitate was transferred to a beaker by making a hole in the centre of filter paper and by giving

washings of H_2SO_4 (2N, 5 ml) twice. Then solution was heated to 70°C and titrated against N/100 $KMNO_4$, simultaneously a blank was also run.

1ml of 0.01N $KMNO_4$ = 0.2004 mg calcium

3.2.4.5 Determination of phosphorus

Phosphorus contents were determined by the colorimetric method. To an aliquot of mineral solution (0.1 ml) of ammonium molybdate, 1 ml of hydroquinone and 1 ml of sodium carbonate solutions were added. The volume was then made to 15 ml with distilled water and the solution was mixed thoroughly. After 30 min the optical density of this solution was measured in a photoelectric colorimeter, against a reagent blank (prepared in the same way as the test except that the test solution was omitted) using a red filter (660 nm). The phosphorus content of the sample was read from a standard curve prepared with standard phosphate solution (rang 0.01-0.1 mg P) following the same procedure as described above.

3.2.4.6 Determination of magnesium

Magnesium was determined by method given by Ranganna, (1986). In an alkaline solution from which calcium and iron have been removed, magnesium is precipitate as magnesium ammonium phosphate. The precipitate is dissolved in acid and the amount of phosphorus is determined calorimetrically. Magnesium is then calculated.

3.2.4.7 Estimation of potassium

It was determined by using flame photometric technique. The sample for potassium estimation was digested using $HClO_4$ and HNO_3. The 0.5 g sample was taken. In that, 5 ml HNO_3 was added and kept overnight. Next day, again 5 ml HNO_3 was added and sample digested by boiling on gas burner. Boiling continued till it becomes colorless. The volume digested made 100 ml by adding distilled water and potassium was estimated by flame photometer.

3.2.5 Isolation and purification of starch from sorghum grains

Sorghum grains (50 g) were cleaned and healthy grains were steeped in water (1:2, w/v) for 10 hours with few ml of toluene. In addition, the mercuric.chloride was added in very low concentration (0.001 M) to arrest the aamylase activity during steeping. The steeped grains were washed thoroughly with water and then subjected

to homogenization. The resultant slurry was filtered through muslin cloth followed by sieving through standard mesh sieve (150 p). The upper supernatant was siphoned off and the crude starch was collected by centrifugation at 4000 x g for 10 minute. The residue left after the crude starch extraction was further processed as above until most ofthe starch recovered from it (till - ve test with I_2-KI reagent). The crude starch was further purified by suspending in distilled water (1:5) and the sodium chloride (NaCl) was added to achieve the final concentration to 0.1 M to which toluene was added (3:1, v/v). It was then kept for shaking for 1-2 hours and the denatured protein was removed by centrifugation. Thus, purified starch was suspended in water and recovered by centrifugation. Then, it was filtered through Buchner funnel (with acetone wash) and air-dried.

3.2.5.1 Determination of swelling index of starch:

The method as described by (Olaitan *et al*., 2014) was used in the determination of the swelling index. Three gram (dry basis) of sample was transferred into clean, dry, graduated (50 ml) cylinder. The sample was gently level and the volume noted. Distilled water (30 ml) was added to sample. The cylinder was swirled and allowed to stand for 60 min while the change in volume (swelling) was recorded every 15 min. The ratio of the initial volume tothe final volume gave the swelling index.

$$\text{Swelling index} = \frac{\text{Change in volume of sample}}{\text{Original weight of sample}} \times 100$$

3.2.5.2 Determination of solubility index of starch:

The solubility index was determined using the method described by (Ebunoluwa *et al*., 2017). 1 g of dried starch was weighed into a 50 mL centrifuge tube. 50 mL of distilled water was added and mixed gently. The slurry was heated in a water bath at 90 ºC for 15 minutes. During heating, the slurry was stirred gently to prevent clumping. On completion, the tube containing the paste was centrifuged at 3,000 rpm for 10 minutes using a centrifuge machine. The supernatant was decanted immediately after centrifuging. The weight of the sediment was taken and recorded. The moisture content of sediment gel was thereafter determined to get thedry matter content of the gel.

$$\text{Solubility index} = \frac{\text{Weight of dry solids after drying}}{\text{Weight of sample}} \times 100$$

3.2.6 Production of maltodextrin from Sorghum starch

Maltodextrins were produced by combination of depolymerization i.e. hydrolysis of glycosidic linkages and transglycosylation. Depolymerization can be affected with either an acid (HC1 or H_2SO_4) or an enzyme or by combination treatment. These processes are referred to as acid conversions, enzyme conversions and combination conversions respectively. 5 g air-dried starch was allowed to react with known concentration of HCI at 50 °C for specific interval of time. Then acidic slurry was neutralized with the help of standard alkali solution. This neutralized paste was vacuum dried and washed with iso-propanol, air dried and weighed. The per cent yield of maltodextrin was then calculated.

3.2.6.1 Enzyme Hydrolysis Method:

Starch

↓

Slurry (35% with distilled water)

↓

Enzyme hydrolysis (α-amylase 2% , 95 ^{0}C, 60 min)

↓

Drying (55 ^{0}C for 4 hr)

↓

Maltodextrin

3.2.6.2 Acid Hydrolysis Method:

Starch

↓

Acid Hydrolysis

(4.5% HCL concentration at 50 ^{0}C, 120 min)

↓

Drying (55 ^{0}C for 4 hr)

↓

Maltodextrin

3.2.6.3 Dextrose Equivalent (DE) of Maltodextrin:

The dextrose-equivalent (DE) expresses the number of aldehyde groups with reduced ends in relation to pure glucose. Thus, high dextrose equivalent (DE) indicates high hydrolytic conversion and low molecular weight. Depending on the degree of hydrolysis of the starch molecule, the product obtained is classified as maltodextrin (if the DE value is less than 20).

Equation for calculation of DE value:

$$DE = 100 \times \frac{\text{\% Reducing Sugar expressed as dextrose}}{\text{Total Carbohydrate}}$$

3.2.7 Standardization of recipe for Cookies:

The cookies were prepared by mixing all ingredients Wheat flour (Maida), Sugar, Fat, Sorghum Maltodextrin, Baking soda, Ammonium Bicarbonate and Milk) to form a dough. The Sorghum Maltodextrin was used as a fat replacer at the rate of 10 %, 20%, 30%, 40% and 50% in different samples of cookies. Baking was carried out at 160^0 C for 20 min in bakery oven. The desirable qualities are obtained in the bakery product (Cookies) by using ingredients in specific proportions and these are presented in Table No. 3.2.7.

Table No.: 3.2.7 Standardized recipe for Cookies

To standardize the recipe following variations were made

Ingredients	T_0	T_1	T_2	T_3	T_4	T_5
Wheat Flour (Maida) (g)	100	100	100	100	100	100
Sugar (g)	55	55	55	55	55	55
Fat (g)	45	40.5	36	31.5	27	22.5
Maltodextrin (g)	-	4.5	9	13.5	18	22.5
Baking Soda (g)	1.5	1.5	1.5	1.5	1.5	1.5
Ammonium Bicarbonate (g)	0.5	0.5	0.5	0.5	0.5	0.5
Milk (ml)	33	33	33	33	33	33

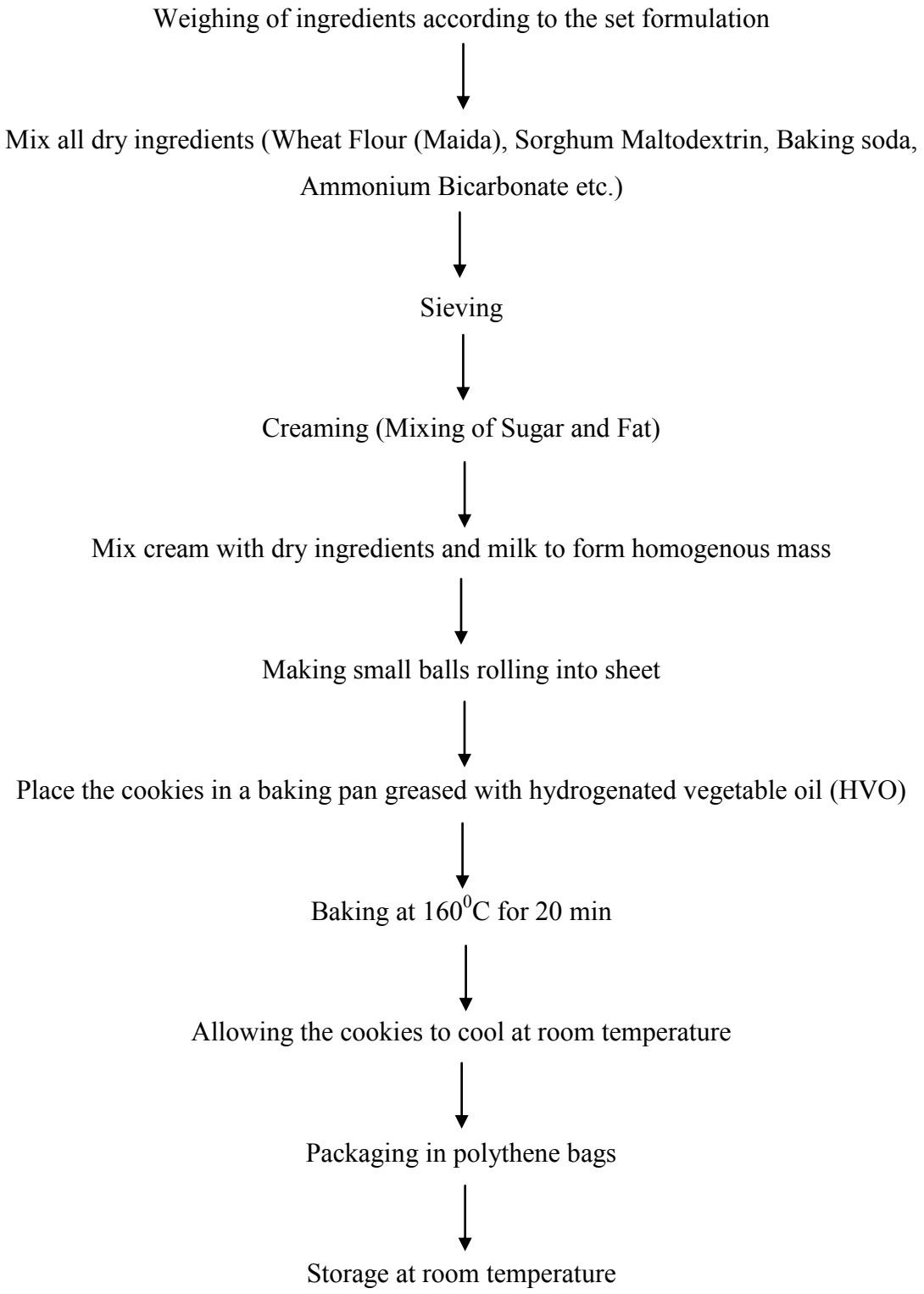
*Each value is average of three determinations

Table No.: 3.2.7.1 Percentage of fat and maltodextrin used in cookies

Sample	Fat	Maltodextrin
T_0	100% (45g)	0% (0g)
T_1	90% (40.5g)	10% (4.5g)
T_2	80% (36g)	20% (9g)
T_3	70% (31.5g)	30% (13.5g)
T_4	60% (27g)	40% (18g)
T_5	50% (22.5g)	50% (22.5g)

The recipe of cookies was standardized by keeping Wheat Flour (Maida), Sugar, Baking soda, Ammonium Bicarbonate and Milk value constant and replacing fat by Sorghum maltodextrin at the rate of 10 %, 20%, 30%, 40% and 50% in different samples of cookies. Then all the samples were prepared for sensory analysis.

