



DEVELOPMENT OF VALUE-ADDED HIGH FIBRE MILLET COOKIES INCORPORATED WITH FLAX SEED AND SUNFLOWER SEED

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Abstract

Bakery products are gaining popularity day by day. Young generation mostly prefer the bakery products. Most of the bakery products are made up of wheat, the major food crop of India produced abundantly in India. Among bakery products, bread, cookies and biscuits are the most popular processed ready-to-eat food items in the country. The use of oilseeds in bakery products has gained popularity in recent years, both for their organoleptic and nutritional characteristics. The aim of this work is to provide an overview of the studies centred on the use of oilseeds in breads and other bakery products. In general, the incorporation of flax seeds improves the nutritional qualities of bakery products with and without gluten, and provides several health benefits. Sunflower seeds are cultivated and consumed globally and contain highly nutritious components like fibre, protein, unsaturated fats, selenium, copper, zinc, iron, vitamin E and have several other nutrients, antioxidants, minerals, and vitamins that play a vital role in the prevention or treatment of certain diseases, like diabetes is one of them. These seeds possess anti-diabetic properties due to the presence of chlorogenic acid, quinic acid, caffeic acid, glycosides, and phytosterols. So it has an anti-diabetic and anti-oxidant effect. Phytochemicals, or beneficial plant chemicals, may inhibit cancer growth, protect against heart disease, and offer protection from colon, prostate and breast cancer. It contains α -linoleic acid, phytoestrogen, anti-inflammatory, laxative effects, and osteoporosis. The current study intends to develop a cookies with improved nutritional and sensory properties by combining flax and sunflower seed flour.

Keywords: Millets, nutraceuticals, Organoleptic property, ω -3 fatty acids, packaging.

1.INTRODUCTION

Recently demand has increased for finger millet-based baking products in urban areas. However, the dark brown colour is the major hindrance to popularizing it in the baking industry. Among both white and brown-seeded finger millet, white-seeded is more suitable for the baking and processing industry due to high protein, low fibre, low tannins, and higher consumer acceptability (Sharathbabu Sonnad et al. 2008).

Bakery items are becoming increasingly popular, particularly among the younger population. These goods, which are mostly derived from wheat, a staple food crop abundant in India, have garnered enormous appeal. With customers looking for new alternatives, the sector has responded by strengthening cookies products to meet India's rising demand from health-conscious consumers. This is because bakery foods have a high nutritional content and are inexpensive, making them a popular staple (Ishrat Majid et al., 2014).

Millets are important crops in tropical regions of the world due to their resistance to pests and diseases, short growing season, and productivity under hardy and drought conditions when major cereals cannot be relied upon to provide sustainable yields. Millets are underutilized in many developed countries. There is an immense potential to process millet grains into value-added foods and beverages in developing countries. Furthermore, millets do not contain gluten and hence are advisable for celiac patients (**Chandrasekara and Shahidi 2010**).

Barnyard millet (*Echinochloa* species) has become one of the most important small millet plants in Asia, reflecting strong growth in global production. The genus *Echinochloa* includes two major species, *Echinochloa esculenta* and *Echinochloa frumentacea*, which are widely grown for human consumption and fodder.

Barnyard millet is a good source of protein, carbohydrates, fibre, and, in particular, contains more micronutrients (iron and zinc) than other major grains, and has a lower glycaemic Index and gluten free grains adds additional benefits, against various health issues such as obesity, diabetes, blood pressure control, cardiovascular disease and celiac disease. (**Anjali Singh et al., 2022**)

Bajra or Pearl Millet (*Pennisetum glaucum*) is one of the oldest millet used by our ancestors. Along with wheat flour even bajra was included in the regular diet. It is known to have a very high fibre content which makes it healthier. It is used as a regular meal in places like Rajasthan, Gujarat. Now a day's it is gaining its importance back. (**Shweta Malik, 2015**) For grain mineral nutrient contents (Fe, Zn, Ca, P, K, Mg, Mn, S, Na, Cu and β -carotene).

The production of bakery products holds an important place in the food industry. As the production of bakery products is increasing with wide range of consumers now have a variety of options in bakery products. As there is a wide range of baked goods in the bakery industry, consumer is getting newer option thus the industry has a reason

to fortify and invention in bakery products to satisfy health-conscious customers. At the global level, the incidence of diabetes and obesity is increasing exponentially due to food habits, and to overcome them, a rise in demand for food containing complex carbohydrates with higher levels of dietary fibre and beneficial phytochemicals, and low glycaemic and calorie food has been in demand.

Therefore now food industry has focused on increasing the nutritional value of these products. The current trend is to create bakery products that are beneficial for health. Nowadays dietary fibre is considered a very important ingredient in bakery products.

