E-ISSN: 2790-6094
P-ISSN: 2957-4587

Journal Biological And Allied Health Sciences


# Development and Nutritional Assessment of Proximate Analysis of Ragi Flour Cookies as A Potential Dietary Intervention for Non-Communicable Diseases.

**Original Article**

Ayeza Imtiaz Khan[1], Rashida Perveen[2], Tabeen Irfan[2]

**ARTICLE INFORMATION**

**Corresponding Author:**

- **email**

**Affiliations:**

[1]Student of MS-Allied Health Sciences, Faculty of Allied Health Sciences, Superior University, Lahore.
[2]Faculty of Allied Health Sciences, Superior University, Lahore, Pakistan

**Keywords:** Finger millet, Ragi flour, diabetes, non-communicable disease, prevention, control, formulated cookies, Health benefits.

**ABSTRACT**

This study aimed to develop cookies enriched with ragi flour and oats flour to create a functional food for preventing non-communicable diseases like cardiovascular disease, diabetes, and cancer. This study offers a thorough grasp of the snack food market as well as potential areas for development. This research can show the potential of ragi flour as a novel component for snack food creation and non-communicable disease prevention by contrasting ragi cookies with currently available gluten-free or NCD-targeted snacks. Three formulations were developed, varying the ratio of ragi flour or oats flour: T1 (80% ragi flour, 20% oats), T2 (70% ragi flour, 30% oats flour), and T3 (60% ragi flour, 40% oats flour). Proximate analysis, conducted in accordance with the Association of Official Analytical Chemists (AOAC) standards, revealed that T2 exhibited the highest protein content. These cookies are evaluated for physical properties (breaking force, thickness, diameter, spread ratio), nutritional content (fiber, moisture, ash, fat, protein, carbohydrates, flavonoids, phenolics), and sensory attributes (flavor, color, texture, overall appeal) using a scale is 9-point hedonic scale. Results showed that increasing ragi flour enhanced the cookies' protein, carbohydrate, flavonoid, and phenolic content. While higher ragi concentrations (70%, 60%) improved nutritional value without compromising sensory acceptability, cookies with 80% ragi flour had a stronger flavor and thicker texture, reducing acceptability. These results showed that T2 contain protein 30.43 ±0.58 this rage of protein very beneficial as well as ragi cookies contain greater amount of phenolic content. the use of ragi flour cookies as a dietary intervention to reduce non-communicable diseases and inform public health practices and policy. These cookies provide benefits for public health as a dietary intervention for NCDs. They provide implications for population level and health promotion. This study concludes that ragi flour can enhance the nutritional quality of bakery products like cookies, making them suitable for individuals with non-communicable diseases, without negatively impacting their sensory appeal. Ragi cookies enhanced the bioavailability of essential nutrients includes fiber, iron, minerals. And also, better the gut health. The unique combination of antioxidants in ragi flour and oats flour and other ingredients in our cookies increased antioxidant activity, protecting against oxidative inflammation and stress.

**Introduction:**

In portions of India as well as eastern and central Africa, Ragi flour (finger millet) is a staple meal. That's high in iron, calcium, potassium, phosphorus, protein, fiber, and vitamin content. Its calcium level surpasses that of cereals, and iodine concentration is good for all food grains. Vitamin A, B, and Phosphorus are present in ragi along with the highest quality protein and necessary amino acids. Thus, ragi is a healthy food option for growing kids, diabetes, chronic diseases, expectant mothers, and the elderly and injured people. Ragi flour offers the highest concentration of antioxidants, calcium, and phytochemicals and make it rapidly or readily absorbed (1).

They are high in minerals like iron, calcium, and magnesium, as well as complex carbohydrates, proteins, dietary fiber, and vitamins like riboflavin, thiamine, and niacin. To further add to the health-promoting qualities of millets are a variety of antioxidants, phytochemicals, and bioactive substances (2). A factor contributing to millet's rising popularity is its gluten-free status. Grain proteins like rye, barley and wheat include gluten which can cause negative reactions in those who have celiac disease or gluten sensitivity. Millets don't contain gluten by nature. For people who must avoid gluten, millets offer a wholesome and safe substitute (3).

Ragi flour may be produced on a big scale to generate economies of scale, which lower the prices and boost its

competitiveness with other grains. Government subsidies and incentives to promote the production and processing of ragi it is possible to lower the cost and increase availability of ragi by offering the farmers and producers. The composition of macronutrient content in ragi flour includes 1.04% free sugars minerals 1.3% fat, 19.1% dietary fiber. 72.6% carbohydrates, 7.3% protein, 3.6%.,11.5% non-starchy polysaccharides. In ragi, 72% of carbohydrate is present in the form of starch, which is considered as the main constituent. Finger millet have around 44.7% essential amino acids. Finger millets have the lipid contents is 5.2%. Fat content in the form of free lipids is 1.3%. Finger millet grain has a low-fat content. Finger millet have total dietary fiber of 22% which is higher in comparison to the other grains. Employing ragi flour to create value-added products like drinks, baked goods and snacks. its value can be raised and its market appeal increased, allowing for a higher price point. Raising knowledge about ragi flour's cultural signific (4).

