

A DISSERTATION ON

Development of Millet Based Edible Cutlery carrying Beetroot powder

**SUBMITTED TO THE
DEPARTMENT OF BIOENGINEERING
FACULTY OF ENGINEERING & INFORMATION TECHNOLOGY
INTEGRAL UNIVERSITY, LUCKNOW**



**IN PARTIAL FULFILMENT
FOR THE
DEGREE OF MASTER OF TECHNOLOGY
IN FOOD TECNOLOGY**

**BY
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UNDER THE SUPERVISION OF

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DECLARATION FORM

I, **Sadaf Ishtiyag**, a student of **B.Tech.-M.Tech. Dual Degree Food Technology** (V Year/ X Semester), Integral University have completed my six months dissertation work entitled **“Development of Millet based edible cutlery carrying Beetroot powder”** successfully from **Integral University, Lucknow** under the able guidance of **Mrs. Poonam Sharma**.

I, hereby, affirm that the work has been done by me in all aspects. I have sincerely prepared this project report and the results reported in this study are genuine and authentic.

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CERTIFICATE

Certificate that Ms. **Sadaf Ishtiyaq** (Enrollment Number 1800103914) has carried out the research work presented in this thesis entitled “**Development of Millet based edible cutlery carrying Beetroot powder**” for the award of **B.Tech.-M.Tech. Dual Degree Food Technology** from Integral University, Lucknow under my supervision. The thesis embodies results of original work and studies carried out by the student himself and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution. The dissertation was a compulsory part of her **B.Tech.-M.Tech. Dual Degree Food Technology** degree.

I wish her good luck and bright future.

Mrs. Poonam Sharma

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This is to certify that **Sadaf Ishtiyag**, a student of **B.Tech.-M.Tech. Dual Degree Food Technology** (V year/ X Semester), Integral University has completed her six months dissertation work entitled **“Development of Millet based edible cutlery carrying Beetroot powder”** successfully. She has completed this work from Integral University, Lucknow under the guidance of Mrs. Poonam Sharma, Assistant professor, Department of Bioengineering. The dissertation was a compulsory part of her **B.Tech.-M.Tech. Dual Degree Food Technology**.

I wish her good luck and bright future.

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TO WHOM IT MAY CONCERN

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I wish her good luck and bright future.

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Place: Lucknow

Sadaf Ishtiyag

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ABSTRACT

Nowadays, waste disposal is the major problem due to industrialization and urbanization. Improper waste disposal leads to various environmental problems. Agricultural waste and plastic waste disposal have increased very fast in the last few decades. Plastic cutlery is most commonly used for food but it contains many toxins and carcinogens that are very harmful for humans and the environment. The aim of study was to develop millet based edible cutlery carrying beetroot powder. Developed cutlery was nutritious, ready to eat and biodegradable. Beetroot powder was used of natural color contain betalains, and antioxidant and natural pigment with anti-inflammatory properties. Sorghum contains high levels of phytochemicals, phenolic compound and high in fiber content. In this study, the control sample was made from sorghum flour and the cutlery was made in three different compositions using beetroot powder, not only to give color but also to add nutritional value to the cutlery. The edible spoons were analyzed for nutritional parameters such as moisture, ash, fat and protein content using standard methods. Total 5 samples were made in which one sample was considered as Control. Control C comprises whole sorghum flour. In the remaining samples the concentration was varied. Cutlery was evaluated on the basis of their physicochemical properties. Percent moisture ranged between 2 to 6.5%, ash content found in cutlery ranges between 2 to 6.5%, fat content determined ranged between 3.61 to 14.5%, water absorption tendency of cutlery was ranged between 47 to 134, water solubility ranged between 33 to 44.5% and sensory analysis was done for overall acceptability by using 9-point hedonic scales and scores of the cutlery ranges between 2 to 8.5.

Key words - Edible cutlery, Sorghum flour, Beetroot powder.

CHAPTER 1

INTRODUCTION

Edible cutlery represents a groundbreaking creation crafted from plant-derived materials, enhancing the dining experience by offering utensils that not only serve meals but also can be consumed once the dining is done. Originating in India back in 2010, a company known as Bakeys introduced this innovation as a response to the environmental issues posed by single-use plastic utensils (Poonia & Yadav, 2017). As single use plastics is grave threat to entire ecological community, there is a substantial need to replace single use plastic cutlery with better alternatives like edible cutlery. Cutlery stands as one of the fundamental yet highly efficient tools for consuming food, with its production and global usage being pervasive and effective. Historically, spoons are recognized as one of the earliest eating implements utilized by human beings, crafted from natural resources like wood, animal bones, and seashells. The earliest documented instances of cutlery highlight its role as one of the most fundamental yet remarkably efficient tools for worldwide food consumption. It claimed that spoons are one of the oldest eating facilities that human beings have used and made of natural elements such as wood, animal bones, seashells. The earliest documented evidence of spoons dates back to the year 1259 in England. Knives, fork was introduced by 18th century for eating. Silver is nonreactive metal to most of the food so it was the most preferred metal used until the stainless steel was introduced. Stainless steel is strong and non-reactive metal and its maintenance is easy. The introduction of plastics into the market significantly reduced the cost of cutlery production, simultaneously making it widely accessible and affordable. A multitude of options and sizes were introduced to cater to people's preferences, including variations like cups, bowls, spoons, forks, knives, and more. In the present day, stainless-steel cutlery commands a higher price compared to plastic or edible alternatives.

With an increased urbanization women starts their jobs; they have hardly any time for cooking and washing utensil (Deepshikha, 2018). So, the demand for plastic container increased. The plastic industry in India holds a significant value, estimated at around 3000-4000 crore rupees. According to the Central Pollution Control Board's 2016 report, India

generated over 15000 tons of plastic waste daily, out of which approximately 9000 tons were recycled, leaving a substantial portion uncollected or scattered as litter. The plastic waste generation escalated to approximately 25000 tons in the year 2017. The utilization of plastics and the challenges associated with their disposal have become significant issues observed in our country today (Patil & Sinhal, 2018). A type of plastic commonly used in the production of plastic cutlery is polystyrene. In a broader context, polystyrene or extended polystyrene is commonly referred to as Styrofoam. Recycling this material is particularly challenging. Numerous communities lack the infrastructure to recycle Styrofoam, which often results in plastic cutlery placed in recycling bins being separated at recycling facilities and either sent to landfills or discarded without further recycling or repurposing considerations. As a result, this disposable cutlery has been deposited in water bodies like lakes, rivers, and seas, leading to contamination and pollution of the waterways. Compounding the issue, these contaminated water bodies serve as the very sources for supplying domestic water, industrial water, and drinking water, exacerbating the widespread impact of the pollution. Due to its composition derived from a mixture of flours, edible cutlery is classified as EBO-eco-friendly, biodegradable, and organic (Das, 2016). The adoption of edible cutlery offers two primary advantages over plastic: biodegradability and environmental friendliness. This shift is particularly important as plastic poses a serious threat to both human society and the ecosystem at large. According to several studies, plastics contain a hazardous chemical known as bisphenol A (BPA). BPA, recognized as a hormone-mimicking chemical, has been associated with a range of adverse health effects in children. These effects encompass altered behavior, obesity, reproductive abnormalities, cardiovascular changes, and even cancer (Schug & Birnbaum, 2014).

Edible cutlery stands as the quintessential alternative to harmful plastic utensils. It not only holds ecological benefits but also contains nutritious ingredients that add to its value. Edible cutlery can also called ready to eat. Edible cutlery is versatile, suitable for all types of foods regardless of temperature or consistency. It can be used to enjoy a hot soup and a cold dessert simultaneously, accommodating both liquid and solid foods. It is completely biodegradable and we can eat after eating our meal (Deepshikha, 2018). Edible cutlery is

composed of essential nutrients including calcium, potassium, vitamin B, vitamin A, and a substantial amount of dietary fiber (Munir, 2017). Given that whole grains constitute the primary ingredients, edible cutlery promotes health by aiding in the prevention of various diseases such as obesity, constipation, coronary heart disease (CHD), and other potentially harmful health conditions. Agriculture cause air pollution, soil contamination, harmful gas, smoke, dust and pollute water also. So, the concept of edible cutlery may help in reducing agriculture waste.

Sorghum (*Sorghum bicolor*), also known as great millet, Indian millet, Milo durra, or shallu, is a cereal grain plant belonging to the grass family (Poaceae). Its starchy seeds are edible and used for various purposes. (*Sorghum bicolor*) holds a significant position as one of the most important cereal crops in India, ranking behind rice and wheat. It is cultivated in regions including Madhya Pradesh, Gujarat, and Rajasthan. India holds the distinction of being the world's third-largest producer of sorghum (Anitha et al., 2021). The majority of sorghum varieties contain elevated levels of phytochemicals, particularly phenolic compounds. Sorghum boasts a notable fiber content, predominantly composed of insoluble fiber (75%–90%) and soluble fiber (10%–25%). Sorghum is the primary ingredient being utilized. In comparison to rice, sorghum cultivation requires 60 times less water. Sorghum requires 60 times less water than rice. Edible cutlery made from sorghum also holds the potential to be a viable alternative to the single-use plastic cutlery that negatively impacts the planet's ecosystem. Due to its super absorbent capacity, sorghum is exceptionally adaptable for crafting edible cutlery. Sorghum's drought tolerance makes it well-suited for cultivation in semi-arid and arid regions of Africa. Furthermore, sorghum grains are employed in the production of opaque beer (such as Chibuku or Bojalwa Jwa Setswana) and non-fermented porridge (Mosokwane).

Sorghum grains serve as sources of starches, proteins, fibers, minerals (ash), lipids, and B-vitamins. However, they also contain antinutritional factors like condensed tannins and phytic acids. Sorghum's protein digestibility is recognized to be relatively low compared to other cereal grains. This digestibility further decreases when cooked due to the presence of cross-linked kafirin protein. Additionally, sorghum is deficient in essential amino acids such as lysine and essential fatty acids like omega-3. Sorghum-based functional foods hold

appeal for individuals with celiac disease since they lack allergenic wheat-type gluten proteins. These foods are also suitable for creating low-calorie diets for individuals dealing with health issues related to high glycemic load. Additionally, sorghum is valued for its content of polyphenolic antioxidants.

Beetroot, also known as red beet, is derived from the taproot of the beet plant (*Beta vulgaris* L). Beetroot is a widely popular vegetable in various regions around the world, including India. Beetroot is cultivated across temperate regions worldwide, with major production hubs located in North America, Europe, Asia, and North Africa (Kowalski and Szadzinska, 2014). Beetroot holds a traditional and widespread popularity as a vegetable across the globe (Sawicki et al., 2016). Red beetroot finds numerous applications in human nutrition. It is utilized in various forms as a red food colorant, enhancing the color of products such as tomato paste, sauces, desserts, jams and jellies, ice cream, sweets, and cereals (Gokhale and Lele, 2011; Kaur and Singh, 2014). Additionally, it is incorporated in dried formats like chips, tea, and powder for bakery items, food supplements, and more.

Beetroot comprises 87.57% water, 9.56% carbohydrates (with 29.3% as fiber and 70.7% as sugar), 1.61% protein, and 0.17% lipids. Additionally, it serves as a source of essential nutrients like potassium, choline, vitamin C, and niacin (USDA, 2013). Red beetroot boasts a wealth of beneficial active compounds, including carotenoids, betalains, polyphenols, flavonoids, and saponins (Figiel, 2010; Kaur and Singh, 2014; Nistor et al., 2017). Numerous potential health benefits for humans have been reported, particularly related to the antioxidant and anti-inflammatory activities found in red beetroot. In modern times, there is a growing preference for preventing the onset of diseases rather than simply treating them. Beetroot serves as a potent dietary source of health-promoting compounds that can be beneficial in addressing various pathological disorders.

Refined flour, commonly known as "Maida," is a type of white flour originating from the Indian subcontinent. It is produced from wheat. Refined flour (Maida) is derived from winter wheat with a high gluten content. However, the heat generated during the milling process causes the protein to denature, which restricts its suitability for making leavened breads. Among various cereals, wheat possesses distinctive proteins like gliadin and

glutenin. When mixed with water and mechanically kneaded, these proteins form a gluten network that imparts the wheat dough with elasticity and durability, allowing it to retain its shape during baking. Wheat is acknowledged as a valuable food for promoting good health due to its abundance in dietary fiber, B-group vitamins, minerals, and protein. In the context of edible cutlery, refined wheat flour provides the structural component. When water is mixed with refined wheat flour, the proteins present in the white flour form gluten through interaction. As the dough rises, the elastic structure of gluten expands, accommodating the increasing leavening gases.

