

Studies of Multi-Grain Based Cookies and its Quality Assessment

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Abstract: The present investigations were carried out to evaluate the impact of multigrain flour incorporation on the functional, nutritional, and sensory of cookies. Five treatments (T₀ to T₄) were formulated, varying in proportions of wheat, barnyard millet, ragi, brown top millet, foxtail millet, kodo millet, and bajra. The control (T₀) contained 100% wheat flour, while in other treatments, wheat was partially substituted with millet flours. Each formulation was standardized to contain equal quantities of sugar (65 g/100 g), oil (55 g/100 g), and baking powder (1.25 g/100 g) to maintain consistency across samples. Functional properties such as swelling capacity, water and oil absorption capacities, emulsion activity and stability, foam capacity and stability, gelatinization temperature, least gelation concentration, and bulk density were studied. Physical and nutritional parameters including diameter, thickness, spread ratio, bulk density, moisture, pH, ash, protein, fat, crude fiber, iron, and β -carotene contents were evaluated. Organoleptic attributes like colour, appearance, aroma, taste, and overall acceptability were analysed using sensory evaluation techniques. Among the treatments, T₂ (15:20:20:10:10:15) emerged as the most balanced and consumer-preferred formulation, achieving the highest scores for sensory parameters such as colour, taste, and overall acceptability. Functionally, T₄ exhibited superior oil absorption and foam stability, while T₃ showed higher crude fiber content. The control (T₀) had the highest protein and β -carotene levels. The study concludes that multigrain blends can significantly enhance the quality of cookies. T₂ stands out as the ideal formulation, combining nutritional enhancement, consumer appeal, offering great potential for commercialization in health focused bakery products.

Keywords Multigrain flour, functional, nutritional, fibre content, sensory and cookies

INTRODUCTION

Multigrain cookies are not artificially processed, includes all the whole grains, including fiber rich ingredients. Because of the fiber ingredients, multigrain cookies help to diminish various major health issues like diabetes, cardiovascular diseases, and constipation issues. Advancement of innovative features in product is the new tactical part of the food industry. Nowadays, due to hectic life, people have been demanding ready-to-Cook foods that are easy to prepare, consumes less time in cooking, are healthy, have a good shelf life, and have a delicious taste (Negu *et al*, 2020). So, in this study, all these attractive features are tried to include into the cookie. Cookies are processed food that all age group of people highly eat as a snack. Its production is more and available worldwide. In these days customers are expecting, foods that show two main vital properties: first-one deals with the traditional nutritional features of the food, as well as, a second feature, supplementary health benefits are predictable from its regular ingestion. Foods which are having high nutrition have expanded incredible attention worldwide over the earlier few years

due to healthy lifestyle fluctuations. One of the encouraging reasons to move to a healthier lifestyle is the growing number of people suffering from high blood pressure, cardiovascular diseases (CVDs), diabetes, obesity, and other related diseases (Hussain *et al*, 2018). These conditions are generally due to a lifestyle and poor diet where the regular food consumed holds more quantities of saturated fatty acids (SFAs). The total dietary fiber (TDF) has become an eat worthy element in the daily diet because intake of total dietary fiber has health advantageous effects. One of the foremost tasks in baking trade is the production of gluten-free products. Cookies are extensively familiar and consumed in developing countries. Traditionally cookies are made out of wheat flour. The name "Cookie" originates from the Dutch word „Koekie“ or „Koekie“ that means little cake. Cookies, like cakes, are chemically leavened with baking powder and baking soda. Cookies, however, contains more sugar and shortening agent and less water proportionately. In this study, we tried to access the suitability of replacement of "Maida" by using other

