Policy Research Journal
ISSN (E): 3006-7030 ISSN (P) : 3006-7022 Volume 4, Issue 3, 2026

# NUTRITIONAL, PHYTOCHEMICAL, AND SENSORY CHARACTERIZATION OF GLUTEN-FREE COOKIES DEVELOPED FROM RICE, CHICKPEA, AND BANANA PEEL COMPOSITE FLOUR

**Shabahat Iqbal[1], Anum Urooj*[1], Maryyum Afzal[2], Areeba Bashir[1], Muhammad Mudassir Rasheed[3], Mahmood Khan[1], Muhammad Asif[4], Nimra Arshad[1], Arawat Fatima[5]**

[*1]*National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan.*
[2]*Department of Botany, University of Okara, Okara, Pakistan.*
[3]*Department of Allied Health Sciences, The University of Chenab, Gujrat, Pakistan.*
[4]*Department of Food Science and Technology, UAF Constituent College, Burewala, Pakistan.*
[5]*Department of Food Science and Technology, Government College, University, Faisalabad, Pakistan.*

[*1]anumurooj.uaf@gmail.com

**DOI:** http://doi.org/10.5281/zenodo.19061728

**Keywords**
*Gluten-free cookies; Composite flour; Nutritional enrichment; Functional properties; Celiac disease; Antioxidant activity; Sensory evaluation*

**Article History**
*Received: 18 January 2026*
*Accepted: 03 March 2026*
*Published: 17 March 2026*


**Corresponding Author: ***
**Anum Urooj**

**Abstract**
*Cereal grains are widely consumed to meet human energy requirements; however, gluten proteins present in Wheat, Rye, Barley, and Triticale can trigger health issues such as Celiac Disease. This study aimed to develop nutritionally enriched gluten-free cookies using composite flours of Rice Flour, Chickpea Flour, and Banana Peel Powder in different proportions. Proximate analysis showed improved nutritional composition with increasing chickpea and banana peel flour, including higher protein (6.13–14.97%), fat (7.14–19.23%), fiber (1.82–7.38%), ash (1.03–4.48%), and moisture (2.44–5.43%). The health-promoting properties include total phenolic contents (50.01-125.55 mg GAE/100g), total flavonoid contents (20.40-60.54 mg QE/100g), and antioxidant activity (6.82-8.62%). Physical properties such as weight, diameter, thickness, and spread ratio significantly effect ($p<0.05$) with the addition of composite flour. Sensory evaluation showed the highest overall acceptability for cookies containing 40% rice flour, 50% chickpea flour, and 10% banana peel flour, demonstrating potential for nutritious and consumer-acceptable gluten-free products.*

## Introduction

Celiac disease (CD), also known as gluten-sensitive enteropathy, is a chronic immune-mediated autoimmune disorder that primarily affects the small intestine in genetically predisposed individuals (Bai & Ciacci, 2017; Caio et al., 2019). It is triggered by the ingestion of gluten, a storage protein found in wheat, barley, and rye (Shewry & Hey, 2015). In individuals carrying HLA-DQ2 and/or HLA-DQ8 haplotypes, partially digested gluten peptides, particularly gliadin, induce a T-cell-mediated immune response that leads to villous atrophy, crypt hyperplasia, and impaired nutrient absorption. Clinically, CD presents with a wide spectrum of manifestations ranging from classic gastrointestinal symptoms such as diarrhea, abdominal pain, and weight loss to extra-intestinal complications including iron-deficiency anemia, osteoporosis, dermatitis herpetiformis, and neurological disorders (Singh et al., 2018)

Globally, CD affects approximately 1% of the population, with pooled seroprevalence and biopsy-confirmed prevalence estimated at 1.4% and 0.7% (Singh et al., 2018). The incidence has increased in recent decades due to improved diagnostic awareness and possible epidemiological growth (Agarwal et al., 2020). Asia indicates prevalence rates between 0.5% and 1.6%, while studies from Pakistan suggest that nearly 1.3% of the population may be affected (Mohta et al., 2021). Owing to its chronic nature and associated nutritional deficiencies and complications, CD shows a growing global public health concern (Akhtar et al., 2021).

Gluten is a structural storage protein present in wheat, barley, rye, and spelt, mainly composed of gliadins and glutenins that provide viscoelastic properties to dough (Shewry & Hey, 2015; Ciaccio et al., 2015). In genetically predisposed individuals carrying HLA-DQ2 or HLA-DQ8 haplotypes, gluten ingestion triggers an abnormal immune response that leads to inflammation of the small intestinal mucosa and autoimmune enteropathy (Sapone et al., 2012; Sharma et al., 2020). Highly immunogenic α-gliadin peptides play a crucial role in this process by activating immune responses that cause villous atrophy and impaired nutrient absorption (Jafari et al., 2018; Cabanillas, 2020; Sapone et al., 2012).

Currently, a lifelong gluten-free diet (GFD) remains the only effective management strategy for individuals with CD; however, it may lead to several nutritional challenges (Gun et al., 2021; Choina et al., 2022). Nutrient deficiencies can arise from both intestinal malabsorption and the restrictive nature of the GFD (Pinto-Sanchez & Bai, 2019). Common deficiencies at diagnosis include iron, folate, vitamin B12, vitamin D, and zinc, with iron deficiency reported in up to 28% of pediatric patients (Wessels et al., 2016). Impaired absorption of calcium and fat-soluble vitamins may also contribute to reduced bone mineral density and an increased risk of fractures. Inadequate intake may persist due to limited dietary diversity and the poor nutritional composition of many gluten-free products (Verma, 2021).

Gluten-containing cereals are important sources of iron, folate, calcium, and B-complex vitamins; therefore, their exclusion from the diet may increase the risk of micronutrient deficiencies. Many commercial gluten-free products are often lower in protein, higher in fat, less frequently fortified, and more expensive than conventional products (Allen & Orfila, 2018). Adherence to a GFD can also be challenging due to limited availability, high cost, and insufficient dietary awareness, particularly in developing countries (Hassan & A-Kader, 2014; Salih et al., 2021). Consequently, nutritional monitoring, professional dietary guidance, and the development of nutritionally enriched gluten-free foods are essential for improving health outcomes in individuals with CD (Choina et al., 2022).

The global demand for gluten-free products has increased considerably due to the rising prevalence of CD, gluten sensitivity, and growing consumer health awareness. Market analyses indicate that the gluten-free market expanded from USD 4.18 billion in 2017 to USD 6.47 billion in 2023. Data from the National Health and Nutrition Examination Survey (NHANES) (2009–2012) showed that approximately 0.9% of participants followed a gluten-free diet, although most did not have a confirmed diagnosis of CD (Mardini et al., 2015), indicating increasing consumption of gluten-free products among the general population.