Bakery products such as cookies, and biscuits are consumed in large quantities worldwide which are low in protein and fibre. For this reason, research interest has been developed in increasing fibre and protein content in the diet.

Sunflower seeds are cultivated and consumed globally and contain highly nutritious components like fibre, protein, unsaturated fats, selenium, copper, zinc, iron, and vitamin e and have several other nutrients, antioxidants, minerals, and vitamins that play a vital role in the prevention or treatment of certain diseases, and diabetes is one of them. These seeds possess anti-diabetic properties due to the presence of chlorogenic acid, quinic acid, caffeic acid, glycosides, and phytosterols. They also contain 20% of proteins that provide sulphur and nitrogen so these sulphur-rich proteins are ideal for human consumption as they help to carry out their meta-biological functions such as muscular cell development and insulin production.

The nutrients in flaxseed include lignin's, antioxidants, fibre, protein, and polyunsaturated fatty acids such as alpha-linoleic acid (ALA), or omega-3. Consuming these nutrients may help lower the risk of various conditions. However, there is not currently enough evidence to support all of these claims. Here, find out what the research says about flaxseed and its possible health benefits.

Flaxseed contains some nutrients that may have various health benefits. Like other plant-based foods, flaxseed is rich in antioxidants. These [can help prevent](#) disease by removing molecules called free radicals from the body. Free radicals occur as a result of natural processes and environmental pressures. If there are too many free radicals in the body, oxidative [stress](#) can develop, leading to cell damage and disease.

Antioxidants help remove free radicals from the body. Flaxseed is a good source of lignans, which appear to have antioxidant properties. **(Medically reviewed by Kathy W. Warwick, R.D., CDE, Nutrition — By Yvette Brazier on January 9, 2020)**

OBJECTIVES

The objectives of this study are as follows:

- Create and standardize a cookies recipe that includes flax seeds and sunflower seeds.
- Assess the sensory qualities of the finished cookies.
- Select appropriate packaging methods for the finished product.
- Examine the developed cookie's macro and micronutrient composition.
- Calculate the probable shelf life extension of the product.
- Collectively, these goals contribute to the full examination and improvement of the nutritional and quality elements of cookies formation.

REVIEW OF LITERATURE.

MILLETS

Millets are major food sources for millions of people, especially those who live in hot and dry areas of the world. There are many varieties of millets. Millets are unique among the cereals because of their richness in calcium, dietary fibre, polyphenols and protein. It is a gluten-free cereal grain, an excellent source for people suffering from celiac diseases and also rich in phytochemical which helps to lower cholesterol level and reduced cancer risk due to its phytate content. The major millets were procured from the local market.

The present study was to develop and popularize bakery products using millets. The millets were cleaned, dried under the sun, milled into flour. Popular bakery products such as biscuits, cakes and cookies were developed using foxtail millet, finger millet, proso millet and pearl millet. **(CHANGMEI SHADANG and DOROTHY JAGANATHAN , 2014)**

Banyard millet

Banyard millet (*Echinochloa* species) has become one of the most important small millet plants in Asia, reflecting strong growth in global production. The genus *Echinochloa* includes two major species, *Echinochloa esculenta* and *Echinochloa frumentacea*, which are widely grown for human consumption and fodder.

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benefits, against various health issues such as obesity, diabetes, blood pressure control, cardiovascular disease and celiac disease.

The carbohydrate content in barnyard millet is low and digested slowly, making barnyard millet a natural gift for busy modern humanity. In barnyard millet the fatty acids are linoleic acid followed by palmitic and oleic acid. It also exhibits a high rate of amylase reuptake, facilitating the formation of high levels of resistant starch. The present study highlights the importance of millets in terms of its nutritional values, pharmacological benefits, biological activities and applications of barnyard millet. (Anjali Singh et al., 2022)

The present research work was carried out to explore the possibility of utilization of underutilized but highly nutrient rich barnyard millet in cookies. Preliminary experiments were carried out to find out optimum level of barnyard millet flour with Maida and wheat flour for the preparation of quality cookies. The quality cookies were prepared from 50% Maida and 50% wheat flour (MWF50), 30% Maida and 70% barnyard millet (MBF70) and 20% wheat flour and 80% barnyard millet flour (WBF80).

The selected treatments were packed in LDPE and stored at ambient (30 ± 4 °C) for 90 days to study their storage feasibility. Chemical composition of the fresh cookies prepared from 50% Maida and 50% wheat flour (MWF50) that showed moisture content was 4.0%, protein 11.55%, crude fat 26.30%, crude fibre 1.10%, carbohydrates 71.65%, calcium 35.50 mg/100 g, phosphorous 238 mg/100g and iron 3.80 mg/100 g.

