Article ID 240203-S-11

Development of Innovative Gluten-Free Cookies: Enhancing Flavour and Nutrition

Krishnamurthy Ramyashree[1], Nagesh Raksha[1], Takkalaki Saniyaanjum[1] and Madalageri Deepa[2]

[1]MSc FND 2nd year, Department of Food Technology, Ramaiah University of Applied Sciences,

[2] Assistant Professor, Department of Food Technology, Ramaiah University of Applied Sciences

*Corresponding Author: ramyashree650@gmail.com

In recent years, the demand for gluten-free products has witnessed a substantial surge, driven by both health-conscious consumers, especially individuals with gluten intolerance or celiac disease. The rise in non-communicable diseases such as diabetes, obesity, gluten sensitivity, and cardiovascular issues is a growing global trend. Studies show that limited consumption of gluten is linked to a reduced risk of type 2 diabetes in generally healthy in men and women *(Zong G, et al.2018)*.

To address this concern, it's becoming essential to create nutraceutical foods that are both gluten-free and rich in fiber. One area that has seen significant innovation is the development of gluten-free products. Cookies are one of the best-known snack products *(Farheena et.al, 2015)*. They are nutritive snack produced from unpalatable dough that is transformed into appetizing product through the application of heat in an oven (Olaye *et al.*, 2007). Cookies hold immense global significance among bakery products, serving as vital snacks for both children and adults (Hussain et al., 2000). Precisely, gluten-free cookies are crafted to meet the dietary needs of those who must avoid gluten while also appealing to the taste preferences of the broader consumer base. Here we explore the journey of formulating and perfecting gluten-free cookies, focusing on ingredient selection, baking techniques, sensory quality, and nutritional value.

Through extensive research and examination, our goal is to present a delightful cookie with banana flour, arrowroot powder, papaya seed powder, and activated nuts and oil seeds as main ingredients that offers numerous benefits.

Unripe banana flour contain dietary fibre (DF) for human health and the chemical composition of banana varieties depends on the ripening state. The functional components can be beneficial for human health like reducing high level of cholesterol, constipation, diverticulitis and even colon cancer *(Bezerra,2013)*. *Acevedo, 2012* stated that banana flour may be helpful in control of diabetes, as it is rich in indigestible carbohydrates that cooperate with adequate glycaemic to response. Banana flour, known for its low lipid and high starch content, contributes to the cookie's texture and structure while offering a nutritional boost *(Juarez Garcia, e. et al. 2006)*. Arrowroot powder acts as a binding agent, enhancing the cookie's consistency and aiding in its gluten-free nature *(Amante, 2020)*. Papaya seeds which are sometimes disregarded, offer a distinct nutty flavour and aids digestion with papain, potentially combating infections due to antimicrobial properties *(Shaistha Saba, 2022)*. Additionally nuts and oil seeds are involved in a process called activation which aims to enhance their nutritional value and reduce anti-nutrients *(Yadav, et al., 2019)*. Mainly the use of flax seeds whose significance lies in human nutrition as a vital functional food ingredient rich in active compounds like omega-3, lignans, and proteins, offering health benefits against chronic diseases *(Bernacchia R, et al. 2014)*. Hence, with this choice of ingredients the product will be developed.

Materials and Methods

The present investigation was undertaken during the year 2023 in the Department of Food Technology, M.S. Ramaiah University of Applied Sciences. The study focuses on innovatively developing cookies by incorporating specific ingredients—banana flour, arrowroot powder, papaya seeds powder, and activated nuts and seeds.

Ingredients and equipments

The research requires sourcing banana flour and coconut sugar online, while arrowroot powder from Mangalore. Nuts, seeds, leavening, and flavouring agents are from Kwality Big Bazaar, Choco chips from Nilgiris, and papaya seeds from Amul Café. Production necessitates equipment like a

weighing scale, pan, spatula, mixing bowl, mortar and pestle, food dehydrator, baking oven, cups, plates, measuring spoons, and baking trays for precise and efficient processing.