Raising knowledge about ragi flour's cultural significance in traditional cooking as well as its nutritional and health advantages can aid in overcoming cultural obstacles and promoting adoption. Enhancing the routes of distribution and availability, including internet platforms and retail establishments can make ragi flour more widely available. Ragi is regarded as the perfect food for those with NCDs and diabetes diseases. Diabetes is one of the most prevalent health concerns in a worldwide. Diabetes is an illness of carbohydrates metabolism which enhance the blood glucose level chronically due to insulin's impaired secretion. There are two types of diabetes type I and type II. The development of type 2 diabetes can be accelerated by unhealthy lifestyle choices such as inherited illnesses, inactivity, imbalanced diet, inactivity and stress. The first stages in managing the type 2 diabetes are including the meal planning, weight loss and exercise. Should try to eat that type of foods which cannot increase the blood sugar levels quickly. Peoples should try to use low glycemic foods in their diets (5).

Ragi flour is a gluten-free cereal that can regulate blood sugar levels. Every age group enjoys cookies, and if they include qualities for promoting the health such a low GI it helps to regulate the blood sugar and they might be classified as functional foods. To create the gluten-free cookies with a higher fiber content and a lower GI. Ragi flour is a raw ingredient that can be used to make cookies. The primary advantage of using ragi flour as a food ingredient is that it has more dietary fiber as compared to other grains, which is beneficial for those who have diabetes. Therefore, it is anticipated that cookies prepared with ragi flour was have a low GI value and help to regulate the blood glucose. Ragi has a high magnesium content, which promotes insulin sensitivity, decreases insulin resistance, and aids in the synthesis of insulin. Furthermore, compared to wheat and other grains, the flour itself results in a smaller surge in blood sugar (6).

According to this health advantages of goods made from ragi have been the subject of numerous studies. By enhancing lipid profiles and lowering cholesterol, ragi-based bread was found to minimize the risk of cardiovascular disease (21). It has been demonstrated that ragi-based products contain immunomodulatory properties that can strengthen the immune system. A ragi-based diet enhanced immunological function and decreased infection risk in mice, according to a study. Ragi-based fermented foods enhanced human immunological function and boosted antibody production, according to another study (22).

CVD is a chronic non-communicable illness that ranks among the leading causes of death and disability. The global prevalence of CVD incidents is growing. To lower the rising CVD and associated causing factors, public health agencies around the world have focused on reducing modifiable CVD risk factors such as dyslipidemia, HTN, poor diet, and obesity. A high-fat, high-calorie diet can lead to dyslipidemia and endothelial dysfunction (7).

Previous research has shown that phenolic acids and phenolic acid-rich finger millet extracts have powerful antioxidant and anti-inflammatory properties. However, the capacity of these fractions to limit cancer cell proliferation, as well as the molecular. Finger millet is crucial not only for assessing health benefits but also for recommending this finger millet variety for treating various disorders caused by inflammation and oxidative stress. Secondary metabolites of millets, such as flavones, phenolic, and flavonoids, are known for their capacity to inhibit incitive responses and prevent illnesses caused by oxidative stress (8). Main objectives of this study to prepare cookies by using ragi flour as the main ingredient and determine which bioactive compounds are present in ragi flour cookies and also evaluate the sensory properties of these cookies.

**Materials and Methodology**

Over the course of four months, the research was carried out. The Culinary Lab at Superior University in Lahore handle all cookie formulations and baking operations. They used standardized equipment and procedures to ensure consistent preparation methods. To ensure that all ingredients are both easily accessible and freshly harvested, we shopping at Lahore's markets for ragi flour, oats flour, and other necessities.

**Place of work:**

Faculty of Allied Health Sciences, Superior University Lahore Culinary Lab, and pharmacy lab.

**Study Design:**

Experimental study.

**Duration of Study:**

The study was completed within 4 months after the approval of the synopsis from institutional review board committee.

**Procurement of Raw Materials:**

We purchase every item for the cookie recipe from the local marketplaces in Lahore. This includes any additional ingredients that may be required, such as sugar, ragi flour, and oat flour. Local sourcing ensures freshness and accessibility while also reflecting the typical ingredients that people can purchase.

**Preparing the ragi flour cookies samples:**

Cookies are prepared by accurate weighing of ragi flour with other ingredients vegetable oil, sugar, sodium chloride, baking soda, baking powder, Elechi, oats flour, Milk all the ingredients are mixed well. In simple cookies preparation prepare a dough, dough preparations we mix all the ingredients and blend**.** Kept the dough for 2-3 mints for improve the texture and thickness (9). After that, the cookies were rolled out into uniformly sized rounds and baked for 20 minutes at 180℃ in a preheated oven.

E-ISSN: 2790-6094
P-ISSN: 2957-4587



Next, after taking the cookies out of the oven, they were be allowed to cool until they reach room temperature. After that, put the cookies in an airtight glass container to keep them fresh. These cookies were prepared in three different samples with different percentages of ragi flour its T1, T2, T3. There were be nutritional, sensory, physical, and chemical evaluations of the cookies.