flours (Biradar *et al.*, 2020) Nutritional enhancement is one of existing attention since it is a consumer trends, government guiding principle and altering demographics. These aspects are instigating the industry to be alert of the necessity for nutritional food products. Protein subjoining is one of the ways to light the necessity for nutritious foods, predominantly baked products. The nutritional implication of the bakery products is well known. Efforts are being made to boost the products with fine quality non-wheat flours. Bakery products can oblige as a virtuous vehicle for carrying the added proteins to marked populations for use in fighting the protein malnourishment dominant in innumerable parts of the World. Cookies are generally flat, small, and round. It is available in several flavours. The main ingredients are flour, fat, sugar, salt, and water, depending on the type. In this study the cookies were prepared where refined wheat flour is replaced by whole wheat flour, finger millet flour and oats flour (Sharma *et al.*, 2017). Most of gluten-free products available in market are using starch or refined gluten-free flour, so these products remained only the rich sources of carbohydrates and fat if not fortified with essential nutrients. Absence of gluten in processed products provides weak structure leading to mechanical and organoleptic challenges during preparation of these products. A huge number of starches, flours and other constituents (hydrocolloids, proteins, enzymes etc.) are used to improve visco-elastic properties analogous to that of gluten, for enhancement of sensory and structural features and improving the nutritional composition of gluten-free food products. Millets are distinctive among the cereals because of their abundance in calcium, dietary fiber, polyphenol and protein. Millets are gluten-free and are therefore an exceptional option for people suffering from celiac diseases often irritated by the gluten content of wheat and cereal grains containing gluten (Biradar *et al.*, 2020). Pearl millet have a great potential as food for humans since they are gluten-free, have higher amount of dietary fiber content, similar in lipid content to maize and have higher amount of essential amino acids (isoleucine, leucine and lysine) than other traditional cereals, such as rye and wheat (Amulya and Ramu, 2022) Finger millet is a good sources of dietary fiber (including resistant starch), minerals and trace elements (especially calcium, potassium, iron and phosphorous) as compared to commonly used cereals such as wheat and rice. Soya bean is an inexpensive source of macronutrients and can be used in managing protein-energy malnutrition among children and to improve the nutritional status of the different sections of population in developing countries (Bornare *et al.*, 2015).

MATERIALS AND METHODS

The present study will be undertaken to formulate and evaluate multigrain flour cookies using a standardized combination of cereal and millet flours. The raw materials to be used will include wheat flour, barnyard millet flour, ragi flour, browntop millet flour, foxtail

millet flour, kodo millet flour, and bajra flour. Five treatments will be formulated: a control (T_0) consisting of 100% wheat flour, and four other treatments (T_1 to T_4) with increasing proportions of multigrain flours in the ratios of (90:7.5:2.5), (80:15:5), (70:20:10), and (60:25:15), respectively. All treatments will contain fixed amounts of sugar (65 g/100 g), edible vegetable oil (55 g/100 g), and baking powder (1.25 g/100 g). The cookies will be prepared following a standard method and baked uniformly. A randomized block design (RBD) will be employed with three replications. Functional properties such as swelling capacity, water and oil absorption capacity, emulsion activity and stability, foaming capacity and stability, gelatinization temperature, least gelation concentration, and bulk density will be evaluated to assess the functional quality of the developed multigrain cookies.

Functional parameters

Swelling capacity: The swelling capacity was determined by the method described by Okaka and Potter (1977).

Water absorption capacity: The water absorption capacity of the flours was determined by the method of Sosulski *et al.*, (1976).

Oil absorption capacity: Oil absorption was examined as percent oil bound per gram flour. The oil absorption capacity was determined by the method of Sosulski *et al.*, (1976).

Emulsion activity: The emulsion activity, distilled water and stability by Yasumatsu *et al.*, (1972).

Foam capacity and foam stability: The foam capacity (FC) and foam stability (FS) by Narayana and Narasinga (1982) were determined as described with slight modification.

Bulk Density: The volume of 100 g of the flour was measured in a measuring cylinder (250 ml) after tapping the cylinder on a wooden plank until no visible decrease in volume was noticed, and based on the weight and volume, the apparent (bulk) density was calculated (Jones *et al.*, 2000).

Physico- chemical Parameters

Diameter: The diameter of cookies was measured by laying cookies edge to edge with the help of a scale rotating 90° and again measuring the diameter of cookies and then taking average value.

Thickness: Thickness was measure by staking cookies on top of each other and taking average thickness(cm).

Weight: Weight of cookies (g) was measured as average of values of cookies individual biscuit with the help of digital electronics weighing balance.

Bulk Density: The bulk density is determined according to the method in which fifty (50) g sample is put into a 100 ml graduated cylinder. The cylinder is tapped 40-50 times and bulk density is calculated as weight per unit volume of samples.

Spread Ratio: Spread ratio is calculated by dividing the average value of diameter by average value of thickness of cookies.