Objectives

1. To Develop a millet based edible cutlery carrying beetroot powder.
2. To study the physico-chemical properties of edible cutlery.
3. To estimate the shelf life of edible cutlery.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Importance of cutlery

Cutlery refers to handheld tools utilized for various tasks in Western dining culture, including food preparation, serving, and most notably, eating. Cutlery stands as one of the most basic tools employed worldwide for the purpose of consuming food. The oldest eating implements are thought to be spoons, crafted from natural materials like wood, bones, seashells, and more. Knives and forks were introduced in the 18th century for eating. Silver, due to its non-reactive metal to the most of the foods so it was most preferred metal used until stainless steel was introduced. Stainless steel is strong and non-reactive metal and its maintenance is easy. When plastic cutlery was introduced, it brought down the cost of other cutleries as well as it was available in many varieties and sizes. Cups, plates, forks, knives and many others are made from plastics. Steel cutlery is notably more expensive compared to plastic or edible alternatives (Patil & Sinhal, 2018).

2.2 Importance of Edible Cutlery

As pollution has risen and concerns about health issues caused by plastic consumption have grown, individuals have sought an innovative solution known as edible cutlery. Numerous entrepreneurs have pioneered inventive tableware options that are not only edible but also biodegradable. Edible cutlery was first introduced in the 1400s though, it's not a new concept but seems new for many. The initial instance of edible tableware was introduced in 1427, with the intention of impressing the British Duke. They developed a Bread bowl so; Duke gave Irish nobleman money to an inventor for the innovation so that he could consider opening a bread bowl shop in the city of Dublin. Likewise, during the 1930s, the tostada bowl made from tortilla was introduced, while in the 1980s, the sourdough bowl emerged in the market, serving as a unique vessel for soups (Natarajan et al., 2019).

Plastic cutlery, widely utilized globally, is composed of a material called polystyrene. Polystyrene, commonly known as Styrofoam, presents a recycling challenge as it is difficult to recycle, and some forms of it are non-recyclable. This often results in these

materials being sent to landfills, contributing to solid waste accumulation. Plastic cutlery is a composite of several neurotoxic and carcinogenic chemicals which leach into food and harm human health (Ram Proshad et al., 2018). These harmful plastic cutleries could be replaced by using edible cutleries which are edible as well as biodegradable. Edible cutleries also provide nutritional benefits to consumers and have potential to reduce plastic waste (Rajendran et al., 2020).

Due to rapid urbanization demand for plastic containers increased because women are busy in their jobs so they hardly have time for cooking, washing or doing any other work. Plastic waste became a worldwide concern because use of plastic containers leads to an increase in plastic waste and also it has harmful chemicals which are not good for both human health and environment. To overcome this, edible cutlery is developed which is eco-friendly and biodegradable. Concept of edible cutlery is that they are ready to eat, no further preparation is required. Another benefit of these edible cutleries is that they also aid in nutrition. These materials can be used to serve solid or semi-solid items without the concern of them becoming quickly soggy. They can be used in disaster prone areas or during wars where there is scarcity of food due to lack of resources (Deepshikha, 2018)

2.3 Developed Edible Cutleries

Deepshikha, 2018 developed an Edible plate using Sorghum (Jawar), Rice and Spinach. All the ingredients they use aid in nutrition. Sorghum is an excellent source of dietary calories and protein (Linda et al. 2006) Indeed, rice is consumed as a staple food throughout the world. They add spinach not only for nutritional purpose but also to make edible plate more attractive. Sorbic acid of 1% was used for its antimicrobial properties. Plate was developed by baking method. Crude protein, crude fiber, crude fat, moisture, dietary fiber (ADF and NDF), energy Kcals, starch contents in sorghum flour was calculated as 10.27, 2.57, 2.19, 0.70, 9.45, 7.15, 5.30, 71.33 percent. In case of rice values for the same constituents were in the range of 14.70, 2.35, 1.89, 0.64, 6.82, 0.25, 0.67, 340.00, and 79.43. For spinach values calculated was 93.73, 1.89, 0.60, 0.59, 1.54, 11.46, 29.63, 25.00 respectively and starch was not found. All these parameters were also calculated for edible plate and the results ranges 21 2.57, 1.60, 1.72, 4.81, 0.64, 3.40, 1.64, 4.25, 343.40. Phyto-

chemicals were also calculated in all three sorghum, rice and spinach in which carotenoids (mg/100g) was found in the range of 0.612, 0.09, 4.42 and flavonoid (%) content was found is 0.76, 0.48, 0.82. 21 These two parameters were also estimated in edible plate and results were 0.64 and 2.72. Organoleptic evaluation was conducted to assess consumer acceptability based on criteria such as color, taste, texture, and overall impression. The plate received scores of 7.6, 7.0, 7.0, and 7.2 for color, taste, texture, and overall acceptability, respectively.

Rajendran et al., 2020 prepared an Edible spoon using wheat which contains gliadin and glutenin, pearl millet also called bajra, rich in minerals like zinc, iron and a good source of antioxidants (Gul et al., 2015). The carbohydrate content in pearl millet ranges from 59.8% to 77.3%. Starch, found in pearl millet, contributes to the firmness and structure of products by virtue of its gelatinization properties (Masakuni Tako et al., 2014). Barnyard millet is abundant in dietary fiber and carbohydrates, making it beneficial for individuals with diabetes (Roopashree Ugare et al., 2014). A water absorption test was conducted at three distinct temperatures: room temperature (29°C), cold temperature (10°C), and hot temperature (50°C). Percent carbohydrate, total fat, protein, fiber, energy in edible cutlery was estimated at 83.68, 2.36, 5.67, 1.12 and 350.12 kcal/100g respectively. Texture profile analysis was done on the basis of hardness, fracturability, springiness (mm), cohesiveness, gumminess, chewiness, resilience by soaking it in water for 20 minutes and results evaluated as 14305.70, 314.38, 0.466, 0.240, 1153.60, 617.26, and 0.251. All the samples degraded in 5 days.

Bakeys is a start-up company in Hyderabad, Telangana where Indian edible cutlery is manufactured (Markham, 2018). Narayan Peesapaty is the founder of bakery and his aim was to replace plastic, bamboo and wood utensils. He used sorghum, rice, millet and wheat to developed edible spoons, forks and chopsticks (Micu, 2016). The shelf-life of the products is 24 months and used spoons get naturally decomposed in 3 to 7 days if not consumed (Markham, 2018). They all come in different flavors such as carrot- beetroot, mint-ginger, cumin and sugar (Garfield, 2016).

(Rashid, 2019) worked on Edible cutlery in Bangladesh. He developed an edible spoon by using sorghum as a main ingredient, rice and wheat are others. Sorghum takes 60 times less water than rice during cultivation (Four, 2018) and shows super absorbent ability which makes the usage of edible cutlery versatile. He bakes the spoons to remove all the moisture, resulting in a hard cookie like spoon as a final product.

In another report, Chen Liang-erh, developed an edible plate made from using wheat grain. One can boil his plate and make a nutritious meal for animals (Taiwanese Offers Edible Plate Crockery,1991).

Nobuhiko Arikawa created edible tableware. These were crafted from hardtack, a type of biscuit dough created using a combination of 8 parts flour, salt, and water. He developed plates, bowls and chopsticks. Shelf-life of the biscuits is for months if kept dry (Etherington, 2008). Katsuhiko Sakakibara invented an edible plate using shrimp, potato starch and salt. Potato starch can hold water for up to an hour and it gets swell when baked. He utilized metal molds to bake the mixture under high pressure, resulting in plates that are durable and moisture-resistant (Nakamura, 2020).

2.4 Sorghum and its properties

(Sorghum bicolor) holds a significant position as one of the most important cereal crops in India, ranking behind rice and wheat. It is cultivated in regions including Madhya Pradesh, Gujarat, and Rajasthan. India holds the distinction of being the world's third-largest producer of sorghum (Anitha et al., 2021). The majority of sorghum varieties contain elevated levels of phytochemicals, particularly phenolic compounds. Sorghum boasts a notable fiber content, predominantly composed of insoluble fiber (75%–90%) and soluble fiber (10%–25%). Sorghum grains serve as sources of starches, proteins, fibers, minerals (ash), lipids, and B-vitamins. However, they also contain antinutritional factors like condensed tannins and phytic acids. The existence of condensed tannins exerts a constraining influence on enzymes like α -amylase and α -glycosidase, thereby affecting starch digestibility and the bioavailability of minerals such as iron and zinc. This effect, while contributing to the reduction of hyperglycemia, can have implications on nutrient absorption. Many people around the world use sorghum (also known as jawar) as a source of dietary proteins and calories (Dykes and Rooney 2006). This gluten-free cereal is a

nutritional powerhouse and enhances the flavor of gluten-free baking. Beetroot offers an array of nutritional and therapeutic advantages when incorporated into the diet. Additionally, it provides a delectable alternative to the more common grains and cereals consumed worldwide (Poshadri, Kumar et al., 2019). Dry sorghum contains approximately 163 calories per ¼ cup serving. The protein from sorghum is absorbed at a rate of 46%, which contrasts with wheat's 81% absorption and corn's 73%. A ¼ cup serving of sorghum encompasses 36 grams of carbohydrates and 4 grams of fiber (Leder, 2004). Sorghum is abundant in a diverse range of nutrients, including B vitamins. These vitamins are crucial for functions such as metabolism, neural development, and the health of skin and hair (Soetan, Olaiya et al., 2010). Furthermore, the fiber content in sorghum helps lower blood cholesterol levels, consequently reducing the risk of heart diseases. A single serving of sorghum can provide about 16% of the daily recommended value of fiber (Devi, Vijayabharathi et al., 2014). Sorghum is additionally abundant in magnesium, a mineral crucial for bone development, heart well-being, and more than 600 biochemical processes in the human body, including energy generation and protein metabolism (Xiong, Zhang et al., 2019). Furthermore, sorghum boasts a high content of antioxidants, including compounds like flavonoids, phenolic acids, and tannins. Eating a diet rich in these antioxidants can lower oxidative stress and inflammation in the human body (Dykes and Rooney 2006). Sorghum's protein digestibility is recognized to be comparatively low among various cereal grains, and this digestibility decreases even further when cooked due to the crosslinking of kafirin proteins. Additionally, sorghum is deficient in essential amino acids like lysine and essential fatty acids such as omega-3. Dry milling of sorghum grains results in the removal of bran, causing sorghum flour to have reduced levels of dietary fiber, mineral nutrients, phytic acid, B-vitamins, and lipids. The removal of bran also results in the partial loss of antioxidant-rich phenolic compounds found in the pericarp, seed coat, and aleuronic layer of sorghum grains. Nonetheless, sorghum-based functional foods hold appeal for individuals with celiac disease due to their lack of allergenic wheat-type gluten proteins. They are also suitable for creating low-calorie diets for individuals dealing with health issues related to high glycemic load. Furthermore, sorghum's polyphenol antioxidants contribute to its attractiveness in functional food formulations.

Table 2.4 Nutritional content of sorghum

Calories	130
Carbohydrates	28 grams
Protein	3 grams
Fat	0.5 grams
Fiber	2 grams
Iron	1 milligram (6 percent DV)
Potassium	124 milligrams (2 percent DV)

2.5 Beetroot and its properties

Red beetroot finds application in multiple forms as a red food colorant. Its presence can enhance the color of various products, including tomato paste, sauces, desserts, jams and jellies, ice cream, sweets, and cereals (Gokhale and Lele, 2011; Kaur and Singh, 2014). Additionally, beetroot is utilized in dried forms like chips, tea, and powder in bakery items, food supplements, and more.

Beetroot comprises various components: it is composed of 87.57% water, 9.56% carbohydrates (with 29.3% as fiber and 70.7% as sugar), 1.61% protein, and 0.17% lipids. Additionally, beetroot serves as a source of essential nutrients including potassium, choline, vitamin C, and niacin (USDA, 2013). Red beetroot contains a range of valuable active compounds, including carotenoids, betalains, polyphenols, flavonoids, and saponins (Figiel, 2010; Kaur and Singh, 2014; Nistor et al., 2017). Betalains, which are nitrogen-containing pigments, contribute to the red pigment found in beetroot. These pigments are frequently used to add red-purple color to various foods. The deep red color of beetroots is primarily attributed to the high concentration of water-soluble betalains, particularly betacyanine and betaxanthins. In addition to its abundant antioxidants, beetroot also contains various other nutrient compounds, including soluble fiber, minerals, and vitamins. Beetroots are widely utilized in various industries, including the food industry, as a source of natural colorants.

Numerous potential health benefits for humans have been reported, particularly related to the antioxidant and anti-inflammatory activities found in beetroot. Beetroot serves as a significant source of betalains and plays a role in safeguarding humans against stress-related disorders by inhibiting lipid oxidation and peroxidation (Kaur and Kapoor, 2002). Betalains, owing to their robust antioxidant properties, exhibit potent antibacterial and antiviral activities (Kowalski and Szadzinska, 2014). Furthermore, they play a role in safeguarding the human body against age-related diseases and conditions like cancer and cardiovascular diseases by counteracting the effects of free radicals (Tsai et al., 2009; Pandey et al., 2018). Beetroot is claimed to have various therapeutic uses, including its potential as an antitumor agent, carminative (relieving flatulence), homeostatic (regulating physiological balance), and renal protective properties. It is also considered a potential herb for addressing cardiovascular conditions (Vali et al., 2007; Singh and Hathan, 2014). Drying serves as an alternative to consuming fresh fruits and vegetables, enabling their utilization even during seasons when they are not readily available. Dried beetroot powder offers an extended shelf life and reduced risk of microbial hazards. Moreover, it serves as a potent natural pigment, adding vibrant color to food products. This powder can be utilized as value-added ingredients in a wide range of food items. The color and flavor of dried red beetroot are regarded as the most crucial quality attributes, significantly influencing the extent of consumer acceptance for the product (Sorour and El-Mersey, 2014). Maintaining a high content of betalains during the dehydration process of beetroot poses a significant challenge. To mitigate colorant degradation during the drying process, methods such as convective drying or spray drying are recommended. In this study, alternative drying methods have been investigated for dehydrating beets into powders, including sun drying and hot air drying.