**Table 1 Research layout: Specific % for formulation**

| T⁰ | T1 | T2 | T3 |
|---|---|---|---|
| 100% wheat flour cookies | 80% ragi flour and 20% oats flour cookies | 70% ragi flour and 30% oats flour cookies | 60% ragi flour cookies and 40% oats flour |

**Table 2. Formula used in cookies preparation (AACC, 2002):**

| Ingredients | Amount (g) |
|---|---|
| Ragi flour | 80 |
| Oat's flour | 20 |
| Sugar | 25 |
| Vegetable oil | 20 |

**Course of treatment**

**How ragi cookies affect the body's physiology:**

Using the AOAC technique (2002), we measure the following components of ragi flour cookies: moisture, dietary fiber, protein, fat, carbohydrates, and ash. The bioactive ingredients in Moringa cookies are:

The spectrophotometric approach was be employed to measure the content of polyphenols (10). Total flavonoid content: Was measuring the flavonoid content using the spectrophotometric technique (11).

**Physical assessment:**

Sensory evaluation was carried by 10 untrained panelists. They attribute the sensory evaluation of the ragi flour cookies were be assessed by using a 9-point hedonic scale, with an emphasis on colour, flavour, texture, and overall attractiveness. Participant ratings range from 1 (strongly dislike) to 9 (strongly like), offering a quantitative assessment of consumer tastes and sensory acceptability. The sensory impact of varying quantities of ragi flour in the cookie formulations can be better understood using the data collected. The impact of ragi and oats flour on the cookies' appearance and texture can be better understood with the help of an objective analysis of certain parameters pertaining to sweetness and texture are conducted. Ethical clearance was obtained from Superior University Lahore Ethics Committee because sensory evaluation is part of research (12).

The sensory and nutritional properties of the cookies are evaluated in four treatments that include different amounts of ragi flour. T0, the control group, is a typical wheat cookie without ragi flour and contains zero ragi flour. There is 80% ragi flour in Treatment T1, 70% in Treatment T2, and 60% in Treatment T3. In order to find the sweet spot for nutritional advantages and sensory appeal, the study was gradually increasing the ragi content of the cookies and see how it changes the nutritional value, flavor, texture, and acceptability.

**Statistical Analysis:**

The data of this study was analyzed by SPSS software 26.0. All generated data were analyzed by (CRD) design by using ANOVA. Differences between means was determined by the least significant difference test, and significance was defined at $p<0.05$. All measurements were carried out in triple times.

**RESULTS**

**Table 3 Extraction of different treatments of carbs, proteins, ash, fiber, fats,**

| Parameters | Carbs(g) | Moisture (%) | Ash (%) | Protein(g) | Fat(g) | Fiber (%) |
|---|---|---|---|---|---|---|
| T⁰ | 43 | 3 | 1.90 | 30.5 | 14 | 3.8 |
| T1 | 43.87 ±0.62 | 3.88 | 1.99 | 21.78 ±0.73 | 13.98 ±0.19 | 3.2 |
| T2 | 52.13 ±0.31 | 3.33 | 1.60 | 30.43 ±0.58 | 14.49 ±0.47 | 3.5 |
| T3 | 47.33 ±0.29 | 4.1 | 1.4 | 23 ±0.62 | 12.73 ±0.67 | 1.6 |

The nutritional analysis of the control cookie sample (T0), which contains no ragi flour, revealed the following composition per 100 grams: 43grams of total carbohydrates, 3 grams of moisture, and 1.99 grams of total ash. The crude fiber content was measured at 3.8 gram, with crude protein at 30.58 grams and crude fat at 14 grams. The sample analysis revealed the following nutritional composition per 100 grams: 43.87 grams of total carbohydrates, 3.88 grams of moisture, and 1.99grams of total ash. Crude fiber content was measured at 3.2 grams, while crude protein 21.78grams and crude fat were found to be 13.98 grams respectively. The nutritional analysis of the sample per 100 grams indicated 51.23 grams of total carbohydrates, 3.6 grams of moisture, and 1.6 grams of total ash. Crude fiber content was measured at 1.7 grams, with crude protein at 30.43 grams and crude fat at 25 grams. The nutritional analysis of the sample cookies indicated a carbohydrate content of 47.33g per 100 g, with moisture at 4.1 g per 100 g, reflecting the product's hydration level. The total ash level was quantified 1.4 grams. The crude fiber, vital for digestive health, was 2.0 g. The crude protein content, essential for bodily repair and growth, was notably high at 23.21g whilst the crude fat was measured at 12.73 g, enhancing the energy density of the cookie. Mineral analysis showed calcium at 76 mg and iron at 74mg while the total phenolic content was recorded at 161mg of gallic acid equivalents (GAE), flavonoids were recorded 125mg. Each parameter was determined using standardized methods, ensuring consistent and reliable measurements. The mineral analysis showed calcium at 55.21 mg. Additionally, the total phenolic content was recorded at 143.87mg and total flavonoids content was recorded 118.98mg of acid equivalents (GAE). Mineral analysis showed calcium at 30.43 mg. The total phenolic content was recorded at 161.43mg and flavonoids 125.34mg of gallic acid equivalents (GAE). The mineral composition included calcium at 76 mg, so augmenting the nutritious value. The total phenolic content was measured at 154.98 mg and total flavonoids content was recorded 121.67mg of GAE per 100g, indicating possible antioxidant characteristics. Each measurement was conducted

using established AOAC methods or Chemical Analysis of Food by Pearson. Each parameter was determined using established AOAC methods or the Chemical Analysis of Food by Pearson.