Determination of moisture content: Moisture of fresh sample was obtained by the standard method (AOAC, 1990).

pH: The samples of multi-grain was crushed with equal quantity of distilled water and the pH will be determined using digital pH meter after calibration with standard buffers of 4 and 7 (Ranganna, 2010).

Ash content: Total ash was determined gravimetrically by taking known weight of samples (5 g) in tarred silica crucibles. The dried samples after moisture determination would be slowly heated over hot plate until the bulk of organic matter was burnt. The crucibles would be then placed in a muffle furnace for ashing at 550°C to obtain a carbon free white ash with a constant weight (Ranganna, 2010),

Protein: Protein in mushroom was determined by Lowry's method (Sadasivam and Manickam, 1991).

Fat: Crude fat was estimated by standard method of analysis (AOAC, 1990) using Soxhlet extraction apparatus.

Crude fibre: Crude fibre was estimated by employing standard method of analysis (AOAC, 1990).

β- Carotene: β-Carotene was determined with the procedure recommended by (Shrivastava and Kumar, 2002).

Sensory Evaluation

Sensory evaluation is important to access the consumer's requirements. It is difficult to classify 100% by machine because it is a subjective factor. Dehydrated products should have a typical taste, flavor, and texture. To test these organoleptic characteristics, sensory evaluation was done on the basis of 9 points hedonic scale. The sensory evaluation will be carried out for color, texture and overall acceptability. A sample of dehydrated product will be served for the evaluation to 10 panelists at a time. The score sheet was provided with product and of all the panelists was computed on 9-point hedonic scale

RESULTS AND DISCUSSIONS

The present study was carried out to evaluate the impact of multigrain flour combinations on the quality of cookies. The experiment was meticulously designed to incorporate five treatments, each varying in the proportion of different flours—wheat, barnyard millet, ragi, browntop millet, foxtail millet, kodo millet, and bajra. The study was conducted using a randomized block design (RBD) with three replications to ensure reliability and minimize experimental error. The cookies were stored in HDPE packaging at room temperature,

and observations were made at regular intervals (0, 30, 60, 90, and 120 days). The results obtained from this study provided valuable insights into the functional and nutritional enhancement of cookies through multigrain incorporation.

Functional Parameters

The functional properties of multigrain cookies varied significantly among treatments, influenced by the proportion of grains used in each formulation. Swelling capacity ranged from 1.15 ml/g (T₄) to 2.5 ml/g (T₃), with T₃ exhibiting the highest value, likely due to its higher proportion of swelling enhancing ingredients such as millets or fiber-rich grains. Water absorption capacity (WAC) followed a similar trend, with the highest value recorded in T₃ (160%), indicating improved hydration properties which are desirable for cookie dough consistency and texture. In contrast, the control (T₀) showed the lowest WAC (84%). Oil absorption capacity (OAC) was highest in T₄ (146%) and lowest in T₀ (76%). This suggests T₄'s composition had better fat-holding capacity, potentially contributing to improved mouthfeel and flavor retention. Emulsion activity and emulsion stability also increased in T₄ (73% and 52.67%, respectively), highlighting its potential for forming and maintaining stable emulsions, which can enhance texture and shelf stability. Foam capacity and foam stability were most notable in T₂ and T₄, with T₂ showing the highest foam capacity (31.51%) and T₄ the highest foam stability (39%). These parameters are important in applications involving aeration, suggesting that these treatments might support better textural properties in baked products. Least gelation concentration (LGC) was lowest in T₂ (6%), indicating a strong gelling ability at lower concentrations. This may be advantageous for structural integrity and cohesiveness in cookies. T₄ showed a moderate LGC (8%), suggesting a balance between gel formation and flexibility in texture. Gelatinization temperature ranged from 57°C (T₁) to 79°C (T₄). The higher temperature in T₄ could imply a more complex starch structure, affecting baking behaviour and final product texture. Bulk density was highest in T₂ (91 g/ml), suggesting denser flour blends, whereas T₁ had the lowest (53 g/ml), potentially leading to lighter baked products. Overall, T₄ emerged as a promising formulation due to its superior oil absorption, emulsion stability, foam stability, and balanced gelation and swelling properties, making it suitable for enhancing the functional and sensory qualities of multigrain cookies (Fig.1).