Chemical composition of the fresh cookies prepared from 30% maida and 70% barnyard millet flour (MBF70) that showed moisture content was 3.10%, protein 7.64%, crude fat 26.81%, crude fibre 6.95%, carbohydrates 68.02%, calcium 20.90 mg/100 g, phosphorous 232 mg/100g and iron 4.31 mg/100 g.

Chemical composition of the fresh cookies (WBF80) prepared from 20% wheat flour and 80% barnyard millet flour that showed moisture content was 3.0%, protein 7.38%, crude fat 27.10%, crude fibre 8.22%, carbohydrates 66.28%, calcium 30.60 mg/100 g, phosphorous 295 mg/100g and iron 4.98 mg/100 g.

The sensory evaluation of cookies was carried out regularly at an interval of one month for 3 month during storage. The results on overall acceptability score of cookies are influenced by storage. The results indicated that score for overall acceptability decreased for control from 7.35 to 7.10, for MWF50 from 7.50 to 7.15, for MBF70 from 8.45 to 8.00 and for WBF80 from 8.63 to 8.15 in LDPE was observed for 90 days of storage.

Storage study of cookies showed that the cookies prepared by incorporation of Maida, wheat and barnyard millet flour can be stored up to 3 month in LDPE with minimum losses in sensory, nutritional and textural characteristics.

There was no significant difference in protein, crude fibre, calcium and iron content with advancement of storage period during 3 month.

The cookies were found to be acceptable up to 3 month storage at ambient temperature. The total cost of production of cookies prepared from Maida and wheat flour (MWF50) for 1 kg was Rs. 110. The total cost of production of cookies prepared from Maida and barnyard millet flour (MBF70) for 1 kg was Rs. 164. The total cost of production of cookies prepared from wheat and barnyard millet flour (WBF80) for 1 kg was Rs. 172. **(PP Salunke et al., 2019)**

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Pearl millet

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is an important staple cereal cultivated in the arid and semi-arid tropics of Asia and Africa, regions severely affected by malnutrition. Knowledge about the extent of genetic variability and patterns of agro-morphological variation in local germplasm from a target region is an important prerequisite for efficient crop improvement.

To assess the potential of Sudanese pearl millet landraces as sources of desirable traits for pearl millet improvement including bio fortification, a total of 225 accessions were evaluated in Sudan at three locations for agro-morphological traits and at one location for grain mineral nutrient contents (Fe, Zn, Ca, P, K, Mg, Mn, S, Na, Cu and β -carotene).

Significant and positive correlations among most of the nutritional traits were observed; therefore, enhancement of the concentrations of some nutrients will lead to the improvement of other related nutrients. No significant associations were observed between the nutritional and agro-morphological traits, indicating good prospects for simultaneous improvement of both trait categories.

No clear patterns of geographic differentiation for specific traits were detected for pearl millet. Nutrient-rich accessions were identified and those with acceptable agro-morphological traits are encouraging materials for future pearl millet bio fortification programmes in Sudan. **(Elfadil MA Bashir et al., 2014)**

Sunflower seed

An overview of sunflower seeds, nutritional value, and health benefits. Sunflower seeds are inexpensive, readily available, and nutritious all year long. Some of the most important nutrients for humans are found in them in particularly high concentrations. There are several vitamins in sunflower seeds, including vitamin B1 and B5, vitamin E and foliate.

Additionally, they contain important minerals like copper, magnesium, selenium, and phosphorous. The fats in sunflower seeds are also heart healthy fats that can increase high density lipoprotein cholesterol and provide cardiovascular protection. One of these nutrients is vitamin E, a powerful antioxidant that plays an important role in preserving cardiovascular health.

The vitamin E in sunflower seeds is quite high, with a quarter cup providing ninety per cent of the recommended daily allowance. Furthermore, lignin, arginine, and phenolic acids support cardiovascular health. The benefits of consuming these substances are increasingly emerging, even though they are less well known by most people. **(Yamunadevi Puraikalan and Michelle Scott, 2023)**