3.2.7.2 Preparation of Cookies



3.2.8 Physical analysis of cookies

Cookies were analyzed for physical quality attributes. Weight (g), diameter (mm), thickness (mm), and spread ratio were determined following standard methods of (A.A.C.C., 2000).

3.2.8.1 Weight

The weight of cookies was determined by using digital weighing balance. (A.A.C.C., 2000).

3.2.8.2 Diameter

The diameter of the cookies was measured by using digital vemeir caliper. (A.A.C.C., 2000).

3.2.8.3 Thickness

The thickness of the cookies was measured by using digital vemeir caliper. (A.A.C.C., 2000).

3.2.8.4 Spread ratio

Spread ratio was calculated by dividing the average value of diameter by average value of thickness of cookies. (A.A.C.C., 2000)

3.2.9 Chemical composition of cookies

3.2.9.1 Moisture

The moisture content in the sample was estimated according to the method of AOAC (1984). 5 gm of sample was taken in pre-weighed moisture box, dried at 105ºc for 24 hrs in hot air oven, cooled in desiccators again weighed. The difference in weight of moisture box represents the moisture content of the sample.

$$\text{Moisture (\%)} = \frac{\text{Difference in the weight}}{\text{Weight of the sample (g)}} \times 100$$

3.2.9.2 Protein

The protein content in sample was determined by using conventional Micro-Kjeldhal digestion and distillation procedure as given in AOAC (1984).

Reagents are (a) Catalyst mixture- A mixture of 100 gm K_2SO_4, 20gm of $CuSO_4$ and 2.5 gm of SiO_2, (b) Sodium hydroxide 40%(w/v), (c) Boric acid 2 %(w/v), (d) Concentrated sulphuric acid, (e) Mixed indicator 2 parts 0.2 % (w/v) Methyl red and 1 parts 0.2% (w/v) methyl blue in absolute alcohol, (f) Standard sulphuric acid (0.1N).

3.2.9.2.1 Procedure

0.5 gm of sample was weighed accurately and transferred to a Kjeldhal flask taking care to see that the material did not stick to the neck of the flask. The catalyst mixture of about 1g and concentrated sulphuric acid (5ml) were added. Then the flask in an inclined position in digestion chamber was heated for about 4-6 hours till the liquid became clear (green blue colour). Distillation The content in the flask were allowed to cool and the digestion material was transferred quantitatively to a vacuum jacketed flask of micro Kjeldhal distillation apparatus and the ammonia liberated by the addition of 10 ml of 40% NaOH on heating was absorbed in 20 ml boric acid containing 2-3 drops of mixed indicator in 100ml conical flask. The distilled off ammonia was titrated against 0.1N sulphuric acid. The blank was also run in a similar way.

$$N\ (\%) = \frac{\text{Normality of } H_2SO_4 \text{ X Volume of 0.1N } H_2SO_4 \text{ X 14 x 100}}{\text{Weight of sample X 1000}}$$

Crude protein (%) = N X 6.25

3.2.9.3 Fat

The fat content of the sample was determined by the procedure as described in AOAC (1984). 5 gm of sample was weighed accurately, placed in thimble and plugged with cotton. The extractor-containing thimble was placed over a pre weighed extraction flask (A). Fat content was determined by extracting the sample with solvent petroleum ether (AR grade 60-80°c) for 8 hr using soxhlets extraction procedure. After extraction the excess of solvent was distilled off and the residual solvent was removed by heating at 80ºC in oven for 4-6 hours. The fat content was determined as below:

$$\text{Crude fat (\%)} = \frac{\text{Weight of flask (b)-weight of flask (A) X 100}}{\text{Weight of sample}}$$

3.2.9.4 Carbohydrate

Total carbohydrate in the samples was estimated by hydrolysis method as described in AOAC (1984).

Reagents are Conc. HCl (specific gravity 1.25), Fehling's solution

- Fehling's solution A: 34.64 gm of $CuSO_4.5H_2O$ was dissolved in 500ml of distilled water.

- Fehling's solution B: 173 gm of sodium potassium tartarate and 50 g of sodium hydroxide were dissolved in 500 ml of distilled water. The Fehling's solution was prepared by mixing the equal volume of solution A and solution B. It was prepared fresh daily. Sodium Hydroxide 40% (w/v). Methyl blue indicator 0.1 % (w/v) in 95% alcohol. 3N HCl – 68.18 ml concentrated HCl was made up to 250 ml with distilled water. Dextrose 1%- 1 gm of dextrose was dissolved in 100 ml distilled water. Procedure: 2.5gm sample was taken in the flask and suspended in 200 ml of distilled water. 20ml of 3N HCl was added refluxed in an air condenser for 3 hrs. On cooling, it was neutralized with alkali to pH 7.0, filtered and volume was made to 250 ml with distilled water. The total carbohydrate in the filtrate was determined by titrating it with Fehling's solution (A & B, %ml each) using 1 ml of methyl blue indicator. Factor was worked out by titrating 1% dextrose with Fehling's solution. In each titration Fehling's solution in the conical flask was heated with a constant flame and titration was done with filtrate in the burette until the end point (Brick- Red colour) was obtained. The total carbohydrate content was calculated as under.

$$\text{Dextrose \%} = \frac{\text{Factor} \times 250 \times 100}{\text{Titrated value} \times \text{weight of sample}}$$

Total carbohydrate (%) = Dextrose % X 0.9 24

3.2.9.5 Total Ash

The ash content in the sample was estimated according to AOAC (1984).

3.2.9.5.1 Procedure

5 gm of sample was weighed accurately into pre weighed porcelain (which has previously been heated to about 600^0C and cooled). The crucible was heated in a muffle furnace for 6-8 hours at 600-700ºC. It was then cooled in desiccators and weighed. To ensure completion of ashing, the crucible was again heated in a muffle furnace for 1-2 hour, cooled and weighed. This was repeated till the consecutive weights were the same and the ash was almost grayish-white in colour.

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

3.2.9.6 Crude Fibre

Crude fibre of sorghum grains was determined by method of AOAC. (1975). Weigh 10 gm sample in a 250 ml beaker. Add 200 ml of H_2SO_4 (1.25 %). Boil for 30 minutes and during boiling adjust the volume 200 ml constantly with hot water. After 30 minutes, filter the residue. Wash residue with hot water. Again take residue in 250 ml beaker. Add 200 ml of NaOH (1.25 %). Boil for 30 minutes, adjust volume 200 ml with hot water. Filter the residue and wash with hot water until the clear water comes. Wash with ethanol. Allow to dry and weigh in silica crucible. It was then heated in muffle furnace at 600 °C for 5-6 hours.

$$\%\text{Crude fibre} = \frac{\text{Weight before heating} - \text{Weight after heating}}{\text{Weight of sample}} \times 100$$

3.2.10 Texture profile analysis of cookies

Stable Micro System TAXT2 plus Texture Analyzer was used for texture profile analysis (TPA) of Cookies. The test was configured so that the hardness calculated at the time of the test by determining the load and displacement at predetermined points on the TPA curve. Hardness (h,) was the maximum load expressed in kg applied to the samples during the first compression. S-5 probe with 20 mm/sec. of pre-test and post-test speeds; and 75% compression was taken for TPA analysis. The maximum force required to just break the cookies is hardness. TPA is "one-bite" test, which includes the compression cycles. The cycle indicates the force vs. time data during the compression of the product by the instrument probe.

Hardness (kg) = F1 Where, F1- Positive Peak Force (Cycle 1)

3.2.11 Sensory evaluation

The cookies were evaluated for the sensory characteristics using standard procedure Amerine *et al.,* (1965) The cookies were evaluated for sensory attributes by a panel of 10 semi-trained judges, using a 9 point Hedonic scale ranging from like extremely to dislike extremely for different parameters like colour, flavour, taste, texture and overall acceptability. The mean values of 10 semi-trained judges were considered for evaluating the quality.

3.2.12 Storage studies

The cookies were packed in Low Density Polyethylene (LDPE) pouches of thickness 75 microns, High Density Polyethylene (HDPE) pouches of thickness 100

microns, aluminum foil of thickness 125 microns and Polyethylene Terephthalate (PET) jar of thickness 300 microns. The sensory quality of cookies was evaluated at an interval of 30 days for a period of 3 months.

3.2.13 Microbial evaluation of developed product

Microbial examination is the perfect quality assessment protocol performed in food products quality analysis. However, in every shelf life study of products, it is mandatory one. In the microbial study of cookies, the total plate count (TPC), yeast and mold count were determined. The results were expressed in terms of colony forming unit (CFU)/g of sample (Ranganna *et al*., 2010).

3.2.13.1 Total plate count

Microbial analysis was done to determine total plate count (TPC) of the samples on the nutrient agar media for bacterial count. Nutrient agar media was prepared and the samples were serially diluted up to 10^{-2} dilution factor. 1g of the samples, suspended in saline solution, was transferred to the respective petri dishes of nutrient agar media. Three replicates were taken for each dilution. The inoculated petri dishes were incubated for 48 hrs at 37 ± 1^{0}C and total colonies were calculated by the following formula.

TPC (cfu/ml) = No. of colonies x dilution factor

3.2.13.2 Yeast and mould count

Microbial analysis was done to determine total yeast and mould count of the samples on the potato dextrose agar media for yeast and mould count. Potato dextrose agar media was prepared and the samples were serially diluted up to 10^{-2} dilution factor. 1g of the samples, suspended in saline solution, was transferred to the respective petri dishes of potato dextrose agar media. Three replicates were taken for each dilution. The inoculated petri dishes were incubated in a incubator for 48 hours at $37+1^{0}$C for counting of yeast and mould.

3.2.14 Techno-economical feasibility of the cookies

The cost of production of most acceptable cookies was calculated by considering the raw materials cost, processing cost, packaging cost and miscellaneous cost.

CHAPTER -IV

RESULTS AND DISCUSSION

CHAPTER - IV

RESULTS AND DISCUSSION

The present investigation entitled **"**Preparation of maltodextrin from Sorghum and its utilization in bakery product (Cookies)**"** was carried out in the Department of Food Chemistry and Nutrition in collaboration with Department of Food Process Technology, Department of Food Microbiology and Safety, Department of Food Engineering, Niche Laboratory, College of Food Technology and Department of Soil Science, College of Agriculture, V.N.M.K.V., Parbhani (MS).