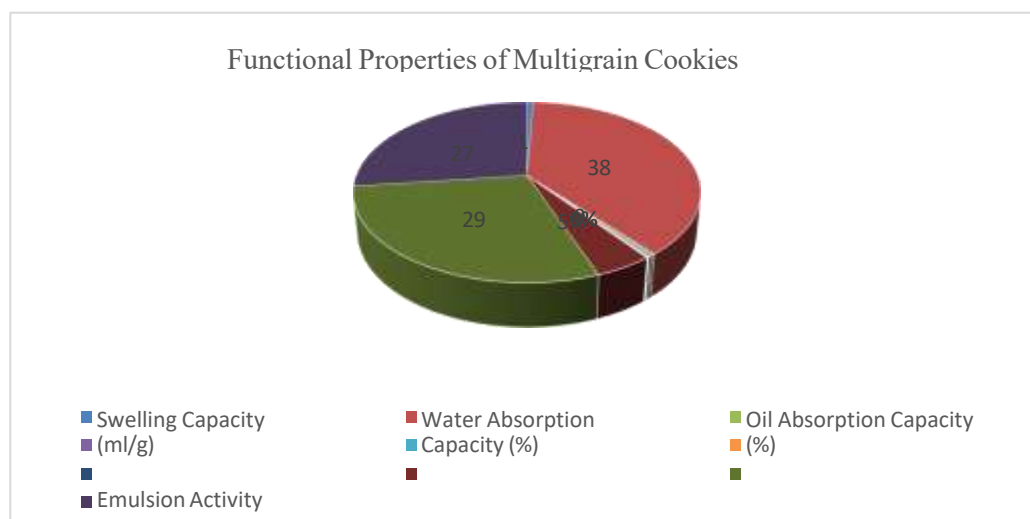


Fig. 1 Distribution of Functional Properties in Composite Flour Formulations for multigrain cookies.

Physico- chemical and Nutritional Parameters

The diameter of the cookies varied from 5.24 cm (T_0) to 6.81 cm (T_1). T_1 showed the largest diameter, suggesting greater spread during baking, likely due to its specific flour and fat composition. The smallest diameter was observed in T_0 , indicative of a more compact structure. Thickness ranged from 0.87 cm (T_1) to 1.98 cm (T_0), where a higher thickness corresponded to less spread, typical of denser doughs. Cookie weight ranged from 11.45 g (T_2) to 16.85 g (T_4), with heavier cookies potentially reflecting higher moisture or denser grain components. Bulk density varied between 0.67 g/ml (T_2) and 0.98 g/ml (T_1), indicating textural differences; lower values generally denote a more porous and crisp structure. Spread ratio, an important texture indicator, was highest in T_4 (9.67) and lowest in T_3 (6.43). A higher ratio suggests a more desirable cookie spread and palatability. Moisture content was maximum in T_4 (7.56%) and minimum in T_2 (4.76%), affecting shelf life and texture. Lower moisture is typically flavoured for enhanced crispness.

pH levels ranged from 5.34 (T_3) to 6.98 (T_4), with near-neutral pH in T_4 promoting better microbial stability. Ash content, representing mineral presence, was highest in T_4 (2.76%). Protein content was highest in T_0 (11.01 mg/100g) and decreased across treatments, lowest in T_4 (7.89 mg/100g), indicating the role of grain composition. Fat content ranged between 10.54% (T_4) and 14.76% (T_2), possibly influenced by oil-rich ingredients. Crude fibre was notably high in T_3 (3.21%), highlighting potential digestive benefits. β -Carotene content was highest in T_0 (1.23 μ g/100g), decreasing to 0.65 μ g/100g in T_4 . This antioxidant's concentration is likely tied to the inclusion of orange-fleshed or colored cereals. Overall, the data reflect that formulation significantly influences nutritional and physical characteristics, offering opportunities to tailor multigrain cookies for health and quality (Fig.2).