Table 2.5 Nutritional value of Beetroot

Calories	43
Water	88%
Protein	1.6 grams
Carbs	9.6 grams
Sugar	6.8 grams
Fiber	2.8 grams
Fat	0.2 grams

2.6 Refined flour and its properties

Maida is a type of white flour commonly used in the Indian subcontinent. It is made from wheat that has been finely milled to remove bran, refined, and bleached. Maida closely resembles cake flour in its texture and characteristics. Maida is widely utilized for creating fast foods, baked goods like pastries, bread, various types of sweets, and traditional flatbreads.

Maida is produced from the endosperm, which constitutes the starchy white portion of the grain. The bran is isolated from the germ and endosperm, after which it is refined by being sifted through a sieve with a mesh size of 80 per inch (31 per centimeter). Although Maida is naturally yellow due to pigments in wheat, it is usually bleached either naturally by air oxygen or with any of a number of flour bleaching chemicals. Although it is made from winter wheat with a high gluten concentration, the heat created during the milling process denatures the protein, restricting its application in the creation of leavened breads. Of all the cereals, wheat is the only one that contains special proteins like gliadin and glutenin that, when coupled with water and mechanical kneading, form a gluten network that gives the grain its elastic toughness and aids in maintaining its shape during baking.

Due to its high dietary fiber, B-group vitamin, mineral, and protein content, wheat is regarded as a fantastic food for maintaining good health. Due to the quality and amount of the unusual protein it contains known as gluten, it has subsequently evolved into the main grain and is used more frequently than any other cereal in the production of bread

(Choeybundit et al., 2022). Refined wheat flour serves as the structural component in edible spoons. The white flour's proteins mix with the water in the presence of refined wheat flour to create gluten. The elastic gluten structure enlarges to hold the growing leavening gas during rising (Krishnapriya and Jagdeesh, 2021). Maida's (refined wheat flour's) nutritional value 11 grams of protein, 107 grams of carbohydrates, 2 grams of fiber, and 1 gram of fat make up the 496 calories in this serving.

CHAPTER 3

MATERIAL AND METHODS

The study was conducted at the Department of Bioengineering, Integral University Kursi road Dashauli, Lucknow.

3.1 Procurement of materials

Beetroot was procured from local market Thedi pulliya Kursi road Lucknow. Sorghum flour and refined flour was procured from super store.

Materials and Glassware

Sorghum flour, Beetroot powder, Refined flour, Sugar, Butter, oil, salt Baking soda, baking powder, Petri plates, stirrer, beaker, conical flask, and measuring cylinder.

Chemicals used

DPPH (2,2-diphenyl-1-picrylhydrazyl), methanol, ether, Folin reagent, sodium hydroxide, sodium carbonate, copper sulfate, and sodium potassium tartrate.

Table 3.1 List of chemicals used

S.No.	Chemicals	Chemical formula	Company
1.	2,2-diphenyl-1-picrylhydrazyl (DPPH)	$C_{18}H_{22}N_5O_6$	Sisco Research laboratory
2.	Phenolphthalein indicator	$C_{20}H_{24}O_4$	Qualigens, Nice and Merck
3.	Di ethyl ether	$(C_2H_5)_2O$	
4.	Folin reagent	$C_{10}H_5NaO_5S$	HiMedia Laboratories
5.	Sodium hydroxide	NaOH	Fisher Scientific (Qualigens)
6.	Sodium carbonate	Na_2CO_3	
7.	Copper sulfate	$CuSO_4$	
8.	Methanol	CH_3OH	Vinati Organics

Equipment used

1. Digital Electronic Balance

An electronic balance (model no: # AB 600) of MAC company was used to weigh all the ingredients required for the development of edible spoons and plate. The maximum limit of the balance was 600g.

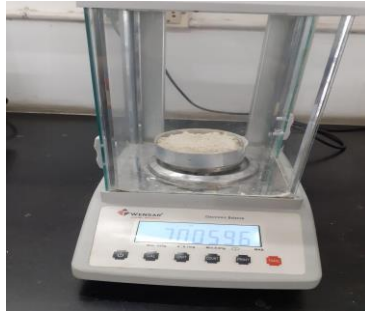


Fig.3.2.1 Digital electronic balance

2. Hot Air Oven

A hot air oven was used for drying of spoons, plate and also for determining the percent moisture content in spoon samples and in material used. The study's oven was equipped with a chamber measuring 30cm x 30cm x 30cm (length x width x height). The oven's power input demand amounted to 650 watts. The oven structure comprised a double wall construction, consisting of an inner and an outer chamber, both crafted from mild steel sheets. To ensure insulation, mineral glass wool material was utilized, placed between these two chamber walls. The front door of the oven, which is insulated, featured brass hinges and a ball catch lock mechanism. The heating elements, constructed from nichrome 80/20, were positioned at the bottom of the chamber. Temperature is generally controlled with the help of a capillary thermostat. A 3-heat switch is also given for power saving.



Fig.3.2.2 Hot air oven

3. Hand Sealing Machine

The sealing machine is used to seal the product, like plastic pouch or aluminium pouch by using heat.



Fig.3.2.3 Hand sealing machine

4. Muffle Furnace

Muffle furnace is designed to heat the materials to significantly high temperatures. It is fully packed enclosure that keep material isolated from external contaminants, substances, and chemicals. It is used for ashing



Fig.3.2.4 Muffle furnace

5. Spectrophotometer

Spectrophotometers are instruments designed to quantify light intensity in relation to wavelength and find widespread application in determining the concentration of substances within aqueous solutions. The specific type of spectrophotometer utilized influences the range of wavelengths that can be examined.



Fig. 3.2.5 spectrophotometer

6. pH meter

A pH meter is an electronic gadget that includes a unique measuring probe and an electronic meter that shows the pH reading. An electronic EUTECH pH 700 used in the study. pH meter must be calibrated before using. The pH meter measure the electrical potential difference between pH electrode and reference electrode.



Fig. 3.2.6 pH meter

7. Thermometer

A thermometer is a tool used to gauge temperature or temperature variations. It consists of two key components: a temperature sensor, which undergoes alterations corresponding to temperature fluctuations, and a mechanism for translating these changes into numerical values.



Fig. 3.2.7 Thermometer

8. Hot plate

Hot plates serve as heat sources capable of uniformly heating solutions and materials. They possess a straightforward design, featuring a flat surface embedded with heating elements. Importantly, they do not generate open flames, making them particularly suitable for applications involving oil or sand baths.



Fig. 3.2.8 Hot plate

9. Baking Oven

An oven is a confined chamber or passage where dough or batter is enveloped by a heated environment, undergoing baking and metamorphosing into bread, cookies, or other culinary items. Ovens employ energy generation sources, which could include the combustion of fuels like gas or oil, as well as electricity, to facilitate the baking process and produce the final products.



Fig. 3.2.9 baking oven

3.3 Methodology for the development of Edible Cutlery

Preparation of beetroot powder

The sample was drying by using two different methods

1. Sun drying
2. Hot air drying

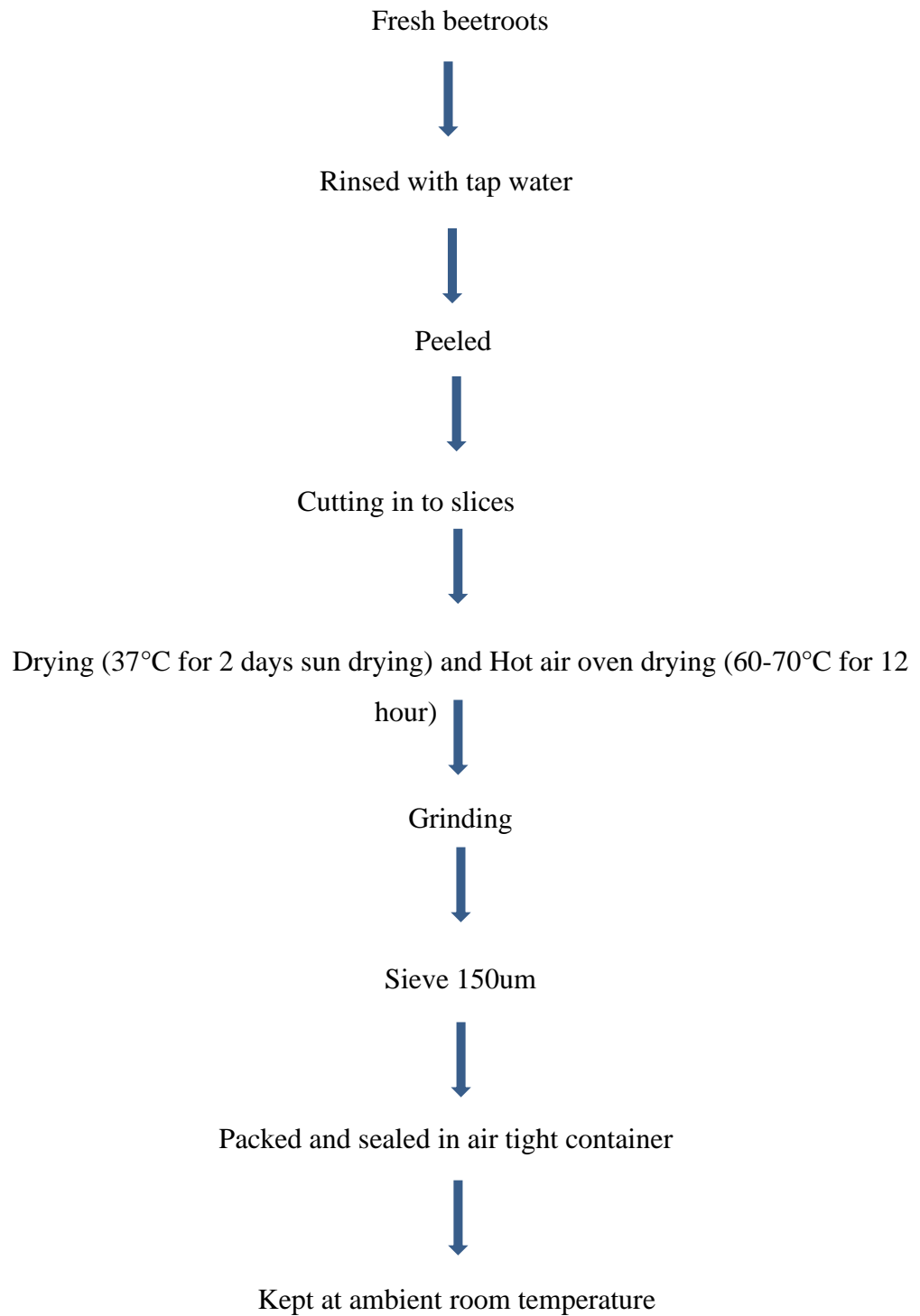
1.Sun drying

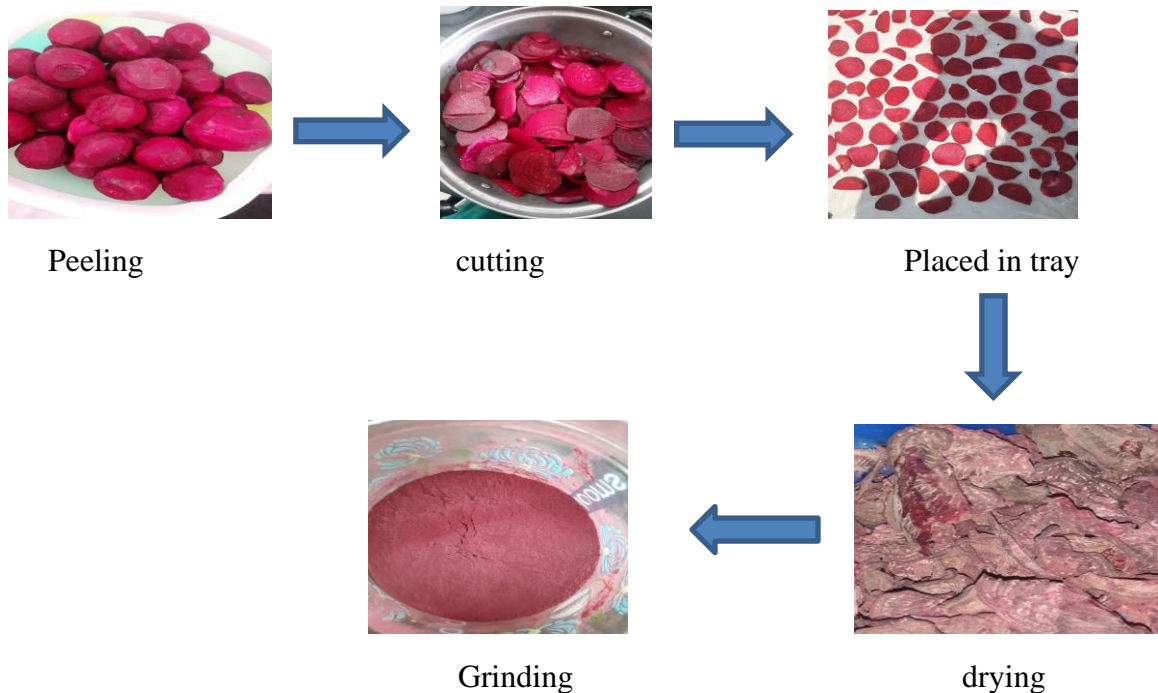
Fresh beetroots were acquired from a local market to serve as the primary raw material. Upon purchase, the beetroots underwent a washing process using tap water to eliminate dust and any adhesive particles. Following this, the beetroots were peeled utilizing a peeler and subsequently grated into slices using a grater. These sliced portions were left to undergo complete sun drying (dehydration) over a span of 2 days at a temperature of 37 °C. Once thoroughly dehydrated, the beetroot pieces were ground to transform them into a fine powder, allowing for extended shelf life and storage capabilities.

