Development of Fiber Rich Cookies Using Barnyard Millet and Study of its Physio-chemical Properties.

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Abstract

In the current research, Barnyard millet serves as the primary ingredient for making cookies, where sweet potato mash is used as the main source of starch. However, we have formulated and developed gluten-free and fiber-rich cookies by incorporating various millets. To enhance fiber content and nutritional value, we selected barnyard millet, sweet potato, and flaxseed for the formulation. Different formulations were developed by varying the concentration in three different ratio of barnyard millet flour, sweet potato mash, flax seed powder and sugar in the ratio of 45:20:20:15 for T1, 40,25,15,20 for T2, and 50:15:10:25 is for T3. Sensory evaluation was conducted to assess the quality of cookies among three formulations, and according to the panelists, Formulation T2 was consistently favored across all quality parameters. From the developed formulation T2 shows 2.95% moisture, 0.217% ash, 5.2% protein, 19% fat, 12 % dietary fibre, and 61.63% carbohydrates per 100 g. Formulation T2 reveled that higher fiber content as compared to prior arts. Hence, to check the shelf life study, sensory evaluations performed on monthly withdrawal during till three month. Finally cost estimation were analysed for the all the formulation which were Rs165, 158 and 164/ Kg for T1, T2, and T3 respectively.

Keywords – Barnyard millet, cookies, sweet potato, flax seed, nutritional attributes, shelf life.

1.   Introduction

The bakery industry in the country has seen consistent growth, emerging as the largest sector within processed foods. Bread and biscuits, the primary segments, together make up approximately 82% of the total bakery product market. Annual production of bakery goods is estimated to exceed 3.0 million tonnes (www.biscuitfederation.org) India is acknowledged as the world's second-largest biscuit producer after the United States, with production increasing from 7.40 lakh metric tonnes in 1997-98 to 17.14 lakh metric tonnes in 2005-2009 (Agrawal, 1990) Total biscuit production in the country, including both organized and unorganized sectors, is estimated to be around 11 million tonnes. Cookies are readily consumable, convenient, affordable, and rank among the most favored and extensively consumed processed food items in India (Shukla and Shipla, 2000). Cookies are widely enjoyed by individuals across all age groups, known for their convenience and popularity as a snack. Characterized by low water content and a high ratio of sugar and shortening, cookies boast an extended shelf life. The primary ingredients used in making cookies are refined wheat flour, hydrogenated fat, and sugar, all of which are deficient in essential nutrients. Refined flour lacks dietary fiber and essential micronutrients, vital for promoting health. Hydrogenated fats, found in cookies, contain trans-fats, which are known to be detrimental to human health. (Mitkal KT et al.,2021)

India faces high malnutrition rates; developed nations battle celiac disease due to gluten-rich diets. Opting for gluten-free or low-gluten diets can improve nutrition and manage gluten intolerance globally.(Kulkarni, D.B. et.al.,2021) Millets offer protection from gluten sensitivities, supply essential nutrients, and show potential in combating malnutrition. Despite their health benefits, consumer acceptance is currently low. (Purva Asrani et al., 2023) Numerous efforts have been made to create nutrient-rich cookies by incorporating various ingredients, yet fewer attempts have focused on using millets in cookie development.

Barnyard millet is well known for its exceptional nutritional profile and health benefits, still has been limited exploration into developing nutrient-rich cookies. This grain, being gluten- free and rich in dietary fiber with a low glycemic index, is suitable for consumption by individuals suffering from celiac disease and constipation. By leveraging the nutritional advantages of barnyard millet in cookie formulations, there is a n opportunity to offer consumers a healthier snacking option without compromising on taste or convenience, thereby catering to a broader range of dietary preferences and requirements. The formulation and analysis of barnyard millet cookies with varying combinations of sweet potato mash and flaxseed powder offer an intriguing exploration of

their nutritional properties and potential health benefits. These ingredients, known for their rich nutrient profiles, are increasingly being applied in baked goods, particularly cookies, to enhance both flavor and nutritional value. Alongside the formulation process, the study likely delves into sensory analysis techniques to evaluate cookie quality, ensuring that the final products meet consumer preferences. Moreover, discussions on Physicochemical methods relevant to food product development are crucial, to ensure the nutritional quality of the cookies. Through this comprehensive approach, research aims to not only create delicious and nutritious cookiesbut also contribute valuable insights into the utilization of alternative ingredients in baked goods.