**Figure 1: Carbs**

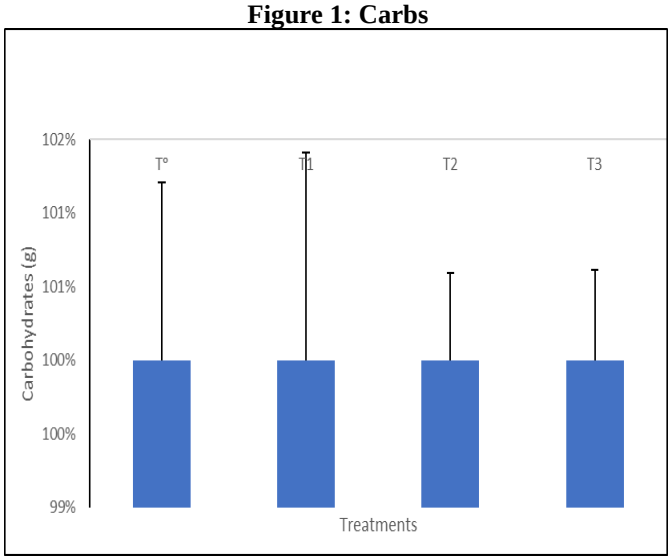



**Figure 2: Moisture**

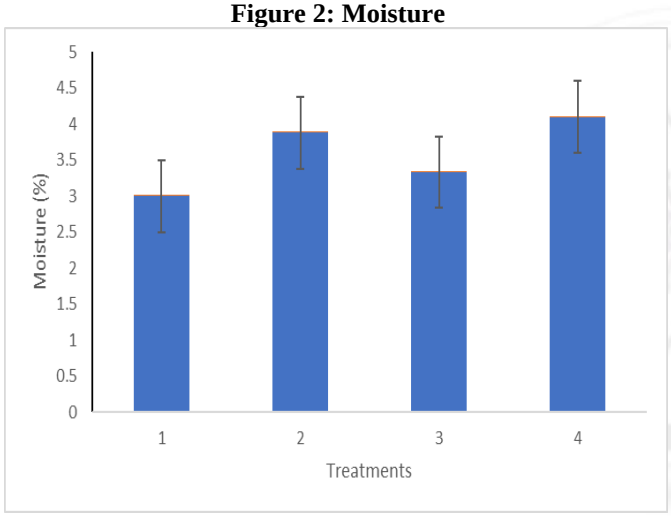



**Figure 3: Ash**

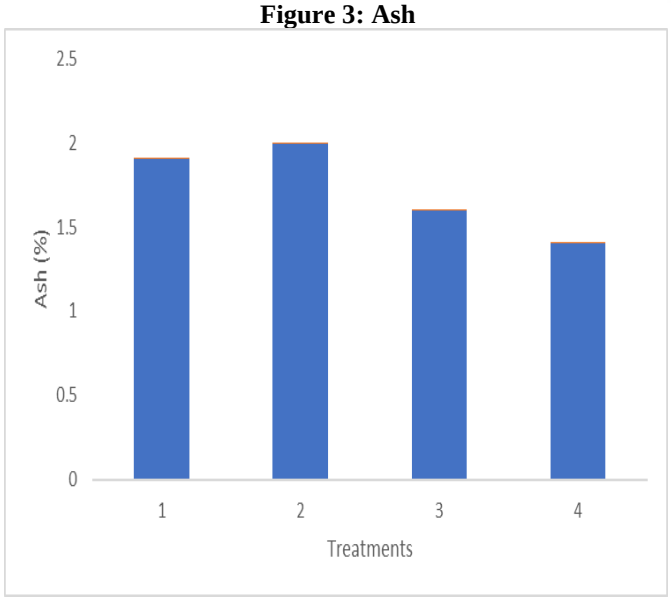



**Figure 4: Protein (g)**

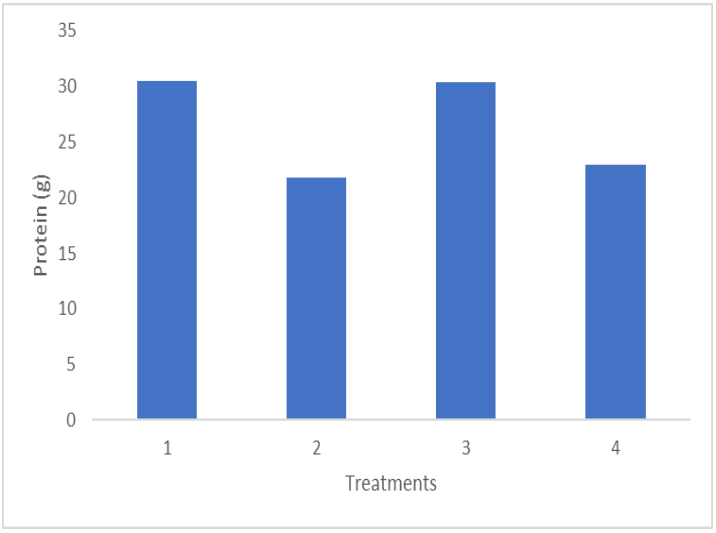



**Figure 5: Fat (g)**

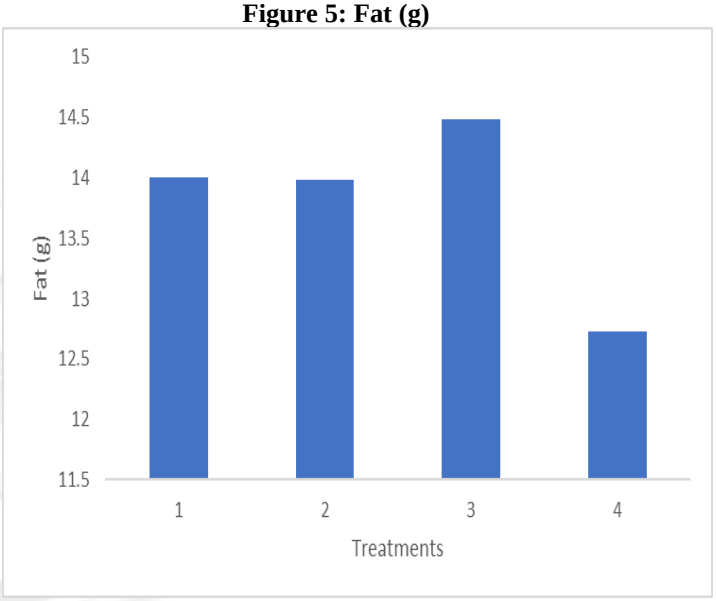
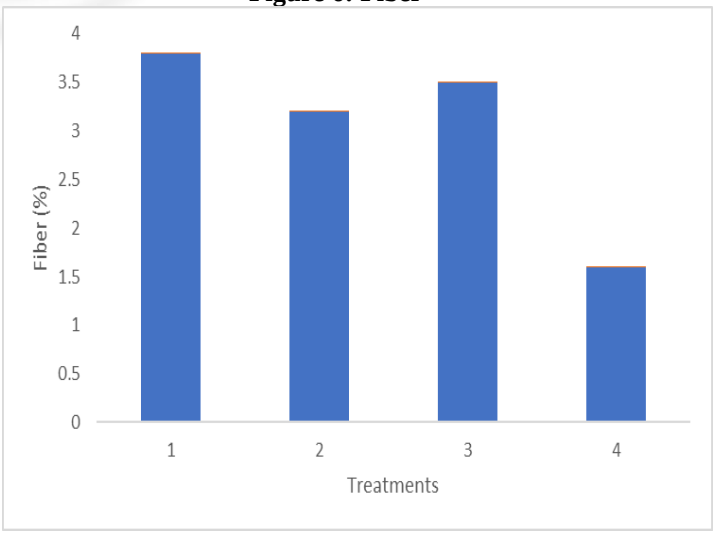



**Figure 6: Fiber**




**Sensory:** The sensory assessment of cookies enriched with ragi flour cookies demonstrated a significant trend in acceptance correlating with increasing ragi flour concentrations. The control cookies (wheat cookies are without ragi flour) achieved elevated scores in all sensory aspects, with overall

E-ISSN: 2790-6094
P-ISSN: 2957-4587



acceptability, color, taste, flavor and texture ranked near the maximum of 9. Cookies containing 80 % ragi flour exhibited a moderate reduction in color, taste, flavor, and texture, although overall acceptance remained very high. Cookies containing 70% ragi flour exhibited great acceptability, with marginally superior flavor and overall acceptability scores relative to the control, indicating that minimal ragi flour fortification boosts sensory appeal. At 60% ragi flour, sensory scores decreased further, with notable reductions in flavor and texture, suggesting that elevated ragi flour concentrations may diminish consumer attractiveness. The Least Significant Difference (L.S.D) values indicate that these sensory differences are statistically significant at 0.05 level.

