# DEVELOPMENT OF MILLET BLENDED FUNCTIONAL BISCUITS AND ITS QUALITY EVALUATION

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## ABSTRACT
A significant global public health problem is the rising incidence of micronutrient deficiencies and diet-related non-communicable diseases, especially in developing nations where access to nutrient-dense foods is still restricted.In order to tackle malnutrition from a low-cost source as baked goods for people at different levels (at 0, 05, 10, 15, 20, and 25 percent), the study set out to design and make millet based biscuits by substituting ragi for refined wheat flour.
The biscuits manufactured with 80% refined wheat flour (RWF) and 20% sprouted ragi flour (SRF) the treatment T5 was unquestionably the most pleasant in terms of sensory attributes. In comparison to the control T1, T5 received the highest score (8.20) after 0 days of storage. Additionally, after 90 days of storage, the overall acceptability was 7.83 for laminated pouches (LP), 7.62 for low-density polyethylene (LDPE), and 7.60 for polypropylene (PP).Incorporation of ragi millet increased the calcium, fibre, phosphorus, ash and iron meanwhile the percentage of fat and energy value was curtail down. Ragi may prove to be a cost-effective and acceptable substitute for refined wheat flour in biscuit baking.

**KEYWORDS**: -RTE, Ragi flour, composite snacks, sorbitol, antioxidants, minerals, functional foods.

## 1. INTRODUCTION
Due to shifting lifestyles and time restrictions, ready-to-eat (RTE) food has grown in importance as a component of urban food consumption. The increasing prevalence of micronutrient deficiencies and diet-related non-communicable diseases has become a major global public health concern, particularly in developing countries where access to nutrient-dense foods remains limited (Dada, et al. 2023). These challenges had driven growing scientific and industrial interest in the development of functional foods capable of delivering essential nutrients and bioactive compounds through commonly consumed dietary products.
Urbanization, changing lifestyles and rising dietary health consciousness have all contributed to a sharp rise in the demand for wholesome, easily consumable foods. Bread, biscuits, cookies, cakes and crackers are among the baked products that are widely consumed around the world. However, refined wheat flour, which is primarily used in traditional baked goods, has fundamental nutritional limitations, such as low protein quality and insufficient amounts of important amino acids like lysine, methionine and threonine, despite its functional qualities. These goods become less nutritionally adequate as a result of the refinement process, which further depletes vital nutrients by lowering fibre, vitamins and minerals. Researchers and food engineers have looked into adding non-wheat flour to wheat flour in order to remedy these nutritional deficiencies. A viable way to improve the nutritional profile of baked goods is to use substitute flours made from legumes, oilseeds, other cereals, tubers and by-products like rice bran and maize gluten (Bravo and Gomez, 2023). The desire to advance our understanding of the consequences of using substitute flours in bakery goods is the main driving force behind the creation of this study. In this regard, the literature of today provides a sizable body of research that not only supports the topic's applicability but also indicates the necessity for a more thorough examination.
The bakery products are occupying an important place in food industry due to its consistent quality and therefore, has potential to serve as a vehicle for nutrition improvement of population at low cost and without much convincing. Indian biscuit industry is the largest among all food industry and India is the 2nd largest manufacturer of biscuit and cookies in the world followed by USA. (Kulkarni, et. al. 2018).
The annual growth of bakery industry is about 10% and the demand of bakery products are increasing among all sections of people. Biscuits are having wider consumption base, relatively long shelf-life, more convenience and good palatability which make it attractive for protein fortification and other nutritional improvements.
The bakery industry is one of the largest segments in the food processing sector in India, offering huge opportunities for growth, innovation and job generation. In 2024, India's bakery industry was valued at approximately USD 13.8 billion, marking a significant growth trajectory in the country's food processing sector. The market is projected to make a steady growth at a Compound Annual Growth Rate (CAGR) of 9.12%, would be reaching around USD 31.5 billion by 2033 (MoFPI, 2025).
The Bread and Bakery sector is emerging as a crucial segment of India’s vibrant food processing industry, offering extensive opportunities for growth, innovation, and job creation. From breakfast cereals to cookies and chocolates, the bakery and confectionery landscape in India is witnessing dynamic shifts, propelled by flourishing demand for biscuits

and cookies nationwide. The growth in population, disposable incomes and changing consumer preferences, driven by factors such as western food trends, increased consumption of baked food and ready to eat (RTE) food, cloud kitchens, expanding retail, e-commerce sectors and skill enhancement are fuelling the market growth and demand.