Despite the growing demand for gluten-free bakery products, these foods are often more expensive, less accessible, and nutritionally inferior to conventional products, particularly in terms of protein and micronutrient content (Allen & Orfila, 2018; Muir et al., 2019). To improve their nutritional quality, the incorporation of nutrient-dense ingredients such as legumes, cereals, and fruit by-products has been widely explored (Woomer & Adedeji, 2021; Mir et al., 2016). In developing countries, including Pakistan, the limited availability and high cost of gluten-free products highlight the need to develop affordable and nutritionally enriched bakery products using locally available ingredients (Atsawarungruangkit et al., 2020).

Rice (*Oryza sativa*) is widely used as a gluten-free substitute for wheat due to its hypoallergenic nature, high digestibility, and desirable sensory properties. However, rice flour is relatively low in protein and deficient in lysine, which limits its nutritional value (Jiao et al., 2020; Wu et al., 2019; Kim et al., 2021). To improve its nutritional quality, rice flour can be combined with legume-based flours such as chickpea (*Cicer arietinum*), which is rich in protein, dietary fiber, minerals, and bioactive compounds. Incorporation of chickpea flour has been reported to enhance protein content and resistant starch in gluten-free products without adversely affecting sensory quality (El-Sohaimy et al., 2020; Wang et al., 2021). Banana (*Musa sapientum*) peel (an agro-industrial waste) flour has gained attention as a functional ingredient due to its high levels of dietary fiber, polyphenols, carotenoids, and essential minerals (Gomes et al., 2022).

Despite the increasing prevalence of CD and the growing demand for gluten-free foods, nutritionally balanced and affordable gluten-free bakery products remain limited, particularly in developing countries. Many commercial gluten-free products are expensive and nutritionally inferior, often containing low protein and limited micronutrient fortification. Although rice flour is widely used in gluten-free formulations, its low protein content reduces the overall nutritional quality of the final product. Therefore, the development of nutritionally enriched gluten-free cookies using composite flours. Subsequently, the effect of composite flour on chemical composition, physical properties, biofunctional characterization, and sensorial attributes of gluten free cookies

## Materials and methods

### Procurement of raw material

Raw materials (rice grains, chickpea seeds, and banana peels) were purchased from the local market in Faisalabad. Other baking ingredients, including sugar, salt, baking powder, eggs, butter, and flavoring agents were purchased from local shops. All chemicals and reagents used for analyses were purchased of analytical grade (Merck, Germany). All raw materials were stored at room temperature (25 ± 2 °C) before analysis.

### 2.2 Preparation of raw material

Rice grains and chickpea seeds were manually cleaned to remove extraneous matter, such as dust and stones. Samples were ground using a laboratory mill and passed through a standard sieve to obtain a uniform particle size. Banana fruits were washed thoroughly with distilled water, peeled, and sliced. Banana peels were dried in a hot-air oven at 60–70°C until constant weight, then ground to a fine powder (60-mesh sieve), following the procedure described by Urooj et al. (2026a). All flours were stored in airtight polythene bags to prevent moisture absorption and contamination.


**Figure 1: Flow diagram for preparation of rice, chickpea, and banana peel flours**

**Cookies Development**

Cookies were prepared using varying concentrations of rice, chickpea, and banana peel flour by following the method outlined by Oyeyinka et al. (2018). Cookie dough was prepared by mixing composite flour (rice flour, chickpea flour, and banana peel flour), sugar, salt, baking powder, eggs, butter, vanilla essence, and water using a laboratory mixer for 10 minutes to obtain a homogeneous dough consistency. The dough was rested for 10-15 minutes to improve dough viscoelastic properties. The dough was then sheeted to approximately 5 mm thickness and cut using standard cookie molds. Baking was performed at 180-220 °C for 15-25 minutes according to treatment design. After baking, the cookies were cooled at ambient temperature (25 ± 2 °C) and packed in polythene bags for subsequent analysis, following the study method of gluten-free approach to cookies preparation as described by Kohli et al. (2023)

**Table 1. Development of cookies using composite flours**

| Treatments | Rice flour (%) | Chickpea flour (%) | Banana peel flour (%) |
|---|---|---|---|
| $T_0$ | 100 | 0 | 0 |
| $T_1$ | 70 | 20 | 10 |
| $T_2$ | 40 | 50 | 10 |
| $T_3$ | 10 | 80 | 10 |

**Product characterization**

**Proximate composition analysis**

The proximate composition of cookies, including moisture, crude protein, crude fat, crude fiber, ash, and carbohydrate content, was determined according to the standard methods of the AOAC (2019).

**Physical properties**

The diameter of cookies was measured using a vernier caliper at different positions, and the average diameter was recorded. The thickness was determined by stacking three cookies on top of each other and measuring their combined height using a vernier caliper. The measurements were repeated by rearranging cookies, and the average thickness was calculated. The spread ratio is determined by dividing the diameter by the thickness (Zahid et al., 2025).

$$Spread\ Ratio = \frac{Diameter}{Thickness}$$

**Phytochemical characterization**

**Preparation of Extracts**

For the extraction of bioactive compounds, 2 g of the cookie sample was mixed with 20 mL of 80% methanol. The mixture was placed on a mechanical shaker and agitated at 200 rpm for 2 hours to facilitate the extraction of phenolic and flavonoid compounds. Subsequently, the mixture was centrifuged at 3500 rpm for 10 minutes, after which the supernatant was carefully collected and used for the determination of total phenolic content (TPC), total flavonoid content (TFC), and DPPH radical scavenging activity, following the method described by Asif et al. (2024).

**Total phenolic contents (TPC)**

Total phenolic content of the cookie samples was determined using the Folin–Ciocalteu (FC) colorimetric method following the procedure described by Asif et al. (2023) and Urooj et al. (2026a). The sample extract was mixed with Folin-Ciocalteu reagent (1:1, v/v), followed by the addition of 2.5 mL sodium carbonate solution (7.5%). The sample mixture was incubated at room temperature for 30 min to allow color development. The absorbance of the resulting solution was then measured at 765 nm using a UV–Vis spectrophotometer. Total phenolic content was expressed as milligrams of gallic acid equivalents (mg GAE/100 g) of sample based on the calibration curve of gallic acid.