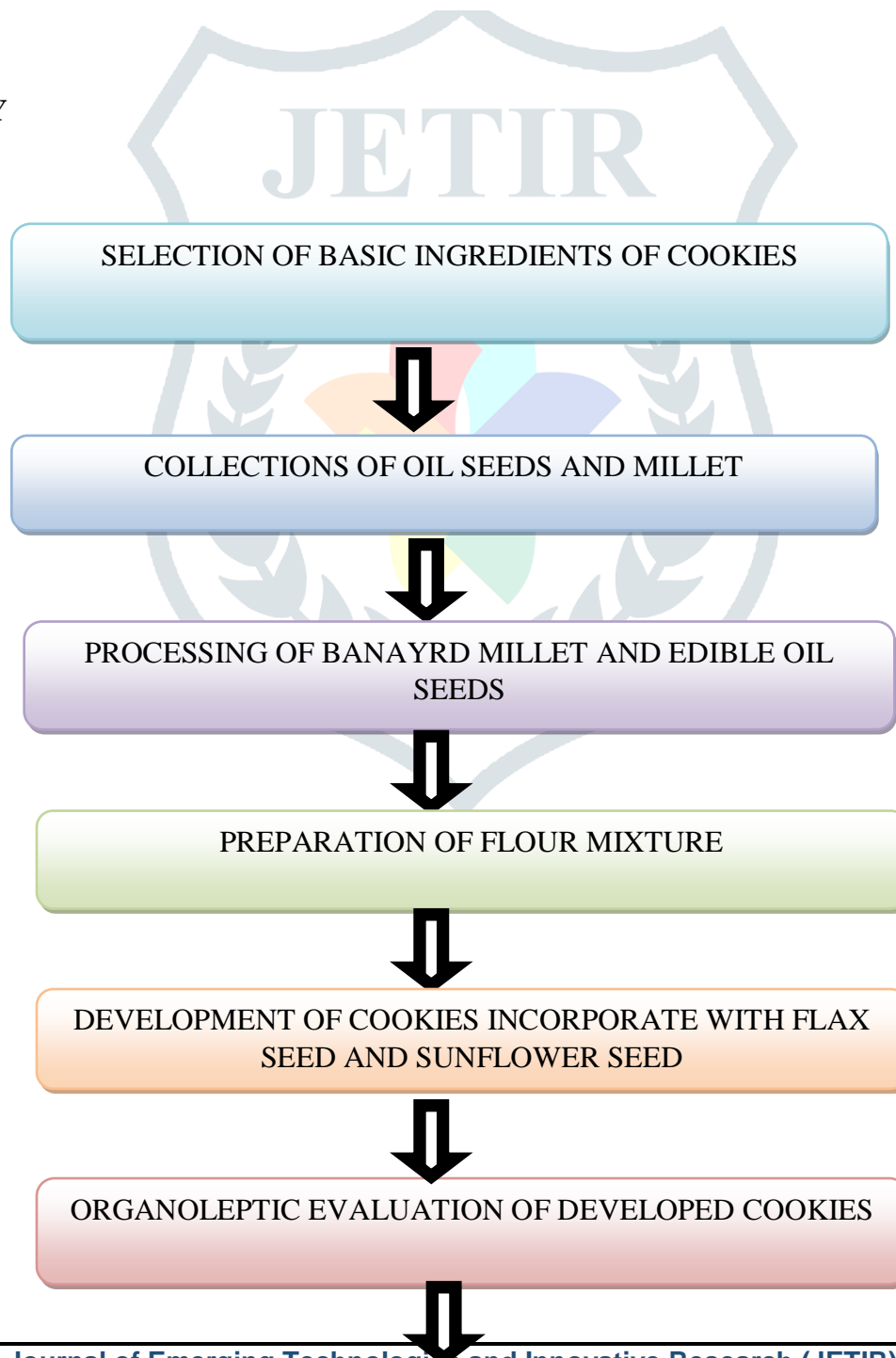
Flax seed

Flaxseed or linseed (*Linum usitatissimum* L.) comes from the flax plant, an annual herb. The main importance of flaxseed is in the human nutrition sector because it is emerging as an important functional food ingredient thanks to the content of active compounds, pointed to provide health benefits. There are several ways to eat flaxseed: milled, in the form of oil or added to bakery product.

Scientific evidences support consumption of flaxseed for the high content in omega-3, omega-6 rich oil, α -linolenic acid, lignans, high quality proteins and fibres, compounds which are biologically active in the prevention of some chronic diseases such as many types of cancer, diabetes, cardiovascular diseases and cerebrovascular stroke. Furthermore, advantages in flaxseed consumptions are shown in animal nutrition sector and therefore result in healthier food from animal origin.