Sincere efforts have been made to prepare cookies from easily available raw materials by indigenous methodology. Raw material which was used for preparation of maltodextrin was sorghum grain, it was analyzed for its physical characteristics, chemical characteristics and mineral composition. Prepared maltodextrin was analyzed for its chemical composition. Physical characteristics, chemical characteristics, sensory attributes, shelf life study, packaging study and microbial study of developed cookies were evaluated. Techno-economic feasibility of developed complementary food was also assessed. Data generated during this investigation are tabulated and statistically analyzed. The results obtained during present investigation are presented and discussed with respect to experimental data obtained during course of study and relevant information available in scientific literature under subsequent headings and sub headings. The purpose behind this research project is to develop cookies by incorporating fat replacer i.e. maltodextrin in order to reduce fat utilization in cookies.

4.1 Physical properties of Sorghum

The Physical properties of sorghum was carried out and the results obtained are tabulated in Table 4.1.

Table No. 4.1: Physical properties of Sorghum (Parbhani Shakti)

Physical parameter	Mean Value
Thousand kernel weight (g)	27.8 ± 0.02
Thousand kernel volume (ml)	22 ± 0.12
Bulk Density (g/ml)	0.71 ± 0.03
True Density (g/ml)	1.18 ± 0.15
Angle of Repose (Degrees)	32^0 ± 0.2

*Each value represents the mean of three determinations

Physical parameters of raw sorghum was studied and values recorded for Thousand kernel weight, Thousand kernel volume, Bulk Density, True Density, and Angle of Repose as 27.8g, 22ml, 0.71g/ml, 1.18g/ml and 32^0 respectively.

4.2 Chemical Composition of Sorghum (Parbhani Shakti)

The chemical composition of raw material was carried out and the results obtained are tabulated in Table No.4.2. Data concerning to various chemical properties like moisture, fat, carbohydrates, protein, ash, and crude fiber were investigated and results obtained are depicted inTable No.4.2:

Table No.4.2: Chemical Composition of Sorghum (Parbhani Shakti)

Chemical Parameters	Sorghum
Moisture (%)	10.1 ± 1.0
Total Fat (%)	2.2 ± 0.06
Total Carbohydrates (%)	73.09 ± 0.70
Total Protein (%)	10.71 ± 0.43
Ash (%)	1.53 ± 0.05
Crude Fibre (%)	1.91 ± 0.01

*Each value represents the mean of three determinations

Sorghum (Parbhani Shakti) analyzed for the proximate nutritional composition and values recorded for moisture, fat, carbohydrate, protein, ash and crude fibre content of raw Sorghum as 10.1%, 2.2%, 73.09%, 10.71%, 1.53%, 1.91% respectively.

4.3 Mineral composition of Sorghum

The minerals in foods are micronutrients and present in little amounts but they

are very important for proper growth and development of human body in order to avoid hidden hunger in adults and malnutrition in children.

Data pertaining to various chemical properties like calcium, phosphorus, potassium, magnesium, iron, sodium, manganese and zinc were investigated and results obtained are depicted in Table 4.3.

Table No.4.3 : Mineral composition of Sorghum

Minerals	Sorghum (mg/100g)
Calcium (Ca)	39 ± 0.31
Phosphorus (P)	532 ± 0.75
Potassium (K)	566 ± 0.63
Magnesium (Mg)	208 ± 0.22
Iron (Fe)	4.8 ± 0.08
Manganese (Mn)	1.70 ± 0.09
Zinc (Zn)	3.1 ± 0.06

*Each value represents the mean of three determinations

Sorghum is found as richest source of phosphorous, potassium and magnesium in amounts 532mg/100g, 566mg/100g and 208mg/100g respectively. Sorghum also found as fair source of other minerals. These results were in close agreement with (Chavan *et al*., 2009).

Sorghum (Parbhani Shakti) was found to rich in Iron and Zinc content 4.8mg/100g and 3.1mg/100g respectively.

4.4 Chemical composition of Sorghum Starch

Table No. 4.4 : Chemical composition of Sorghum Starch

Chemical Parameters	Sorghum Starch
Moisture (%)	11.04 ± 0.43
Protein (%)	1.34 ± 0.06
Fat (%)	0.83 ± 0.07
Total carbohydrate (%)	95.05 ± 0.68
Ash (%)	0.26 ± 0.03
Crude fibre (%)	0.52 ± 0.01
Yield (%)	78.52 ± 0.25

*Each value represents the mean of three determinations

Sorghum starch was analysed for the proximate nutritional composition and values recorded for moisture, fat, carbohydrate, protein, ash crude fibre content and yield of Sorghum starch as 11.04%, 0.83%, 95.05%, 1.34%, 0.26%, 0.52% and 78.52% respectively.

Table No.4.5 Effect of soaking time on yield of starch

Time (hr)	Starch Yield (%)
9	55
12	64
16	73
20	78.6
24	75
28	70

The effect of soaking time on the yield of starch was assessed. The experiment was performed at 55° C. It is evident from the data (Table No.4.5) on effect of soaking time on the yield of starch that as the soaking time increases from 9-20 hours there was an increase in the yield of starch. The maximum yield of starch (78.6 per cent) was observed at 20 hours of soaking time. However, the yield of starch declined after 20 hours of soaking time. This may be attributed to the theory that the soaking water enters the kernel through the porous tip cap and moves quickly into voids in the pericarp by capillary action. Once equilibrium has attained further diffusion of water

stops, as the diffusion of water into endosperm and germ follows standard diffusivity law. Hence, the yield gradually decreases after 20 hours of soaking time.

Table No. 4.6 Effect of temperature on yield of starch

Temperature (^{0}C)	Starch Yield (%)
35	72.84
45	73.21
55	78.52
65	74.64

The results (Table No.4.6) on the effect of temperature on yield of starch indicated that the starch yield (78.52 per cent) was optimum at 55 °C. It can also be seen from the result that as the temperature increased from 35 °C - 55 °C the liberation of starch increased considerably from 72.84 to 78.52 per cent. Further decreased in yield was noted at 65 °C. Hence the 55°C temperature was selected as optimum. At hyper physiological temperature i.e. 50 - 60 °C, protein matrix has the highest degree of globulatization, which was directly related to the maximum starch recovery on grinding. These results are in good conformity with the results reported by Watson (1967).

4.7 Solubility and swelling characteristics of sorghum starch

The swelling and solubility characteristics are of significance in understanding the organization of molecules within the granules. The results on per cent solubility and swelling power are presented in Table No.4.7 and 4.8 . The data indicated that the starch solubility was increased with increasing the temperature from 40 to 90 °C . The resultant increase at higher temperature may attributed to the pasting / gelatinization temperature of respective starches. The increase in solubility may be mainly due to the dissociation of hydrogen bonds in amylose of the starches, which possess micelle structure units together. Therefore an enhancement in the temperature was found to accelerate the destruction rate of hydrogen bonds during heating of starch paste.

Table No. 4.7. Solubility Characteristics of Sorghum starch

Temperature (^{0}C)	% Solubility
40	0.67
50	0.92
60	2.81
70	8.82
80	14.5
90	17.3

Table No. 4.8 Swelling power of Sorghum starch

Temperature (^{0}C)	% Swelling Power
40	1.53
50	1.84
60	4.01
70	5.23
80	11.42
90	19.04

The swelling power of starch was increased from 40 to 90 °C. The swelling power was maximum at 90°C. The abrupt increase in swelling is due to the effect of temperature on the uncoiling of starch molecules which found to facilitate water penetration inside the starch granules and its molecule, bound to the active center of the starch which in turn, resulted in an increase in swelling power of starch molecule. The results of present investigation are in good conformity with the results reported by Wankhede *et al.,* (1989) and Carcea *et al.,* (1992).

Table No.4.9 Effect of acid concentration on yield of maltodextrin production

Conc. Of HCL (%)	% Yield of maltodextrin
2	91.8
2.5	92.4
3.0	92.9
3.5	93.5
4.0	94.9
4.5	95.5
5.0	94.3

Plate 3.1 Raw material (Sorghum)

Plate 3.2 Prepared Sorghum Maltodextrin

The results on the effect of hydrochloric acid concentration on yield of maltodextrin from sorghum starch are presented in Table No.4.9. It can be seen from the results that the maximum yield (95.5 per cent) of maltodextrin was obtained at 4.5 per cent acid concentration at 120 minutes reaction time at 50°C from starch of sorghum. As the concentration of acid increased from 2 to 4.5 per cent the amount of maltodextrin released was increased.

Table No.4.10 Effect of enzyme (α-amylase) concentration on yield of maltodextrin production

Conc. of enzyme (%)	% Yield of maltodextrin
0.5	92.4
1	93.9
1.5	95.8
2	97.8
2.5	96.3

The results on the effect of enzyme (α-amylase) concentration on yield of maltodextrin from sorghum starch are presented in Table No.4.10. It can be seen from the results that the maximum yield (97.8 per cent) of maltodextrin was obtained at 2 per cent enzyme concentration at 60 minutes reaction time at 95°C from starch of sorghum. As the concentration of enzyme increased from 0 to 2 per cent the amount of maltodextrin released was increased.

4.11 Chemical Composition of Sorghum Maltodextrin

Table No. 4.11: Chemical Composition of Sorghum Maltodextrin

Chemical Parameters	Sorghum Maltodextrin	Standard Maltodextrin
Moisture (%)	8.5 ± 0.31	8.3 ± 0.12
Total Fat (%)	0.08 ± 0.02	0.09 ± 0.04
Total Carbohydrates (%)	96.80 ± 0.67	97.56 ± 0.88
Total Protein (%)	0.04 ± 0.08	0.05 ± 0.06
Ash (%)	0.28 ± 0.01	0.29 ± 0.02
Crude Fibre (%)	0.32 ± 0.04	0.40 ± 0.01

*Each value represents the mean of three determinations

Sorghum maltodextrin analyzed for the proximate nutritional composition and values recorded for moisture, fat, carbohydrate, protein, ash and crude fibre content of 8.5%, 0.08%, 96.80%, 0.04%, 0.28% and 0.32% respectively.

Standard maltodextrin analyzed for the proximate nutritional composition and values recorded for moisture, fat, carbohydrate, protein, ash and crude fibre content of 8.3%, 0.09%, 97.56%, 0.05%, 0.29% and 0.40% respectively.

4.12 Theoretical energy value of Sorghum Maltodextrin

Energy value was calculated for Sorghum Maltodextrin sample by calculation method.

Table No. 4.12: Theoretical energy value of Sorghum Maltodextrin

Energy value was calculated for Sorghum Maltodextrin sample by calculation method.