Nutritional Enhancement of cookies

Enhancing the flavour and nutritional value of cookies involves incorporating a blend of sunflower seeds, sesame seeds, pumpkin seeds, almonds, and papaya seeds. Sunflower seeds provide a nutty essence and vitamin E, while sesame seeds contribute richness, calcium, and healthy fats. Pumpkin seeds offer texture and are rich in magnesium and zinc, complementing the protein and healthy fats from almonds. Additionally, the inclusion of papaya seeds brings potential digestive benefits through their enzyme content. Activating the nuts and oilseeds further increases their nutrient value and removes anti-nutritive factors, ensuring a delicious and nourishing cookie experience. (Luo, et al., 2018).

Preparation of raw materials

Preparation of activated nuts and oil seeds

Nuts and oil seeds undergo a process known as activation, designed to boost their nutritional content while diminishing anti-nutritional factors (Yadav et al., 2019). The almonds, sesame seeds, sunflower seeds, and pumpkin seeds are selected for activation. Seeds or nuts are soaked in water for 8 hours with the addition of 5 g salt per 250 g seeds. After draining and tapping with muslin cloth, seeds undergo 8 to 12-hour dehydration at 55 °C – 60 °C in a food dehydrator. This crucial step removes moisture, aiding preservation and preventing harmful microorganism growth.

Preparation of Papaya seeds powder

Papaya seeds are separated, washed, and then dehydrated in a food dehydrator for 8 to 12 hours at 50 °C. The dried seeds are ground into powder and stored airtight for use.

Roasting of flours and nuts and oilseeds

Flax seeds, almonds, pumpkin seeds, sunflower seeds, sesame seeds, banana flour, and arrowroot powder were roasted to enhance their flavour and texture, with flax seeds ground into a powder and soaked with cinnamon for 15-20 minutes, while the rest were briefly roasted for around 2 minutes to eliminate any raw undertones, enhancing the overall taste and making them more palatable. The combination of roasting and soaking improves the digestibility and nutrient absorption.

Method of Preparation

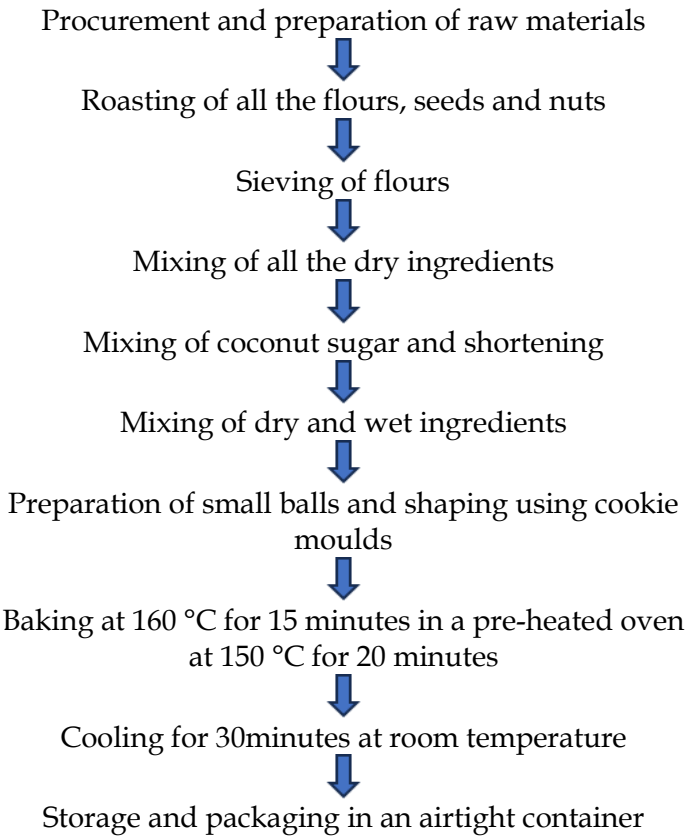

Fig. 1 Flow sheet for preparation of cookies

Sensory evaluation

A semi-trained panel of 21 individuals from M.S. Ramaiah University conducted sensory evaluation using a 9-point hedonic scale. The panel assessed appearance, aroma, texture, and taste, providing subjective feedback. This process determined the optimal combination of ingredients and proportions for cookies, refining them for palatability and consumer acceptance. The evaluation guided recipe optimization, ensuring the final product met both nutritional and sensory goals. Thus, the sensory evaluation was crucial in creating gluten-free, nutrient-rich cookies that excel in taste and overall consumer satisfaction. (Ranganna,1986)

Physio-chemical analysis

Physio-chemical analysis is a critical aspect of scientific research, providing a comprehensive understanding of the physical and chemical properties

of substances. This methodological approach involves the examination of various parameters. In the context of this study, physio-chemical analysis serves as a fundamental tool for evaluating the characteristics of the innovative cookie ingredients—banana flour, arrowroot powder, papaya seeds powder, and activated nuts/seeds (Marta Igual.et.al., 2022).