In fact, the fatty acid profile of the meat and fat is directly affected by the source of fat in diet in swine and poultry, feeding omega-3 enriched diets by the addition of flaxseed would increase the omega-3 content in eggs and meat and thus enrich the products. The present review is focused on recent data on flaxseed chemical composition and its beneficial effects. (R Bernacchia et al., 2014)

METHODOLOGY



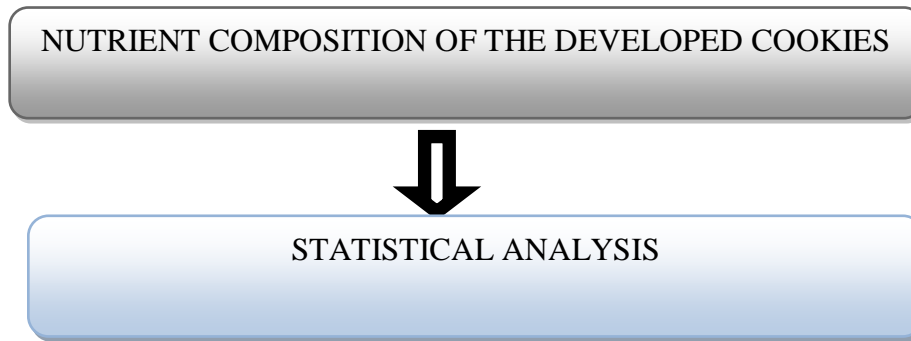


Figure 3.1 FLOWCHART OF METHODOLOGY

SELECTION OF BASIC INGREDIENTS OF COOKIES

Cookies essential components included whole wheat flour, sugar, yeast, salt, margarine (vegetable oil), Banyard millet (*Echinochloa frumentacea*), flax seed (*Linum usitatissimum*), and sunflower seed (*Helianthus annuus*). The combined ingredients were accessible in Madurai's local supermarkets. These substances were kept in extremely clean and sanitary settings.

PROCESSING OF BARNYARD MILLET AND EDIBLE OIL SEEDS

The drying procedure was carried out in a rigorously clean setting, ensuring that neither the Barnyard millet nor the seeds had any traces of insect activity, microbiological deterioration, or unpleasant odours. The first stage was to carefully choose and properly clean the components, which were then sun-dried for a short length of time in the early morning. Following that, the components were processed into a fine powder using a mixer grinder, yielding the necessary flour. To retain the quality of these flours, they were stored in carefully sealed, dry canisters. They were later used in the cookies-making process.

PREPARATION OF FLOUR MIXTURE

The flour is separated into two halves after briefly toasting the Barnyard millet, flax seed, and sunflower seed.

S.No	Ingredients	Sample A	Sample B	Sample C (Normal wheat cookies)
1.	Barnyard millet	25g	25g	---
2.	Pearl millet	25g	25g	---
3.	Flax seed	10g	15g	---
4.	Sunflower seed	10g	15g	---
5.	Whole wheat flour	75g	75g	75g
6.	Refined wheat flour (Maida)	100g	100g	100g
7.	Margarine (vegetable oil)	20g	20g	20g
8.	Sugar	50g	50g	50g
9.	Milk	1 ml	1 ml	1ml

10.	Butter	0.5 g	0.5 g	0.5 g
11.	Salt	3.5 g	3.5 g	3.5 g
12.	Water	150 ml	150 ml	150 ml
13.	Weight of dough	250g	250g	250g
14.	Weight of cookies	350g	350g	350g

Table 3.1 DEVELOPMENT OF COOKIES INCORPORATED WITH FLAX SEEDS AND SUNFLOWER SEEDS

The cookies-making procedure started with dry-mixing all of the fundamental components. This combination was then blended with flour made from Barnyard millet, flax seed, and sunflower seed. The dough was then ideally stirred for 10 to 15 minutes with a mixer until it acquired a soft and elastic consistency.

Following mixing, individual sections of 300 grammes were measured and hand shaped before fermenting for 45 minutes at 32-35°C. The moulded dough was then put on a greased tray in a 30°C atmosphere. After 1.5 to 2 hours, the dough was transferred to a baking pan and cooked for 1 hour at 180 degrees Celsius in a baking machine. The loaves were made and allowed to cool before being weighed; each loaf weighed roughly 350 grammes. Finally, the loaves were stored and distributed in plastic bags.

ORGANOLEPTIC EVALUATION OF DEVELOPED COOKIES



Figure 3.2 Samples of cookies

To assess the acceptability of the newly created millet cookies, organoleptic testing was performed. A numerical scoring system was used to evaluate critical criteria such as the cookies's appearance, colour, flavour, texture, and taste. For this examination, 32 college students were recruited as panel lists. They were asked to rate how much they liked each cookies sample, and their ratings were recorded. Panel lists used a 5-point scale for quality analysis in this review, with 5 being excellent, 4 denoting very good, 3 denoting good, 2 denoting fair, and 1 denoting bad.

It's worth mentioning that these cookies were created with the nutritional requirements of fat people and children in mind.

NUTRIENT COMPOSITION OF THE DEVELOPED COOKIES

The nutritious profile of the produced cookies samples was thoroughly evaluated. This assessment included vital nutritional components such as carbs, protein, fat, crude fibre, and other vitamins and minerals found in cookies.

