

Original Research

Received 16 June 2026

Revised 25 July 2026

Accepted 08 Aug 2026

Natural Resources for Human Health 2026, Vol. 6 (16s): 488–509

KEYWORDS:

Functional cookies, in vitro antioxidant properties, Kachri (*Cucumis callosus*), sensory evaluation, Nutritional enrichment.

Development and Evaluation of Cookies Incorporated with Kachri (*Cucumis Callosus*) Powder

Kuldeep Kumar Singh¹, Prerna Singh², Hradesh Rajput^{1*}, Sudhir Kumar¹, Jyoti Rani³

¹Department of Food Technology, Chhatrapati Shahu Ji Maharaj University, Kanpur 208024, Uttar Pradesh, India

²Department of Life Sciences and Biotechnology, Chhatrapati Shahu Ji Maharaj University, Kanpur 208024, Uttar Pradesh, India

³Department of Human Genetics, Guru Nanak Dev University, Amritsar 143005, Punjab, India

Corresponding author: hrdesh802@gmail.com

ABSTRACT: Cookies are baked goods. Traditional recipes often lack dietary fiber and bioactive compounds. This study aimed to improve the value of cookies by adding Kachri powder (*Cucumis callosus*). The cookies were made by replacing part of the wheat flour with Kachri powder at 5%, 7.5% and 10% levels. The control cookies had 100% wheat flour. The study tested properties, proximate composition, physical traits, antioxidant activity, sensory quality and storage stability using standard methods. Results showed that adding Kachri powder improved cookie quality. Water absorption capacity rose from 1.42 to 1.71 g/g. Crude fiber content increased from 2.40% in the control to 5.50% in cookies with 10% Kachri powder. Total phenolic content, DPPH scavenging activity and ferric reducing antioxidant power all rose as more Kachri powder was added. This means the antioxidant potential was stronger. Calcium and iron levels also increased with Kachri levels. Higher levels of Kachri led to a lower spread ratio and reduced sensory appeal. The cookies became darker. Had a stronger flavor. Among all the versions the 5% Kachri cookies had the best sensory acceptability. Storage tests over 60 days at room temperature showed a rise in moisture, peroxide value and microbial counts. Still the findings show that Kachri powder can be used effectively as an ingredient. This leads to cookies that're more nutritious, rich, in antioxidants and have good sensory and storage qualities.



1. INTRODUCTION

The bakery industry is one of the fastest-growing segments of the Indian food processing sector, driven by increasing urbanization, changing consumer lifestyles, and rising demand for convenient ready-to-eat foods (Kaushik et al., 2025). Within this sector, biscuits and cookies constitute a major product category and remain among the most widely consumed bakery products across all age groups, owing to their affordability, convenience, and extended shelf life (Kaushik et al., 2025). However, conventional cookies are generally formulated using refined wheat flour, sugar, and fat, resulting in products that are energy-dense but relatively poor sources of dietary fiber, minerals, vitamins, and bioactive compounds (Ironi et al., 2024). Growing consumer awareness regarding the relationship between diet and health has increased demand for bakery products that provide additional nutritional and functional benefits beyond basic nourishment. Consequently, considerable research efforts have focused on developing functional bakery products through the incorporation of plant-derived ingredients rich in dietary fiber, phenolic compounds, natural antioxidants, and other health-promoting constituents (Guiné & Florença, 2024).

Recent studies have demonstrated that the incorporation of fiber-rich plant materials into cookies and other bakery products can significantly improve nutritional quality while maintaining acceptable sensory characteristics (Krajewska & Dziki, 2023). Similarly, plant-based bakery formulations developed using functional ingredients rich in phenolic compounds have exhibited improved free-radical scavenging activity and greater consumer interest due to their potential health benefits (Bakir, 2026).

In recent years, underutilized and climate-resilient crops have received increasing scientific attention owing to their nutritional richness, adaptability to harsh environmental conditions, and potential contribution to sustainable food systems. Among such crops, *Cucumis callosus* (Rottler) Cogn., commonly known as Kachri or wild melon, is an indigenous cucurbitaceous species widely distributed in the arid and semi-arid regions of India (Boora et al., 2025). Kachri is traditionally consumed in fresh and dried forms and is valued for its characteristic flavor, culinary applications, and ethnomedicinal importance (Vaghasiya & Ishnava, 2024). Previous studies have reported that Kachri contains appreciable amounts of dietary fiber, minerals, vitamins, phenolic compounds, flavonoids, cucurbitacins, and other phytochemicals possessing antioxidant and anti-inflammatory properties (Chaudhary & Gupta, 2025). Its ability to thrive under conditions of drought, high temperature, and poor soil fertility makes it a promising climate-resilient crop with potential applications in food product development (Samadia et al., 2024). Despite these advantages, the utilization of Kachri in modern processed foods remains limited, and scientific information regarding its incorporation into bakery products is still scarce.