2.   Materials and Method

2.1   Materials

Barnyard millet, Sweet potato, Roasted flax seeds, Sugar, Unsalted Butter, Salt, Flavoring agent, and Leavening agent are procured from the local market of Vadodara.

2.2.   Method

2.2.1   Formulation for the cookies

Three different formulations were created to develop nutritionally rich cookies, each with varying combinations of ingredients. Formulation No. 1 (T1) includes 45g of barnyard millet flour, 20g of sweet potato mash, 20g of flaxseed powder, and 15g of sugar. Formulation No. 2 comprises 40g of barnyard millet flour, 25g of sweet potato mash, 15g of flaxseed powder, and 20g of sugar. Formulation No. 3 consists of 50g of barnyard millet flour, 15g of sweet potato mash, 10g of flaxseed powder, and 25g of sugar.

Table 1- Formulation of barnyard millet cookies-

Ingredient	Formulation 1	Formulation 2	Formulation 3
Barnyard millet flour	45g	40g	50g
Sweet potato Mash	20g	25g	15g
Roasted flax seed powder	20g	15g	10g
Powdered sugar	15g	20g	25g

Preparation of Cookies

Firstly, barnyard millet, crystal sugar, and roasted flax seeds are individually ground into a fine powder, ensuring uniformity and ease of incorporation into the recipe. Meanwhile, sweet potato mash is created through a series of steps, beginning with pressure cooking to soften the sweet potatoes. Once cooked, the sweet potatoes undergo peeling to remove the outer skin, followed by mashing to achieve a smooth and consistent texture. This meticulous processensures that each ingredient is properly prepared to contribute to the overall flavor, texture, and nutritional profile of the final product. The process of preparing barnyard millet cookies begins with creaming together the fat and sugar, followed by the addition of flavoring and leavening agents. Creaming should be done for 20-25 minutes to capture air cells, resulting in a light and airy texture. Next, barnyard millet flour, sweet potato flour, and flaxseed powder are sifted and added in three different compositions. The ingredients are mixed thoroughly, and the dough is kneaded and prepared. Afterward, the dough is refrigerated for 15 minutes to firm up. Once chilled, the dough is rolled and shaped. The shaped cookies are then baked in a preheated oven at 180 degrees Celsius for 20 to 25 minutes until golden brown. After baking, the cookies are left to cool at room temperature before being packaged in LDPL (Low-Density Polyethylene) for storage.

2.2.2   Proximate analysis -

2.2.2.1.   Moisture

Weigh about 5gm of ground sample into the dish, now place the dish with the sample in the hot air oven for 2 hrs at 105°C. After drying, transfer the dish to the desiccator to cool. Reweigh the dish with dried sample and calculate moisture % by using formula.

Calculation

Moisture (%) = $\dfrac{(W1-W2)}{(W)} \times 100$

2.2.2.2 Ash

Place approximately 10 g of sample in the crucible now place it into furnace for 6 hrs at 550˚c then cools it down in a desiccator and weigh the ash with a crucible.

Calculation

Ash (gm%) = Weight of ash/ Weight of sample x 100

2.2.2.3.   Protein

0.5 gm of sample is taken in a Kjeldahl digestion flask. Then, 10 ml of concentrated sulfuric acid and a pinch of digestion mixture are added to the flask. The sample is digested and made up to 100 ml with distilled water in a volumetric flask. Subsequently, a 10 ml aliquot of the digested sample is transferred to another Kjeldahl flask. To this flask, 10 ml of 50% sodium hydroxide (NaOH) and 10 ml of distilled water are added, and the flask is connected to the distillation assembly. The sample is then boiled for 10-15 minutes. Liberated ammonia is collected in a flask containing 10 ml of 2% boric acid with 2-3 drops of mixed indicator. This ammonia is titrated with 0.02 N sulfuric acid until a pink color appears. For blank titration, 5 ml of diluted sulfuric acid is taken and treated as a sample. This method enables the determination of nitrogen content, which can be used to calculate the protein content of the sample.

Calculation:-

%N = Protein (gm %) =%N ×6.25 (std value)

2.2.2.4. Total Fat

5 grams of sample is placed in an extraction thimble then the thimble is inserted into the extractor of a Soxhlet apparatus, containing 25 ml of petroleum ether. The extractor is connected to a reflux condenser and refluxed for 5-6 hours, typically through 15-16 cycles. Following extraction, the petroleum ether extract is evaporated to obtain the fat residue. This

residue is further processed by dehydrating it in a hot air oven at 50-60℃ for 20 minutes,followed by cooling in desiccators. Finally, the residue is weighed to determine its mass.