Sample	Nutrients per 100g			
	Carbohydrates x 4	Protein x4	Fat x 9	Energy Value (Kcal/100g)
Sorghum Maltodextrin	387.2	0.16	0.72	388.0
Standard Maltodextrin	390.2	0.20	0.81	391.2

The energy value of Sorghum Maltodextrin and Standard maltodextrin was calculated and value 388.0 Kcal/100g and 391.2 Kcal/100g recorded respectively. This shows that prepared Sorghum maltodextrin has less energy value than standard maltodextrin.

Table No.4.13: Enzyme Hydrolysis of Sorghum Starch

Enzyme Hydrolysis of Sorghum Starch				
Concentration of α-amylase	Temperature(^{0}C)	Time (min)	DE value	Yield (%)
2%	95 ^{0}C	60 min	8	97.8%

Table No.4.13 revealed that Enzyme hydrolysis of Sorghum starch at 2% Concentration of α-amylase at 95^{0}C temperature for 60 min gives 97.8% yield of maltodextrin and DE value was 8.

Table No.4.14: Acid Hydrolysis of Sorghum Starch

Acid Hydrolysis of Sorghum Starch				
Concentration of HCL (%)	Temperature(^{0}C)	Time (min)	DE value	Yield (%)
4.5%	50 ^{0}C	120 min	7	95.5%

Table No.4.14 revealed that Acid hydrolysis of Sorghum starch at 4.5% concentration of HCL at 50 ^{0}C temperature for 120 min gives 95.5% yield of maltodextrin and DE value was 7.

The similar result was observed by Wankhede *et al*. (2005) which shows that maximum amount of maltodextrin was liberated at 4.5% concentration of HCL at 120min i. e. 95%.

4.15 Sensory evaluation of cookies

4.15 Sensory evaluation of cookies

Table No. 4.15: Sensory evaluation chart of cookies

Sensory evaluation by using 9 points hedonic scale by 5 trained panel members.

Samples	Colour and Appearance	Flavour	Taste	Texture	Overall Acceptability
T0	7.8	7.5	7.8	8.0	8.0
T1	7.6	7.8	7.0	7.6	7.5
T2	7.2	7.3	7.2	7.5	7.3
T3	7.9	8.0	7.8	8.1	8.2
T_4	7.5	7.8	7.8	6	7.2
T_5	7.2	7.4	7.8	6	7.1
SE±	0.0799	0.0895	0.1442	0.2493	0.1332
CD at 5 %	0.2425	0.2717	0.4376	0.7562	0.4025

*Each value is average of three determinations

All 6 samples T_0, T_1, T_2, T_3, T_4, and T_5 the scores for color and appearance were 7.8, 7.6, 7.2, 7.9, 7.5 and 7.2 respectively. For samples T_0, T_1, T_2, T_3, T_4, and T_5 the scores for flavor parameter are 7.5, 7.8, 7.3, 8.0, 7.8 and 7.4 respectively. For samples T_0, T_1, T_2, T_3, T_4, and T_5 the scores for taste parameter are 7.8, 7.0, 7.2, 7.8, 7.8 and 7.8 respectively. For samples T_0, T_1, T_2, T_3, T_4, and T_5 the scores for texture parameter are 8.0, 7.6, 7.5, 8.1,6.0 and 6.0 respectively. For samples T_0, T_1, T_2, T_3, T_4, and T_5 the scores for overall acceptability parameter are 8.0, 7.5, 7.3, 8.2, 7.2, and 7.1 respectively.

For all parameters sample **T_3** scored highest and so that it is selected for further analysis purpose.

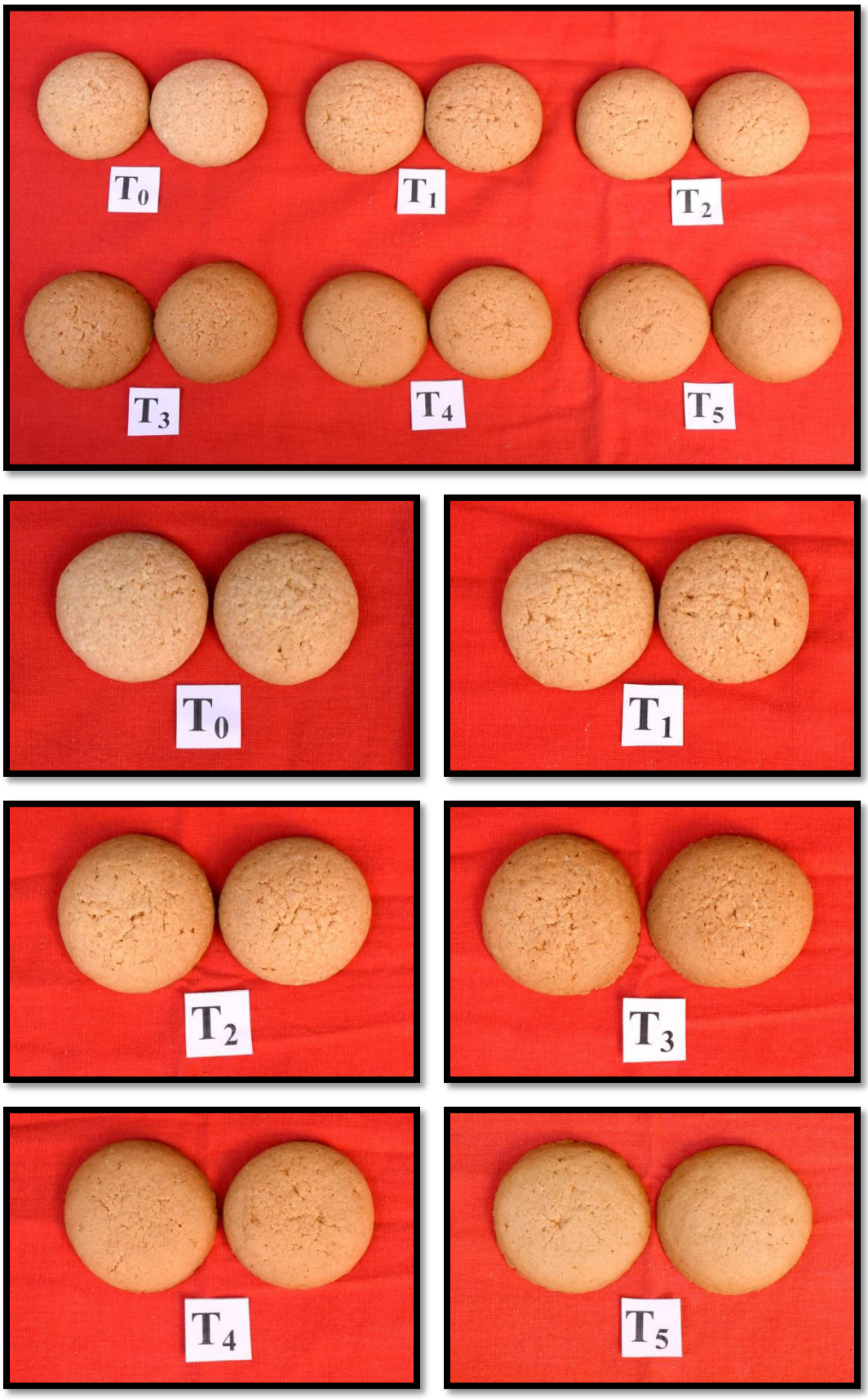


Plate 3.3 Prepared samples of cookies

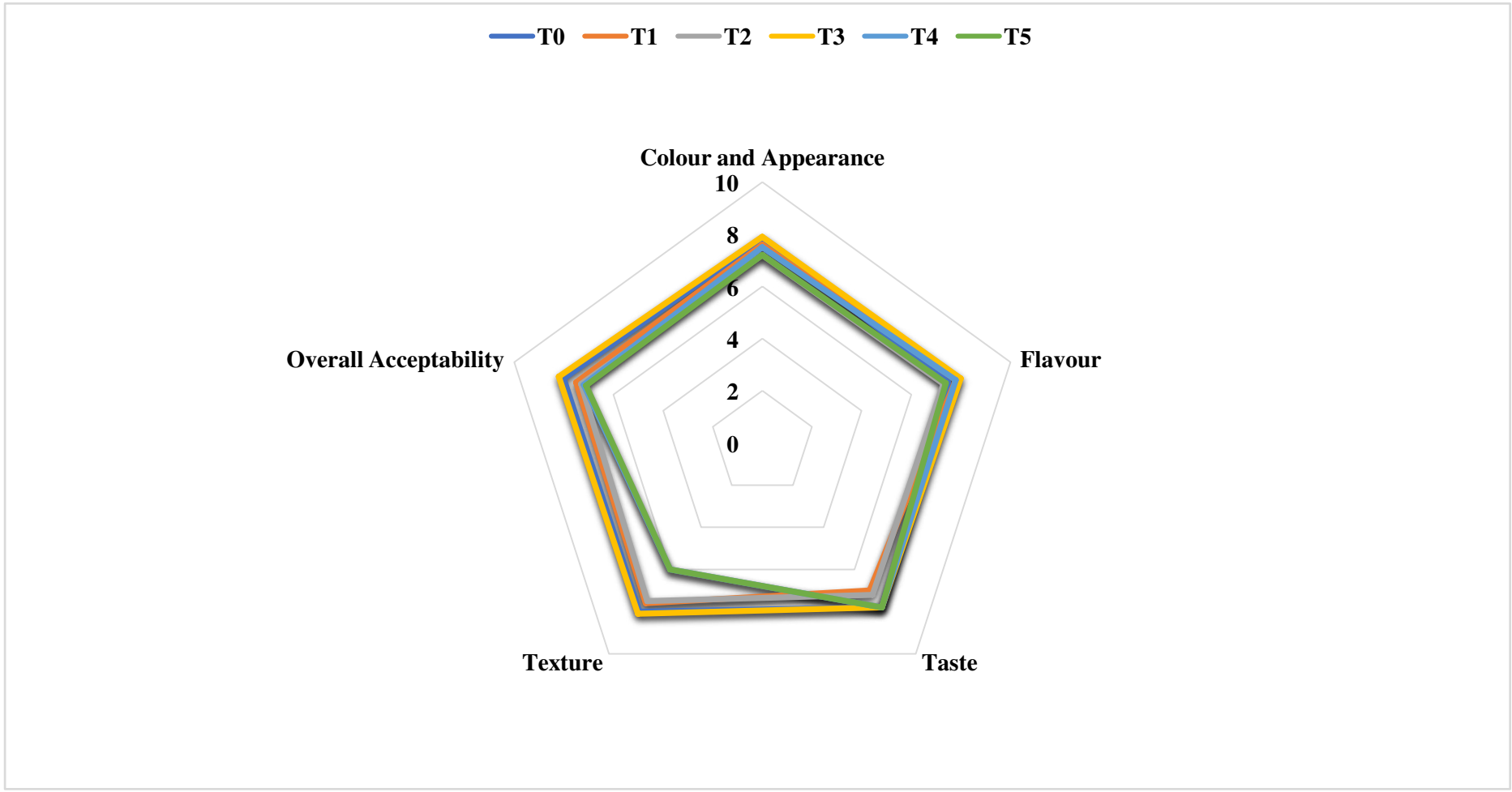


Fig. 4.1 Sensory evaluation chart of cookies

4.16 Physical properties of prepared Cookies:

Table No. 4.16: Physical properties of prepared Cookies

Sample	Weight (g)	Diameter (mm)	Thickness (mm)	Spread Factor
T_0	13.5 ± 0.22	45.8 ± 0.13	15.1 ± 0.12	3.03 ± 0.15
T_1	13.5 ± 0.14	45.7 ± 0.25	15.3 ± 0.24	2.9 ± 0.18
T_2	13.2 ± 0.13	45.5 ± 0.17	16.3 ± 0.31	2.79 ± 0.20
T_3	13.1 ± 0.24	45.2 ± 0.26	16.9 ± 0.36	2.67 ± 0.16
T_4	13.3 ± 0.20	45.1 ± 0.30	17.5 ± 0.40	2.57 ± 0.31
T_5	13.2 ± 0.19	45.0 ± 0.29	18.0 ± 0.25	2.50 ± 0.29

*Each value is average of three determinations

4.16 Physical properties of prepared cookies

4.16.1 Weight

The weight of different samples was calculated. The weight of different samples are different. Highest and lowest weight was recorded for sample T_0 and T_3 respectively.