3.Hot air drying

Fresh beetroots were procured from a local market to serve as the initial raw material. Following their acquisition, the beetroots underwent a washing process using tap water to eliminate any dust and adhering particles. Subsequently, the beetroots were peeled using a peeler, and then grated into slices using a grater. These sliced components were subjected to a hot air-drying process at temperatures ranging between 60-70 °C for a duration of 12 hours. After thorough dehydration, the beetroot pieces were ground to attain a fine powder consistency, facilitating extended shelf life and storage capabilities.

3.3.1 Preparation of beetroot powder





3.3.2 Processing of Edible Cutlery

Weighing of each sample was done according to the proportion needed in making edible cutlery. A total of 4 sample of edible spoons and plate were made in which C were considered as control. C comprised of 100% sorghum flour and remaining three other sample were develop using beetroot powder and sorghum flour and refined flour of different proportion as given in the table 3.3.1 below. The dough was created by combining a mixture of sorghum flour, refined flour, and beetroot powder, resulting in the formulation of five distinct compositions: Control, Sample 1, Sample 2, Sample 3, and Sample 4.

The compositions are documented in Table-1. For each blend of flours, consistent quantities of additional ingredients such as sugar, salt, oil, baking soda, baking powder, and butter were added individually to create the samples. Subsequently, the combination of five separate samples was interacted with lukewarm refined water. The resulting mixture was then kneaded in a kneader for a duration of 8 to 10 minutes. To achieve a uniform texture, the dough was additionally hand-kneaded for approximately 30 to 60 seconds. Pre-sheeting of the dough was performed manually, followed by utilizing a dough sheeter to achieve the desired length and width. The resulting dough sheets were then precisely cut

into the desired shapes and sizes. The dough was shaped into spoons and plates before undergoing baking in an oven at a temperature of 180°C for a period of 25 to 30 minutes. This was then allowed to cool. The sample were left out at room temperature for 1-2 hours and then packed in an air- tight High- density polyethylene pouches. The utensils were allowed to cool down before proceeding with subsequent analysis.

Table.3.3.3 Ratios takes in cutlery making

SAM PLE	SORGH UM FLOUR (%)	REFIN ED FLOU R (%)	BEE T ROOT POW DER (%)	SUG AR (%)	BUT TER (%)	BAKI NG SODA (%)	BAKI NG POW DER (%)	OIL (%)	WA TER (%)
C	100	-	-	23	25	1	1	5	30
S1	60	40	-	23	12	1	1	3	30
S2	70	25	5	23	10	0.5	0.5	2	40
S3	70	20	10	23	10	0.5	0.5	1.5	50
S4	70	15	15	23	10	0.5	0.5	1.5	50

3.3.4 Flow chart of the Development of Edible cutlery using sorghum flour and beetroot powder is as follows

Preparation of edible cutlery

Mixing of all dry ingredients



Kneading



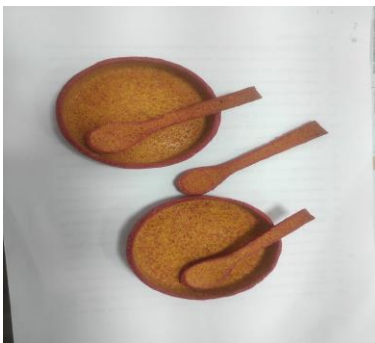
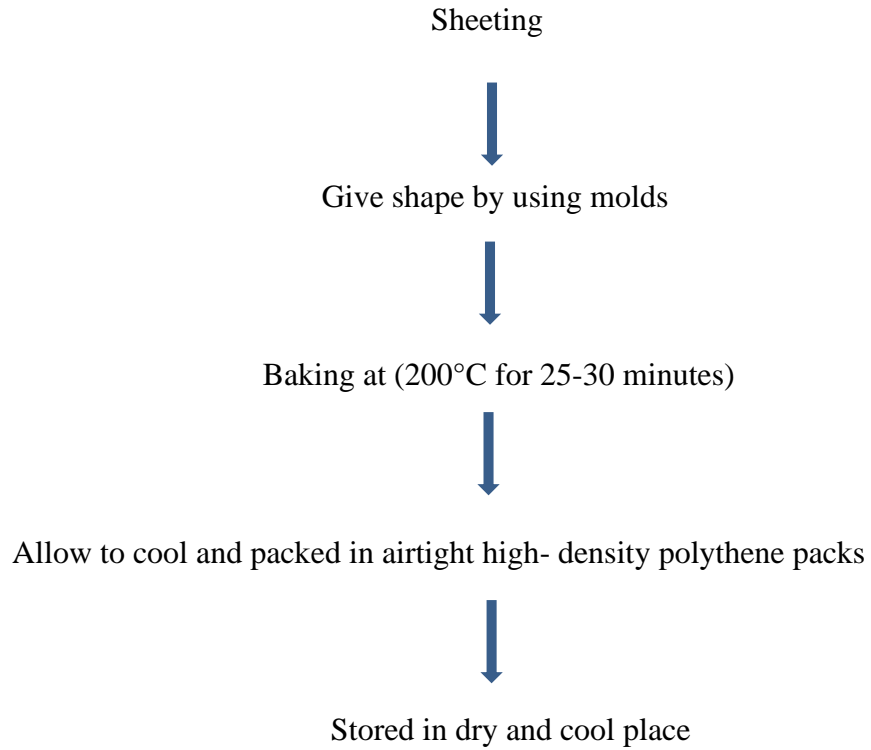


Fig.3.3.5 Development of millet based edible cutlery carrying beetroot powder



SAMPLE 1



SAMPLE 2



SAMPLE 3



SAMPLE 4

Fig.3.3.6 Edible cutlery sample

3.4 Physicochemical Analysis

Raw materials, as well as the final product, were evaluated for physical as well as nutritional constituents by using standard methods.

1. Water absorption

In water absorption, 2g sample from each spoon was immersed into water in a beaker. Following a specific time interval, a sample was extracted from the beaker, and any surplus water on the tissue was eliminated. The samples were then weighed, and the alterations in the weight of the spoons were documented (Rajendran et al., 2020). The formula employed for computing the percentage of water absorption is as follows:

Calculation

$$\text{Water absorption} = (w_2 - w_1) \times 100 / w_1$$

Where:

w1 = Initial weight of cutlery before water absorption

w2 = weight of cutlery after water absorption

2. Water solubility index

The assessment of water solubility involved immersing 3g of each sample in 30 ml of distilled water. These samples were subsequently placed on a rotary shaker set at 120 rpm and maintained at a temperature of 25°C for a duration of 24 hours. Any insoluble components were separated by filtration using filter paper and were then dried in a hot air oven at 105°C for a period of 24 hours. The solubility of the SPI cutlery was computed using the following formula:

$$\text{Solubility} = (\text{Initial dried weight} - \text{Final weight}) / (\text{Initial dried weight}) \times 100$$

3. Organoleptic evaluation

Organoleptic evaluation was done for the assessment of odour; flavor, appearance, and mouth feel of the product. It is essential for ensuring that products completely with organizational and customer requirements. Spoons were evaluated by the panel of eight judges evaluate the spoons on the basis of their sensory attributes. Each panel member participated in an evaluation process based on taste, texture, aroma, color, and overall acceptability (OA) using a 9-point hedonic scale. This scale features a range of 9 verbal descriptors, spanning from 'dislike extremely' to 'like extremely,' to capture varying degrees of liking. These verbal categories are typically converted into numerical values for statistical analysis. Specifically, 'like extremely' is assigned a value of '9,' while 'dislike extremely' is assigned a value of '1' (Nicolas et al., 2010).

Table 3.4.1 (9-Point Hedonic Scale)

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

4. Moisture Content

Moisture content determination was essential to control the quality as well as the shelf-life of the food (Zambrano et al., 2019). The aim was to determine the amount of moisture present in the sample. It was done by comparing dry weight of the sample to the weight taken before drying. The procedure for determination of moisture content was carried out by tacking 2 gram from each sample in pertri dish. Place the sample it in a hot air oven at 135 C for two hours. After drying, allow them to cool in a desiccator and be weighed.

Calculation:

$$\text{Moisture Content (MC)} = (W - d / W) \times 100$$

Where:

w = weight of the sample

d = weight of the sample after drying

5. Ash Content

The main aim of the Ash content determination is to measure the inorganic substance in food. It was done by burning away organic substances, leaving inorganic minerals. It is important for determining the amount minerals present in food. Dry ashing requires heating the sample at 500–600 °C in a muffle furnace (Park, 1996). The procedure takes place by taking 2-gram sample from each in a tarred crucible. Place crucible in a cool muffle furnace. Burn the samples for 4 hours at temperature 550°C. After 4 hours turn off the furnace and allow it cool to at least 250°C. Transfer crucibles in a desiccator by using tongs. Close the desiccator and cool to room temperature and then weigh the sample.

Calculations:

$$\text{Ash Content} = (z-x) / (y-x) \times 100$$

Where:

x = Weight of empty crucible

y = Sample + crucible weight

z = Crucible weight after ashing

6. Fat content

The total fat content present in a food is generally by extracting the organic solvent from it. Hexane, ethyl ether, petroleum benzene, petroleum ether, and others are solvents that are frequently used for fat analysis. Since lipids typically combine with proteins and polysaccharides, alkaline or acid hydrolysis is necessary to release the lipids before extracting them into organic solvents (Jiang et al., 2014). Fat content determination was done by using Fat Analyzer in which lipid is extracted from the solid material. The solvent was then removed by evaporation distillation after the fat in the food sample was dissolved into the solvent (the solvent has a far lower boiling point than oils or fat). The procedure for the determination of fat content in Edible cutlery was carried out by washing of boiling. Flask Dry the flask by putting it in a hot air oven set to 12°C for three to four hours. First, weigh the flask and make sure to label it appropriately. Similarly, weigh the extraction filter paper thimbles and ensure they are properly labeled as well. Begin by transferring 2 g of the samples into thimbles that have been pre-weighed and properly labeled. Record

the exact weight of the samples. Proceed to seal these thimbles with non-absorbent cotton and position them directly within the fat extraction tubes. Fill the extraction tubes with the designated solvent. Next, switch on the heaters. Once the boiling process is initiated, activate the water connected to the condensers and let the extraction continue for a duration of 2-3 hours. Afterward, allow the setup to cool down. A solvent is evaporated using a heating mantle and a flask with oil was weighed.

Calculation:

$$\% \text{ Fat} = (W1-W2) / S \times 100$$

Where:

W1 = Weight of empty flask (g)

W2 = Weight of flask and extracted fat (g)

S = Weight of sample

7. Protein content

Protein contents are analyzed by Lowry method estimation of protein. Start by adding 4.5 ml of reagent 1 to the mixture and allow it to incubate for a period of 10 minutes. Following this incubation, introduce 0.5 ml of reagent 2 and allow it to incubate for a longer duration of 30 minutes. Once the second incubation period is completed, measure the absorbance of the solution at 660nm. Utilize the obtained absorbance data to calculate the protein content present in the provided sample.