**Total flavonoid content (TFC)**

Total flavonoid content of the cookie samples was determined using the method outlined by Asif et al. (2025b). 0.25 mL of the sample extract was mixed with 0.75 mL of 5% sodium nitrite and 1.25 mL of distilled water, and the mixture was allowed to stand at room temperature for 6 min. Subsequently, 150 µL of 10% aluminum chloride solution was added, and the total volume was adjusted to 2.5 mL with distilled water. The absorbance of the resulting solution was measured at 510 nm using a UV–Vis spectrophotometer. Total flavonoid content was expressed as milligrams of quercetin equivalents (mg QE/100 g) of the sample based on the quercetin calibration curve.

**Free radical scavenging activity (DPPH)**

The antioxidant activity of the cookie samples was determined using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay spectrophotometric analysis following the modified method described by Tüter et al. (2025). Briefly, cookies samples were extracted using methanol, and appropriate aliquots of extract (75-200 µL) were diluted with methanol to obtain a final volume of 200 µL. The extract solutions were then mixed with 3.8-4.0 mL of DPPH working solution ($6 \times 10^{-5}$ mol/L). The reaction mixtures were incubated in the dark at room temperature for 30-60 minutes. After incubation, absorbance was measured using a spectrophotometer at 515 nm against 95% methanol as a blank. Antioxidant activity was expressed as percentage DPPH radical scavenging capacity.

$$DPPH\ Radical\ Scavenging\ Activity(\%) = \frac{(\mathrm{AB} - AS)}{AB} \times 100$$

Where:
AB = Absorbance of blank
AS = Absorbance of sample

**Color analysis**

Color characteristics of cookie samples were determined using a calibrated colorimeter following standard instrumental color measurement techniques by Naqvi et al. (2025) and Saadoudi et al. (2024). Measurements were taken from different surface points of each cookie sample. Color difference (ΔE), chroma (C*), and whitening index (WI) were calculated using the following equations:

$$\Delta \mathrm{E} = \sqrt{\left(\mathrm{L}^* - \mathrm{L}^*_{\mathrm{std}}\right)^2 + \left(\mathrm{a}^* - \mathrm{a}^*_{\mathrm{std}}\right)^2 + (\mathrm{b}^* - \mathrm{b}^*_{\mathrm{std}})^2}$$

$$\mathrm{C}^* = \sqrt{(\mathrm{a}^*)^2 + (\mathrm{b}^*)^2}$$

$$\mathrm{WI} = 100 - \sqrt{(100 - \mathrm{L}^*)^2 + (\mathrm{a}^*)^2 + (\mathrm{b}^*)^2}$$

Here, std indicates the standard sample.

**Sensory evaluation**

Sensory evaluation of cookie samples was conducted using a 9-point hedonic scale following methods reported by Urooj et al. (2026b), with semi-trained panelists. A total of 20-25 panelists participated in the evaluation. Panelists were trained to evaluate sensory attributes, including color, taste, flavor, texture, mouthfeel, crispness, and overall acceptability. Cookie samples were presented in coded, randomized order to avoid bias. Panelists were instructed to rinse their mouths with water between samples to minimize carryover effects. Sensory scores were recorded using a structured 9-point hedonic scale, where 9 = like extremely and 1 = dislike extremely.

**Statistical analysis**

All experiments were conducted in triplicate, and the results were expressed as mean values ± standard deviation (SD). Significant differences were determined using Tukey's Honest Significant Difference (HSD) test for pairwise comparison of treatment means at a significance level of $p < 0.05$. Different superscript letters within the same column of tables indicate statistically significant differences among treatments. All statistical analyses were performed using Statistix 8.1 software (Analytical Software, USA) (Urooj et al., 2026; Naqvi et al., 2024; Asif et al., 2024).

## Results and discussion

### Chemical composition of cookies

The chemical composition of gluten-free cookies was significantly affected by the incorporation of chickpea flour and banana peel powder ($p<0.05$), as presented in Table 2. Moisture content increased from 2.44% in $T_0$ to 5.43% in $T_3$, which may be attributed to the higher water-holding capacity of chickpea flour and the fiber-rich nature of banana peel powder as reported in legume-enriched bakery products (Dahal et al., 2022), although increased moisture may reduce shelf stability due to greater microbial susceptibility (Javed et al., 2021). Fat content also increased significantly, ranging from 7.14% in $T_0$ to 19.23% in $T_3$, likely due to the higher lipid content of chickpea flour (Jabeen et al., 2022). Similarly, crude fiber content increased from 1.82% to 7.38%, reflecting the substantial dietary fiber contribution of chickpea flour and banana peel powder (Bayomy & Alamri, 2022; Jabeen et al., 2022). Ash content increased from 1.03% to 4.48%, indicating enhanced mineral content in composite flour formulations compared with rice flour (Dhankhar et al., 2021). Likewise, protein content increased significantly from 6.13% to 14.97%, primarily due to the high protein content of chickpea flour (18-25%). Similar improvements in protein levels following legume flour incorporation have been reported by Sofi et al. (2019).

**Table 2. Chemical Composition of Cookies supplemented with composite flour**

| Treatments | Moisture (%) | Fat (%) | Fiber (%) | Ash (%) | Protein (%) |
|---|---|---|---|---|---|
| $T_0$ | $2.44±0.0124^d$ | $7.14±0.0163^d$ | $1.82±0.0125^d$ | $1.03±0.0163^d$ | $6.13±0.0082^d$ |
| $T_1$ | $3.87±0.0124^c$ | $10.35±0.0124^c$ | $3.34±0.008^c$ | $2.14±0.0047^c$ | $8.18±0.0125^c$ |
| $T_2$ | $4.67±0.0124^b$ | $14.81±0.0124^b$ | $5.36±0.0125^b$ | $3.32±0.0169^b$ | $11.57±0.0169^b$ |
| $T_3$ | $5.43±0.0124^a$ | $19.23±0.0205^a$ | $7.38±0.0125^a$ | $4.48±0.0082^a$ | $14.97±0.0125^a$ |

### Physical properties

The physical properties of gluten-free cookies, including spread ratio, diameter, thickness, and weight, were significantly influenced by composite flour substitution, as presented in Table 3.