4.16.2 Diameter

The diameter of cookies varied from 45.8 to 45 mm (Table 4.16). The maximum and minimum value of diameter of cookies was for sample T_0 and T_5 i.e. 45.8 mm and 45 mm respectively.

4.16.3 Thickness

Thickness value was highest for sample T_5 (18 mm) and lowest for sample T_0 (15.1 mm). Thickness value gradually increased from control sample T_0 to sample T_5.

4.16.4 Spread factor

The spread factor of biscuit varied from 3.03 to 2.5. The maximum and minimum spread factor was observed in sample T_0 (3.03) and sample T_5 (2.50) respectively. Hence the value of spread factor decreased from control sample T_0 to sample T_5.

From the Table No. 4.16 it is evident that there was decrease in diameter and spread factor (ratio of diameter to thickness) and there was increase in thickness from control sample T_0 to sample T_5 was noted.

4.17 Proximate composition of prepared Cookies

Table No. 4.17: Proximate composition of prepared Cookies

Chemical Parameters	T_0	T_3
Moisture (%)	1.2 ± 0.16	1.3 ± 0.19
Total Fat (%)	22.05 ± 0.28	8.96 ± 0.31
Total Carbohydrates (%)	72.73 ± 0.47	83.82 ± 0.62
Total Protein (%)	2.91 ± 0.36	2.97 ± 0.28
Ash (%)	1.03 ± 0.04	1.28 ± 0.03
Crude Fibre (%)	0.151 ± 0.03	2.061 ± 0.01

*Each value is average of three determinations

From the Table No. 4.17 it is evident that the selected sample (T_3) has moisture, fat, carbohydrate, protein, ash and crude fibre content of 1.3%, 8.96%, 83.82%, 2.97%, 1.28%, and 2.061% respectively. The selected sample was superior in carbohydrate content and less in fat content than control sample (T_0).

The selected sample T_3 was superior in carbohydrate content and less in fat content than control sample T_0 due to replacement of fat with 30% maltodextrin in preparation of cookies sample T_3.

The selected sample T_3 was recorded with higher value of protein, ash and crude fibre content compared to control sample T_0 due to incorporation of maltodextrin as a fat replacer in sample T_3, maltodextrin contained trace amount of these nutrients i.e. protein, ash and crude fibre.

4.18 Theoretical energy value of Cookies

Table No. 4.18: Theoretical energy value of Cookies

Samples	Nutrients per 100g			
	Carbohydrate ×4	Protein× 4	Fat× 9	Energy value (Kcal/100 g)
Control	290.92	11.64	198.45	501.01
T3	335.28	11.88	80.64	427.8