Calculation:-

Fat (gm %) = wt of flask containing oil - wt of empty flask / Wt of sample x 100

2.2.2.5. Determination of Dietary fibre

According to centre of food safety AOAC 985.29 Total Dietary Fibre in Foods is determined by using Enzymatic- Gravimetric Method- Duplicate test portions of sample followed by Enzymatic digestion i) α-amylase ii) protease iii) amyloglucosidase then Precipitation and filtration (residue)

Calculation -

Total dietary fibre = weight (residue) – weight (ash + protein)

2.2.2.6. Determination of carbohydrates

The carbohydrate content was calculated by deducting the sum of the value of moisture, fat, protein, total ash, and crude fiber. The NFE was calculated by the following formula.

NFE % = 100 – (Crude Protein% + Crude Fibre% + Crude Fat% + TOTAL ASH %)

2.2.2.7.   Determination of energy value-

Formula used to calculate the energy value (Carbohydrate x 4) + (protein x 4) + (fat x 9)

2.2.2.8.   pH

pH is measured by using a pH meter and pH strips.
Procedure -Preparation of 10% sample solution by taking 10 gm of sample in 90 ml of distilled water followed by stirring with magnetic stirrer for 10-20 min.to ensure proper mixing Subsequently, the solution is allowed to stand for 5 minutes to settle. Now a calibrated pH electrode with a buffer solution of pH 7 is dipped into the sample solution. After waiting for 3 to 4 minutes for stabilization, the pH value displayed on the pH meter is noted.

3.   Result and Discussion

Generally refined wheat flour is found to be the main ingredient in the development of cookies, here we have replaced it with barnyard millet flour. Attempts were made to develop gluten free and fibre rich barnyard millet cookies by incorporating sweet potato mash and flax-seed powder. Three different formulation of cookies were developed to by using three different combination of ingredients. This article discusses the findings from the study 'Formulation of fiber rich millet-based cookies: Effect on nutrition and sensory properties'**.** In barnyard millet cookies, the addition of flax seed powder and sweet potato mash enhances their nutritional qualities, particularly their fiber content. To determine the quality of cookies product was analyzed for Physicochemical and sensory analysis.

3.1   Sensory evaluation

Sensory attributes of prepared products were scored by 15 members using 9 point hedonic scale. The sensory attributes of experimental samples T1, T2, and T3 were assessed across various attributes such as colour, aroma, taste, appearance, flavor, and overall acceptability. The results were shown in Table no. 2, the variation of ingredients leads to the different sensory score which leads to selection of best formulation for further analysis. Formulation no.2 which is made up of 40g of millet flour, 25 g of sweet potato mash, 15g of flax seed and 20g of sugar is found to be the most approved formulation in all the sensory attributes. In

terms of color and appearance T2 ranked higher with the score of 8 and 8.5 while T1 and T3 exhibited slight

discrepancies in score. Among the taste significant differences were noted in all the three samples here also T2 is the most approved sample with score of 8.5 while T1 and T3 has the score of 6.6 and 7.5. Panelists favored and endorsed T2 as the most preferred sample in all the attributes, while T1 lagged in all aspects except aroma. Regarding flavour, T2 and T3 showed remarkable similarity. Nevertheless, T2 retained the highest overall acceptability rating of 8, thus positioning it as the preferred choice among these attributes.

Table 2 – Sensory Analysis Results

Parameters	T1	T2	T3
Colour	7 ± 0.9	8 ± 1.06	7.3 ± 1.2
Aroma	7.5 ± 1.18	7 ± 0.99	6.8 ± 1.27
Taste	6.6 ± 1.2	8.5 ± 1.10	7.5 ± 1.3
Flavour	6.7 ± 1.08	7.6 ± 0.99	7.4 ± 1.50
Appearance	7.2 ± 1.01	8.5 ± 1.04	7.4 ± 1.5
Overall acceptability	7 ± 0.9	8 ± 1.08	7.3 ± 1.1

Formulation no.1(T1)   Formulation no.2 (T2)   Formulation no.3 (T3)