**Table 4. Effect of ragi flour fortification on sensory evaluation of ragi cookies**

| Samples | Color (9) | Taste (9) | Flavour (9) | Texture (9) | Overall Acceptability (9) |
|---|---|---|---|---|---|
| **T⁰** (Control cookies) | 8.1a | 8.2a | 7.6a | 7.5a | 7.8a |
| Cookies with 80% FM **T1** | 7.5a | 6.6b | 7.1a | 5.5c | 7.1a |
| Cookies with 70% FM **T2** | 8.3a | 8.1a | 7.9a | 8.4a | 8.9a |
| Cookies with 60% FM **T3** | 6.5c | 7.1a | 5.5c | 6.7c | 6.8c |
| L.S. D | 1.5 | 1.2 | 1.3 | 1.1 | 0.9 |

The data shows that Treatment 2 (T2) received the highest scores across all sensory attributes, with taste at 8.7± 0.47, texture at 8.8 ± 0.47, color at 8.9 ± 0.35, appearance at 7.7 ± 0.64, and smell at 8.5 ± 0.4, suggesting it was the most preferred overall. Treatment 1 (T1) followed, with relatively high ratings in all categories but notably lower than T2, especially in appearance and smell. Treatment 3 (T3) had a moderate acceptance level, with scores lower than T2 and T1, particularly in texture. Treatment 0 (T0) consistently scored the lowest across all attributes, indicating the least favorable sensory profile. This analysis suggests that T2 offers the best combination of sensory qualities among the treatments tested.