8. Antioxidant activity

The DPPH radical scavenging assay was conducted using a UV Vis-1800 spectrophotometer from Shimadzu in Tokyo, Japan. In this assay, the presence of antioxidants in the sample leads to the reduction of DPPH radicals. To prepare the extract, a mixture of beetroot powder sample and cutlery (1 ml per 10 ml) was centrifuged at 10,000 rpm for 15 minutes. The resulting supernatant was collected for use in the assay. A DPPH radical solution was prepared by dissolving 10 mg of DPPH in 25 ml of 80% ethanol. Then, 1 ml of the dilution was mixed with 3 ml of the DPPH solution and incubated in darkness

for 30 minutes. After this incubation period at room temperature, the absorbance was measured against a blank at 517 nm.

$$\text{(Percent Inhibition)} = (\text{A blank} - \text{A sample}) / \text{A blank} \times 100$$

Where,

- A Blank represents the absorbance of the control reaction (containing all reagents except the test compound)
- A sample is the absorbance of the test compound

By using this formula, the percentage inhibition of the DPPH solution's activity by the cutlery and beetroot powder was calculated, and the antioxidant activity was subsequently estimated.

9. Shelf-life Analysis

Shelf-life estimation of edible cutlery was analysis of moisture content, pH.

10. pH

The pH analysis was conducted using a digital pH meter, following calibration with a standard buffer solution at 30°C. This calibration step was performed each day prior to using the pH meter.

11. Texture analysis

The textural characteristics of the edible cutlery spoons and plates were assessed using a Texture Profile Analyzer (FTC TMSpro Texture Analyzer). The hardness of the samples was evaluated using a 75mm cylindrical probe, which was employed to test the spoons (Krishnapriya & Jadeesh, 2021).

CHAPTER 4

RESULT AND DISCUSSION

Edible cutlery was prepared with an objective of development of millet based edible cutlery carrying of beetroot powder. 5 Samples were made among which 1 sample were considered as a control, one is C (100% sorghum flour). The remaining other samples composition varies in each sample and their effects are discussed below. The results are summarized in this chapter based on physicochemical analysis.

4.1 Chemical Properties of Edible Spoons and Plates

4.1.1 Moisture content

The moisture content of all the spoons and plates samples has been shown below in table 4.1.1. Initial moisture content observes in control C 6.5%. Control C had the highest amount moisture in which sorghum concentration was 100% and the amount of moisture found was 6.5%. This is attributed to the remarkable super absorbent capacity of sorghum, which renders it exceptionally suitable for the production of edible cutlery. In addition, the value of MC for Sample S1 was 4.5%, Sample S3 had 6% and Sample S4 3.5%. Least amount of moisture was determined in sample S3 which comprises of both sorghum and beetroot. The amount of moisture was found is 2%. So, it proves that S3 was the ideal sample of spoon and plate regards to moisture content because the higher moisture amount is not desirable for the spoon and plate to sustain the self-life. A notable distinction was observed across all moisture content values of the edible cutlery, as indicated in Table 4.1.1.

Table 4.1.1 Moisture Content (%) of edible cutlery

S. No.	Sample	Moisture content
Control	100% Sorghum	6.5%
S1	60% Sorghum & 40% refined flour	4.5%
S2	70% Sorghum & 25% refined flour and 5% beetroot powder	6%
S3	70% Sorghum & 20% refined flour and 10% beetroot powder	2%
S4	70% Sorghum & 15% refined flour and 15% beetroot powder	3.5%

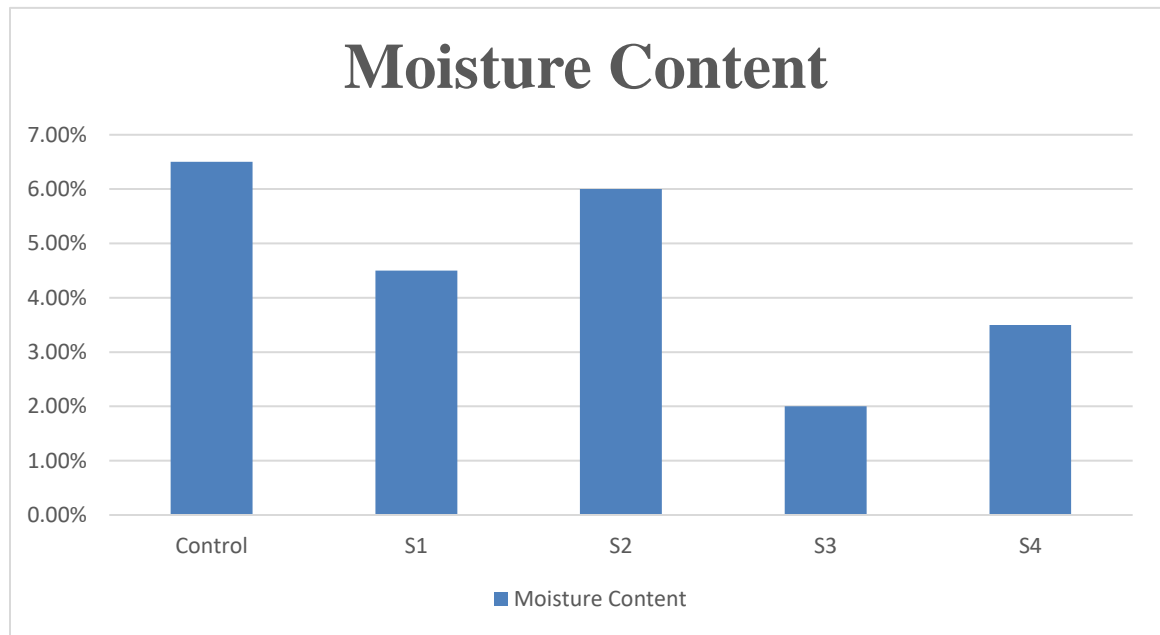


Fig 4.1.1 Graphical Representation of moisture content



4.1.1 Plate I. Moisture content

4.1.2 Ash Content

Ash content is used to measure the inorganic substance present in food. It is done by incineration of organic matter, leaving inorganic minerals (Park, 1996). Percent Ash of all the cutlery samples is shown in table 4.1.2. The amount of ash determined in Control C 2%. Different amount of ash was determined in Sample, S1, S2, S3 and S4 changes was seen in ash content by increasing sorghum concentration. Ash content in sample S1, S2, S3 and S4 increased by the increasing the concentration of sorghum. The amount of ash was found in the above mentioned samples were 6.5% because of the minerals present in beetroot powder. The significant difference was found in the values of ash content of edible cutlery shown in table 4.1.2.

Table 4.1.2 Ash Content (%) of edible cutlery

S. No.	Sample	Ash content
Control	100% Sorghum	2%
S1	60% Sorghum & 40% refined flour	3.5%
S2	70% Sorghum & 25% refined flour and 5% beetroot powder	4.5%
S3	70% Sorghum & 20% refined flour and 10% beetroot powder	5.5%
S4	70% Sorghum & 15% refined flour and 15% beetroot powder	6.5%

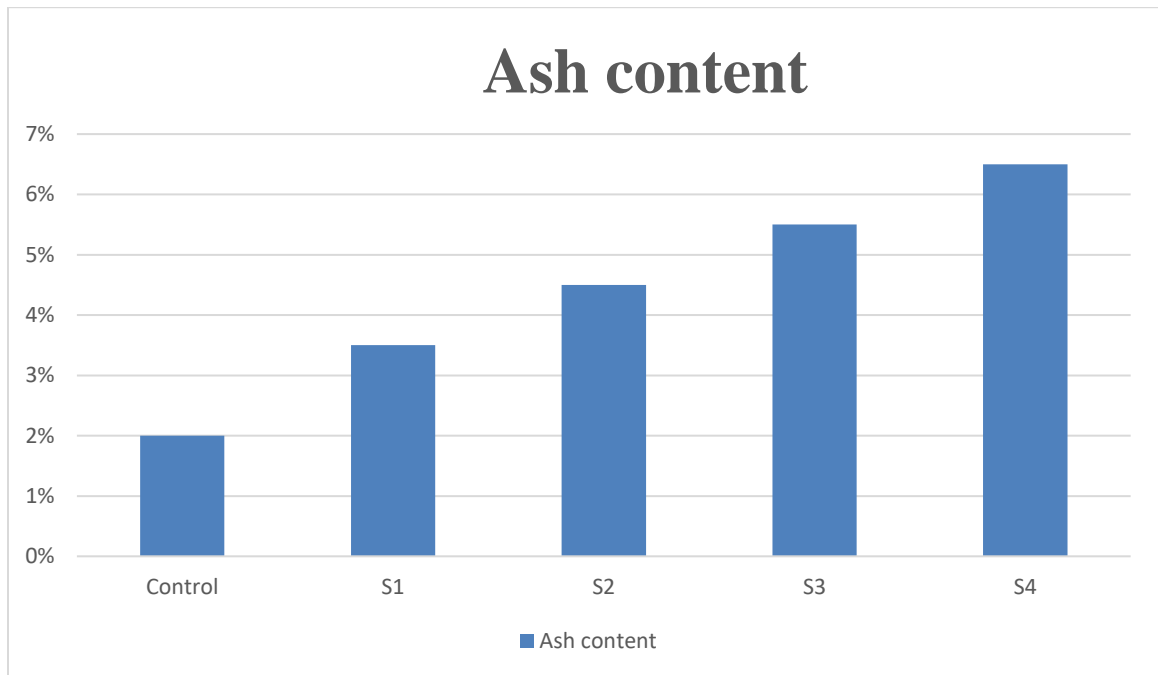
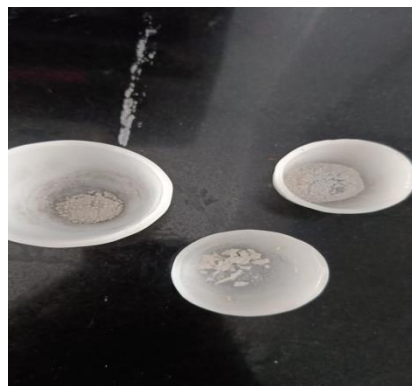


Fig 4.1.2 Graphical Representation of ash content



4.1.2 Plate II. Ash content

4.1.3 Fat Content

It was done to determine the total fat content of a food. The fat percentage varies in the results of Control C. More amount of fat was found in C which was 14.5% of fat this is because sorghum flour contains more amount of fat. C which was 100% sorghum had the high amount of fat in respect to other samples because sorghum contains 1g of fat. Sample

S1, S2, S3 and S4 had minor difference in their percentage of fat content. Sample S1 had 7.1% of fat while S2 had 3.45%, S3 had 3.57% and S4 had 3.61%. Similarly from sample S3 to S4 also had very little difference in their values. But sample C had the highest amount of fat which was 14.5% which tells that sample C shows better results in the case of fat content. Fat content decreased by increasing concentration of sorghum flour and beetroot powder in the samples. The amount of fat content of all the cutlery sample had been shown in table 4.1.3.

Table 4.1.3 Fat Content (%) of edible cutlery

S. No.	Sample	Fat content
Control	100% Sorghum	14.5%
S1	60% Sorghum & 40% refined flour	7%
S2	70% Sorghum & 25% refined flour and 5% beetroot powder	3.45%
S3	70% Sorghum & 20% refined flour and 10% beetroot powder	3.57%
S4	70% Sorghum & 15% refined flour and 15% beetroot powder	3.61%

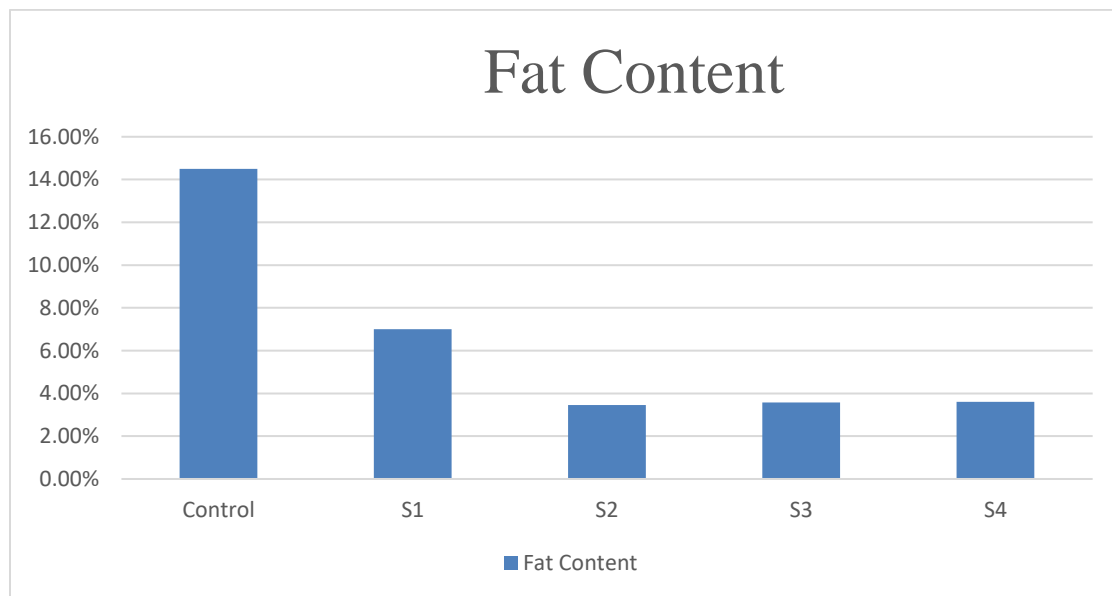


Fig 4.1.3 Graphical Representation of fat content

4.1.4 Protein Content

The protein content was assessed in all variants of the edible cutlery, including the control sample denoted as C. The results revealed slight variations in the protein percentages among S1, S2, S3, and S4. Specifically, S1 contained approximately 3.85% protein, S2 had 3.98%, S3 exhibited 4.55%, and S4 showed 4.93%. Notably, the beetroot powder-based edible cutlery demonstrated higher protein levels. Based on these findings, it can be deduced that S3 possesses the highest nutritive value, followed by S1, S2, and S4 in that order. The protein content values for all cutlery samples are provided in Table 4.1.4.