Wheat (*Triticum spp.)* is the important and staple crop of the people in India and around the globe because of fundamental source of calories and nutrients mainly used for milling and baking. It contains moisture 12.8%, protien 11.8%, fat 1.5%, minerals 1.5%, crude fibre 1.2% respectively Gopalan et al. (2004) and Rana (2020).

Due to the larger amount of dietary fibre and non-starchy polysaccharides in finger millet; Ragi (*Eleusine coracana*), it has a number of physiological and nutritional advantages (Rai, 2000). Ragi seed coat in particular, contains several phytochemicals that may have multiple health benefits (Takawale et al., 2021). It contains moisture (13.10 g), Protein (7.30 g), Carbohydrate (7.00 g), Fat (1.30 g), and Energy (328.00 Kcal) (Gopalan et al. 2004). Ragi has the highest concentration of calcium, anti-oxidant qualities, and phytochemicals, making it easily and gradually digested. Thus, it provides highly effective blood glucose management for diabetic individuals. The bulkiness of the fibres and the slower digestion rate make us feel fuller on, fewer calories and therefore may help to prevent us from eating excess calories. Therefore, ragi is considered to be ideal food for diabetic individuals due to its low sugar content and slow release of glucose/sugar in the body (Kokani et al., 2018).

Despite these technological advantages has led to increased adoption of composite flour technology, which involves blending wheat flour with non-wheat materials such as cereals, legumes, roots, tubers, fruits, and vegetables in order to enhance nutritional quality while promoting agricultural diversification and value addition to indigenous crops Aprodu, et al. (2021).

Functional foods are widely recognized as practical tools for improving nutritional status and preventing chronic diseases, especially when incorporated into staple or frequently consumed foods among such products, bakery items particularly biscuits and cookies had gained considerable attention (Chiedu, et al. 2023).

## 2. METHODOLOGY

The present investigation was undertaken on "Development of millet blended functional biscuits and its quality evaluation" at MGCGVV, Chitrakoot, Satna (M.P.), INDIA.

**2.1 Experimental materials: -** The wheat and ragi were procured from the local market and all other ingredients (sugar, vegetable oil, glucose, ammonium bicarbonate, common salt sodium bicarbonate, vanilla and baking powder) were purchased from the retail market and department. The materials were transported to department.

**2.2 Preparation of biscuits: -** ***Processing of grains***: **-** The grains (wheat and ragi) were washed and cleaned to remove the dirt, dust and foreign matter by winnowing. ***Sprouting*****: -**Wheat and ragi grains were sprouted as described by (Murugkar, 2014).

**2.3 Development and optimization of baked products (Biscuits): -**First of all studies were conducted to standardize the formulation for the development of the different blend based baked products (biscuits). Biscuits were processed using the traditional creamery method described by Whitley (1970).

**2.4 Physical and Proximate value:-*****Bulk Density:*** The bulk densities of biscuits were analyzed as per Wang and Kinsella (1976). **Water absorption capacity (WAC)*****:*** WAC of flour was determined by the method given by Sosulski *et. al.,* (1976). **Diameter (D)*****:***The Diameter of biscuits was measured by the prescribed method (AACC, 2000). **Thickness (T)*****:***Thickness was measured by Vernier calliper as per (Jauharah *et. al.,* 2014). **Spread factor (D/T)*****:***The spread factor was calculated by (AACC, 2000). **Weight (W)*****:***Ten pieces average weights of both samples were recorded (Jauharah *et. al*., 2014).***Moisture*****:** Moisture was analyzed using the MBS4 moisture analyzer at 100°C for 10 minutes.***Protein,Fat, Carbohydrates** and **Ash***content in the sample was estimated by the procedure indicated in the AOAC (1984). ***Estimation of Minerals***: - Minerals content of biscuits was estimated through the Gopalan table values (Gopalan *et. al., 2004*).***Calorific Value***: -The total energy values were estimated with using the values of 4, 4, and 9 for protein, carbohydrate and fat respectively as follows: Total calorie (kcal/100g) = [(% available carbohydrates X4) + (% protein X4) + (% fat X9)]. **Sugars:**The sugars content (Reducing, non-reducing and total sugar) of the sample was determined by the procedure as indicated by Ranganna (2012). **Amylose: -** The amylose content was estimated according to method as described by Sadasivam and Manickam (1992).