**Table 5. Sensory Evaluation among different Treatments**

| Treatment | Taste | Texture | Colour | Appearance | Smell |
|---|---|---|---|---|---|
| **T0** | 7.54 ± 0.58 | 7 ± 0.84 | 7.1 ± 0.47 | 7.44 ± 0.41 | 7.15 ± 0.66 |
| **T1** | 7.1 ± 0.52 | 7.61 ± 0.43 | 7.72 ± 0.53 | 7.02 ± 0.67 | 7.02 ± 0.44 |
| **T2** | 8.92 ± 0.58 | 8.1 ± 0.74 | 8.9 ± 0.55 | 8.76 ± 0.64 | 8.37 ± 0.52 |
| **T3** | 6.66 ± 0.26 | 5.82 ± 0.5 | 6.34 ± 0.37 | 6.06 ± 0.33 | 7.5 ± 0.4 |

**Figure 7 BSA standard curve for protein analysis**

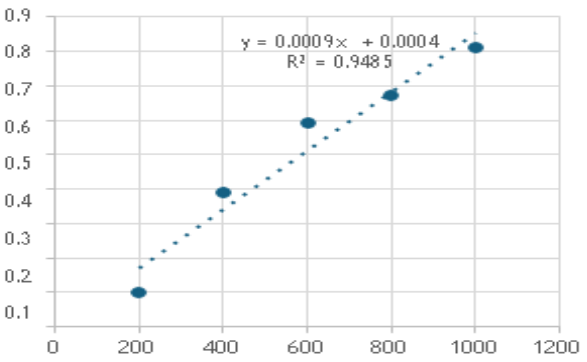
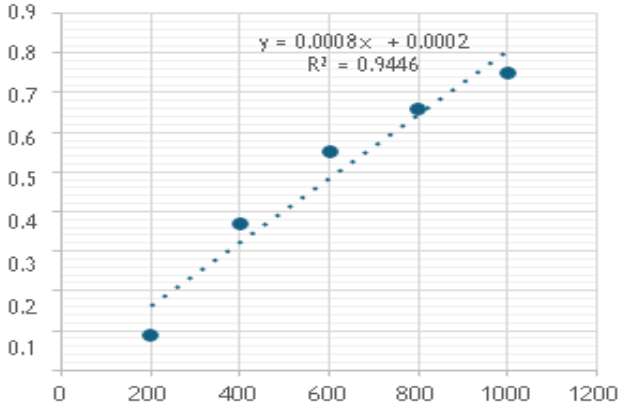



**Figure 8 Glucose standard curve**




Investigating the development and evaluation of ragi flour and oats flour cookies as a potential weapon against non-communicable diseases, the study compares the absorbance graphs of samples T0, T1, T2, and T3 at different BSA (Bovine Serum Albumin) concentrations, revealing notable variations in protein content. Increasing the quantity of BSA resulted in a consistent rise in absorbance across all samples, indicating an increase in the protein content, which is crucial for nutritional value. The absorbance values of T0 (control) were lower than those of T1, T2, and T3, suggesting that the inclusion of ragi flour and oats flour in these formulations increased protein levels. T2 stood out with its maximum absorbance, indicating the perfect combination for protein enrichment. Cookies made with ragi flour and oats flour have the makings of a healthy nutritional intervention for everyone, according to this trend.

**Discussion:**

The high phenolic content and flavonoids contents concentration was found in the 70% of FM flours included cookies but concern to acceptability of the customer 70% of integrated cookies was preferred by all the age groups. Ragi flour fortified cookies contain larger percentage of moisture, ash, fat, protein, fiber and also rich in calcium, antioxidants carbohydrates, and phenolics compared to the control cookies Similar findings were observed by Bacchetti (3). In addition, ragi flour contains larger amount of iron content. So, eating of FM (ragi flour) cookies helps to reduce the non-communicable diseases and other iron deficiency associated diseases. The sensory features were examined to analyses the average preference of the evaluators to FM (ragi flour) integrated cookies. This examination also carried without any alteration of 9-point hedonic scale. The scores were awarded to each characteristic such as colour, look, texture, taste and aroma from highest point 9 (like highly) to the lowest point 1 (dislike excessively) Similar findings were observed by GK Rana (10). This study also attempted to analyze the heterogeneity nature in the consumer preference. Moreover, FM included cookies preference to different age group was also examined by sensory analysis. This study studied the nutritive status of the FM flour cookies. The FM flour contains greater amount of essential alpha amino carboxylic acids like leucine and methionine. FM flour which is combined into cookies to provide huge health benefits from younger to elder and to manage non-communicable dieses for upcoming health issues Similar findings were observed by Nancy j thics at e (13,14). FM intake has been demonstrated to have a number of positive health impacts. No research has looked into the relationship between

FM use and diet-induced obesity and associated changes. According to this research, eating WG low in glycemic index or following a diet enhanced with FM is more effective at preventing weight gain Similar findings was observed by Nida Murtaza at e (23).