Traditionally, Kachri has been used both as a food ingredient and a medicinal plant (Singh et al., 2026). The fruits are consumed fresh or dried and are commonly used in traditional dishes, chutneys, spice blends, and as natural meat tenderizers due to the presence of proteolytic enzymes (Meena et al., 2016). Nutritionally, Kachri fruits contain considerable amounts of dietary fiber, essential minerals such as iron and zinc, vitamins (such as vitamin C) and carotenoids, and several bioactive phytochemicals such as phenolic compounds, flavonoids, and cucurbitacins (Meena et al., 2016). These phytochemicals contribute to antioxidant and anti-inflammatory properties, suggesting Kachri's potential in vitro antioxidant activity (Singh et al., 2026). Despite these nutritional advantages, Kachri remains largely underutilized in modern food processing and value-added product

development (Alshammari et al., 2026). Such value addition can support agricultural diversification, encourage sustainable use of underutilized crops, and provide economic opportunities for farmers in arid and semi-arid regions.

The novelty of the present study lies in the utilization of *Cucumis callosus* powder as a functional ingredient in cookie development and the comprehensive evaluation of its effects on product quality attributes. Unlike previous studies that have largely emphasized the nutritional characterization of Kachri or the incorporation of other plant-based ingredients into bakery products, the present work simultaneously examines functional properties, nutritional composition, antioxidant activity, sensory quality, and storage stability of Kachri-enriched cookies. It was hypothesized that partial replacement of refined wheat flour with Kachri powder would significantly improve the dietary fiber, mineral content, and antioxidant potential of cookies while maintaining acceptable sensory characteristics and storage stability. Accordingly, the present study was undertaken to develop cookies enriched with Kachri (*Cucumis callosus*) powder at different incorporation levels and to evaluate their physicochemical, functional, nutritional, antioxidant, sensory, and storage characteristics, with the aim of identifying an optimal incorporation level for functional food applications.

2. MATERIALS AND METHODS

2.1 Raw materials

The present research work was carried out in the Department of Food Technology, CSJM University, Kanpur, Uttar Pradesh, India, during the year 2025–2026. Fresh mature Kachri (*Cucumis callosus*) fruits were procured from a local farmer in Kalyanpur, Kanpur, ensuring that the samples were cultivated and not wild-collected to maintain uniform quality and maturity.

The collected samples were subjected to preliminary processing operations including sorting, grading, and washing with clean potable water. The cleaned Kachri were then cut into uniform thin pieces using a stainless-steel knife to facilitate efficient drying.

Before drying, the sliced Kachri samples underwent blanching. Fresh Kachri slices were dipped in hot distilled water in a ratio of 1:10 (w/v) and maintained at a temperature of 90 ± 2 °C for 60 seconds. After blanching, the Kachri slices were drained and subjected to solar drying using a solar dryer (Model: SDM-50, IIT Kanpur, India) as shown in Figure 1. Drying was carried out under ambient climatic conditions until a constant weight was achieved. The drying process required approximately 18–24 h of effective drying time over 2–3 consecutive days, depending on prevailing weather conditions. The final moisture content of the dried Kachri slices was reduced to approximately 6.65%.

Subsequently, the dried Kachri samples were ground into a fine powder using a laboratory mixer grinder and passed through a standard sieve to obtain a uniform particle size suitable for cookie preparation. The powder was then stored in airtight containers at room temperature until further use.

Every ingredient needed to make the cookies was purchased from reliable commercial sources. Refined wheat flour (commercial food-grade), jaggery powder, baking powder, salt, and vanilla essence were procured from the local retail market in Kalyanpur, Kanpur, Uttar Pradesh, India. Milk was purchased fresh from a local dairy supplier, and fat (commercial bakery shortening) was procured from a standard food-grade supplier. All ingredients were of food-grade quality and were used without further purification.