Table 4.1.4 Protein Content (%) of edible cutlery

S. No.	Sample	Protein content
Control	100% Sorghum	3.06%
S1	60% Sorghum & 40% refined flour	3.85%
S2	70% Sorghum & 25% refined flour and 5% beetroot powder	3.98%
S3	70% Sorghum & 20% refined flour and 10% beetroot powder	4.55%
S4	70% Sorghum & 15% refined flour and 15% beetroot powder	4.93%

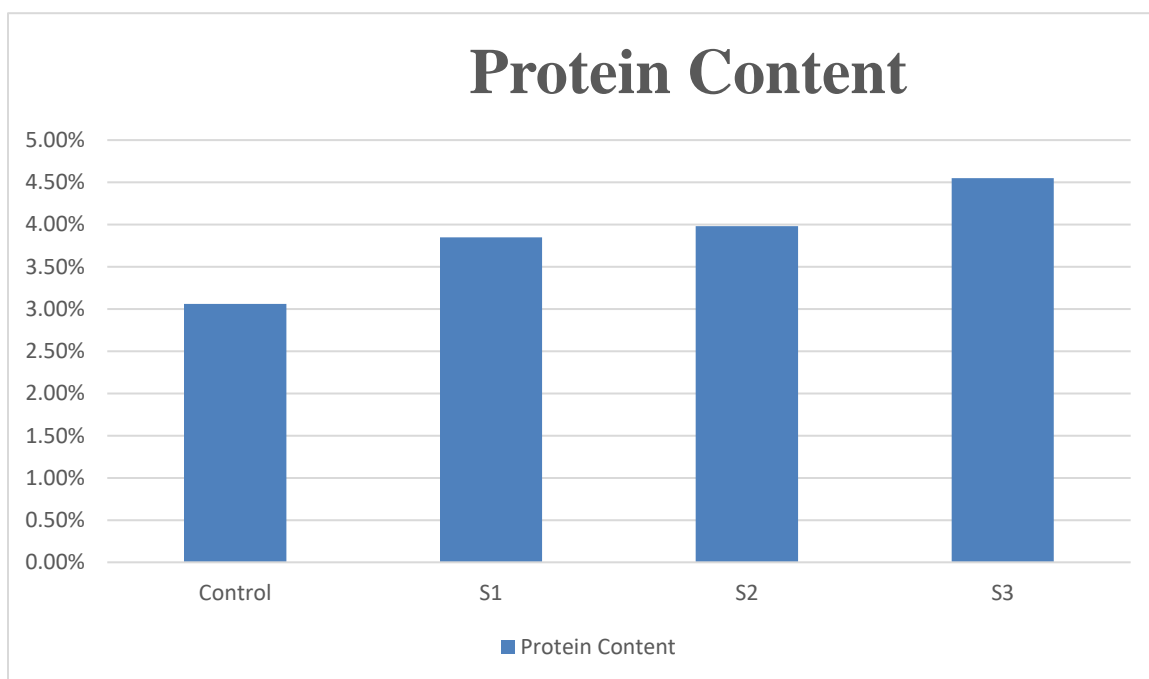
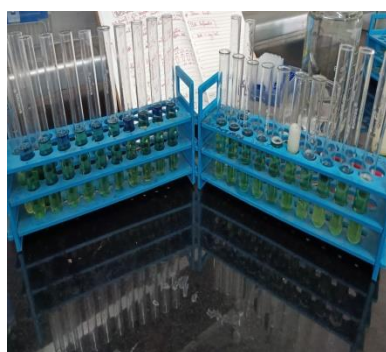


Fig 4.1.4 Graphical Representation of protein content



4.1.4 Plate III. Protein content

4.1.5 Antioxidant Activity

The antioxidant activity of edible cutlery spoons and plates, which were enriched with sorghum flour, refined flour, and beetroot powder, was investigated and the outcomes are presented in Table 4.1.5. Observing the results, it is evident that the antioxidant activity exhibited an increase with higher supplementation of sorghum flour and beetroot powder in the formulations. Notably, the results indicated that sample S1 displayed the highest antioxidant activity value (58.51%), surpassing S3 (25.18%) and S2 (24.74%). This

elevated antioxidant activity value can be directly attributed to the total phenolic content of the beetroot powder. Furthermore, the antioxidant activity of beetroot powder subjected to sun drying (73.77%) surpassed that of hot air oven drying (43.70%).

Table 4.1.5 Antioxidant Activity (%) of edible cutlery

Sample	Antioxidant activity
Control	30.66%
S1	58.51%
S2	24.74%
S3	25.18%
S4	26.56%
S5(Beetroot powder (sun drying))	73.77%
S5 (Hot air oven drying)	43.70%

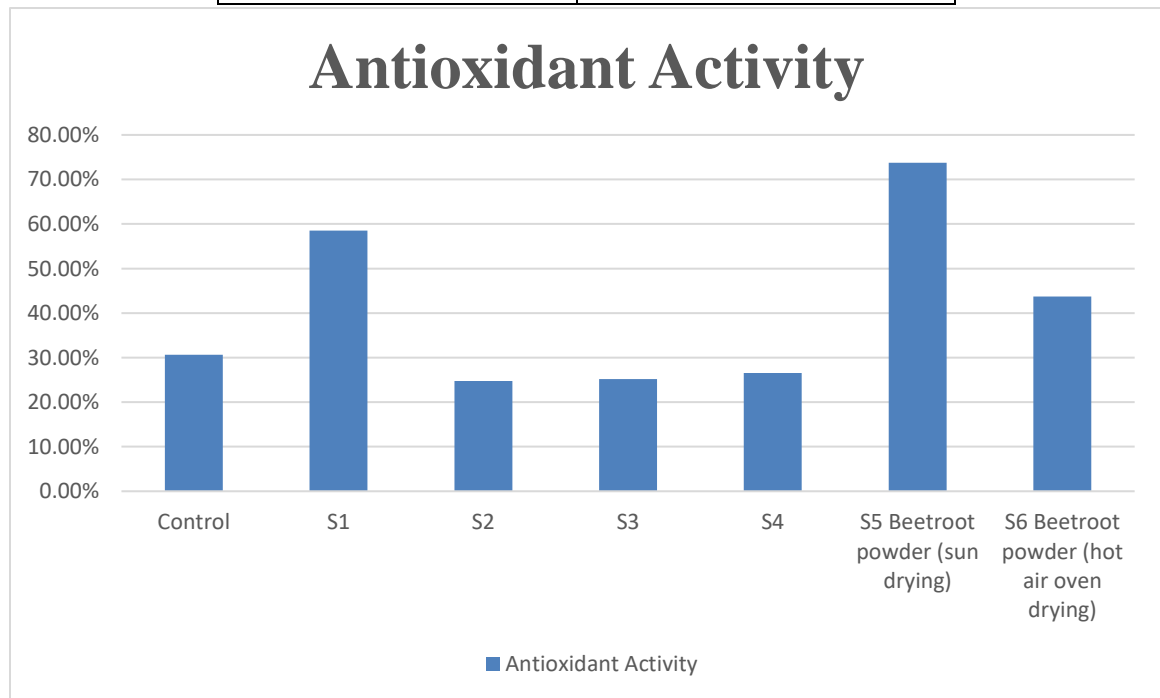


Fig 4.1.5 Graphical Representation of Antioxidant activity

4.1.6 Texture analysis

The textural characteristics of the edible cutlery were assessed using a texture analyzer. The hardness values of the edible cutlery were presented in Table 4.1.6. The hardness measurements were conducted using the Brookfield Texture Analyzer. Specifically, for the control sample, denoted as C, the hardness was recorded as 3.95N. In the case of S1, which incorporates sorghum flour, the hardness was 12.87N. Sample S2, also containing sorghum flour along with refined flour, exhibited a hardness of 17.56N. The highest hardness values were observed for S3 (20.93N) and S4 (19.05N), which involve the addition of beetroot powder. The control sample (C) demonstrated higher resistance to compression compared to the other samples. Notably, S1 and S2 differ in their ratios of sorghum flour and refined flour and beetroot powder, while S2, S3 and S4 incorporate beetroot powder. S3 I best in texture than S4.

Table 4.1.6 Texture Analysis of edible cutlery

S. No.	Hardness
Control	3.95
S1	12.87
S2	17.56
S3	20.93
S4	19.05

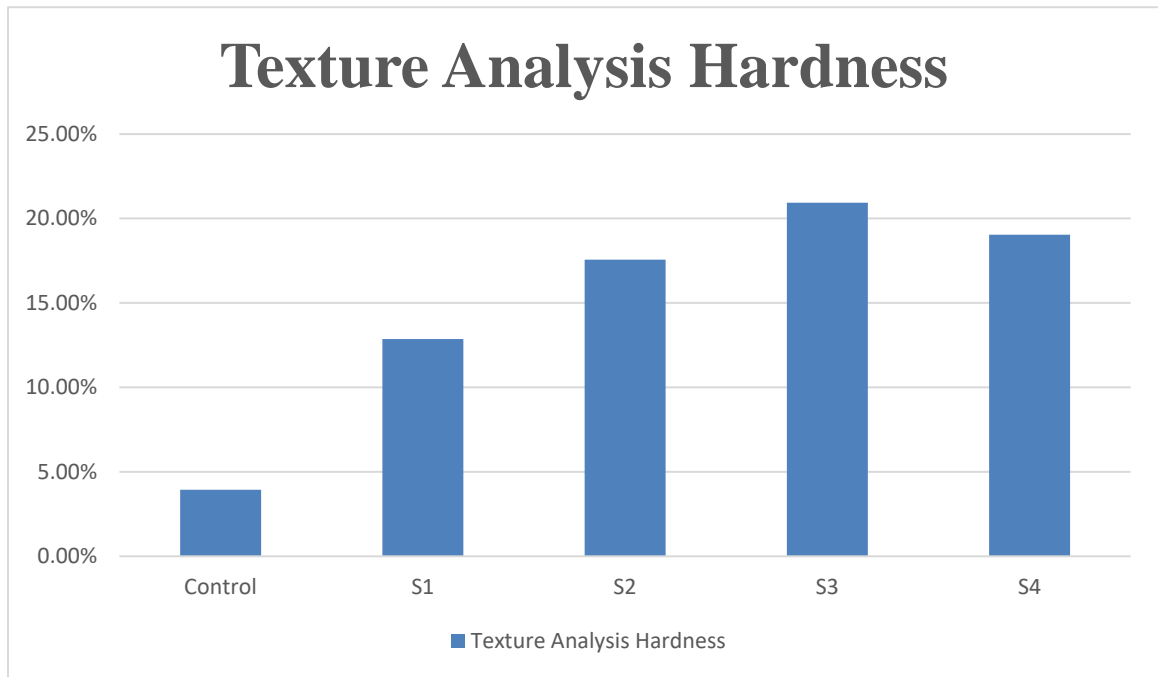


Fig 4.1.6 Graphical Representation of Texture analysis

4.1.7 Shelf-life Analysis

Shelf-life is recommended maximum period of time for which items to preserve. The flavor of the utensils will not be interfering with the taste of the dish it is used with. Under shelf life moisture content, pH and titrable acidity is evaluated. The shelf life of all five samples were evaluated on every 10 days for 1 month and shown in table 4.1.7.