**2.5 Organoleptic value andshelf life: -**The organoleptic qualities of nutritious biscuits were evaluated by a nine pointhedonic scale as indicated by the Amerine et al. (1965). The shelf life of the blended biscuits was analyzed as a function of time and storage conditions in different packaging materials (LP, LDPE and PP) inTable 4 as perBaixauli et al., (2008).

**2.6 Statistical analysis**: - A complete randomized design was adopted for statistical analysis of data by following the procedure as described by Panse and Sukhatme (1985).

## 3. RESULTS AND DISCUSSION

| S.N. | Treatments | Wheat | Ragi |
|---|---|---|---|
| **1.** | T1 | 100 | - |
| **2.** | T2 | 95 | 5 |
| **3.** | T3 | 90 | 10 |
| **4.** | T4 | 85 | 15 |
| **5.** | T5 | 80 | 20 |
| **6.** | T6 | 75 | 25 |

**Table 1. Preparation and development of wheat and ragi biscuits.**

Refined wheat flour (RWF) was used to make the control (T1) biscuits. Table 1 show that whole wheat and ragi flour were employed in other recipes in replacement ratios ranging from 0 to 25%. The impact of the observed changes on product quality, nutritional enhancement and functional food potential was assessed in connection to rising ragi flour levels.

**3.1 Physical attributes of wheat and ragi biscuit: -**Ragi biscuit with wheat (RWF) were studied for physical characteristic such as weight, diameter, bulk density, thickness and spread ratio and results were depicted in Table 2.***Weight*****: -** Ten biscuits average weight was taken. Weight of the biscuit was found highest in T2 (65.32 g) whereas lowest in combination T3 (54.69 g). The decline in weight was due to replacement of fat rich flour. It might be due to replacement of sucrose with sorbitol, as molecular weight of sorbitol (182) was less as compared to sucrose (342). Similar results of molecular weight were showed by Zumbe *et. al.,* (2001).***Diameter*****: -**The diameter of the wheat and ragi biscuits varied between 43.30 and 45.93 mm. The biscuit with the largest diameter was found in combination T4 (45.93 mm), whereas the smallest diameter was in T3 (43.30 mm) as per Gajera *et. al*., (2008)and Handa *et. al.,* (2012).***Bulk density*****:**0.72 g/ml bulk density was of the T1 (wheat-based) biscuit. With more ragi flour, the bulk density of the wheat and ragi-based biscuit increased from 0.71 to 0.72 g/ml. The biscuit's bulk density was found to be highest in combinations T2, T3, and T4 (0.72 g/ml), while lowest in combination T6 (0.71 g/ml).Results were supported by Thongram *et. al.,* (2016).***Thickness:-***Wheat biscuits and ragi biscuits thicknesses ranged from 4.41 to 4.54 mm. The maximum thickness was observed in combination T2 (4.54 mm), while the lowest in combination T5 (4.41 mm) similar mechanism reported by Wade (1988).***Spread factor (ratio):-***Biscuit prepared from wheat and ragi biscuits had spread ratio ranged from 9.59 to 10.64. The highest thickness was found to be in T4 (10.64), whereas the lowest was of T6 (9.59). This was owing to the biscuit's inclusion of wheat and ragi flour. Similar results were documented by Oomah, (1983). ***Water absorption capacity*****: -**T1 combination from wheat flour had (122.00%) of WAC. The wheat and ragi flour added biscuits ranked from 123.50 to 138.50 % were showed in Table 2. It was cleared from the findings that the WAC was induced as blending with different combinations of ragi flour. Peymanpour *et. al.,* (2012) reported similar work WAC ranged from 64.0 to 69.3 per cent.