Weight

The Weight of the cookies was determined by taking ten individual cookies were weighed using the digitalized sensitive balance average was calculated and expressed in grams (g).

Diameter

Diameter (D) was measured by arranging six cookies in a row, touching each other. The combined width was measured in millimetres with a ruler. This process was repeated twice, turning the cookies 90 degrees each time, and the average diameter was recorded.

Thickness

The thickness (T) was determined by stacking six cookies on top of each other. Using a ruler, the combined height of the cookies was measured in milli meters. This process was carried out again to obtain an average value, and the results were reported in milli meters.

Spread factor

The spread factor (SF) was determined from the diameter and thickness ratio.

SF = diameter/thickness

Nutritional analysis

The moisture, total fat, protein, total dietary fibre, crude fibre, ash and energy contents were determined by testing in the Pristine laboratory. 1300 g of cookies packaged in a zip lock pouches and sealed were submitted to the laboratory on 18/11/2023 for testing.

Texture analysis

Cookies underwent textural analysis using a Texture Analyzer (TA-XT2). Hardness, the maximum force before breakage, was measured with an HDP/BSK blade set. Settings for hardness measurement were adjusted according to the application guide. The probe was calibrated and then a test was run by placing sample on the platform of the texture analyser (Poonam Dhankhar,2013).

Results and Discussion

Development of recipe for the preparation of nutrition enriched cookies

The recipe for nutrition enhanced cookies was developed using different ingredients such as Raw Banana flour, Arrowroot powder, shortening, sugar, leavening agent, flavouring agent and different activated nuts such as Flax seeds, Pumpkin seeds, Sunflower seeds, Sesame seeds and Almonds. After various trials with variations of flour, sugar, fats, leavening agents involving systematically testing of different combinations and quantities of these ingredients, the most optimal and consistent ratio is determined. The cookies were prepared using the following method shown in Fig.1

Table 1: Standardized proportions of two different cookies

Ingredients (g)	Percentage (%w/w)	Standardised recipe Basic-TW1 (g)	Enhanced with nuts and oilseeds – TW2 (g)
Raw Banana Flour	23.00	55.00	55.00
Arrowroot Powder	2.00	5.00	5.00
Coconut sugar	33.00	50.00	80.00
Butter	12.40	17.00	30.00
Baking powder	0.60	1.00	1.50
Baking soda	0.60	1.00	1.50
Flax seeds	3.30	8.00	8.00
Water(ml)	-	20.00	25.00
Pumpkin seeds	6.00	-	14.00
Sunflower seeds	6.00	-	14.00
Sesame seeds	2.00	-	5.00
Papaya seeds	0.50	-	1.00
Almonds	6.00	-	15.00
Choco chips	4.00	-	10.00
Vanilla extract	0.25	2 drops	4drops

*TW-Tropical Wonders

**TW1- The standardised recipe of the cookies by various proportion trials.

***TW2- The standardised recipe of the cookies is enhanced with Activated nuts and oil seeds and Choco chips to enrich the cookies with nutrients.