Figure 1. Sequential preparation of Kachri (*Cucumis callosus*) powder

2.2 Cookie preparation

Various ratios of Kachri powder were used to standardize the cookies. Three variations were prepared: CC (control, 100% refined wheat flour), KC1 (Kachri powder incorporated at 5% of total formulation weight), KC2 (Kachri powder incorporated at 7.5%), and KC3 (Kachri powder incorporated at 10%), with corresponding reductions in refined wheat flour to maintain a constant total formulation weight. The overall process for preparation of Kachri-enriched cookies is illustrated in Figure 2. The formulation of control and Kachri-incorporated cookies used in the present study is presented in Table 1. A graphical overview of the experimental workflow, product development, analytical evaluations, and major findings of the study is presented in the Graphical Abstract.

Table 1. Formulation of control (CC) and Kachri-incorporated (KC) cookies (ingredient proportions (g) normalized to total dough weight).

Ingredients	CC	KC1-5%	KC2-7.5%	KC3-10%
Refined wheat flour (g)	47.30	42.30	39.80	37.30
Kachri powder (g)	0.00	5.00	7.50	10.00
Fat (g)	23.64	23.64	23.64	23.64
Jaggery powder (g)	18.91	18.91	18.91	18.91
Milk (mL)	9.46	9.46	9.46	9.46
Baking powder (g)	0.24	0.24	0.24	0.24
Vanilla essence (mL)	0.24	0.24	0.24	0.24

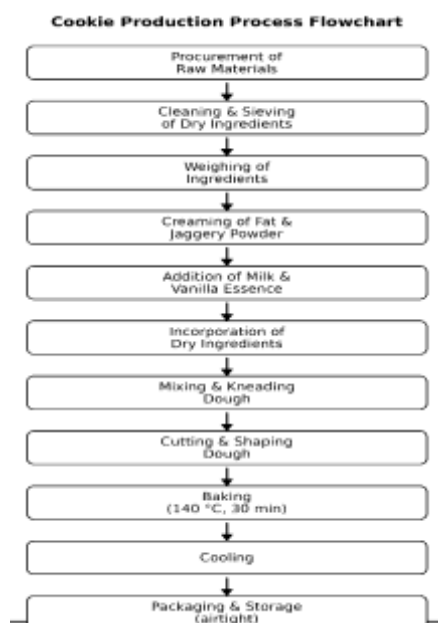


Figure 2. Process flowchart for cookie production.

The incorporation levels of Kachri powder (5%, 7.5%, and 10%) were selected based on preliminary formulation trials and previous studies involving the inclusion of fiber-rich plant powders in bakery products (Guiné & Florença, 2024). Higher incorporation levels of similar plant powders (e.g., >10% *Portulaca oleracea* leaf powder) have been shown to adversely affect dough stability, color and sensory attributes, while lower levels (<5%) of various plant powders generally have minimal impact on sensory quality (BENAM et al., 2021). Therefore, these levels were selected to evaluate the effect of gradual replacement of refined wheat flour with Kachri powder while maintaining acceptable product quality.

Following the mixing stage, the resulting dough was laminated into sheets. The cookies were baked in a microwave oven operating in convection mode (Model: Samsung MC28H, made in Malaysia) at 140 °C for 30 min. Once baking was complete, the cookies were cooled to room temperature and sealed in high-density polyethylene (HDPE) packaging to await sensory evaluation and chemical analysis. Cookies prepared with different levels of Kachri powder incorporation are presented in Figure 3.

Experimental replication: For each formulation, three independent batches of cookie dough were prepared and baked separately under identical processing conditions. Each batch was considered one independent experimental replicate. Samples from these independently prepared batches were used for all subsequent physicochemical, nutritional, antioxidant, microbial, storage, and instrumental analyses.