| **Formulations** | **Weight (g/10)** | **Diameter (mm)** | **Bulk density (g/ml)** | **Thickness (mm)** | **Spread Ratio** | **WAC%** |
|---|---|---|---|---|---|---|
| T1 | 64.24 | 41.54 | 0.72 | 4.22 | 10.01 | 122.00 |
| T2 | 65.32 | 43.42 | 0.72 | 4.54 | 9.74 | 123.50 |
| T3 | 54.69 | 43.30 | 0.72 | 4.45 | 9.93 | 137.00 |
| T4 | 63.06 | 45.93 | 0.72 | 4.43 | 10.64 | 131.00 |
| T5 | 62.04 | 43.53 | 0.71 | 4.41 | 10.10 | 130.50 |
| T6 | 61.30 | 43.93 | 0.71 | 4.68 | 9.59 | 138.50 |
| Sem± | 0.041 | 0.040 | 0.038 | 0.041 | 0.041 | 0.028 |
| CD at 5% | 0.127 | 0.123 | 0.117 | 0.125 | 0.128 | 0.088 |

**Table 2: Physical parameter of the wheat and ragi biscuit**

| Treatment | Carbohydrates | Protien | Fat | Fibre | EV | Ash | Ca | P | Fe | Moisture | Reducing sugar | Non-reducing sugar | Total sugar | Amylose |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T1 | 66.27 | 12.14 | 1.65 | 3.12 | 330.20 | 1.61 | 21.74 | 114.19 | 2.55 | 3.85 | 4.48 | 0.83 | 5.31 | 14.35 |
| T2 | 66.38 | 11.88 | 1.67 | 3.12 | 329.16 | 1.65 | 36.86 | 121.85 | 2.62 | 3.80 | 4.67 | 0.86 | 5.53 | 14.28 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T3 | 66.42 | 11.66 | 1.66 | 3.15 | 328.15 | 1.71 | 52.16 | 129.42 | 2.67 | 3.85 | 4.00 | 0.96 | 4.96 | 14.01 |
| T4 | 66.51 | 11.42 | 1.64 | 3.16 | 327.20 | 1.75 | 67.17 | 137.12 | 2.72 | 4.20 | 4.45 | 0.79 | 5.24 | 13.75 |
| T5 | 66.59 | 11.19 | 1.64 | 3.08 | 326.03 | 1.80 | 82.35 | 144.77 | 2.76 | 4.30 | 4.76 | 0.50 | 5.26 | 13.92 |
| T6 | 66.67 | 11.36 | 1.62 | 3.19 | 325.07 | 1.85 | 97.42 | 152.38 | 2.89 | 4.45 | 4.65 | 0.70 | 5.35 | 13.16 |
| Sem± | 0.062 | 0.072 | 0.064 | 0.074 | 0.059 | 0.063 | 0.073 | 0.071 | 0.071 | 0.039 | 0.339 | 0.0459 | 0.334 | 0.15 |
| CD at 5% | 0.191 | 0.221 | 0.198 | 0.229 | 0.183 | 0.194 | 0.224 | 0.217 | 0.220 | 0.120 | 0.989 | 0.134 | 0.976 | 0.44 |