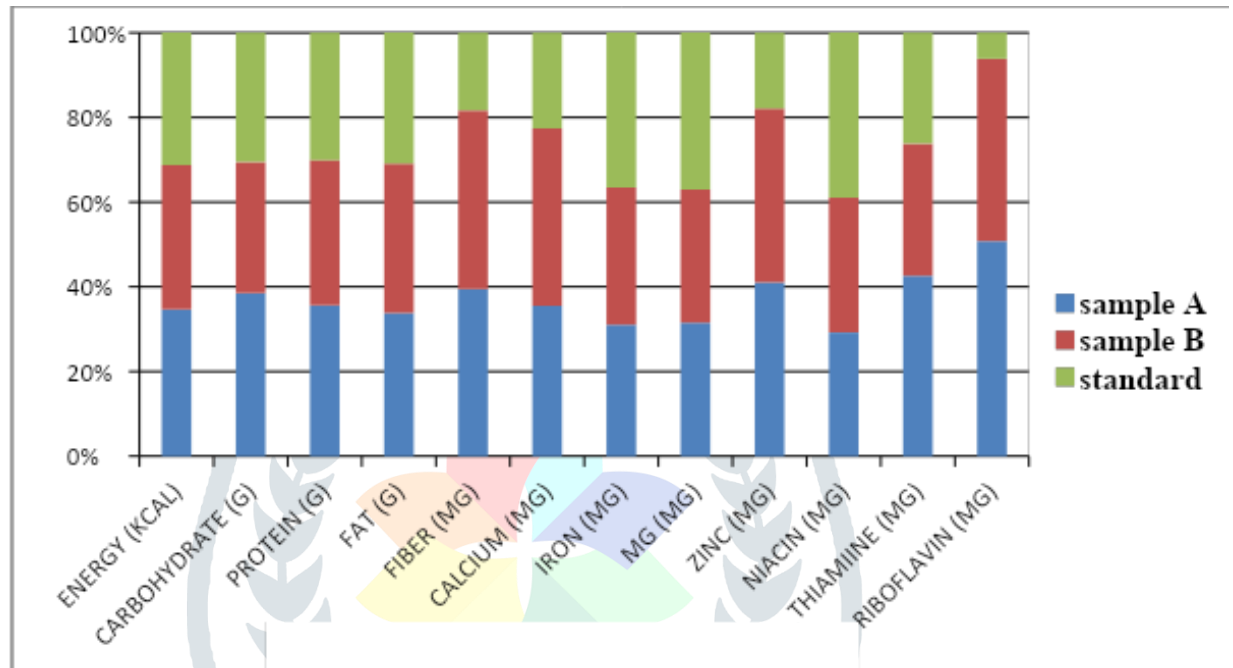


Figure 3.3 TOTAL NUTRIENT COMPOSITION OF THE DEVELOPED COOKIES

STATISTICAL ANALYSIS

Following data collection, it is critical to organise the information properly in order to promote correct interpretation and generate scientifically sound outcomes. To do this, the main data obtained was aggregated and statistically analysed in Microsoft Excel. The mean score for each test across the three replicates was computed for all cookies samples. This process aids in generating a trustworthy average value for each parameter, offering a more solid foundation for drawing inferences and comparing data.

S.No	Nutrients	Barnyard millet (100g)	Pearl millet (100g)	Flax seed (100g)	Sunflower seed (100g)
1.	Calorie (kcal)	331	360	530	620
2.	Carbohydrate (g)	69.6	67.5	28.9	17.9
3.	Protein (g)	12.3	12	20.3	19.8

4.	Fat (g)	4.3	5	37.1	52.1
5.	Fiber (g)	8.0	1	4.8	1.0
6.	Vitamin E (mg)	---	23	8.28	12.93
7.	Calcium (mg)	31	42	170	280
8.	Iron (mg)	2.8	8	2.7	5.0
9.	Phosphorous (mg)	290	242	370	670

RESULTS AND DISCUSSION

COMPUTATION OF NUTRIENTS PRESENT IN BARNYARD MILLET, FLAX SEED AND SUNFLOWER SEED

The table shows the nutritional value of barnyard millet, flax seed, and sunflower seed.

Table 4.1 Computation of nutrients present in barnyard millet, pearl millet, flax seed and sunflower seed

The table above shows that Barnyard millet, flax seed, and sunflower seed are good sources of protein and fat per 100g. Sunflower seed, in particular, stands out due to its increased phosphorus level when compared to the other components. Overall, the nutritional value of these three fundamental ingredients—Barnyard millet, flax seed, and sunflower seed—is high, with sunflower seed having a high phosphorus content.