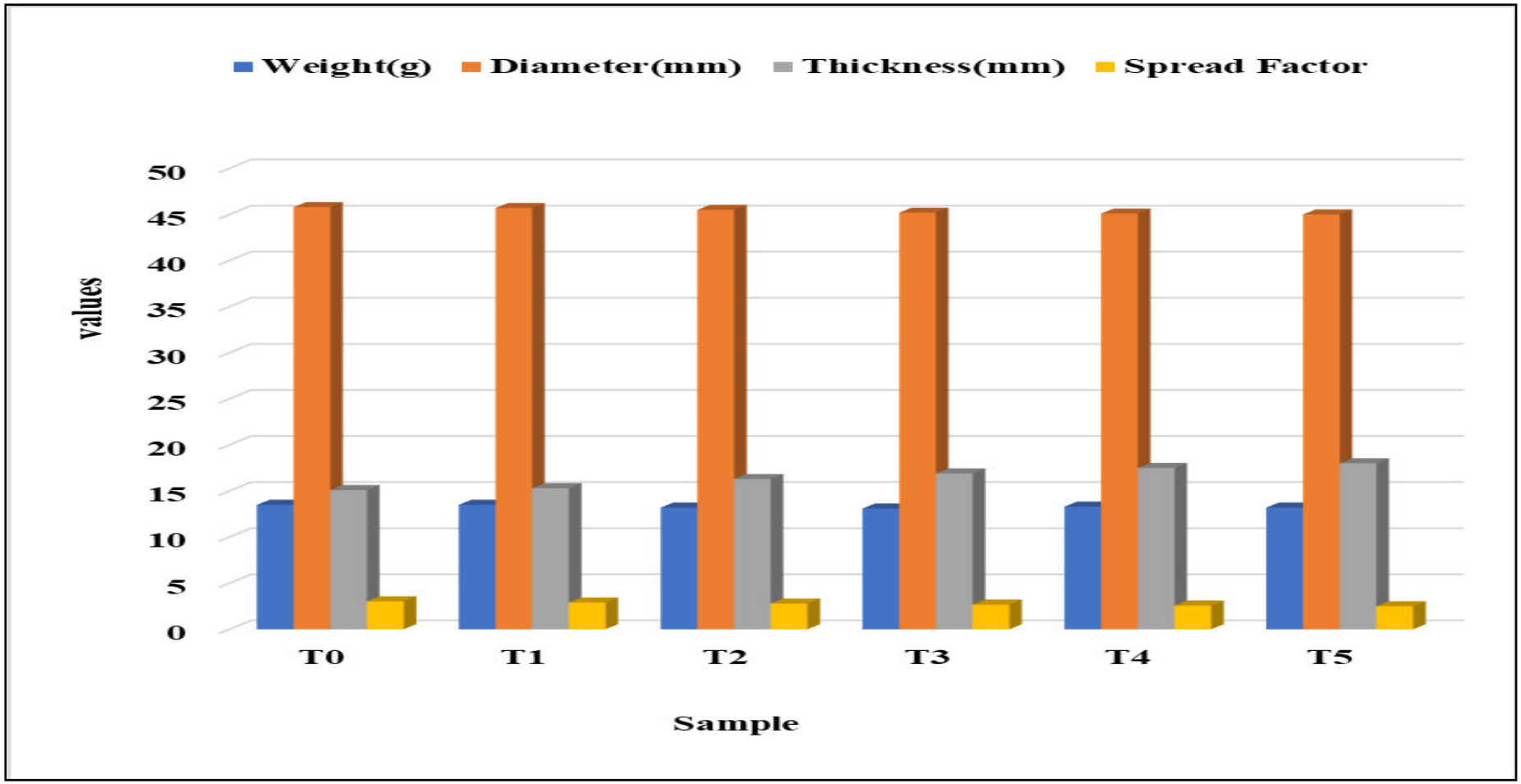


Fig. 4.2 Physical properties of prepared Cookies

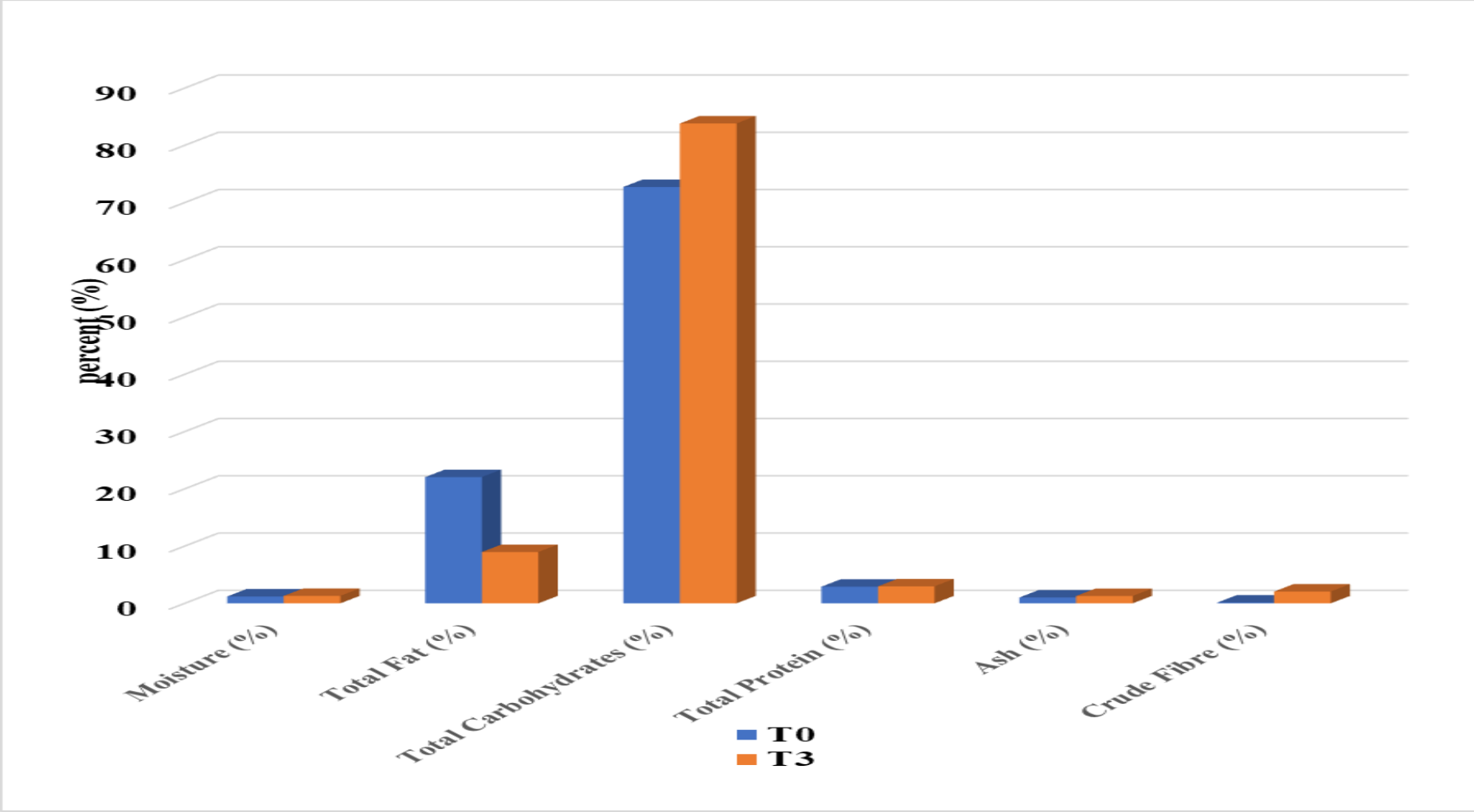


Fig. 4.3 Proximate composition of prepared Cookies

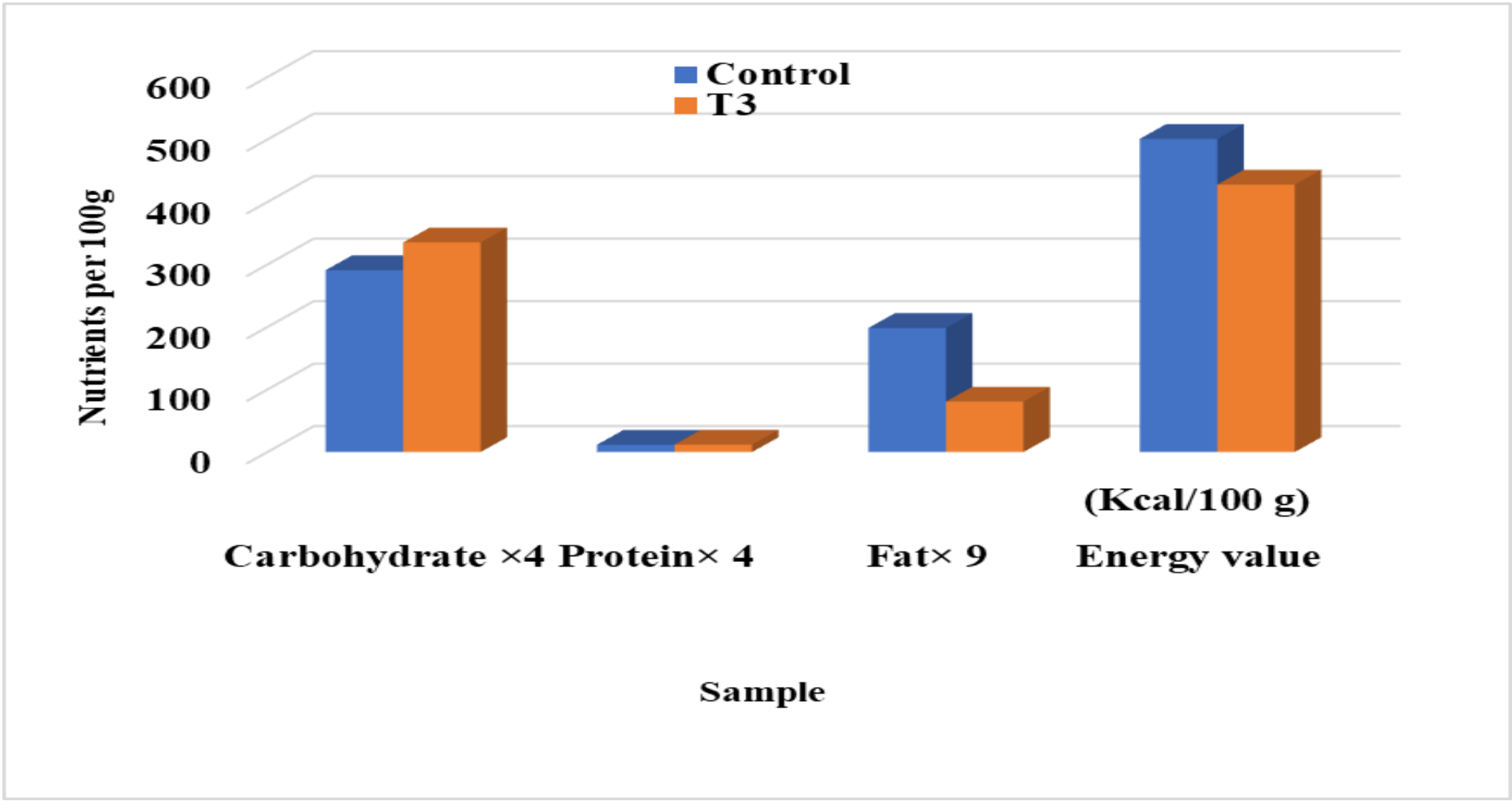


Fig. 4.4 Theoretical energy value of Cookies

The energy value of final product was calculated and value 427.8 Kcal/100g recorded. This shows that prepared product has good energy value.

The selected sample (**T3**) has moisture, fat, carbohydrate, protein, ash and crude fibre content as 1.3%, 8.96%, 83.82%, 2.97%, 1.28%, and 2.061% respectively. The energy value of final product was calculated and value 427.8 Kcal/100g recorded. This shows that prepared product has good energy value.

From the Table No. 4.18 it is evident that cookies are unique source of energy as the total energy values obtained from control sample and T_3 were 501.01 and 427.8 kcal respectively. Carbohydrate is the main source of energy in the cookies as it can be seen from the table No.4.17 that the carbohydrate content of control sample and T_3 were 72.73 and 83.82 per cent. The energy value of the selected cookies sample is less than control sample. This was due to lower fat content in T_3 sample as compare to control sample.

4.19 Texture measurement of cookies by TA_XT Texturometer

Table No. 4.19: Texture measurement of cookies by TA_XT Texturometer

Samples	Hardness (Kg)
T_0	7.12
T_1	7.76
T_2	8.02
T_3	8.66
T_4	9.13
T_5	9.85

From the Table 4.19, it could be observed that the hardness differed significantly among the samples. The sample T_0, T_1, T_2, T_3, T_4, and T_5 were evaluated for their hardness and the values of hardness of samples were recorded as 7.12 kg, 7.76 kg, 8.02 kg, 8.66 kg, 9.13 kg, and 9.85 kg respectively. The highest value of hardness observed in sample T_5. The selected sample T_3 has hardness of 8.66 kg.

The highest value of hardness observed in sample T_5 (9.85 Kg) which might be due to 50% replacement of hydrogenated fat with maltodextrin. Similar results

were reported by Chugh *et al.* (2013) who observed that hardness increased with increase in the level of fat replacers and decrease in the fat level.

The gradual increase in hardness of cookies was observed due to 10 %, 20%, 30%, 40% and 50% replacement of fat with maltodextrin in samples T_1, T_2, T_3, T_4, and T_5 respectively. Control sample has lowest value for hardness as compared to all other samples of cookies which contained maltodextrin at different concentrations.

Table No. 4.20: Effect of storability on overall acceptability of developed cookies packed in different packaging materials

Formulation	0 days	30 days	60 days	90 days
$P_1 T_0$	8.0	7.1	7.0	6.5
$P_2 T_0$	8.0	7.2	7.0	6.6
$P_3 T_0$	8.0	7.4	7.2	6.8
$P_4 T_0$	8.0	7.6	7.4	7.0
$P_1 T_1$	7.5	7.3	7.1	6.1
$P_2 T_1$	7.5	6.7	6.5	6.3
$P_3 T_1$	7.5	6.9	6.7	6.5
$P_4 T_1$	7.5	7.1	6.9	6.7
$P_1 T_2$	7.3	7.2	7.0	6.0
$P_2 T_2$	7.3	6.8	6.4	6.1
$P_3 T_2$	7.3	7.0	6.7	6.6
$P_4 T_2$	7.3	7.1	6.9	6.8
$P_1 T_3$	8.2	8.1	7.8	6.3
$P_2 T_3$	8.2	7.6	7.2	6.4
$P_3 T_3$	8.2	7.8	7.5	6.8
$P_4 T_3$	8.2	7.9	7.6	7.2
$P_1 T_4$	7.2	7.1	6.8	6.0
$P_2 T_4$	7.2	6.4	6.3	6.1
$P_3 T_4$	7.2	6.7	6.4	6.2
$P_4 T_4$	7.2	69	6.6	6.3
$P_1 T_5$	7.1	7.0	6.8	6.1
$P_2 T_5$	7.1	6.3	6.1	6.2
$P_3 T_5$	7.1	6.5	6.3	6.3
$P_4 T_5$	7.1	6.8	6.6	6.5