**Proximate composition of finger millet flours:**

Food stability and quality, as well as the prediction of food behavior during preparation, consumption, and storage depend on the estimation of moisture content and total solids Similar findings was observed by Awuchi at e (15). The FM cookies had 4.1 ±3.6 % moisture. Following baking, the components lose moisture, which lowers the finished product's moisture content as a measure of the moisture of finger millet cookies Similar findings was observed by Salunke at e (16). Consequently, its low moisture content allows it to be stored at room temperature, reducing the risk of microbial and fungal infections. Proteins have metabolic and structural functions in addition to influencing food's nutritional content, texture, and sensory appeal Similar findings were observed by Awuchi at e (15). The amount of protein found in optimized cookies was 30.43 ±0.58 %, which is comparable to the amount calculated using in control group Similar findings were observed by Eneche (17). In ether, chloroform, and other organic solvents, are class of compounds called lipids dissolves more readily than in water Similar findings were observed by Awuchi Chinaza (17). Butter was added to the recipe, resulting in a fat level of 14.49 ± 0.47 g/100grams, which is comparable to estimate. Lipids gives a product tenderness and helps to improve its texture, which makes it more consumer-friendly and edible Similar findings were observed by Florence Suma at e (18). The overall number of mineral components in food is indicated by its ash content Similar findings were observed by Awuchi at e (15). The measured ash of FM was 1.9 ± 1.4 g/100 g. Use baking soda for leavening agent in the formulation or bake it in high temperature may be the cause of the 1.6 g/100 g rise in ash from individual raw ingredients to the finished product, as determined by IFCTs. A high ash level in cookies may indicate that there are a lot of minerals in cookies Similar findings were observed by Eneche (17). Crude fiber, or the residue left over after acid-alkali digestion, was 3.5. ± 1.6 g/100 g for FM. Among other illnesses, it helps prevent diabetes, colon cancer, and heart disease. The risk of colon cancer is decreased by crude fiber because it lowers intracolonic pressure and the rate at which blood glucose is absorbed Similar findings were observed by E.C. Omah (20). The difference approach yielded 52.23 ± 0.21 g/100 g of carbohydrates, which is similar to the 53.472 g/100grams predicted value for raw materials. Given that cookies are high in carbs, which give the body energy while sparing protein, they may be a good way to treat non communicable disease. Proteins are utilized for fundamental function formation and repairing the damaged tissues rather than as a source of energy. There should be a lot of carbohydrates in breakfast meals and weaning formulae. As a result, these cookies could be utilized for every meal time Similar findings were observed by Salunke at e (20).

**Conclusion:**

Nutritional analysis of formulated ragi flour cookies with oats flour showed that the cookies contain rich amount of carbohydrates, protein, ash, fats, fiber, calcium, iron, flavonoids phenolic content and antioxidants, while low in fat. These cookies enhance the dietary fiber and carbohydrates, they provide adequate energy. Diets frequent in carbs and minor in fat can help you lose weight by controlling your cholesterol levels. The cookies' high iron content was help fight iron-deficient anemia, particularly in women and small children. While the cookies' high calcium content was aid in the development of stronger bones, their higher percentage of phytochemicals was offer anti-oxidant, anti-aging, and anti-inflammatory qualities. The developed cookie was now be able to help a greater number of people, from kids to working adults. Future researches will focus on determining the best dosage and relative effectiveness of ragi-based products, as well as performing clinical trials to verify health claims. Furthermore, research on storage stability including shelf-life and safety of ragi flour goods. Encourage the adoption and consumption of sustainable agriculture, especially among populations that are more susceptible, and aid to improve health and nutrition results. Using the availability and affordability of ragi, a drought-resistant crop, the creation of ragi flour cookies offers a financially viable dietary intervention for diabetes and NCDs. Scalability from tiny personal kitchens to massive industrial bakeries is made possible by the straightforward production method. Ragi's consistent supply, market demand fueled by awareness campaigns, effective distribution networks, and government and non-governmental organization backing are all essential components for scalability. Significant improvements in public health, a decrease in the incidence of diabetes and other NCDs, and economic stimulation through sustainable livelihoods for small-scale producers and farmers are some of the wider effects. Ragi flour cookies can be made more widely available and nutrient-dense for disease prevention and nutritional enhancement by taking care of these issues.

**REFERENCES:**

1. Nakarani UM, Singh D, Suthar KP, Karmakar N, Faldu P, Patil HE. Nutritional and phytochemical profiling of nutracereal finger millet (Eleusine coracana L.) genotypes. Food Chemistry. 2021 Mar 30; 341:12827.
2. Asrani P, Ali A, Tiwari K. Millets as an alternative diet for gluten-sensitive individuals: A critical review on nutritional components, sensitivities and popularity of wheat and millets among consumers. Food reviews international. 2023 Aug 18;39(6):3370-99.
3. Saturni L, Ferretti G, Bacchetti T. The gluten-free diet: safety and nutritional quality. Nutrients. 2010 Jan 14;2(1):00016-34.
4. Jagati P, Mahapatra I, Dash D. Finger millet (Ragi) as an essential dietary supplement with key health benefits: A review. International Journal of Home Science. 2021 May;7(2):94-100.
5. Zhang S, Hu J, Sun Y, Ji H, Liu F, Peng X, Zhong Y, Geng F, Nie S. In vitro digestion of eight types of wholegrains and their dietary recommendations for different populations. Food Chemistry. 2022 Feb 15; 370:131069.
6. Schmulson MJ, Drossman DA. What is new in Rome IV. Journal of neurogastroenterology and motility. 2017 Apr;23(2):151.
7. Hedayatnia M, Asadi Z, Zare-Feyzabadi R, Yaghooti-Khorasani M, Ghazizadeh H, Ghaffarian-Zirak R, Nosrati-