Result of organoleptic evaluation of cookies

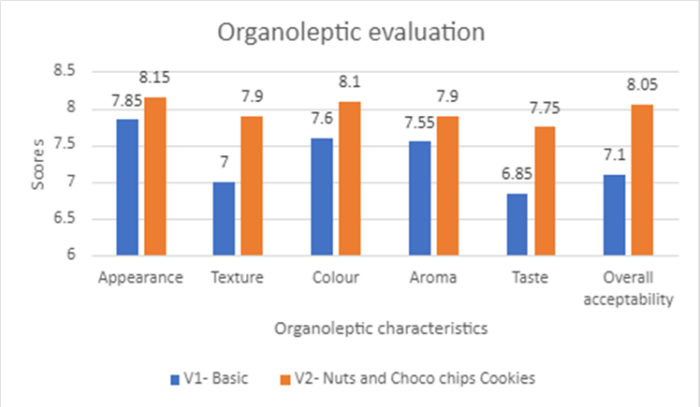

Fig. 2 Graph depicting Organoleptic evaluation

The organoleptic evaluation of two cookie samples, TW1 and TW2, conducted by 10 semi-trained panellists from the Department of Food Technology, Ramaiah University, Bangalore, indicated that TW2, enhanced with activated nuts, oil seeds, and choco chips, received higher scores for texture, color, aroma, taste, and overall acceptability compared to TW1, the standardized basic cookies.

Physio-chemical analysis

Table 2: Representing the Physical properties of the cookies

	Sl. No	Parameters	Results
Sample TW2	1.	Weight (g)	10.01
	2.	Diameter(cm)	6.16
	3.	Thickness (cm)	1.2
	4.	Spread ratio	5.13

Physical properties of TW2 cookies revealed a weight of approximately 10.01 grams, a diameter of 6.16 centimeters, and a thickness of 1.2 centimeters, resulting in a spread ratio.

Figure 3. depicts the nutrient composition of cookies. Nutritional analysis per 100 grams showed TW2 cookies contained 508.00 kilocalories of energy, 9.66 grams of protein, 58.08 grams of carbohydrates, and 26.32 grams of total fat, with a significant dietary fiber content of 19.51 grams, predominantly insoluble fiber.

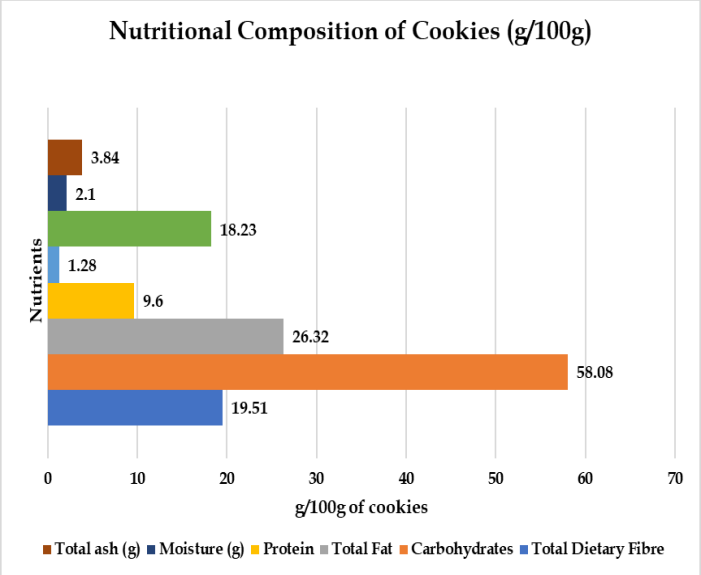

Fig. 3 The nutritional composition of the cookies enhanced with nuts and seeds

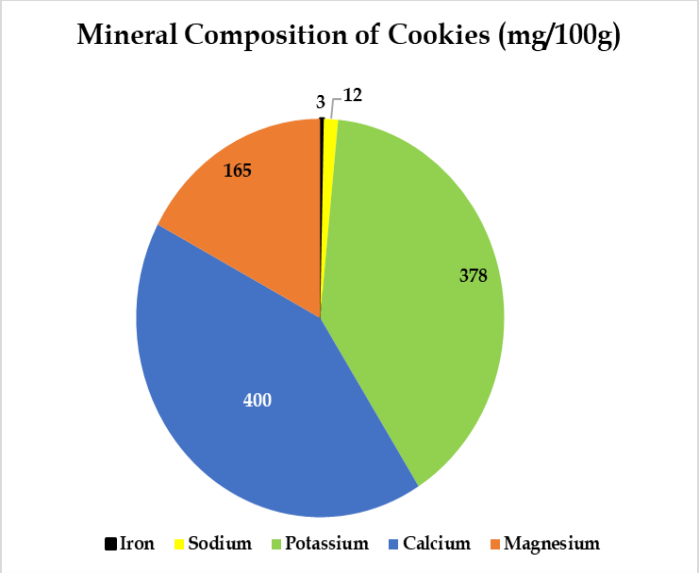

Fig. 4 The mineral composition of the cookies

Figure 4 represents the mineral composition of cookies. Mineral composition included 3 mg of iron, 12 mg of sodium, 378 mg of potassium, 400 mg of calcium, and 165.00 mg of magnesium per 100 grams.