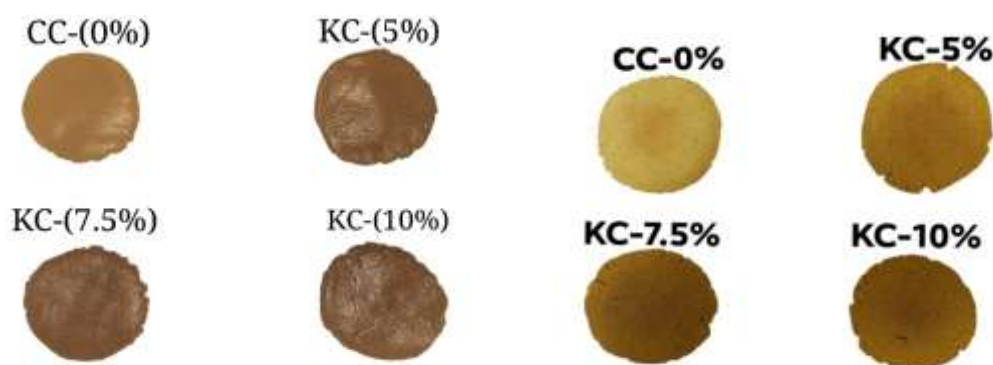


Figure 3. Prepared cookies arranged before and after baking

2.3 Functional properties of cookie flour

Water absorption capacity (WAC) and oil holding capacity (OHC) were determined according to standard methods described by Nawabueze (2006) and Chau and Huang (2003), respectively. Pasting properties were evaluated using a Rapid Visco Analyzer (RVA-4, Newport Scientific, Australia), while texture profile analysis was performed using a Texture Analyzer (TA.XT Plus, Stable Micro Systems, Surrey, UK). Cookie samples were analyzed using a cylindrical aluminum compression probe (P/75, 75 mm diameter). The instrument was operated with a pre-test speed of 1.0 mm/s, test speed of 1.0 mm/s, and post-test speed of 5.0 mm/s. Samples were compressed to 50% of their original thickness in a two-cycle compression test with a trigger force of 5 g. Parameters including hardness, cohesiveness, springiness, adhesiveness, chewiness, and fracturability were calculated automatically using the Exponent software supplied with the instrument.

2.4 Nutrient composition and Physicochemical characteristics of cookies

The proximate composition of control and Kachri-incorporated cookies, was determined in triplicate using standard AOAC methods (AOAC, 2005). Total carbohydrate content was calculated by difference, and calorific value was determined using a bomb calorimeter. Results were expressed on a percentage basis.

Calcium (Ca), iron (Fe), and Zinc (Zn) contents of cookie samples were determined using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES). Samples were subjected to appropriate digestion and dilution prior to instrumental analysis. Calcium, iron, and zinc were quantified at analytical wavelengths of 396.847, 238.204, and 213.857 nm, respectively. Mineral concentration was determined from the respective calibration curves and expressed on a sample-weight basis.

The physical properties of the cookies were determined using standard methods (AACC, 1983). The average weight of six cookies was measured in grams using an electronic balance. Cookie volume was determined by the grain amaranth seed displacement method. The average thickness was obtained by stacking six cookies and measuring the total height to the nearest millimeter. Similarly, the width of the cookies was measured by arranging six cookies edge-to-edge and recording the total width to the nearest millimeter.

Cookie diameter, thickness, spread ratio, spread factor, volume, and bulk density, were determined according to AACC (1983) standard procedures. Water activity is determined according to (AOAC, 2005). Color measurements (L^* , a^* , b^*) were recorded using a HunterLab ColorFlex colorimeter after calibration with a standard white plate using the method described by Pathare et al., 2013.

2.5 Total phenolic content and antioxidant activity of cookies

In the present study, antioxidant properties were evaluated only in the baked cookie samples. The antioxidant profile of raw Kachri powder prior to baking was not analyzed. Therefore, the extent of thermal degradation or retention of bioactive compounds during baking could not be quantified.

Total phenolic content was determined using the Folin–Ciocalteu method (Herzi et al., 2013). The absorbance was measured at 765 nm using a UV–Visible spectrophotometer. Results were expressed as mg gallic acid equivalents (GAE) per 100 g of sample.

The antioxidant activity of cookie extracts was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method (Ribeiro et al., 2019). The decrease in absorbance was measured at 517 nm.

FRAP assay was carried out according to Benzie and Strain (1996). The absorbance was recorded at 593 nm. Results were expressed as $\mu\text{mol Fe}^{2+}$ equivalents per gram of sample.

2.6 Phytochemical analysis

Steroids in Kachri powder were qualitatively analyzed using the Salkowski test. Briefly, the extract was mixed with chloroform, and concentrated sulfuric acid was carefully added along the sides of the test tube to form a separate layer. The formation of a reddish-brown ring at the interface indicated the presence of phytosterols, following standard procedures (Harborne, 1998).

2.7 Sensory and evaluation of cookies

Freshly baked cookies were subjected to sensory evaluation by a panel of 70 judges from the CSJM University, Kanpur. The panelists evaluated the sensory attributes of the cookies using a nine-point hedonic scale, where a score of 1 indicated “dislike extremely” and 9 “like extremely”. Panelists independently assessed and rated the samples based on their sensory perceptions. Before the evaluation, all participants were informed about the product quality, safety, and the use of non-toxic, allergen-free ingredients in the formulation. The sensory evaluation protocol involving human participants was conducted in accordance with institutional ethical guidelines. The mean scores obtained from all panelists were used for statistical analysis.