The weight of cookies increased significantly ($p<0.05$) from 6.44 ± 0.02 g in $T_0$ to 9.93 ± 0.02 g in $T_3$. This increase may be due to the higher protein and fiber contents of chickpea and banana peel flour, which enhance water absorption and retention in the dough matrix as outlined by Kaur & Gill (2020). The diameter of cookies increased slightly from 5.12 ± 0.01 cm in $T_0$ to 5.25 ± 0.02 mm in $T_3$. This increase may be associated with enhanced water absorption and changes in dough structure due to higher protein and fiber content in the composite flour. Similarly, cookie thickness increased significantly ($p<0.05$) from 4.23 ± 0.01 cm ($T_0$) to 4.66 ± 0.02 cm ($T_3$). The increase in thickness may be attributed to the formation of a stronger dough resulting from protein enrichment, which improves structural stability during baking (Dogruer et al., 2023a; Soni et al., 2018). The spread ratio increased significantly ($p<0.05$) from 5.23 ± 0.01 in $T_0$ (control) to 10.14 ± 0.01 in $T_3$. The increase in the spread ratio may be attributed to modifications in the dough viscoelastic properties caused by the incorporation of chickpea flour, as reported by Soni et al. (2018).

| Table 3. Physical characteristics of cookies prepared from composite flour | | | | |
|---|---|---|---|---|
| Treatments | Weight (g) | Diameter (mm) | Thickness (mm) | Spread Ratio (-) |
| $T_0$ | 6.44 ± 0.02$^{d}$ | 5.12 ± 0.01$^{b}$ | 4.23 ± 0.01$^{b}$ | 5.23 ± 0.01$^{d}$ |
| $T_1$ | 7.30 ± 0.01$^{c}$ | 5.14 ± 0.01$^{b}$ | 4.50 ± 0.08$^{b}$ | 6.99 ± 0.01$^{c}$ |
| $T_2$ | 8.61 ± 0.01$^{b}$ | 5.23 ± 0.02$^{a}$ | 4.53 ± 0.01$^{a}$ | 8.29 ± 0.01$^{b}$ |
| $T_3$ | 9.93 ± 0.02$^{a}$ | 5.25 ± 0.02$^{a}$ | 4.66 ± 0.02$^{a}$ | 10.14 ± 0.01$^{a}$ |

**Phytochemical characterization**

The phytochemical properties of gluten-free cookies were evaluated through total phenolic content (TPC), total flavonoid content (TFC), and DPPH radical scavenging activity as presented in Table 4. TPC increased significantly from 50.01 mg GAE/100 g in $T_0$ to 125.55 mg GAE/100 g in $T_3$, which may be attributed to the high concentration of phenolic compounds present in banana peel powder and legumes. Similar increases in phenolic content following plant-based fortification of bakery products have been reported by Shahwar et al. (2012). A comparable trend was observed for TFC, which increased from 20.40 mg QE/100 g in $T_0$ to 60.54 mg QE/100 g in $T_3$, indicating enrichment of bioactive flavonoids from chickpea flour and banana peel powder. The DPPH radical scavenging activity ranged from 6.82% to 8.62%, with the highest activity observed in $T_1$ (8.62 ± 0.05%). The improved antioxidant capacity of composite formulations may be associated with the presence of phenolic and flavonoid compounds. However, the slight reduction at higher substitution levels ($T_3$) may be due to thermal degradation of phenolics or phenolic-protein interactions during baking. Similar observations have been reported in plant-fortified bakery products (Shalaby et al., 2022).

| Table 5. Phytochemical characterization of cookies prepared from composite flour | | | |
|---|---|---|---|
| Treatments | TPC (mg GAE/100 g) | TFC (mg QE/100 g) | DPPH (%) |
| $T_0$ | 50.01± 0.2$^{a}$ | 20.40 ±0.5$^{a}$ | 6.82±0.03$^{d}$ |
| $T_1$ | 80.04 ± 0.3$^{b}$ | 35.55 ±0.2$^{b}$ | 7.52±0.01$^{c}$ |
| $T_2$ | 110.05 ±0.4$^{c}$ | 50.40 ±0.5$^{c}$ | 7.79±0.02$^{b}$ |
| $T_3$ | 125.55 ±0.5$^{d}$ | 60.54 ±0.3$^{d}$ | 8.62±0.05$^{a}$ |

**Color analysis**

Color is an important quality attribute affecting the consumer acceptability of baked products. The color parameters of gluten-free cookies showed significant differences ($p$<0.05) among treatments, as presented in Table 5. The total color difference (ΔE) increased from 0.00 to 6.08, indicating noticeable color variation between the control and composite formulations. It may be attributed to the natural pigments' hydrolysis, non-enzymatic browning, which contributes to browning during baking. Chroma (C*) values showed only minor variation (27.38–28.63), indicating a reduction in color saturation, due to the higher redness (a*) of supplemented cookies. The decrease in Chroma may be due to the dilution of yellow pigments (b*) and increased fiber content affecting light reflection (Hernández *et al.*, 2016). The whiteness index (WI) also showed a significant increase from 37.11 in the control to 42.40 in $T_3$. Although composite flours generally tend to darken bakery products, the specific balance of rice flour with chickpea and banana peel components may have influenced light scattering and surface characteristics, resulting in higher WI values. Changes in moisture content and surface structure during baking may also affect the reflection of light, contributing to variations in whiteness. These findings are consistent with Dogruer et al. (2023b) showing that the incorporation of chickpea flour significantly influences the CIELAB color parameters of gluten-free cookies due to ingredient pigments and Maillard browning reactions during baking.

| Table 5. Effect of composite flour on change in color, chroma and whiteness index of cookies | | | |
|---|---|---|---|
| Treatments | ΔE | Chroma (C*) | WI |
| $T_0$ | 0±0.00$^d$ | 27.38±0.08$^b$ | 37.11±0.15$^d$ |
| $T_1$ | 2.09±0.05$^c$ | 28.02±0.10$^{ab}$ | 38.55±0.10$^c$ |
| $T_2$ | 4.89±0.07$^b$ | 28.63±0.12$^a$ | 41.80±0.12$^b$ |
| $T_3$ | 6.08±0.08$^a$ | 28.69±0.09$^a$ | 42.40±0.11$^a$ |

**Sensory Evaluation**

Sensory evaluation of gluten-free cookies was conducted to assess color, texture, taste, flavor, and overall acceptability. The results indicated that the incorporation of chickpea flour and banana peel powder significantly influenced the sensory characteristics of the cookies (Figure 2). Color scores increased from 6.11 ± 0.0125 ($T_0$) to 7.74 ± 0.0125 ($T_3$), which may be attributed to the natural pigments of chickpea flour and enhanced Maillard browning reactions during baking. Similar effects of legume flour on color development have been reported by Sibian and Riar (2020). Texture scores also improved with increasing levels of chickpea flour, rising from 7.49 ± 0.0125 ($T_0$) to 8.57 ± 0.0125 ($T_3$), possibly due to the higher protein and dietary fiber content contributing to a desirable crisp texture. Comparable findings were reported by Benkadri et al. (2018). Taste and flavor scores ranged from 7.02 ± 0.0169 to 8.17 ± 0.0163 and 7.02 ± 0.0205 to 7.81 ± 0.0082, respectively, indicating that the composite flour formulation enhanced sensory perception. Similar observations regarding the influence of fiber-rich ingredients on sensory properties were reported by Paciulli et al. (2018) and Sharma and Devi (2021). Overall acceptability followed a similar trend, with the highest score observed for $T_3$ (8.23 ± 0.0163) compared to 7.60 ± 0.0817 in $T_0$. These results suggest that the incorporation of chickpea flour and banana peel powder improved the sensory quality of the cookies, with $T_3$ identified as the most acceptable formulation. A review on the application of legumes in gluten-free foods indicates that the inclusion of legume and high-fiber flours can influence sensory attributes such as color, texture, and overall acceptability, particularly when appropriately balanced with other ingredients (Imam et al., 2024).