Table 4.1.7 Shelf life of (Moisture content)

S. No.	Sample	Moisture content		
		Day 10	Day 20	Day 30
Control	100% Sorghum	4.5%	4%	3.5%
S1	60% Sorghum & 40% refined flour	4.5%	3%	5.5%
S2	70% Sorghum & 25% refined flour and 5% beetroot powder	5.5%	4%	5%
S3	70% Sorghum & 20% refined flour and 10% beetroot powder	3%	1.5%	7.5%
S4	70% Sorghum & 15% refined flour and 15% beetroot powder	3.5%	3%	8.5%

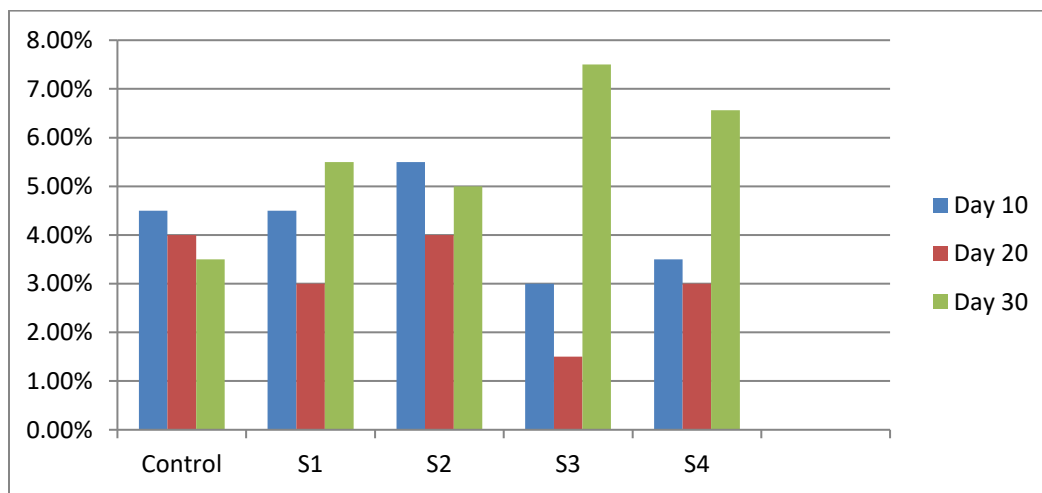


Fig 4.1.7 Graphical Representation of moisture content (shelf-life)

Table 4.1.8 Shelf life (pH)

Sample	Day 10	Day 20	Day 30
Control	8.91	8.21	7.72
S1	7.88	7.54	7.21
S2	7.87	7.10	6.88
S3	6.93	6.52	6.37
S4	6.98%	6.87	6.56

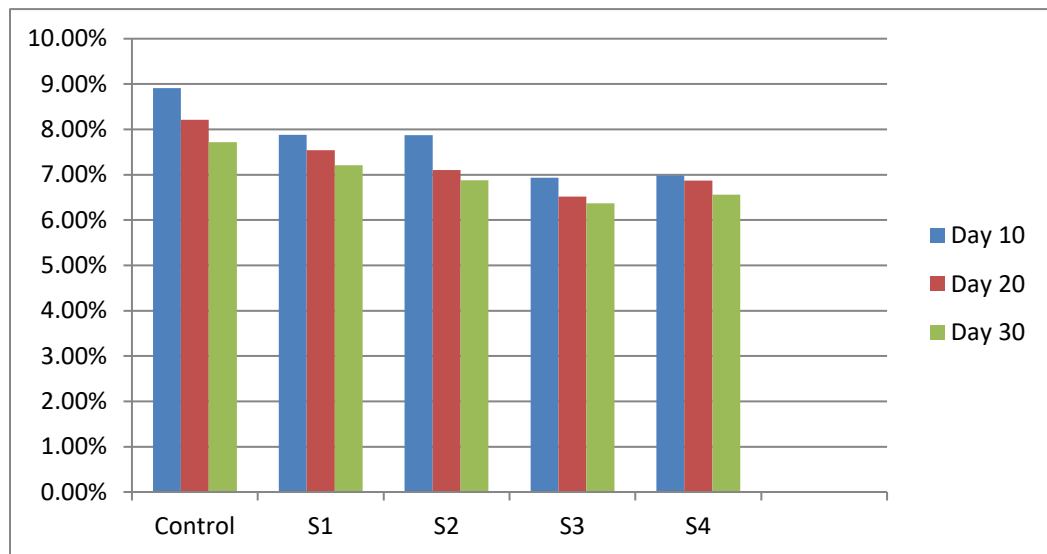
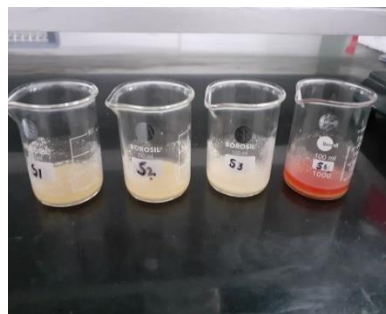


Fig 4.1.8 Graphical Representation of pH (shelf-life)



4.1.8 Plate V. Ph

4.2 Physical properties of edible cutlery

4.2.1 Water Absorption

Water absorption was done to determine the strength of cutlery by observing that how much time one spoon and plates takes to absorb water and start dissolving because the more time it takes in dissolving the longer they last. It was done at three different temperature, room temperature (29°C), Hot water at a temperature of 50°C and cold water at a temperature of 10°C. The amount of water absorbed by all the cutlery samples has been shown in table 4.2.1. In room temperature (29°C) Control C withstands 20 minutes and absorbs 53.665% of water because of soft in texture provide strength to spoons. Sample S1 absorbs 84.61% of water in 5 minutes because in S1, concentration of refined flour was high they absorb more water. Similarly, Sample S1 absorbed 113.1% in 15 minutes, sample S2 absorbed 93% in 10 minutes, sample S3 absorbed 70.34% and S4 absorbed in 5 minutes. Water absorbing tendency of above mentioned samples was less because the concentration of sorghum was high in these samples. When concentration of refined flour increased in samples S1 to S2 their water absorption capacity increased because refined flour is water loving substance hence, these samples had more amount of water. It was found that Sample S3 in which the concentration of sorghum and beetroot powder was 62.55% had the least amount of water and was more durable among all the other samples. Significant difference was found in water absorption test all the samples made shown in table 4.2.1.

In hot water (50°C) Control C absorb 59.25% water in 20 minutes. Sample S1 absorb 130.03% in 15 minutes, Sample S2 absorb 77.31% in 10 minutes and Sample S3 absorb 62.55 and S4 absorbed 75.05% in 5 minutes. The best sample is found in S3. In cold water (10°C) Control C absorb 47.70% water in 20 minutes. Sample S1 absorb 118.01% in 15 minutes, Sample S2 absorbs 89.05% in 10 minutes and Sample S3 absorb 51.84 and S4 59.65% in 5 minutes. The best sample is found in S3.

Table 4.2.1 Water absorption (hot water 50°C)

S. No.	Sample	5 Min	10 Min	15 Min	20 Min
Control	100% Sorghum	51.83	53.94	55.78	59.25
S1	60% Sorghum & 40% refined flour	99.54	121.07	130.03	132.03
S2	70% Sorghum & 25% refined flour and 5% beetroot powder	76.69	77.31	80.34	96.66
S3	70% Sorghum & 20% refined flour and 10% beetroot powder	62.55	64.41	72.41	84.87
S4	70% Sorghum & 15% refined flour and 15% beetroot powder	75.05	78.65	84.45	95.87

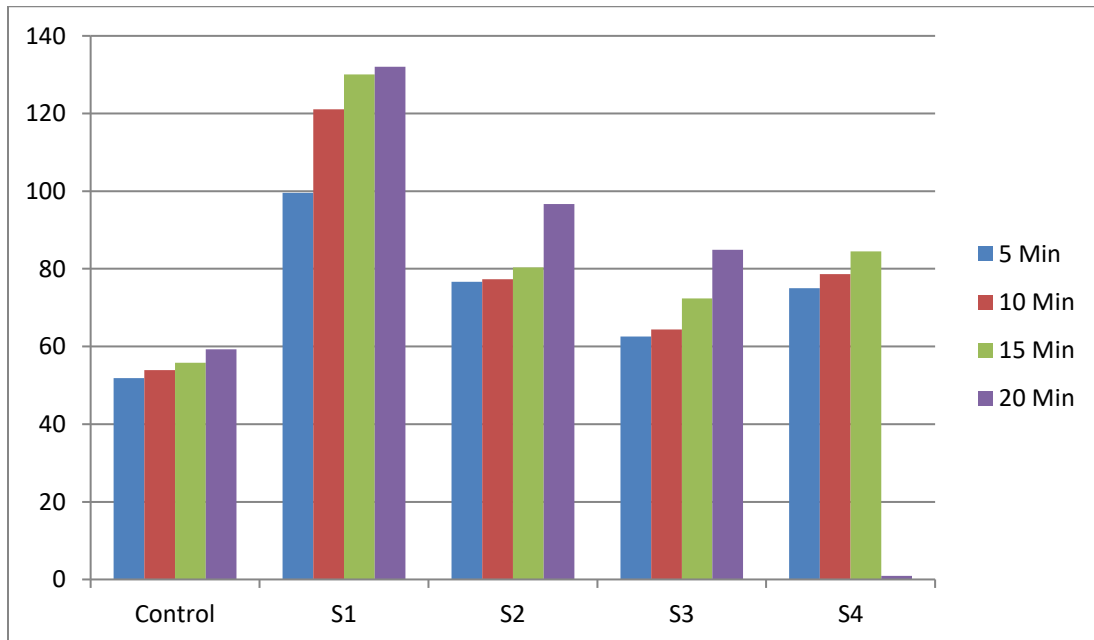


Fig 4.2.1 Graphical Representation of water absorption (Hot water)

Table 4.2.2 Room temp (29°C)

S. No.	Sample	Water absorption			
		5 Min	10 Min	15 Min	20 Min
Control	100% Sorghum	43.62	47.89	49.36	53.66
S1	60% Sorghum & 40% refined flour	84.61	95.42	113.1	126.56
S2	70% Sorghum & 25% refined flour and 5% beetroot powder	77.31	93	102.36	113
S3	70% Sorghum & 20% refined flour and 10% beetroot powder	70.34	85	87.5	93.5
S4	70% Sorghum & 15% refined flour and 15% beetroot powder	73.05	89	93.03	99

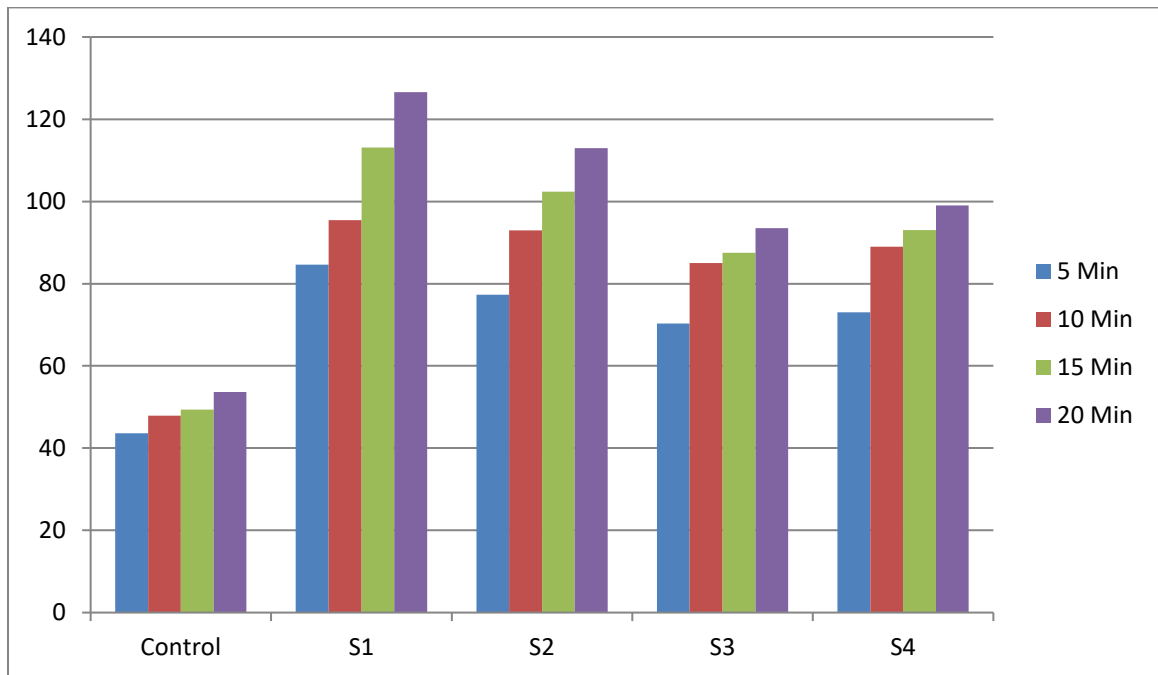


Fig 4.2.2 Graphical Representation of water absorption (Room temperature)

Table 4.2.3 Water absorption (Cold water 10°C)

S. No.	Sample	Water absorption			
		5 Min	10 Min	15 Min	20 Min
Control	100% Sorghum	28.90	36	39.48	47.70
S1	60% Sorghum & 40% refined flour	87	100	118.0	134.98
S2	70% Sorghum & 25% refined flour and 5% beetroot powder	71.07	89.05	95.17	103
S3	70% Sorghum & 20% refined flour and 10% beetroot powder	51.84	75.56	86	92.02
S4	70% Sorghum & 15% refined flour and 15% beetroot powder	59.65	78.67	91.34	96.65