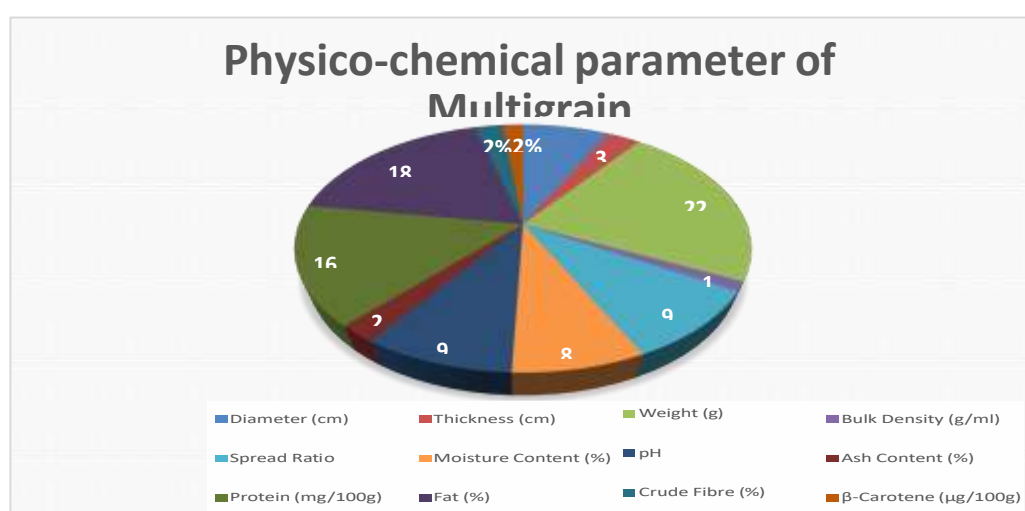


Fig. 2 Proximate Composition of Multigrain Cookies and Comparison of Macronutrient Content Across Treatments (T_0 – T_4). Sensory Attributes

The organoleptic properties of multigrain cookies were evaluated based on colour, appearance, aroma, taste, and overall acceptability for five different treatment formulations (T_0 to T_4). The control sample (T_0) received a moderate

score in all sensory parameters, with the highest rating for taste (8.9) and the lowest for overall acceptability (6.9), indicating good taste but less favorable overall perception. Among all treatments, T₂ (15:20:20:10:10:15) achieved the highest overall acceptability score (8.6), suggesting a well-balanced formulation. It also scored highest for colour (8.5), appearance (8.4), and had a desirable taste (8.4), indicating that this formulation was most preferred by the panelists in terms of visual and sensory appeal. Treatment T₁ (25:10:10: 10:10:20:15) and T₄ (10:15:15: 10:15:20:15) showed moderately good scores across parameters. T₁ was appreciated for its appearance (8.3) and aroma (8.3), while T₄ had the highest aroma rating (7.9) but a lower taste score (6.5), which negatively affected its overall acceptability (7.9). This indicates that although aroma was appealing in T₄, its taste limited its overall preference. T₃ (20:10:10: 20:15:10:15) had the lowest average scores among the modified treatments, though its overall acceptability (7.8) was still higher than the control. It was average in all categories, suggesting a more neutral sensory impact (Igbabul *et al.*, 2018). The results indicate that variation in ingredient ratios.

significantly influenced the sensory attributes of the cookies. T₂ emerged as the most balanced and appealing formulation across all sensory dimensions. The enhancement in aroma, appearance, and taste in T₂ likely contributed to its higher acceptability. This suggests that incorporating a balanced ratio of multigrain flours can enhance the sensory quality of cookies without compromising acceptability.

CONCLUSION

The study conclusively demonstrated that incorporating multigrain flours into cookie formulations significantly influences their functional, and nutritional. Among the five treatments, T₂ emerged as the most favorable, balancing desirable functional traits. Its superior ratings in appearance, aroma, taste, and overall acceptability indicate that a carefully selected blend of millet flours can enhance cookie quality without compromising consumer appeal. While T₄ exhibited excellent functional attributes, such as high oil absorption and emulsion stability, its lower taste score reduced its sensory acceptance. On the other hand, T₁ was the most economical but did not achieve the highest preference in sensory evaluation. The study highlights the importance of optimizing flour blends not only for nutritional and functional improvements but also for consumer satisfaction and market feasibility. The findings support the formulation of health-oriented bakery products by integrating nutrient-rich millets. In this context, T₂ stands out as the ideal formulation, offering a compelling combination of quality and cost-effectiveness. This research provides valuable insights for developing nutritious, affordable, and consumer-accepted multigrain bakery products for broader market adoption.

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