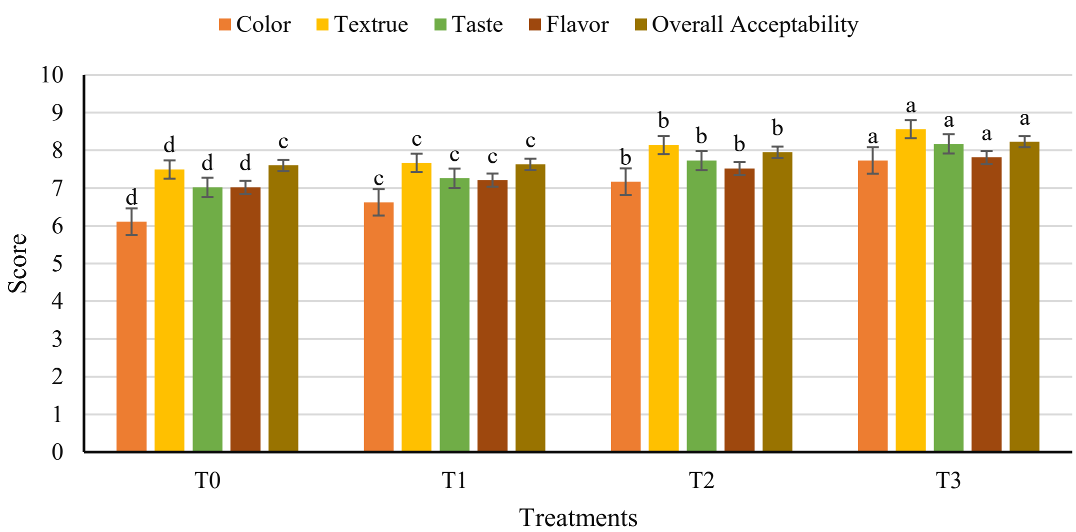


**Figure 2. Effect of various concentration of gluten-free cookies prepared from composite flour**

## Conclusion

The study developed nutritionally enriched gluten-free cookies using composite flours of Rice Flour, Chickpea Flour, and Banana Peel Powder. Incorporation of chickpea and banana peel flour significantly improved the nutritional composition by increasing protein, dietary fiber, fat, and mineral content, along with better moisture retention. Phytochemical analysis showed that moderate levels of these flours enhanced antioxidant activity, indicating the functional potential of banana peel powder. Physical properties such as spread ratio, cookie diameter, thickness, and hardness were also positively influenced, resulting in desirable structural characteristics. Color analysis demonstrated acceptable variations in lightness, redness, and yellowness, contributing to product appeal. Sensory evaluation revealed good consumer acceptance, with improvements in color, texture, flavor, taste, and overall acceptability at higher substitution levels. Overall, composite flour from rice, chickpea, and banana peel offers a cost-effective, locally available ingredient for producing nutritionally balanced gluten-free cookies suitable for individuals with Celiac Disease and health-conscious consumers.

## Conflict of interest

The authors declare that they have no known conflict of interest.

## Funding

The authors did not receive any funding for research.

## References

Abebe, T. G., & Abera, W. G. (2024). Effect of baking conditions on gluten-free biscuit quality made from groundnut oilseed cake protein isolate and teff flour blends. *Cogent Food & Agriculture*, *10*(1). https://doi.org/10.1080/23311932.2024.2437141

Agarwal, A., Chauhan, A., Ahuja, V., & Makharia, G. K. (2020). Opportunities and challenges in the management of celiac disease in Asia. *Journal of Gastroenterology and Hepatology Open*, *4*, 795–799.

Akhtar, K., Fatima, A., Awais, A., Tayyab, H., Lucman, S., & Fatima, T. (2021). Lack of awareness of celiac disease in Pakistan. *Journal of Natural and Applied Sciences Pakistan*, *3*, 819–827.

Akram, S., Chatha, A., Abid, J., Farooq, U., & Ahmad, A. M. R. (2025). Development and quality assessment of gluten-free cookies using rice flour and date fruit. *Frontiers in Nutrition*, *12*, 1645063. https://doi.org/10.3389/fnut.2025.1645063

Allen, B., & Orfila, C. (2018). The availability and nutritional adequacy of gluten-free bread and pasta. *Nutrients*, *10*, 1370.

AOAC. 2019.Official Method of Analysis. The Association of Official Analytical Chemists. 20th Ed. The Association of Official Analytical Chemist, Arlington, U.S.A.

Asif, M., M.K.I. Khan, M.I. Khan, A.A. Maan, H. Helmick and J.L. Kokini. 2023. Effects of citrus pomace on mechanical, sensory, phenolic, antioxidant, and gastrointestinal index properties of corn extrudates. Food Bioscience. 55:103012.

Asif, M., Khan, M. K. I., Khan, M. I., & Maan, A. A. (2024). Effect of citrus pomace and chickpea on physicochemical, biofunctional and organoleptic properties of corn extrudates. *Journal of Tianjin University Science and Technology*, *57*, 49–65.

Asif, M., A.A. Maan, A. Nazir, M.I.M. Khan and M.K.I. Khan. 2025b. Effect of chickpea on the physicochemical, nutritional, antioxidant, and organoleptic characterization of corn extrudates. Journal of the Science of Food and Agriculture. 105:2059-2067.

Atsawarungruangkit, A., Silvester, J. A., Weiten, D., Green, K. L., Wilkey, K. E., Rigaux, L. N., Bernstein, C. N., Graff, L. A., Walker, J. R., & Duerksen, D. R. (2020). Development of the dietitian integrated evaluation tool for gluten-free diets (DIET-GFD). *Nutrition, 78*, 110–819.

Bai, J. C., & Ciacci, C. (2017). World gastroenterology organisation global guidelines: Celiac disease February 2017. *Journal of Clinical Gastroenterology, 51*, 755–768.

Bayomy, H., & Alamri, E. (2022). Technological and nutritional properties of instant noodles enriched with chickpea or lentil flour. *Journal of King Saud University. Science, 34*, 101–833.