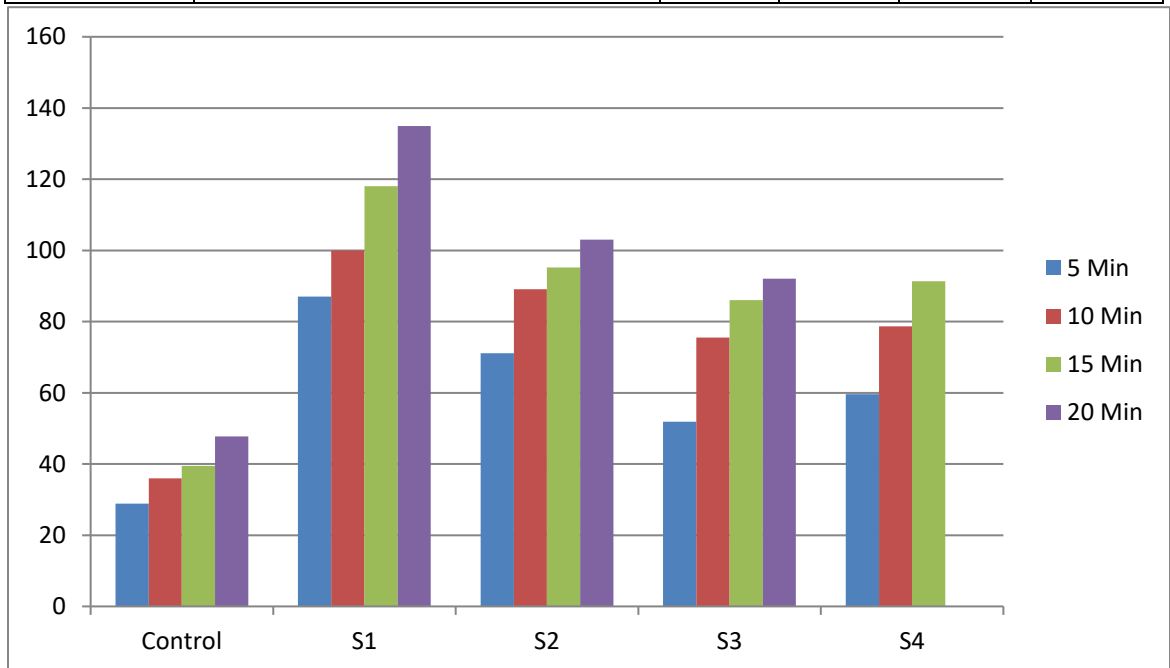


Fig 4.2.3 Graphical Representation of Water absorption (Cold water)

4.2.2 Water Solubility

Water solubility was done to determine the solubility of cutlery. The solubility of Control C 35.5% in water soluble and other Sample S1 45.5% soluble, S2 44% soluble and S3 33% soluble and S4 39.5%. Sample S3 has less soluble than S4. Sample S1 had higher in water solubility. The sample has been shown in table 4.2.2.

Table 4.2.2 Water solubility

Sample	Water solubility
Control	35.5%
S1	45.5%
S2	44%
S3	33%
S4	39.5%

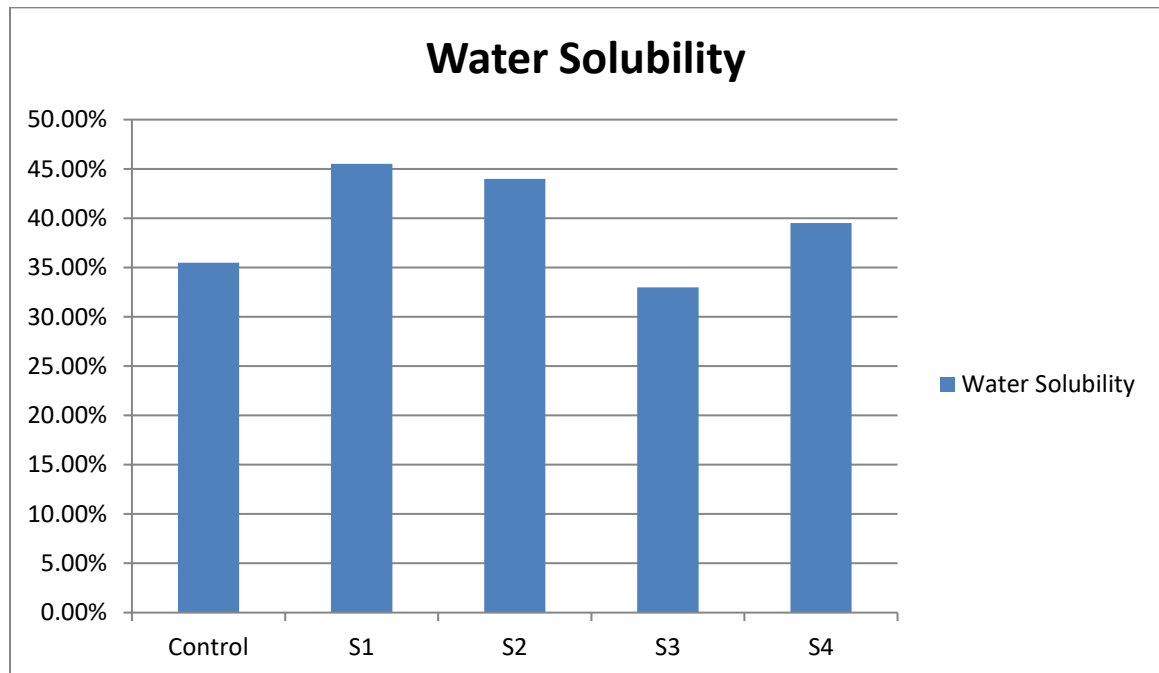


Fig 4.2.2 Graphical Representation of Water solubility



4.2.2 Plate VI. Water solubility

4.2.3 Thickness

The thickness measurement was conducted using a vernier caliper. Specifically, the vernier caliper was utilized to measure the widest section of the cutlery. A first straight line was marked, and then a second line was measured at a distance of 82.5 mm from the first line towards the handle. This is the location where the weight was placed during the mechanical testing of the cutlery samples. Compression was applied at a rate of 50 mm/min using a 6 mm probe, which was aligned at the midpoint of the cutlery's widest part. The deflection (in millimeters) was recorded at a compression force of 0.05 N. All tests were conducted in replicates ($n = 5$).

Additionally, the dimensions of the cutlery samples after compression molding were measured as follows: total length of 10 cm, thickness of the widest part measuring 1.568 mm, and thickness of the handle part measuring 1.733 mm.

4.2.4 Sensory Evaluation

Organoleptic evaluation was conducted, assessing taste, texture, aroma, color, and overall acceptability (OA) using a 9-point hedonic scale. This scale is extensively employed for gauging food acceptability. Teams comprising 7 panelists evaluated the product's attributes including color, taste, texture, and overall acceptability. The Control C or OA which was 7.67%. Sample S3 was highly acceptable among all the samples. S3 and S4 had a different composition of sorghum flour, refined flour and beetroot powder that may be one of the reasons for its highest acceptability rate. Sample S2 which was comprises of 70% sorghum flour and 30% refined flour and sample S1 which embraces 60% sorghum and 40% refined

flour shows the least acceptability rate in overall other samples made and also in comparison of Controls. No significant difference was found in values of sensory evaluation shown in table 4.2.4

Table 4.2.4 Organoleptic evaluation

Sample	Taste	Texture	Colour	Aroma	Overall Acceptability
Control	5	1.5	4.5	6	2
S1	4.5	6	4	5.5	5
S2	7	7.5	6	7	7
S3	8	8	7.5	8	8.5
S4	3	7	5	5.5	5

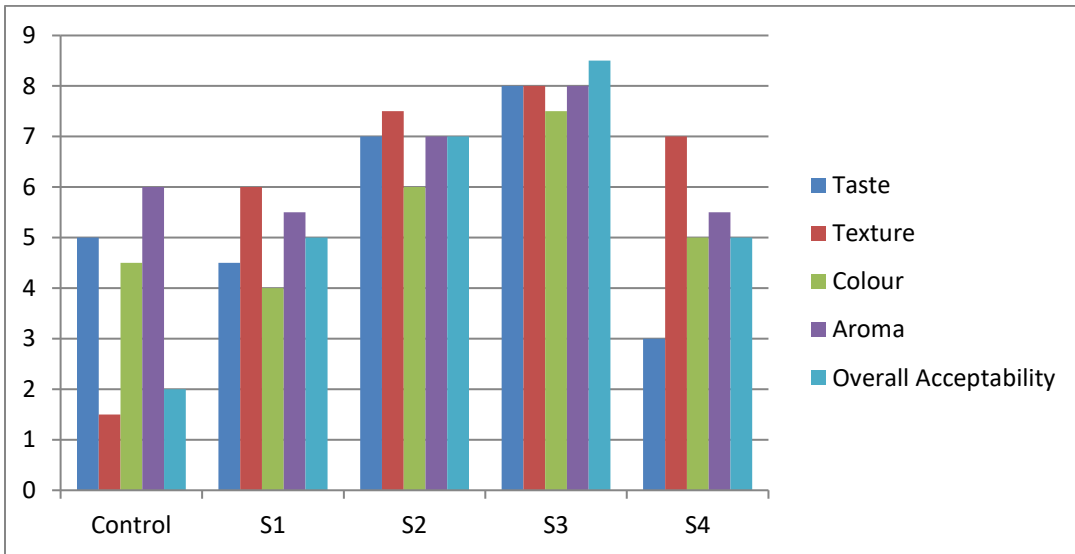


Fig 4.2.3 Graphical Representation of Organoleptic evaluation

CHAPTER 5

SUMMARY AND CONCLUSION

This chapter deal with summary and conclusions drawn based on experimental work done for the project work entitled, "Development of millet based edible cutlery carrying of beetroot powder".

The primary objective of the research was to explore the utilization of sorghum and beetroot powder in the creation of edible cutlery. This innovative approach aimed to provide a suitable and environmentally sustainable alternative to conventional plastic cutlery, which poses threats to biodiversity. In the present project work, edible cutlery samples were made using sorghum flour and beetroot powder, refined flour as a base material. Different amounts of ratios were taken of both and other ingredients butter, sugar, salt, oil were also added for the cutlery preparation. Those ratios were formulated based on strength, nutrition, taste, flavor, and their overall acceptability by the consumers. Different proportion was taken for four samples of cutlery in which one samples were considered as controls. Control C was 100% sorghum flour. Cutlery were prepared by following the normal procedure of procurement then mixing of all dry ingredient and create a smooth dough by kneading the ingredients together. The dough was shaped using a mold and then baked at 200°C for a duration of 25 minutes. Both the controls were taken for comparison of cutlery. These cutlery samples were subjected to physical and chemical analysis. Based on test results some conclusions were drawn:

In the case of Moisture Content, Control C had the highest amount of moisture which is 6.5%. C comprises 100% of sorghum. Sorghum possesses a remarkable super absorbent capacity, rendering it highly versatile for crafting edible cutlery. Least amount of moisture was determined in Sample S3 which was comprises of both sorghum and beetroot powder. The amount of moisture was found is 2%. So it proves that S3 was the ideal sample of edible cutlery regards to moisture content because the higher moisture amount is not desirable for the cutlery to sustain the shelf-life. When concentration of sorghum flour was increased in Sample S2 then sudden rise in moisture content was seen, significant

difference was found in all the samples. In the case of Ash Content, Control C and Also Sample S1, S2, S3 and S4 had the different amount of Ash content but when concentration of sorghum and beetroot powder was increased in Sample S3 and S4 Ash content starts increasing. Ash Content in samples S3 5.5% and S4 6.5%. Fat content in Control C is high because C was made from 100% sorghum flour has 14.4% of fat. In the water absorption test S1 has the highest amount of water and S3 has least amount of water percent. In water solubility S1 has more soluble and S3 has less soluble. In the case of overall acceptability, Sample S3 was highly acceptable by all the panelists, Sample S4 were the least acceptable because of appearance and taste.

Control C has the highest amount of fat because Control C comprise of 100% sorghum hence, C is ideal in the case of fat also. In the water absorption test Control C withstands 20minutes in water Sample S1 withstand 5 minutes absorbs more water. Sample S3 absorbs the least amount of water and S1 has the highest amount of water percent.

In the case of Overall Acceptability, Sample S3 was highly acceptable by all the panelists, and S1, S2 and S4 were the least acceptable. Significant difference was found in all the samples.

A conclusion is made on the basis of above studies that the development of edible cutlery is important because of consumption of plastic container is increasing with time. Also, it is a significant way of utilization of agriculture waste and a great alternative of those plastic. It is biodegradable, edible and possesses numerous health benefits.

In conclusion, the developed edible cutlery proved to be both ready-to-eat and nutritious, offering a promising and environmentally friendly substitute for plastic materials. They were prepared by utilizing sorghum flour and beetroot powder. The Sample S3, which was having different concentrations of 70:20:10, 70% sorghum flour, 20% refined flour, 10% beetroot powder was the best among all the developed cutlery. S3 was best in texture, colour, taste, appearance while S4 was bitter in taste and burn like flavor. S3 is more acceptable than S4 because S3 is an ideal sample of edible cutlery. This technique of developing the millet based edible cutlery using the beetroot powder.

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