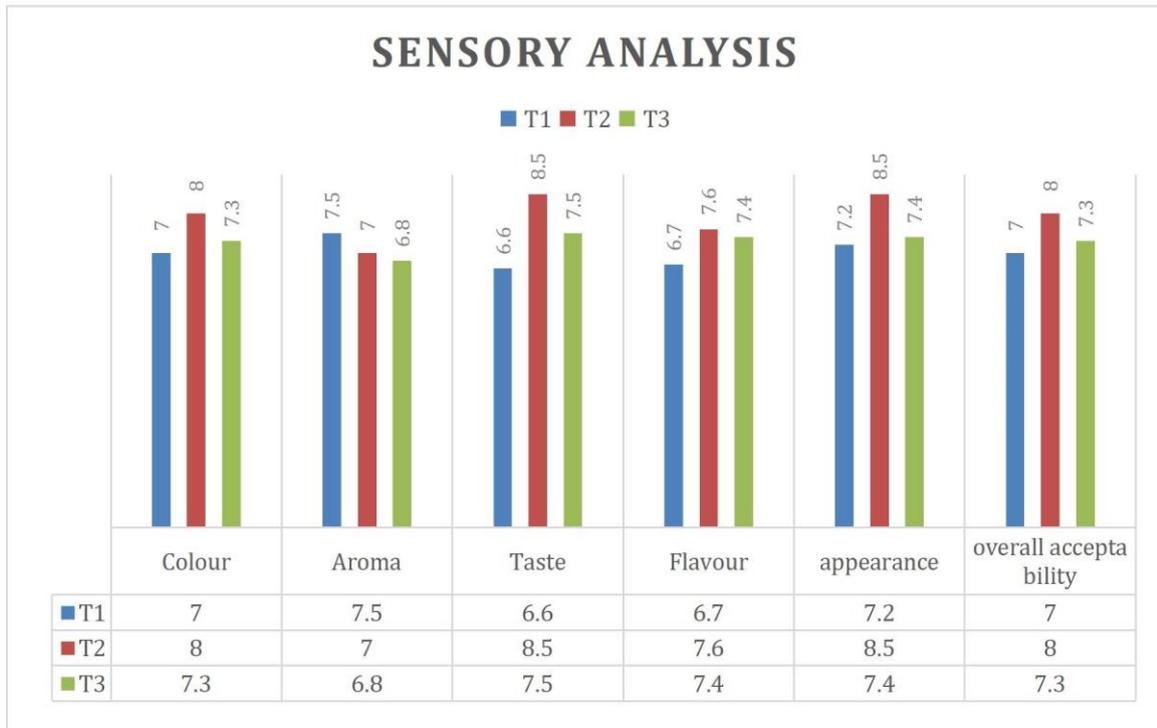Image no. 1- Formulation of Barnyard millet cookies incorporated with sweet potato mashand falx seed powder.

Image no.2 – Graph shows the Comparison of the mean value of sensory analysis results of three different formulations of developed cookies.

3.2   Proximate analysis of barnyard millet cookies

Table 3 presents the chemical composition of three different cookie formulations containing barnyard millet, sweet potato mash, and flaxseed powder. It includes details such as moisture content, ash content, fat content, dietary fiber, protein content, and carbohydrate content. Meanwhile, Table 4 provides a comparative analysis of the nutritionally rich formulation T2 with the other two cookies from the relevant study.

Table 3- Proximate Analysis of developed Cookies

Parameters	T1	T2	T3
Moisture	2.50%	.95 %	.45 %
Ash	.98 mg	2.17mg	.78 mg
Protein	0 g	2 g	9 g
Fat	8.5 g	19 g	18 g
Dietary Fibre	1.5 g	12 g	11 g
Carbohydrates	63.02g	61.63g	64.32g
Energy	38.58 k cal	38.32 k cal	38.88 k cal
pH	7	7.2	6.9

Moisture-

According to FSSR standards, biscuits should ideally have a moisture content of less than 5%. The moisture percentages for T1, T2, and T3 are 2.5%, 2.95%, and 1.45% respectively. T2 has a higher moisture content due to its increased proportion of sweet potato mash compared to the other formulations. When comparing the moisture content of the developed product with others, cookies made from 50% wheat flour and 50% kudo millet have a moisture content of 4% (Mitkal KT et al., 2021). In a study by P.L. Gopinath et al. (2014) on the evaluation of nutritive quality and sensory attributes of Calocybe indica flour fortified barnyard millet cookies, it was found that their cookies contained 3.47% moisture. It can be inferred from that the developed product has a lower moisture content.