Benkadri, S., Salvador, A., Sanz, T., & Zidoune, M. N. (2018). Optimization of xanthan and locust bean gum in a gluten-free infant biscuit based on rice-chickpea flour using response surface methodology. *Foods, 10*, 1–12.

Bheemisetti, B. R., Kumar, A. K., Bhagwan, A., Shankaraswamy, J., & Sathish, G. (2024a). Enhancing the physical properties of biscuits through composite flour of barnyard millet and dragon fruit powder. *International Journal of Advanced Biochemistry Research, 8*(10), 114–117. https://doi.org/10.33545/26174693.2024.v8.i10b.2422

Bheemisetti, B. R., Kumar, A. K., Bhagwan, A., Shankaraswamy, J., & Sathish, G. (2024b). Sensory evaluation of biscuits enriched with composite flour of barnyard millet and dragon fruit powder. *International Journal of Advanced Biochemistry Research, 8*(10), 485–487. https://doi.org/10.33545/26174693.2024.v8.i10g.2511

Bhavani, M., Sonia, M., Saxena, D., & Awuchi, C. G. (2023). Bioactive, antioxidant, industrial and nutraceutical applications of banana peel. *International Journal of Food Properties, 26*(1), 1277–1289.

Cabanillas, B. (2020). Gluten-related disorders: Celiac disease, wheat allergy, and nonceliac gluten sensitivity. *Critical Reviews in Food Science and Nutrition, 60*, 2606–2621.

Caio, G., Volta, U., Sapone, A., Leffler, D. A., De Giorgio, R., Catassi, C., & Fasano, A. (2019). Celiac disease: A comprehensive current review. *BioMed Central Medicine, 17*, 1–20.

Ciaccio, E. J., Bhagat, G., Lewis, S. K., & Green, P. H. (2015). Trends in celiac disease research. *Computational Biology and Medicine, 65*, 369–378.

Choina, M., Gromek, W., Marzęda, M., Wilk, K., & Łysiak, K. (2022). Gluten – a nutritional enemy or indispensable diet ingredient? *Journal of Education, Health and Sport, 12*, 47–54.

Dahal, M. (2022). Effect of fenugreek seed flour on the quality of biscuit. *Journal of Food Science and Technology, 11*, 45–50.

Dhankhar, J., Vashistha, N., & Sharma, A. (2021). Development of biscuits by partial substitution of refined wheat flour with chickpea flour and date powder. *Journal of Microbiology and Biotechnology, Food Science, 20*, 1093–1097.

Dogruer, I., Coban, B., Baser, F., Gulec, S., & Ozen, B. (2023a). Techno-functional and in vitro digestibility properties of gluten-free cookies made from raw, pre-cooked, and germinated chickpea flours. *Foods, 12*, 2829–2837.

Dogruer, I., Baser, F., Gulec, S., Tokatli, F., & Ozen, B. (2023b). Formulation of gluten-free cookies utilizing chickpea, carob, and hazelnut flours through mixture design. *Foods, 12*(19), 3689. https://doi.org/10.3390/foods12193689

Ezegbe, C. C., Okpalanma, F. E., Okocha, S. K., Odoh, E. N., Ohuche, J. C., Orjiakor, S. N., & Ndulue, J. C. (2024). Physicochemical and sensory evaluation of biscuits produced from composite flour of wheat and fermented cowpea hull. *Asian Food Science Journal, 23*(8), 69–79. https://doi.org/10.9734/afsj/2024/v23i8736

El-Sohaimy, S. A., Brennan, M., Darwish, A. M., & Brennan, C. (2020). Physicochemical, texture and sensorial evaluation of pasta enriched with chickpea flour and protein isolate. *Annals of Agricultural Science, 65*, 28–34.

Fernando, W. M. A. D. B., Abdulraheem, R. A., Kariyawasam, K. P., Samarasinghe, A. S., Fernando, W. M. K. T., Barnes, H., Robertson, M., Jayatunga, D. P. W., De Silva, B. G. D. N. K., & Jayasena, V. (2025). Sorghum and sorghum-based products: Nutritional composition, prebiotic potential and health benefits in gut microbiota interactions. *International Journal of Food Science, 2025*, 1.

Giosuè, A., Siano, F., Di Stasio, L., Picariello, G., Medoro, C., Cianciabella, M., Giacco, R., Predieri, S., Vasca, E., Vaccaro, O., & Cozzolino, R. (2024). Turning wastes into resources: Red grape pomace-enriched biscuits with potential health-promoting properties. *Foods, 13*(14), 2195. https://doi.org/10.3390/foods13142195

Gogoi, M., Barooah, M. S., Bordoloi, P. L., & Borthakur, P. K. (2023). Physical and textural properties of gluten free biscuits containing rice flour, soya flour and buckwheat flour. *Asian Journal of Dairy and Food Research, 42*(3), 398–402. https://doi.org/10.18805/ajdfr.DR-1666

Gomes, S., Vieira, B., Barbosa, C., & Pinheiro, R. J. J. O. F. P. (2022). Evaluation of mature banana peel flour on physical, chemical, and texture properties of a gluten-free Rissol. 46, 1441–1457.

Gun, R. D., Kaplan, A. T., Kaymak, N. Z., Koroglu, E., Karadag, E., Simsek, S. J. P., & Therapy, P. (2021). The impact of celiac disease and duration of gluten free diet on anterior and posterior ocular structures: Ocular imaging based study. 34, 102–214.

Hassan, K., & A-Kader, H. (2014). Celiac disease: the search for adjunctive or alternative therapies. *Expert Review of Gastroenterology & Hepatology, 8*, 313–321.

Hernández Salueña, B., Sáenz Gamasa, C., Diñeiro Rubial, J. M., & Alberdi Odriozola, C. (2019). *CIELAB* color paths during meat shelf life. *Meat Science, 157*, 107889. https://doi.org/10.1016/j.meatsci.2019.107889

Imam, Y. T., Irondi, E. A., Awoyale, W., Ajani, E. O., & Alamu, E. O. (2024). Application of legumes in the formulation of gluten-free foods: Functional, nutritional and nutraceutical importance. *Frontiers in Sustainable Food Systems, 8*, 1251760. https://doi.org/10.3389/fsufs.2024.1251760

Jabeen, S., Khan, A. U., Ahmad, W., Ahmed, M. U. D., Ali, M. A., Rashid, S., Rashid, A., & Shariti-Rad, J. (2022). Development of Gluten-Free Cupcakes Enriched with Almond, Flaxseed, and Chickpea Flours. *Journal of Food Quality, 15*, 1–12.