Table 3: Microbial analysis of the cookies

Sl. No	Parameters	Units	Protocol	Results
1	Aerobic microbial count	cfu/g	IS:5402 ;2012	$5.5*10^2$
2	Total coliform count	cfu/g	IS: 5401 (Part-1)2012	<10
3	Yeast and mould	cfu/g	IS: 5403	<10

Table 4: Results of accelerated Stability testing at 40^{0}C and 75% Relative Humidity

Sl. No	Day	Parameters	Results	Protocol	Results
1.	0th day	Yeast and mould	<10 cfu/g	IS: 5403	<10
2.	3rd day		<10 cfu/g	IS: 5403	<10
3.	5th day		<10 cfu/g	IS: 5403	<10
4.	7th day		<10 cfu/g	IS: 5403	<10

Table 3 and 4 gives the microbial analysis and relative Humidity of the cookies. Microbial testing demonstrated low presence of aerobic microorganisms, coliform bacteria, yeast, and mould, with acceptable moisture and ash content. Accelerated stability testing suggested a shelf life of approximately 20 days at room temperature.

Table 5: Representing the results obtained on Texture analysis of the cookie sample (TW2)

Cookie sample TW2	
Test ID	**Hardness Kg Force 1**
Test 1	5.95
Test 2	6.61
Test 3	2.28
Average	**4.95**

Table 5. represents the results of texture analysis of the cookies. Texture analysis indicated an average hardness of 4.95 Kg Force. Computed nutritional information showed slight variations from standard values, emphasizing consistency and accuracy in analysis.

Production cost breakdown for 24 cookies included ingredient expenses at 45%, packaging at 13%, labor at 18%, miscellaneous costs at 6%, and an 18% profit margin.

Conclusions and Future directions

Extensive experimentation led to the development of nutrient-rich gluten-free cookies using banana flour and arrowroot powder. Through systematic testing, optimal ratios of ingredients were determined to ensure consistency and quality. The cookies has significant nutritional value, with 508 kcal energy, 9.66g protein, 58.08g carbohydrates, and 26.32g total fat per 100g, along with high dietary fiber content and essential minerals. The cookies exhibit stability over time, with microbial counts remaining low during accelerated stability testing, aligning with findings from similar studies. Looking ahead, considerations for preservatives and packaging methods could extend shelf life without compromising nutritional integrity. Exploring partnerships for scaling production and market expansion could further enhance the impact of these nutritious gluten-free cookies. Future work includes developing vegan gluten-free cookies, enhancing taste and flavour with real fruit additions, and implementing unique eco-friendly labelling and packaging techniques.

References

Ahmad, A., Zulfiqar, S., & Chatha, Z. A. (2020). Development Of Roasted Flax Seed Cookies And Characterization For Chemical And Organoleptic Parameters. Pakistan Journal of Agricultural Sciences, 57(1).

Amante, P.R.; Emanuelle Cardoso Zibral, S.; Vinícius Tadeu da Veiga, C. 2020. Research Notes: Benefits and Possible Food Applications of Arrowroot (Maranta Arundinaceae L. Journal of Culinary Science & Technology.

Barreca, D.; Nabavi, S.M.; Sureda, A.; Rasekhian, M.; Raciti, R.; Silva, A.S.; Annunziata, G.; Arnone, A.; 2020. Almonds (Prunus Dulcis Mill. D. A. Webb): A Source of Nutrients and Health-Promoting Compounds. Nutrients.

Bascuñán KA; Roncoroni L; Branchi F; Doneda L; Scricciolo A; Ferretti F; Araya M; Elli L.; 2018. The 5 W's of a gluten challenge for gluten-related disorders. Nutr Rev. 2018 1;76(2):79-87.