2.8 Storage Quality Evaluation

Cookies were wrapped in butter paper and packed into unit packs using metallized polyester–polyethylene pouches. The pouches were sealed and stored in aluminum boxes at room temperature for storage studies. During the storage period from October to January, the temperature ranged from 24.30 to 27.48 °C, while the relative humidity varied between 58.55 and 83.00%. Cookie samples were withdrawn at fortnightly intervals to evaluate quality parameters. The storage study was continued until the cookies were considered unacceptable. Packaged cookies stored in metallized polyester–polyethylene pouches used for storage stability studies are shown in Figure 4.



Figure 4. Visual appearance of cookies packaged in polyethylene pouches for storage studies.

Peroxide value (PV) of cookie samples was determined using the iodometric titration method described by the AOAC (2005), and the results were expressed as meq/kg fat.

TPC, yeast and mould counts were determined using the standard plate count method described by Salfinger and Tortorello (2015). Results were expressed as CFU/g.

3. STATISTICAL ANALYSIS

Each cookie formulation was prepared in three independent production batches, which served as biological (experimental) replicates ($n=3$). Analytical measurements were performed on samples obtained from each independent batch, and mean values $\pm$ standard deviation are reported. Data were analyzed using one-way ANOVA followed by the Least Significant Difference (LSD) test at $p < 0.05$.

When significant differences were observed, mean comparisons were performed using the Least Significant Difference (LSD) post hoc test at a 95% confidence level ($p < 0.05$). Assumptions of normality and homogeneity of variance were verified before analysis.

Sensory evaluation data obtained from panelists were also analyzed using one-way ANOVA, and the results are expressed as mean $\pm$ SD. For storage studies, regression analysis was applied to assess the effect of storage duration on moisture content, peroxide value, and sensory attributes of the cookies. Differences among mean values were considered statistically significant at $p < 0.05$, and superscripts (a–d) were used to indicate significant differences between samples within each column.

4. RESULTS

Table 2: The physical parameters of *Cucumis callosus* (Kachri) fruit, including color, shape, length, breadth, and weight.

Parameters	Mean value $\pm$ SD
Colour	light green to yellowish coloration with distinct dark green spots
Shape	Round and oval
Length(cm)	1.6 ± 0.2
Breadth(cm)	4.8 ± 1.6
Weight(gm)	42 ± 0.5

Table 3: Physicochemical composition of refined wheat flour and Kachri powder used as raw materials for cookie formulation (per 100 g)

Chemical constituent	Refined wheat flour	Kachri powder
Moisture (%)	13.40 ± 0.20	6.65 ± 0.15
Protein (%)	11.20 ± 0.30	9.20 ± 0.25
Fat (%)	0.90 ± 0.05	0.80 ± 0.04
Ash (%)	0.48 ± 0.03	11.03 ± 0.06
Crude fiber (%)	0.40 ± 0.02	23.50 ± 0.10
Carbohydrates (%)	73.62	48.82
Energy (kcal/100 g)	347.00	239.00