Tirkani A, Mohammadi-Bajgiran M, Rohban M, Sadabadi F, Rahimi HR. Dyslipidemia and cardiovascular disease risk among the MASHAD study population. Lipids in health and disease. 2020 Dec; 19:1-1.
8. Azamjah N, Soltan-Zadeh Y, Zayeri F. Global trend of breast cancer mortality rate: a 25-year study. Asian Pacific journal of cancer prevention: APJCP. 2019;20(7):2015.
9. Rana GK, Mishra SP, Duggal A, Shukla SS, Singh NK, Rahangdale HK. Proximates and Sensoric attributes of sprouted Ragi flour (SRF) supplemented cookies. The Pharma Innovation Journal. 2021;10(10):2432-5.
10. Ruel-Bergeron JC, Stevens GA, Sugimoto JD, Roos FF, Ezzati M, Black RE, et al. Global update and trends of hidden hunger, 1995-2011: The hidden hunger Index. PLoS One. 2015 Dec 1;10(12).
11. Chemists AO. Association of Official Analytical Chemists (AOAC) Official methods of analysis. AOAC Washington, DC, USA. 2004.
12. Mutshinyani M, Mashau ME, Jideani AI. Bioactive compounds, antioxidant activity and consumer acceptability of porridges of finger millet (Eleusine coracana) flours: Effects of spontaneous fermentation. International Journal of Food Properties. 2020 Jan 1;23(1):1692-710.
13. Thiex NJ, Anderson S, Gildemeister B. Crude fat, diethyl ether extraction, in feed, cereal grain, and forage (Randall/Soxtec/Submersion method): Collaborative study. J AOAC Int. 2003;86(5):888–98.
14. Ruel-Bergeron JC, Stevens GA, Sugimoto JD, Roos FF, Ezzati M, Black RE, et al. Global update and trends of hidden hunger, 1995-2011: The hidden hunger Index. PLoS One. 2015 Dec 1;10(12).
15. Twinomuhwezi H, Awuchi CG, Rachael M. Comparative study of the proximate composition and functional properties of composite flours of amaranth, rice, millet, and soybean. American Journal of Food Science and Nutrition. 2020;6(1):6-19.
16. Salunke P, Chavan U, Kotecha PM, Lande SB. Studies on nutritional quality of barnyard millet cookies. Int J Chem Sci. 2019;7(4):651-7.
17. Eneche EH. Biscuit-making potential of millet/pigeon pea flour blends. Plant foods for human nutrition. 1999 Mar; 54:21-7.
18. Godswill AC. Proximate composition and functional properties of different grain flour composites for industrial applications. International Journal of Food Sciences. 2019 Nov 19;2(1):43-64.
19. Florence Suma P, Urooj A, Asha MR, Rajiv J. Sensory, physical and nutritional qualities of cookies prepared from pearl millet (Pennisetum typhoideum). J Food Process Technol. 2014;5(377):2.
20. Omah EC, Okafor GI. Selected functional properties, proximate composition of flours and sensory characteristics of cookies from wheat and millet-pigeon pea flour blends. Pakistan Journal of Nutrition. 2015 Sep 1;14(9):581.
21. Reddy et al, Ragi-based bread reduces cardiovascular disease risk by lowering cholesterol levels and improving lipid profiles. Journal of Food Science and Technology, 2018 55(2), 539-546.
22. Kumar et al. Ragi-based porridge improves glycemic control and reduces the risk of type 2 diabetes in patients with impaired glucose tolerance. Journal of Nutrition and Metabolism, 2019 25, 1-9.
23. Murtaza N, Baboota RK, Jagtap S, Singh DP, Khare P, Sarma SM, Podili K, Alagesan S, Chandra TS, Bhutani KK, Boparai RK. Finger millet bran supplementation alleviates obesity-induced oxidative stress, inflammation and gut microbial derangements in high-fat diet-fed mice. British journal of nutrition. 2014 Nov;112(9):1447-58.

**CONFLICT OF INTEREST**

Authors declared no conflict of interest, whether financial or otherwise, that could influence the integrity, objectivity, or validity of their research work.

**GRANT SUPPORT AND FINANCIAL DISCLOSURE**

Authors declared no specific grant for this research from any funding agency in the public, commercial or non-profit sectors

**DATA SHARING STATEMENT**

The data that support the findings of this study are available from the corresponding author upon reasonable request



JBAHS web address: www.jbahs.pk
Email address: editor.jbajhs@superior.edu.pk