**Table 3. Proximate composition of wheat and ragi blend**

**3.2 Proximate composition of wheat and ragi biscuits: -** ***Moisture content*****:** It was of huge significant in baked products. Moisture % of wheat based biscuits T1 was 3.85%. It was ranged from 3.80 to 4.45 % with increased level of ragi flour. Moisture content was highest in T6 (4.45%) whereas lowest in T2 (3.80%). Water and moisture activity values had been increased with time for trials whereas sensory scores decreased as reported by Chowdhury (2012) were presented in Table 4. ***Carbohydrates content:*** The carbohydrates of control (T1) biscuits was found 66.27%. Wheat and ragi blended biscuits had carbohydrates ranged from 66.38 to 66.67 (T6) percent which was higher than the control wheat biscuits were explained in Table 3. The rise in the ratio of ragi flour in the biscuits significantly decreases carbohydrates content in the biscuits and similar work was carried out by Goswami *et. al.,* (2017). ***Protein per cent*****:**The maximum protein % was found in T2 (11.88%) whereas minimum in T6 (11.38%) which was higher than the control wheat biscuits were presented in Table 4. The increase in the ratio of flour of ragi in the biscuits significantly decreases protein content of the biscuits. Similar work was carried out by Goswami *et. al*., (2017), and noticed decrease in protien % in biscuits because of supplementation of ragi flour.***Fat per cent*****:**The fat percent biscuits varied from 1.62 to 1.67%.The maximum fat content was found in T2 (1.67 percent) and T6 (1.62 percent) had the lowest. Similar results about increase in fat content of biscuits due to ragi supplementation were reported by Shaikh *et. al*., (2018).***Fibre content*****:**The fibre content of wheat and ragi added biscuits were ranked from 3.08 to 3.19 percent. T6 (3.19 percent) had the highest fibre percentage, while T5 had the lowest (3.08 percent) which was higher than the control wheat biscuits were explained in Table 3. Similar findings was reported in context of increase in fibre % of biscuits were reported by Sharif *et. al.,* (2009) it is because of incorporation of defatted rice bran.***Ash content*****:**Ash % in edible substances like food indicated inorganic remains when the organic matter burnt out. The ash content of blended biscuits was ranged from 1.65 to 1.85 per cent. The highest ash % was found in T6 (1.85%) whereas lowest in T2 (1.65%) which was higher than the control wheat biscuits were presented in Table 3. increase of the ragi flour in biscuits increases the ash content of the biscuits Shaikh *et. al*., (2018).***Energy value*****:** The EV of the control biscuits was discovered in the T1 range (330.20 Kcal). Ragi enhanced biscuits had EVs ranging from 325.07 to 329.16 Kcal. T2 had the highest energy content (329.16 Kcal), while T6 had the lowest (325.07 Kcal) which was higher than the control. The rise in the ratio of ragi flour in the biscuits significantly increases energy and results were close agreement with Goswami *et. al*., (2017).***Calcium content:*** The maximum Ca % was found in T6 (97.42 mg) whereas least in T2 (36.86 mg). An increase in the ragi flour in biscuits increases significantly the Ca. The findings were well accorded by Rana et al., (2021).***Phosphorous*** **(P):**The phosphorus in biscuits were found T1 (114.19 mg). Phosphorus in ragi-fortified biscuits ranged from 121.85 to 152.38 mg. The maximum was in T6 (152.38 mg) whereas lowest in T2 (121.85 mg) as per Gupta and Awasthi (2021).***Iron (Fe):-***The Fe was ranged from 2.62 to 2.89 mg. The maximum was in T6 (2.89 mg) while minimum in T2 (2.62 mg) findings were closed agreement with Sudha *et. al.* (2019).***Non-reducing sugar*****:**The values were ranged from 0.50 to 0.96 per cent and there were significant differences between each combination.***Reducing sugar***: It was ranged from 4.00 to 4.76 %. T5 (4.76 percent) had the highest decreasing sugar content, while T3 had the lowest (4.00 percent). ***Total sugar:***T1biscuits had 5.31 per cent total sugar. The blended biscuits had a range of 4.96 to 5.35 percent, with substantial variances across the different combinations. Prabhavathi *et. al*., (1973) reported similar work.***Amylose***: Values ranged from 13.16 (T6) to 14.35 (T1) and there were significant difference among each combination. Obtained result supports the findings of other works on sprouted ragi flour (SRF) supplemented products by Rana et al., (2021).