Jafari, M., Koocheki, A., & Milani, E. J. L. (2018). Functional effects of xanthan gum on quality attributes and microstructure of extruded sorghum-wheat composite dough and bread. *LWT - Food Science and Technology, 89*, 551–558.

Javed, F., Jabeen, S., Sharif, M. K., Pasha, I., Riaz, A., Manzoor, M. F., Sahar, A., Karrar, E., & Aadil, R. M. (2021). Development and storage stability of chickpea, mung bean, and peanut based ready-to-use therapeutic food to tackle protein energy malnutrition. *Food Science and Nutrition, 9*, 5131–5138.

Jiao, A., Yang, Y., Li, Y., Chen, Y., Xu, X., & Jin, Z. (2020). Structural properties of rice flour as affected by the addition of pea starch and its effects on textural properties of extruded rice noodles. *International Journal of Food Properties, 23*, 809–819.

Kaur, H., & Gill, B. S. (2020). Comparative evaluation of physicochemical, nutritional and molecular interactions of flours from different cereals as affected by germination duration. *Journal of Food*

*Measurement and Characterization, 14*, 1147–1157.

Kim, A.-N., Rahman, M. S., Lee, K.-Y., & Choi, S.-G. (2021). Superheated steam pretreatment of rice flours: Gelatinization behavior and functional properties during thermal treatment. *Food Biosciences, 41*, 101–111.

Kohli, D., Jain, A., Singh, O., & Kumar, S. (2023). Gluten free approach of biscuits preparation. *Journal of Agriculture and Food Research, 14*, 100683. https://doi.org/10.1016/j.jafr.2023.100683

Leahu, A., Ghinea, C., Ropciuc, S., & Damian, C. (2025). Textural, color, and sensory analysis of cookies prepared with hemp oil-based oleogels. *Gels, 11*(1), 46. https://doi.org/10.3390/gels11010046

Li, L., He, C., Liu, B., Wen, Q., & Xia, S. (2022). Incorporation of chickpea flour into biscuits improves the physicochemical properties and in vitro starch digestibility. *Food Science and Technology, 159*, 113–222.

Mardini, H. E., Westgate, P., & Grigorian, A. Y. (2015). Racial differences in the prevalence of celiac disease in the US population: National Health and Nutrition Examination Survey (NHANES) 2009–2012. *Digestive Diseases and Sciences, 60*, 1738–1742.

Mengeneh, I., & Ariahu, C. C. (2022). Production and quality evaluation of biscuits from blends of wheat, millet and sesame seeds composites: Physical and sensory properties. *International Journal of Food Engineering and Technology, 6*(1), 17–20. https://doi.org/10.11648/j.ijfet.20220601.13

Mir, S. A., Shah, M. A., Naik, H. R., & Zargar, L. A. (2016). Influence of hydrocolloids on dough handling and technological properties of gluten-free breads. *Trends in Food Science and Technology, 51*, 49–57.

Mohta, S., Rajput, M. S., Ahuja, V., & Makharia, G. K. (2021). Emergence of celiac disease and gluten-related disorders in Asia. *Journal of Neurogastroenterology and Motility, 27*, 337.

Mouminah, H. H., & Althaiban, M. A. (2025). Production and evaluation of gluten-free cookies for celiac patients made from rice flour and green banana flour. *Current Research in Nutrition and Food Science Journal, 13*(2). https://doi.org/10.12944/CRNFSJ.13.2.25

Muir, J. G., Varney, J., Ajamian, M., & Gibson, P. (2019). Gluten-free and low-FODMAP sourdoughs for patients with coeliac disease and irritable bowel syndrome: A clinical perspective. *International Journal of Food Microbiology, 290*, 237–246.

Naqvi, S. N. U. A., Khadim, M. A., Muzammal, S. F., Gul, S. A., Ahmad, B., Urooj, A., & Asif, M. (2024). Effect of lysozyme and bromelain on physicochemical, textural and sensorial properties of mozzarella cheese. *J. Tianjin Univ. Sci. Technol, 57*(3), 45–61.

Naqvi, S. N. ul A., Anwar, I. A., Almas, I., Khalid, I., Muzammal, S. F., Urooj, A., & Arif, A. (2025). Exploring the storage effect on the physicochemical and microbiological properties of peach-plum juice. *RADS Journal of Food Biosciences, 4*(1), 12–19. https://doi.org/10.37962/jfbs.v4i1.49

Oyeyinka, S. A., Ojuko, I. B., Oyeyinka, A. T., Akintayo, O. A., Adebisi, T. T., & Adeloye, A. A. (2018). Physicochemical properties of novel non-gluten cookies from fermented cassava root. *Journal of Food Processing and Preservation, 42*(11), e13819. https://doi.org/10.1111/jfpp.13819

Paciulli, M., Rinaldi, M., Cavazza, A., Ganino, T., Rodolfi, M., Chiancone, B., & Chiavaro, E. (2018). Effect of chestnut flour supplementation on physico-chemical properties and oxidative stability of gluten-free biscuits during storage. *Food Science and Technology, 98*, 451–457.

Pillai, M. K., Selepe, T. S., Bwembya, G. C., & Kibechu, R. W. (2024). Analysis of physicochemical properties of two varieties of sorghum biscuits from the Kingdom of Lesotho. *Food Research, 8*(6), 138–146. https://doi.org/10.26656/fr.2017.8(6).184

Pinto-Sanchez, M. I., & Bai, J. C. (2019). Toward new paradigms in the follow up of adult patients with celiac disease on a gluten-free diet. *Frontiers in Nutrition, 6*, 153.

Puraikalan, Y. (2018). Characterization of proximate, phytochemical and antioxidant analysis of banana (Musa sapientum) peels/skins and objective evaluation of ready-to-cat/cook product made with banana peels. *Current Research in Nutrition and Food Sciences, 6*, 382–391.

Ramsaran, R., de Gannes, V., & Eudoxie, G. (2024). Quality evaluation of innovative buttermilk biscuits produced from orange-flesh sweet potato flour infused with coconut. *Frontiers in Food Science and Technology, 4*, 1467839. https://doi.org/10.3389/frfst.2024.1467839

Saadoudi, M., Lekbir, A., Aidat, O., Zidani, S., Ferhat, R., Kucher, D. E., Shiyapov, T. I., & Rebouh, N. Y. (2024). Chemical characteristic and sensory evaluation of biscuit prepared from wheat and Aleppo pine seeds flour. *Foods, 13*(15), 2428. https://doi.org/10.3390/foods13152428

Salih, S. N., Mubarak, F. H., Elimam, A., & Arabi, A. (2021). Evaluation of dietary compliance among Sudanese children with coeliac disease. *Sudanese Journal of Paediatrics, 21*, 137.