COMPUTATION OF NUTRIENTS IN DEVELOPED COOKIES

Samples	Energy (kcal)	CHO (g)	Protein (g)	Fat (g)	Fiber (mg)	Calcium (mg)	Iron (mg)
Sample A (10g)	1989.8	213.35	30.33	112.69	4.03	132	10.75
Sample B (15g)	2047.3	215.7	29.4	223.07	4.32	154	11.17
Standard (normal wheat cookies)	1792	193.5	23.3	102.7	1.95	79	9.4

Table 4.2 Computation of nutrients in developed cookies

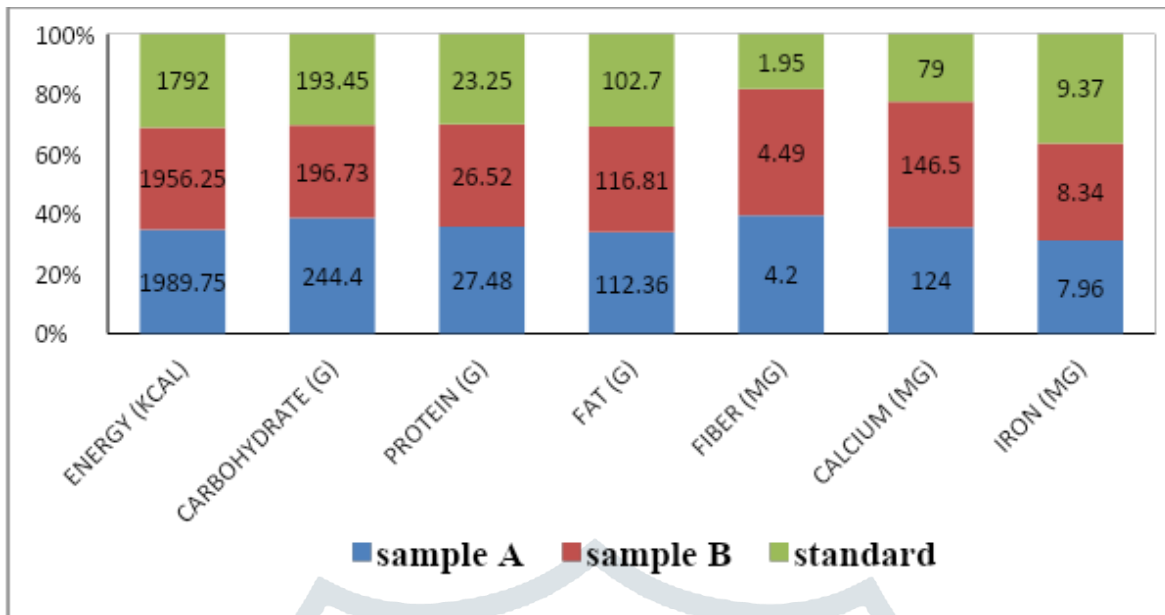


Figure 4.1 Computation of nutrients in developed cookies

Barnyard millet, flax seed, and sunflower seed have high nutritional value due to their high quantity of calories, carbs, proteins, lipids, calcium, and iron. The tables above offer a thorough breakdown of the cookies nutritious makeup, highlighting the important contributions from various elements. This cookies preparation included combining the various flours, followed by baking in an oven. The entire procedure took around an hour. Notably, cookies created with 10g of each component demonstrated greater qualities in terms of appearance, colour, flavour, texture, and taste, resulting in considerably higher overall acceptance than cookies prepared with 5g of inclusion.

Furthermore, based on the amount of incorporation in the cookies, the quantities of fat, protein, fibre, calcium, and iron were significantly enhanced in both sample A and sample B. When compared to ordinary cookies, this suggests a significant increase in the nutritious content of samples A and B. The addition of these nutrients results in a considerable boost in the cookies overall nutritional profile.

CONSUMER ACCEPTABILITY OF DEVELOPED COOKIES

The cookies produced with barnyard millet, flax seed, and sunflower seed were prepared and evaluated by a panel of 32 people using sensory assessment. Each team member was given a 5-point hedonic scale to award a score to. The sensory assessment results will be examined further below, offering vital insights into the acceptance and preference of the produced cookies.