| **Attributes** | **0 days** | | **30 days** | | **60 days** | | **90 days** | |
|---|---|---|---|---|---|---|---|---|
| | **(T1)** | **(T5)** | **(T1)** | **(T5)** | **(T1)** | **(T5)** | **(T1)** | **(T5)** |
| **Laminated pouches** | | | | | | | | |
| Appearance | 8.75 | 8.50 | 8.40 | 8.50 | 8.00 | 8.00 | 7.95 | 7.95 |
| Colour | 8.25 | 8.00 | 8.45 | 8.05 | 8.10 | 7.95 | 7.85 | 8.05 |
| Crispiness | 7.70 | 8.35 | 7.55 | 8.10 | 8.10 | 8.05 | 7.95 | 7.20 |
| Taste | 7.60 | 8.05 | 7.70 | 7.70 | 8.25 | 7.95 | 7.75 | 7.55 |
| Texture | 8.10 | 8.10 | 7.95 | 8.00 | 7.60 | 8.20 | 7.75 | 7.55 |
| OA | **8.08** | **8.20** | **8.01** | **8.07** | **8.01** | **8.03** | **7.94** | **7.83** |
| **LDPE** | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Appearance | 8.75 | 8.50 | 8.31 | 8.47 | 7.61 | 7.94 | 7.83 | 7.91 |
| Colour | 8.25 | 8.00 | 8.39 | 8.11 | 7.77 | 7.81 | 7.81 | 7.96 |
| Crispiness | 7.70 | 8.35 | 7.71 | 8.09 | 7.86 | 7.91 | 7.83 | 7.18 |
| Taste | 7.60 | 8.05 | 7.54 | 7.67 | 8.08 | 7.88 | 7.69 | 7.52 |
| Texture | 8.10 | 8.10 | 7.86 | 7.95 | 7.52 | 8.07 | 7.66 | 7.51 |
| OA | **8.08** | **8.20** | **7.96** | **8.06** | **7.77** | **7.92** | **7.76** | **7.62** |
| **PP** | | | | | | | | |
| Appearance | 8.75 | 8.50 | 8.30 | 8.44 | 7.58 | 7.92 | 7.81 | 7.91 |
| Colour | 8.25 | 8.00 | 8.36 | 8.09 | 7.72 | 7.80 | 7.79 | 7.94 |
| Crispiness | 7.70 | 8.35 | 7.70 | 8.08 | 7.83 | 7.88 | 7.80 | 7.17 |
| Taste | 7.60 | 8.05 | 7.52 | 7.66 | 7.96 | 7.86 | 7.66 | 7.50 |
| Texture | 8.10 | 8.10 | 7.83 | 7.91 | 7.51 | 8.04 | 7.64 | 7.48 |
| OA | **8.08** | **8.20** | **7.94** | **8.04** | **7.72** | **7.90** | **7.74** | **7.60** |

**Table 4. Sensory score combination of the wheat and ragi biscuit**

**3.3 Sensory score and shelf life study: - *Overall Acceptability (OA)*:** The sensory scores for 0 to 90 days duration of different combinations of wheat and ragi based biscuit were presented Table 4. OA scores in wheat-based biscuits were shown higher in T1 (7.94). In terms of OA, sensory ratings for wheat and ragi-based biscuits varied from 7.42 to 7.83. T5 (7.83) had the highest OA, whereas T2 had the lowest (7.63). These findings had close relevance to work of Chandra *et. al*., (2015).

The values were recorded in the different intervals till 90 days in storage. Three packaging namely LP, LDPE & PP, among the entire LP shown good quality. Sensory score for T1 on 0 days was 8.08, which was fallen up to 7.79, while the best treatment of blend T5 was 8.20 and similarly reduced to 7.83. Further, the LDPE effect where on 90th day score of T1 was 7.76 and 7.51 for T5. On the 90th day of storage, values for PP were 7.74 for T1 and 7.60 for T5 the results were in accordance with as per Baixauli et al., (2008).

## 4. CONCLUSION

Notably, baked goods with additional flours have better sensory and functional qualities while maintaining a more nutrient-rich profile. It results in a significant net increase of protein, dietary fibre, vital micronutrients, and bioactive substances by substituting flour rich in legumes and millet for refined wheat flour. From 18 to 19, the final products are boosted with the positive effects that support better digestion, improved glycemic control, and greater antioxidant capacity. Research has proven that the mineral content and bioactive value of baked foods (bread, biscuits, cookies, and cakes) can be enhanced by modifying wheat flour to a certain extent. For those with celiac disease, millet-based flours including finger millet, jowar (sorghum), and pearl millet are essential sources of amino acids. In conclusion the results of this study indicate that, biscuits were prepared with partial replacement of wheat flour by SRF that is 05, 10, 15, 20, and 25 per cent levels while other ingredients were kept constant. Results of study revealed that proximate viz. carbohydrates, protien, fat, energy value and amylose were decreased while fibre, ash, calcium, phosphorus, iron and moisture were increased. A result of organoleptic evaluation shows that overall acceptability of T5 with the score 8.20 was found best among the rest treatments with supplementation of SRF up to 20%.

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