Sapone, A., Bai, J. C., Ciacci, C., Dolinsek, J., Green, P. H., Hadjivassiliou, M., Kaukinen, K., Rostami, K., Sanders, D. S., & Schumann, M. (2012). Spectrum of gluten-related disorders: Consensus on new nomenclature and classification. *BioMed Central Medicine, 10*, 1–12.

Shahwar, M. K., El-Ghorab, A. H., Anjum, F. M., Butt, M. S., Hussain, S., & Nadeem, M. (2012). Characterization of coriander (Coriandrum sativum L.) seeds and leaves: Volatile and non-volatile extracts. *International Journal of Food Properties, 15*, 736–747.

Shalaby, R. A. E. D., Anwar, D. A., & Hussan, R. S. (2022). Acrylamide formation in cake baked in different utensils and novel interventions strategies. *Egyptian Journal of Chemistry, 65*(12), 707–715.

Sharma, C., & Devi, A. (2021). Effects of soy and water chestnut flour on the quality of cookies. *Asian Journal of Dairy and Food Research, 40*, 332–336.

Sharma, N., Bhatia, S., Chunduri, V., Kaur, S., Sharma, S., Kapoor, P., Kumari, A., & Garg, M. (2020). Pathogenesis of celiac disease and other gluten related disorders in wheat and strategies for mitigating them. *Frontiers in Nutrition, 7*, 6–10.

Shewry, P. R., & Hey, S. J. (2015). The contribution of wheat to human diet and health. *Food and Energy Security, 4*, 178–202.

Silva-Paz, R. J., Silva-Lizárraga, R. R., Jamanca-Gonzales, N. C., & Eccoña-Sota, A. (2024). Evaluation of the physicochemical and sensory characteristics of gluten-free cookies. *Frontiers in Nutrition, 10*, 1304117. https://doi.org/10.3389/fnut.2023.1304117

Sofi, S., Isha, G., Meenu, R., & Jagmohan, S. (2019). Effect of germination on proximate composition and antinutritional factors of chickpea flour. *Annals of Biology, 35*, 351–355.

Sibian, M. S., & Riar, C. S. (2020). Formulation and characterization of cookies prepared from the composite flour of germinated kidney bean, chickpea, and wheat. *Legume Sciences, 2*, 42–52.

Singh, G. D., Riar, C. S., Saini, C., Bawa, A. S., Sogi, D. S., & Saxena, D. C. (2012). Indian water chestnut flour-method optimization for preparation, its physicochemical, morphological, pasting properties and its potential in cookies preparation. *Food Science and Technology, 44*, 665–672.

Singh, P., Arora, A., Strand, T. A., Leffler, D. A., Catassi, C., Green, P. H., Kelly, C. P., Ahuja, V., & Makharia, G. K. (2018). Global prevalence of celiac disease: Systematic review and meta-analysis. *Clinical Gastroenterology and Hepatology, 16*, 823–836.

Singh, V. K. (2025). Investigating the moisture sorption behavior of biscuits under controlled humidity conditions. *Journal of Advances in Food Science & Technology, 12*(2), 13–19. https://doi.org/10.56557/jafsat/2025/v12i29151

Soni, N., Kulkarni, A. S., & Patel, L. (2018). Studies on development of high protein cookies. *International Journal of Chemical Studies, 6*, 439–444.

Stoin, D., Poiana, M.-A., Alexa, E., Cocan, I., Negrea, M., Jianu, C., Radulov, I., Suba, M., & Ianasi, C. (2025). Current trends in gluten-free biscuit formulation using rice flour enriched with chestnut flour and fruit powders. *Foods, 14*(23), 4074. https://doi.org/10.3390/foods14234074

Tüter, H., Taşkın, B., & Savlak, N. (2025). Chia-enhanced gluten-free biscuits: A study on nutritional enrichment, antioxidant bioaccessibility, and storage stability. *Food Measurement, 19*, 5857–5870. https://doi.org/10.1007/s11694-025-03359-7

Urooj, A., Shabbir, A., Hafeez, R., Rasheed, M. M., Asif, M., Aslam, I., Fatima, T., Shakoor, A., Zaman, K., & Faryad, A. (2026a). Physicochemical, phytochemical, and sensory evaluation of cookies fortified with jujube powder. Policy Research Journal, 4(3), 273–286. http://doi.org/10.5281/zenodo.18976208

Urooj, A., Shabbir, A., Shahbaz, A., Ahmed, S., Hassan, H. N. U., Asif, M., Usman, A., Tofique, M., Abbas, S., & Safdar, A. (2026b). Synergistic effects of Cinnamomum zeylanicum and inositol on metabolic and hormonal parameters in women with polycystic ovary syndrome. Physical Education, Health and Social Sciences, 4(1), 637–650. https://doi.org/10.63163/jpehss.v4i1.1176

Urooj, A., Mumtaz, F., Shabbir, A., Sultan, M., Tirmazi, S. M., Sarwar, M. S., Iqbal, S., & Asif, M. (2026c). Exploring the ameliorative effects of *Anethum graveolens* and *Foeniculum vulgare* seeds on dyslipidemia: A comparative efficacy in high fat diet-induced model. *Policy Research Journal, 4*, 506–527.

Verma, A. K. (2021). Nutritional deficiencies in celiac disease: Current perspectives. *Nutrients, 13*, 4476.

Wang, J., Li, Y., Li, A., Liu, R. H., Gao, X., Li, D., Kou, X., & Xue, Z. (2021). Nutritional constituent and health benefits of chickpea (Cicer arietinum L.): A review. *Food Research International, 150*, 110790.

Wessels, M. M. S., Van Veen, I. I., Vriezinga, S. L., Putter, H., Rings, E. H. H. M., & Mearin, M. L. (2016). Complementary serologic investigations in children with celiac disease is unnecessary during follow-up. *The Journal of Pediatrics, 169*, 55–60.

Woomer, J. S., & Adedeji, A. A. (2021). Current applications of gluten-free grains–a review. *Critical Reviews in Food Science and Nutrition, 61*, 14–24.

Wu, T., Wang, L., Li, Y., Qian, H., Liu, L., Tong, L., Zhou, X., Wang, L., & Zhou, S. (2019). Effect of milling methods on the properties of rice flour and gluten-free rice bread. *Food Science and Technology, 108*, 137–144.

Zahid, T., S. Nooreen, M. Asif, S. Maqsood, A. Saddiqa, M. Nazar, T. Alvi and M. Rafiq. 2025. Development and characterization of protein-rich cookies fortified with red kidney beans: A nutritional approach to combat malnutrition. Journal of Pure Applied and Agriculture. 10:21-29.