CONSUMER ACCEPTABILITY FOR THREE SAMPLES OF COOKIES

Samples	Appearance	Colour	Flavour	Taste	Texture	Totally overall acceptance
SAMPLE A	3.69	3.54	3.46	3.34	4	3.498

SAMPLE B	3.26	3.48	3.31	3.34	3.58	3.401
SAMPLE C (Standard normal wheat cookies)	4.35	4.60	4.17	4.23	4.46	4.433

Table 4.3 mean score of consumer acceptability of the developed cookies sensory quality of three samples of cookies

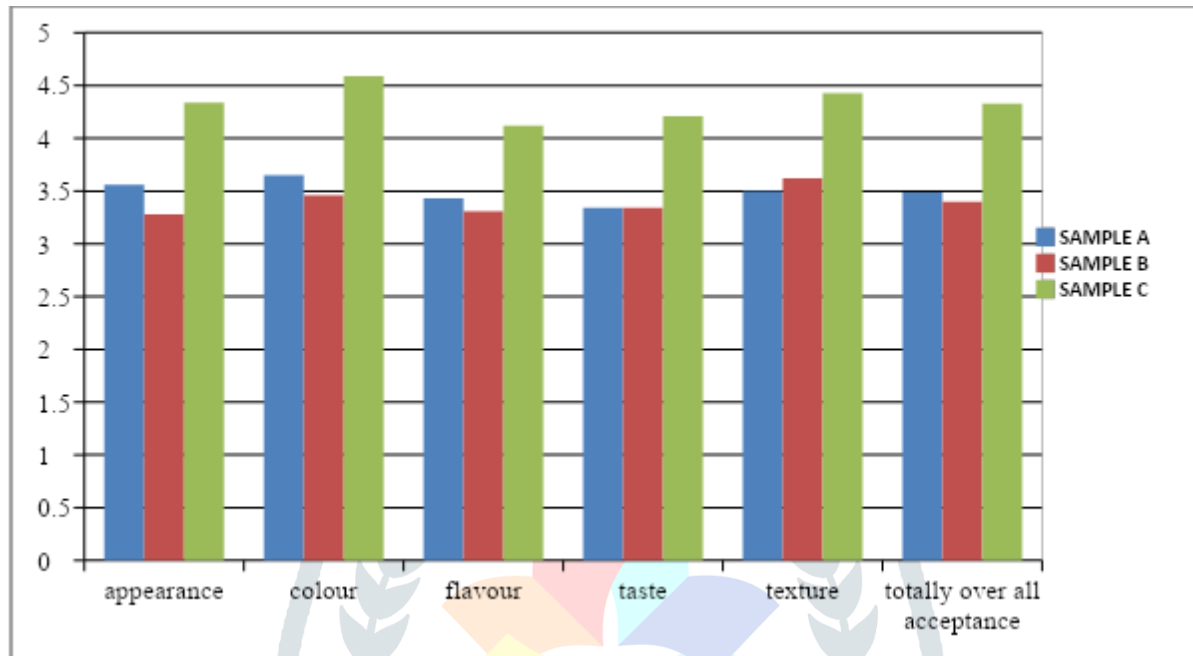


Figure 4.2 mean score of consumer acceptability of the developed cookies sensory quality of three samples of cookies

The data shows the customer acceptance ratings for the created cookies vs the standard (ordinary wheat cookies). The ordinary cookies consistently obtained higher rankings than the developed loaves in numerous qualities such as appearance, colour, flavour, texture, and taste. The standard cookies had a mean value of 4.33 in terms of overall consumer acceptability, indicating a favorable reception. The developed cookies, however, got somewhat lower mean values of 3.49 and 3.40, respectively. When it comes to particular features, sample A cookies had high mean values for look, colour, and flavour. Sample B cookies, on the other hand, had a somewhat lower mean value, notably in terms of colour. Both samples had comparable mean values for taste. Interestingly, there was a minor variation in the texture property, with sample B having a slightly higher mean value by 0.1.

Ultimately, despite these differences in individual qualities, the overall acceptability ratings for samples A and B were relatively similar, indicating that both evolved cookies received a comparable degree of customer satisfaction.

SUMMARY AND CONCLUSION

Individuals in today's health-conscious culture are growing more cognizant of the food they consume and its influence on their well-being. Functional meals that provide extra health advantages are gaining popularity. Barnyard millet, flaxseed, and sunflower seed are good examples of functional foods, each with distinct components that provide a variety of health benefits. As a result, the major goal of this research was to develop a functional diet that gives greater health advantages. Barnyard millet, flaxseed, and sunflower seed were integrated into cookies in this study, a handy and commonly eaten food ideal for people of all ages. The inclusion of these substances increased the nutritious content of the cookies substantially. Both samples included 25g of barnyard millet, as well as 10g of flax seed and 15g of sunflower seed, which distinguished the two samples. Sample A (with 10g inclusion) was considered extremely satisfactory based on sensory assessment ratings. Colour, look, taste, texture, and flavour were all assessed well, indicating that this cookies will be well-received, particularly by college students. Furthermore, the evolved cookies became a significant source of calories, carbs, proteins, lipids, crude fibre, vitamins, and minerals. It was shown to be high in easily accessible crude fibre, proteins, and omega-3 fatty acids, as well as having the ability to decrease cholesterol levels. This highlights the cookies potential as a nutrient-dense and health-promoting meal option.

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