P_1 - Low density polyethylene (LDPE),

P_2 -High density polyethylene (HDPE),

P_3 - Aluminium foil,

P_4 - PET jar

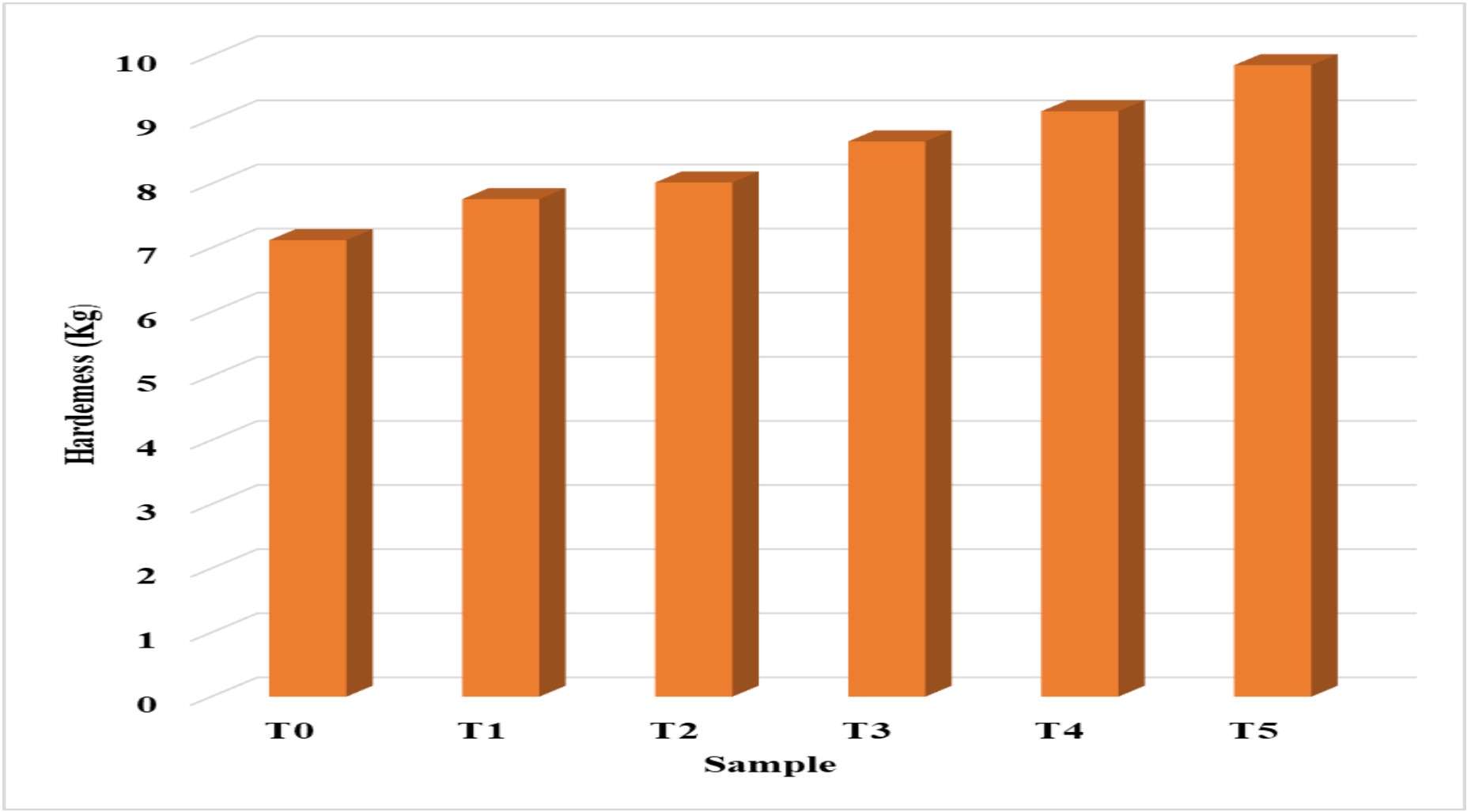


Fig.4.5 Texture measurement of cookies by TA_XT Texturometer

The storage study was conducted for 90 days at ambient temperature (32^0C ± 2 and 65% ± 5 RH) in different packaging materials i.e. low density polyethylene (LDPE), high density polyethylene (HDPE), aluminium foil and PET jar after 0, 30, 60 and 90 days and results are presented in Table No. 4.19. The overall acceptability of all cookies was decreased with increase in storage period.

Cookies sample T_1 (fat relaced with 10% maltodextrin) packed in PET jar (P_4T_1) exhibited the highest acceptability (6.7) up to the end of storage at 90 day followed by packed in Aluminium foil (P_3T_1) with (6.5) score and in high density polyethylene (HDPE) (P_2T_1) with score 6.3 as compared to control sample. Minimum score (6.1) was found in P_1T_1 after 90 day of storage in low density polyethylene (LDPE) package.

Cookies sample T_2 (fat relaced with 20% maltodextrin) packed in PET jar (P_4T_2) exhibited the highest acceptability (6.8) up to the end of storage at 90 day followed by packed in Aluminium foil (P_3T_2) with (6.6) score and in high density polyethylene (HDPE) (P_2T_2) with score 6.1 as compared to control sample. Minimum score (6.0) was found in P_1T_2 after 90 day of storage in low density polyethylene (LDPE) package.

Cookies sample T_3 (fat relaced with 30% maltodextrin) packed in PET jar (P_4T_3) exhibited the highest acceptability (7.2) up to the end of storage at 90 day followed by packed in Aluminium foil (P_3T_3) with (6.8) score and in high density polyethylene (HDPE) (P_2T_3) with score 6.4 as compared to control sample. Minimum score (6.3) was found in P_1T_3 after 90 day of storage in low density polyethylene (LDPE) package.

Cookies sample T_4 (fat relaced with 40% maltodextrin) packed in PET jar (P_4T_4) exhibited the highest acceptability (6.3) up to the end of storage at 90 day followed by packed in Aluminium foil (P_3T_4) with (6.2) score and in high density polyethylene (HDPE) (P_2T_4) with score 6.1 as compared to control sample. Minimum score (6.0) was found in P_1T_4 after 90 day of storage in low density polyethylene (LDPE) package.

Cookies sample T_5 (fat relaced with 50% maltodextrin) packed in PET jar (P_4T_5) exhibited the highest acceptability (6.5) up to the end of storage at 90 day followed by packed in Aluminium foil (P_3T_5) with (6.3) score and in high density

polyethylene (HDPE) (P_2T_5) with score 6.2 as compared to control sample. Minimum score (6.1) was found in P_1T_5 after 90 day of storage in low density polyethylene (LDPE) package.

The score of overall acceptability of cookies packed in PET jar was found highest followed by cookies packed in Aluminium foil and in high density polyethylene (HDPE). Minimum score of overall acceptability of cookies was found in cookies packed in low density polyethylene (LDPE) package.

Hence the overall acceptability of all cookies was decreased with increase in storage period.

4.21 Microbial Analysis of Cookies during three months storage

Table No. 4.21 Microbial Analysis of Cookies during three months storage

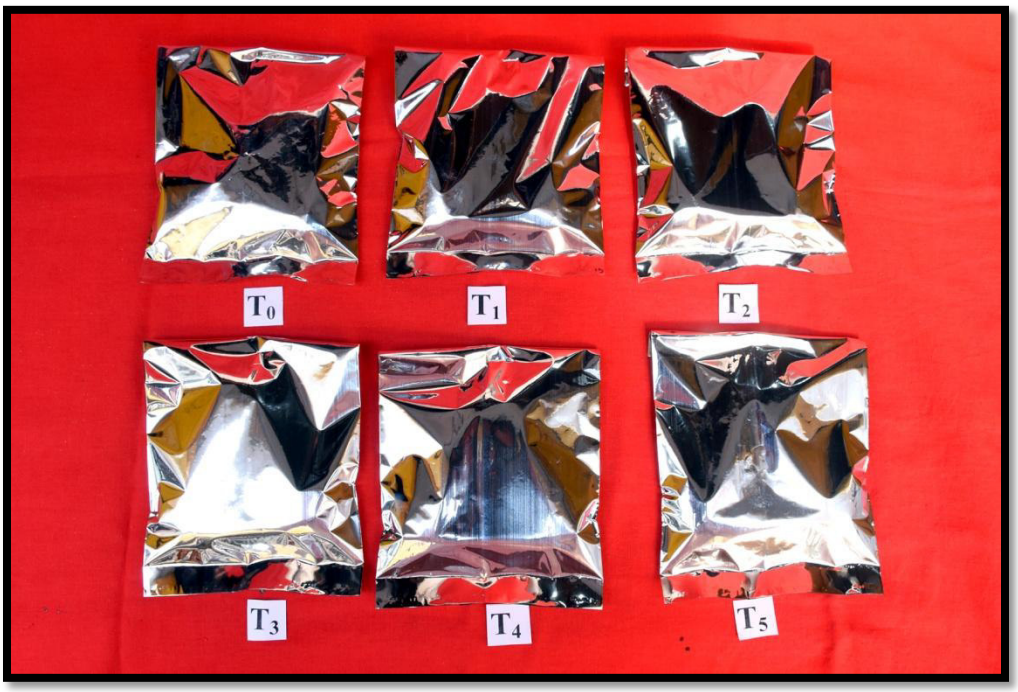
Parameters	0 day	30 day	60 day	90 day
TPC (CFU/g)	ND	ND	1.12×10^2	1.97×10^2
Yeast & Mold count (CFU/g)	ND	ND	ND	ND

ND-Not Detected

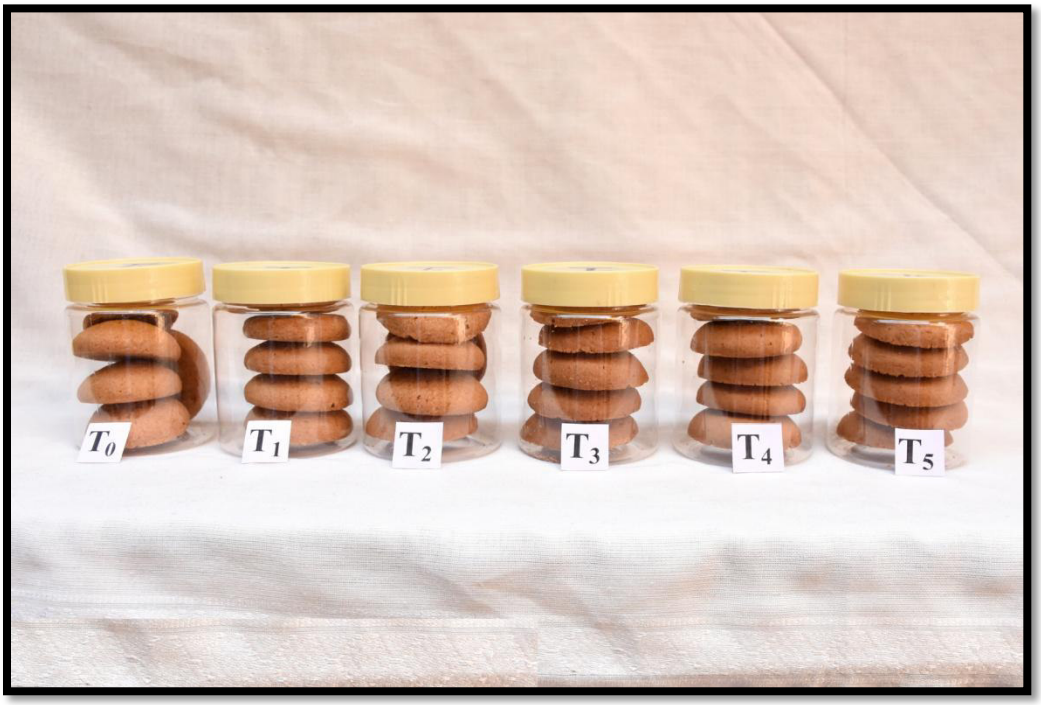
In the present investigation, the susceptibility of Cookies to microbial growth was determined by comparing the colony-forming units (CFU) on petri dishes. Selective growth media were used to differentiate between bacterial and mold/yeast growth. It was observed that the total plate count for the selected sample was found to be nil on 0 days of storage at room temperature and yeast and mold count were not detected up to 90 days. But the total plate count had appeared to be 1.12×10^2 cfu/g on 60^{th} day of storage and 1.97×10^2 cfu/g till 90^{th} day. Selected sample was found to be low for susceptibility to microbial growth in terms of total plate count and yeast/mold count.