Ash-

The ash content of developed cookies of sample code T1, T2 and T3 is 0.198, 0.217, and

0.178 respectively. The ash content of T2 is high as the concentration of sweet potato mash ishigh in it as compared to other two. M.B.F. Jemziya et al., 2015 conducts a study focused on

the sensory evaluation and quality attributes of cookies made with composite mixes of wheat (Triticum aestivum L.) and sweet potato (Ipomoea batatas L.) flour and according to their study the ash content increases from 0.207 to 0.24% when increase the concentration of sweet potato flour from 20 to 100 %. In a study by P.L. Gopinath et al. (2014) on the evaluation of nutritive quality and sensory attributes of Calocybe indica flour fortified barnyard millet cookies, it was found that their cookies contained 0.75% of ash in it.

Protein-

The Maximum protein content was recorded in sample code (T2) i.e. 5.2% and the minimum protein content was recorded in (T3) i.e. 4.95 % /100g. According to (Mitkal KT et al., 2021) cookies developed from 50% wheat flour and 50% kudo millet has protein content of 10.40% per 100g. There is difference in protein content as compared to developed product as kudo millet has 8.3% of protein and wheat flour has of 11% of protein per 100 g. while we have only used barnyard millet which has protein content of 8.8%. According to the study the protein content of barnyard millet cookies incorporated with 8% mushroom flour has protein content of 10.31% per 100g. according to their findingd they have concluded that the protein content of cookies increases with increase in concentration of mushroom (P.L. Gopinath et al., 2014).

Fat-

The fat content is found higher in T2 than in T1 and in T3, with 19, 18.5, and 18 % /100 g respectively. According to (Mitkal KT et al., 2021) – the availability of fat content in cookies prepared from 50% kudo millet flour and 50% wheat flour is 26.05% per 100 g. Barnyard millet cookies incorporated with 6% mushroom flour has fat content of 27.48% per 100 g (P.L. Gopinath et al., 2014). Comparing the results of the fat content of the developed product with other cookies it can be concluded that developed barnyard millet cookies

contain less fat content due to different source of fat used for creaming during their production. Above discussed researchers have used hydrogenated fat and I have used butterin development of cookies.

Dietary fibre-

Barnyard millet cookies containing 40 g of millet flour , 25 g of sweet potato mash and 15 g of flax seed powder (T2) contain more fibre as compared to T1 and T3. The fibre content of T2 was 12% per 100g. cookies developed from 50% kudo millet and 50% wheat flour has fibre content of 4.30% per 100 g (Mitkal KT et al., 2021).

Carbohydrate-

In all of the three samples, T3 is heaving the highest amount of carbohydrates i.e. 64.32% whereas sample T2 contains less amount of carbs in it i.e. 61.63%. According to (Mitkal KT et al., 2021) their developed millet based cookies has carbohydrate % of 69.79% / 100 g. According to (P.L. Gopinath et al., 2014) barnyard millet cookies infused with mushroom flour has 62.76 % of carbohydrate in it.

pH-

The pH content in the finished product as found to be 7.1, 7.2 and 7 for T1, T2, and T3 respectively. The higher pH found to be 7.2 (T2) and lower pH 7 (T3). The pH value fluctuates because of the concentration of sweet potato mash used to make three different composition as the concentration is high in T2 hence has high pH value than the rest of two

i.e T1 and T3. According to FSSAI the ideal pH range of a biscuit is 7 - 7.5 .

Table 4 - Comparative study of the nutritionally rich formulation T2 with the other two cookies from the relevant study.

Parameters	Formulation no.2(T2)	Kudo millet and wheat flour cookies (Mitkal KT et al.,2021).	Barnyard millet cookies incorporated withmushroom (P.L. Gopinath etal., 2014)
Moisture	95 %	4.11%	3.47%
Ash	0.217%	-	0.75%
Protein	2 %	10.08%	10.31%
Fat	19 %	26.05%	27.48%
Dietary Fibre	12 %	4.30%	-
Carbohydrate	61.63%	69.79%	62.76%

4.   Conclusion -

Results obtained were satisfactory and the barnyard millet cookies showed good quality characteristics on Dietary fibre, moisture, Ash, Fat, Protein, pH, carbohydrate, and energy. T2 was the best formulation in terms of both sensory and physico-chemical analysis. It could be concluded that the most approved formulation T2 contained 2.95% moisture, 0.217% of ash, 5.2% of protein, 19% of fat, 12% of dietary fibre, 61.63% of carbohydrate, 438.32 kcal of energy and pH value of 7.2. Storage period revealed the cookies could be kept in LDPE packaging for three months with minimal degradation in sensory, nutritional, and textural qualities. Developed cookies are gluten free , rich in fibre , low in fat , it can be consumed by patients suffering from constipation, celiac and heart disease.

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