Bernacchia, R., Preti, R., & Vinci, G. (2014). Chemical composition and health benefits of flaxseed. Austin J Nutri Food Sci, 2(8), 1045. 6. China, M; A.H., Amadi, G, A.; A. E, U. 2022. Functional and pasting properties of wheat and cooking banana flour blends and their utilization in cookies production. Research Journal of Food Science and Nutrition.

Damirchi, S.A.; sh, E.; J. Hesar; S.H. Peighambardoust; M. Nemati; 2023. Nuts Composition and their

Health Benefits. World Academy of Science, Engineering and Technology.

Dhankhar, P.; 2013. A Study on Development of Coconut Based Gluten Free Cookies. International Journal of Engineering Science Invention.

Dr. Neethu, S.K.; Sreeja, D.P. 2016. The surprising health benefits of papaya seeds: A review. Journal of Pharmacognosy https://www.researchgate.net/publication/327745162 and Phytochemistry.

Elisa, P.; Majdi, D.; Stefania, M.; Cristian, V.; Luciana, D. 2014. Administration Dependent Antioxidant Effect of Carica papaya Seeds Water Extract. Evidence Based Complementary and Alternative Medicine.

Evanson Inyang, U., Effiong, C.F. and Edima-Nyah, A.P. 2018. Physical Properties, Nutritional Composition and Sensory Evaluation of Cookies Prepared from Rice, Unripe Banana and Sprouted Soybean Flour Blends. International Journal of Food Science and Biotechnology.

Filiz, Y. 2014. Effects of Green Banana Flour on Ice Cream's Physical, Chemical and Sensory Properties. https://www.researchgate.net/publication/277351878.

Hussain, S., Anjum, F. M., Butt, M. S., Khan, M. I., & Asghar, A. (2006). Physical and sensoric attributes of flaxseed flour supplemented cookies. Turkish Journal of Biology, 30(2), 87-92.

Iorliam, Benbella & Umana, Etietop. (2015). Physicochemical and Sensory Properties of Cookies Produced From Composite Flours of Wheat, Cocoyam and African Yam Beans. Journal of Food Research. 4.

John A.O., O.; Tinuade A, O.; Oyeku A, O.; Lateef A, A. 2005. Effectiveness of Dried Carica papaya Seeds Against Human Intestinal Parasitosis: A Pilot Study. Journal Of Medicinal Food.

Juarez-Garcia, E.; Agama-Acevedo, E.; Sáyago-Ayerdi; S. et al. 2006. Composition, Digestibility and Application in Breadmaking of Banana Flour. Plant Foods Hum Nutr 61, 131–137.

Menezes, E. W., Tadini, C. C., Tribess, T. B., Zuleta, A., Binaghi, J., Pak, N., Lajolo, F. M. (2011). Chemical composition and nutritional value of unripe banana flour (Musa acuminata, var. Nanicão). Plant foods for human nutrition, 66, 231-237.

N W, H.; T P, P.; Zainal. 2020. Preparation of cookies from banana flour, soy flour, and Moringa leaf flour as an emergency food product. Earth and Environmental Science.

R, B.; R, P.; G, V.; 2014. Chemical Composition and Health Benefits of Flaxseed. Austin Journal of Nutrition and Food Sciences.

Saba, S., & Pattan, N. (2022). The Potential Health Benefits of Papaya Seeds. Int. J. Res. Appl. Sci. Eng. Technol, 10, 44-50. 21. Soni, R.P., et al; 2015. Flaxseed-composition and its health benefits.

Srikaeo, K., & Thongta, R. (2015). Effects of sugarcane, palm sugar, coconut sugar and sorbitol on starch digestibility and physicochemical properties of wheat-based foods. International Food Research Journal, 22(3), 923.

Sunday J. Olakanmi; Digvir S. Jayas; Jitendra Paliwal; 2023. Applications of imaging systems for the assessment of quality characteristics of bread and other baked goods: A review, Comprehensive Reviews in Food Science and Food Safety, 10.1111/1541-4337.13131

Zong G; Lebwohl B; Hu FB; Sampson L; Dougherty LW; Willett WC; Chan AT; Sun Q.; 2018. Gluten intake and risk of type 2 diabetes in three large prospective cohort studies of US men and women.

* * * * * * * *