Cookies packed and stored in LDPE pouches

Cookies packed and stored in HDPE pouches



Cookies packed and stored in Aluminium foil



Cookies packed and stored in PET jars

Plate 3.4 Cookies packed and stored in different packaging materials

4.22 Techno-economical feasibility of Cookies:

Table No. 4.22.1: Techno-economical feasibility of Control Cookies Sample T_0

Raw Material	Rate (Rs)	Quantity	Cost (Rs)
Wheat flour (Maida)	50/kg	1 kg	50 /-
Sugar	40/kg	550 g	22 /-
Fat	160/kg	450 g	72/-
Baking Soda	52/100g	15 g	7.8 /-
Ammonium Bicarbonate	30/100g	5 g	1.5 /-
Milk	10/200ml	350 ml	17.5 /-
Total raw material cost (Rs)			170.8 /-
Packaging cost @ 10% of raw material cost			17.08 /-
Processing cost @ 15% of raw material cost			25.62 /-
Total production cost (Rs) of Cookies/ kg			**213.5 /-**
Total production cost (Rs) of Cookies/10kg			2135 /-

Table No. 4.22.2: Techno-economical feasibility of Cookies Sample T_3

Raw Material	Rate (Rs)	Quantity	Cost (Rs)
Wheat flour (Maida)	50/kg	1 kg	50 /-
Sugar	40/kg	550 g	22 /-
Fat	160/kg	315 g	50.4 /-
Baking Soda	52/100g	15 g	7.8 /-
Ammonium Bicarbonate	30/100g	5 g	1.5 /-
Milk	10/200ml	350 ml	17.5 /-
Maltodextrin	400/kg	135 g	54 /-
Total raw material cost (Rs)			203.2 /-
Packaging cost @ 10% of raw material cost			20.32 /-
Processing cost @ 15% of raw material cost			30.48 /-
Total production cost (Rs) of Cookies/ kg			**254.3 /-**
Total production cost (Rs) of Cookies/10kg			2543 /-

The techno economical feasibility of prepared cookies was determined by calculating the total cost of production for product. The estimation of cost of production was done by using standard calculation method. By considering the raw material cost, processing cost (15% of raw material cost) and packaging cost (10% of raw material cost).

From the Table No.4.22.1 and Table No.4.22.2 it is evident that the cookies with good nutritional properties and low fat content can be successfully prepared by using maltodextrin as a fat replacer and also by using good quality of raw materials. Total production cost of control sample T_0 and sample T_3 Cookies/ kg were 213.5 Rs. and 254.3 Rs. respectively. Total production cost of control sample T_0 and sample T_3 Cookies/10 kg were 2135 Rs. and 2543 Rs. respectively. Prepared cookies sample T_3 has higher production cost than control sample cookies $T_{0.}$ Prepared cookies were economically feasible.

CHAPTER -V

SUMMARY AND CONCLUSION

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SUMMARY AND CONCLUSION

Cookies are 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. The present study was done for low fat (low calorie) cookies by incorporating Sorghum maltodextrin as a fat replacer.

Sorghum (Parbhani Shakti) analyzed for the proximate nutritional composition and values recorded for moisture, fat, carbohydrate, protein, ash and crude fibre content of raw Sorghum as 10.1%, 2.2%, 73.09%, 10.71%, 1.53%, 1.91% respectively. Sorghum (Parbhani Shakti) was found to rich in Iron and Zinc content 4.8mg/100g and 3.1mg/100g respectively.

Sorghum starch was analysed for the proximate nutritional composition and values recorded for moisture, fat, carbohydrate, protein, ash crude fibre content and yield of Sorghum starch as 11.04%, 0.83%, 95.05%, 1.34%, 0.26%, 0.52% and 78.52% respectively. The effect of soaking time on the yield of starch was assessed. The maximum yield of starch (78.6 per cent) was observed at 20 hours of soaking time. However, the yield of starch declined after 20 hours of soaking time. The effect of temperature on yield of starch indicated that the starch yield (78.52 per cent) was optimum at 55 °C. It can also be seen from the result that as the temperature increased from 35 °C - 55 °C the liberation of starch increased considerably from 72.84 to 78.52 per cent. The swelling power of starch was increased from 40 to 90 °C. The swelling power was maximum at 90°C. The data Indicated that the starch solubility was increased with increasing the temperature from 40 to 90 °C. It can be seen from the results that the maximum yield (95.5 per cent) of maltodextrin was obtained at 4.5 per cent acid concentration at 120 minutes reaction time at 50°C from starch of sorghum. As the concentration of acid increased from 2 to 4.5 percent the amount of maltodextrin released was increased. It can be seen from the results that the maximum yield (97.8 per cent) of maltodextrin was obtained at 2 per cent enzyme concentration at 60 minutes reaction time at 95°C from starch of sorghum. As the concentration of enzyme increased from 0 to 2 per cent the amount of maltodextrin released was increased.

Sorghum maltodextrin analyzed for the proximate nutritional composition and values recorded for moisture, fat, carbohydrate, protein, ash and crude fibre content of 8.5%, 0.09%, 96.80%, 0.06%, 0.25% and 0.38% respectively. Standard maltodextrin analyzed for the proximate nutritional composition and values recorded for moisture, fat, carbohydrate, protein, ash and crude fibre content of 8.3%, 0.09%, 97.56%, 0.05%, 0.29% and 0.40% respectively.

The energy value of Sorghum Maltodextrin and Standard maltodextrin was calculated and value 388.0 Kcal/100g and 391.2 Kcal/100g recorded respectively. This shows that prepared Sorghum maltodextrin has less energy value than standard maltodextrin.

The DE value of maltodextrin prepared by acid hydrolysis method is 7 and by enzyme hydrolysis method is 8. The percent yield of maltodextrin prepared by acid hydrolysis method is 95.5% and by enzyme hydrolysis method is 97.8%. Hence The yield of maltodextrin prepared by enzyme hydrolysis method was greater than the acid hydrolysis method.

The study was conducted to develop low fat cookies by incorporating Sorghum maltodextrin as a fat replacer. Fat in Cookies was replaced with Maltodextrin at different replacement levels i.e. 10%, 20%, 30%, 40% and 50% in samples T_1, T_2, T_3, T_4, and T_5 respectively and these samples were evaluated with control sample (T_0). Sample T_3 was found to be most preferred sample with respect to sensory quality such as color, appearance, flavor, taste, texture and overall acceptability.

The selected sample (T_3) has moisture, fat, carbohydrate, protein, ash and crude fibre content of 1.3%, 8.96%, 83.82%, 2.97%, 1.28%, and 2.06% respectively. The energy value of final product was calculated and value 427.8 Kcal/100g recorded. The selected sample is superior in Carbohydrate and mineral content and lower in fat content than control sample. The selected sample T_3 was recorded with higher value of protein, ash and crude fibre content compared to control sample T_0 due to incorporation of maltodextrin as a fat replacer in sample T_3, maltodextrin contained trace amount of these nutrients i.e. protein, ash and crude fibre.

All samples were analyzed for weight, diameter, thickness, and spread ratio. There was decrease in diameter and spread factor (ratio of diameter to thickness) and increase in thickness from control sample T_0 to sample T_5 was noted.

Cookies are unique source of energy as the total energy values obtained from control sample and T3 were 501.01 and 427.8 kcal respectively. Carbohydrate is the main source of energy in the cookies as the carbohydrate content of control sample and T3 were 72.73 and 83.82 per cent. The energy value of the selected cookies sample is less than control sample. This was due to lower fat content in T_3 sample as compare to control sample.

It was observed that the hardness differed significantly among the samples. The sample T_0, T_1, T_2, T_3, T_4, and T_5 were evaluated for their hardness and the values of hardness of samples were recorded as 7.12 kg, 7.76 kg, 8.02 kg, 8.66 kg, 9.13 kg, and 9.85 kg respectively. The highest value of hardness observed in sample T_5. The selected sample T_3 has hardness of 8.66 kg. The gradual increase in hardness of cookies was observed due to 10 %, 20%, 30%, 40% and 50% replacement of fat with maltodextrin in samples T_1, T_2, T_3, T_4, and T_5 respectively.

The score of overall acceptability of cookies packed in PET jar was found highest followed by cookies packed in Aluminium foil and in high density polyethylene (HDPE). Minimum score of overall acceptability of cookies was found in cookies packed in low density polyethylene (LDPE) package.

It was observed that the total plate count for the selected sample was found to be nil on 0 days of storage at room temperature and yeast and mold count were not detected up to 90 days. But the total plate count had appeared to be 1.12×10^2 cfu/g on 60^{th} day of storage and 1.97×10^2 cfu/g till 90^{th} day. Selected sample was found to be low for susceptibility to microbial growth in terms of total plate count and yeast/mold count.

Total production cost of control sample T_0 and sample T_3 Cookies/ kg were 213.5 Rs. and 254.3 Rs. respectively. Total production cost of control sample T_0 and sample T_3 Cookies/10 kg were 2135 Rs. and 2543 Rs. respectively. Prepared cookies sample T_3 has higher production cost than control sample cookies T_0. Prepared cookies were economically feasible.

CONCLUSION

On the basis of findings, it can be concluded that cookies prepared by incorporation of maltodextrin as a fat replacer could be considered as the best from both nutritional and sensory point of view. The yield of maltodextrin prepared by enzyme hydrolysis method was greater than the acid hydrolysis method because enzymes are more specific in substrate hydrolysis as compare to chemical hydrolysis. The cookies sample T_3 (fat replaced by 30% maltodextrin) was good in terms of nutritional quality with acceptable sensorial quality. The fact that these recipes were inexpensive, locally available and nutritious. Low-cost, low-calorie cookies could be developed by using maltodextrin as a fat replacer. Selected cookies sample was found to be low for susceptibility to microbial growth in terms of total plate count and yeast/mold count. During storage study at roomtemperature, it was found to be good for its sensory attributes and maintaining good quality product under the period of 90 days. Thus, it may be concluded that Maltodextrin prepared from Sorghum starch can be successfully incorporated in the formulation of Cookies to reduce the calorie by replacing the fat. Low calorie cookies of acceptable quality can be prepared by incorporating maximum 30% maltodextrin in the formulation of cookies. The production cost of prepared cookies was lower as compare to market sample, hence it can be commercially explored.

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APPENDIX

APPENDIX – I

COLLEGE OF FOOD TECHNOLOGY

Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani

Sensory Evaluation Chart

Date: / /2022

Name of Product **:** Preparation of Maltodextrin from Sorghum and its Utilization in Bakery Product (Cookies)

Name of Evaluator **:**

Designation **:**

Sample Code	Sensory Attributes				
	Colour and Appearance	Flavour	Taste	Texture	Overall Acceptability
Control (T_0)					
T_1					
T_2					
T_3					
T_4					
T_5					
Remark:					

Hedonic Rating Scale

9	Like extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

Signature of the Evaluator

CURRICULUM VITAE

CURRICULUM VITAE

Full Name	:	**Sadaf Tarannum Mohammad Ilyas**
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Title of thesis	:	Preparation of Maltodextrin from Sorghum and its Utilization in Bakery Product (Cookies)

Academic qualification

Qualification	Name of college	University/ Board	Year of Passing	Percentage (%)/Grade	Class/ Grade
S.S.C.	Model Urdu High School, Parbhani	Maharashtra StateBoard, Pune	2013	87.00%	I
H.S.C.	Zakir Hussain Junior College, Parbhani	Maharashtra StateBoard, Pune	2015	84.46%	I
B. Tech (Food Technology)	CFT, VNMKV, Parbhani	VNMKV, Parbhani	2020	8.91	I/D

Place : Parbhani

Date : 30 / 11 **/2022**

Signature of the candidate

Sadaf Tarannum Mohammad Ilyas