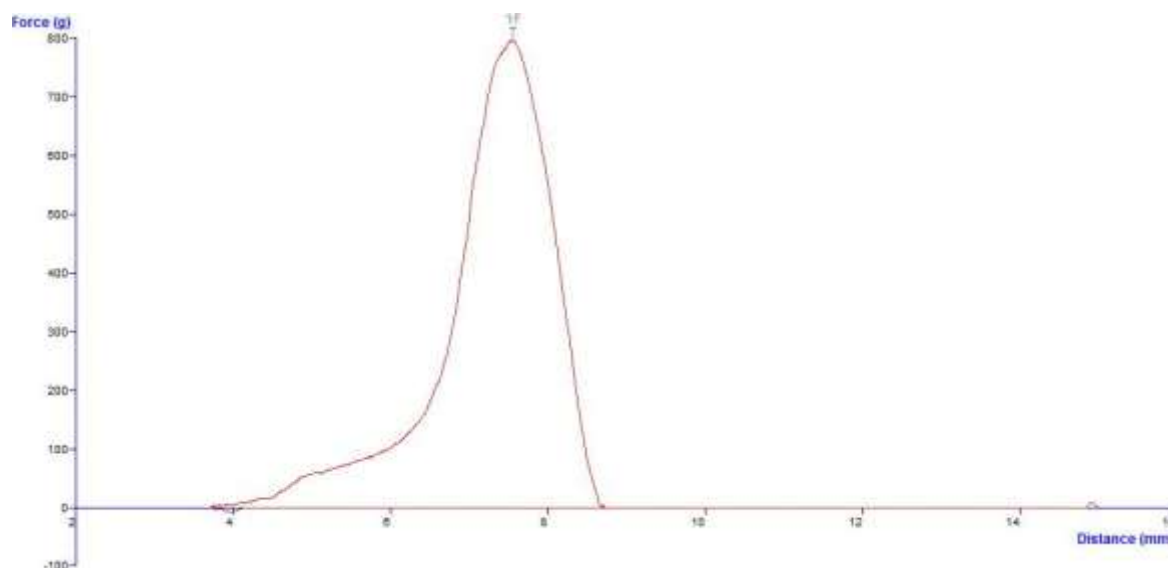
- Values are expressed as mean $\pm$ standard deviation ($n = 3$). Carbohydrates were calculated by the difference method, and energy values were calculated using Atwater factors.

Table 4: Functional Properties of Cookie Flour

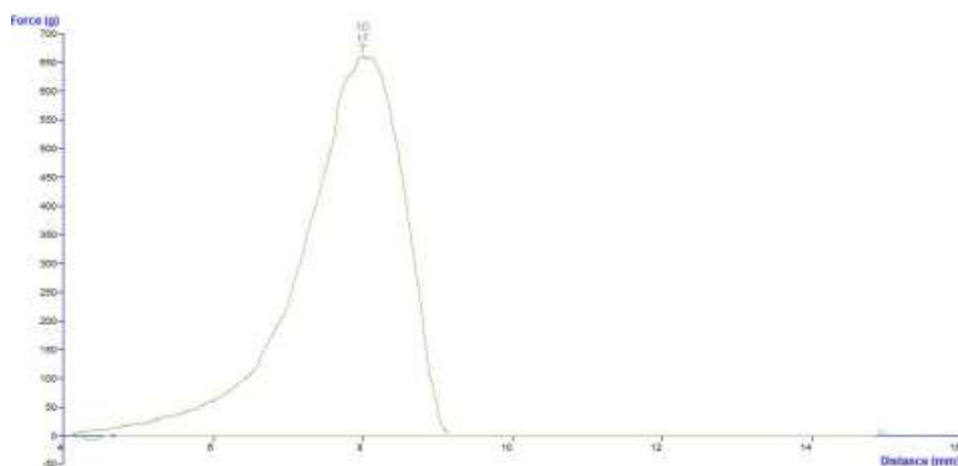
Parameters	CC	KC-5%	KC-7.5%	KC-10%
Water absorption capacity (g/g):	1.42 ± 0.20^d	1.51 ± 0.04^c	1.62 ± 0.05^b	1.71 ± 0.06^a
Oil holding capacity (g/g)	1.18 ± 0.30^d	1.25 ± 0.03^c	1.31 ± 0.03^b	1.39 ± 0.04^a
Pasting properties				

Peak viscosity (cP*)	1301.00 ± 0.50 ^a	1225.00 ± 0.48 ^b	1180.00 ± 0.46 ^c	1125.00 ± 0.44 ^d
Breakdown (cP)	558.00 ± 0.65 ^a	520.00 ± 0.60 ^b	495.00 ± 0.58 ^c	470.00 ± 0.55 ^d
Final viscosity (cP)	1700.00 ± 0.58 ^d	1755.00 ± 0.60 ^c	1805.00 ± 0.62 ^b	1850.00 ± 0.65 ^a
Setback (cP)	798.00 ± 0.51 ^d	835.00 ± 0.53 ^c	870.00 ± 0.55 ^b	910.00 ± 0.58 ^a
Pasting temp. (°C)	85.00 ± 0.31 ^a	86.50 ± 0.33 ^b	87.80 ± 0.35 ^c	89.00 ± 0.38 ^d
Texture profile				
Hardness (g)	795 ± 72.50 ^a	660 ± 68.95 ^b	320 ± 75.57 ^c	278 ± 70.29 ^d
Fracturability (mm)	7.27 ± 0.34 ^d	8.01 ± 0.32 ^c	9.05 ± 0.30 ^b	10.20 ± 0.28 ^a

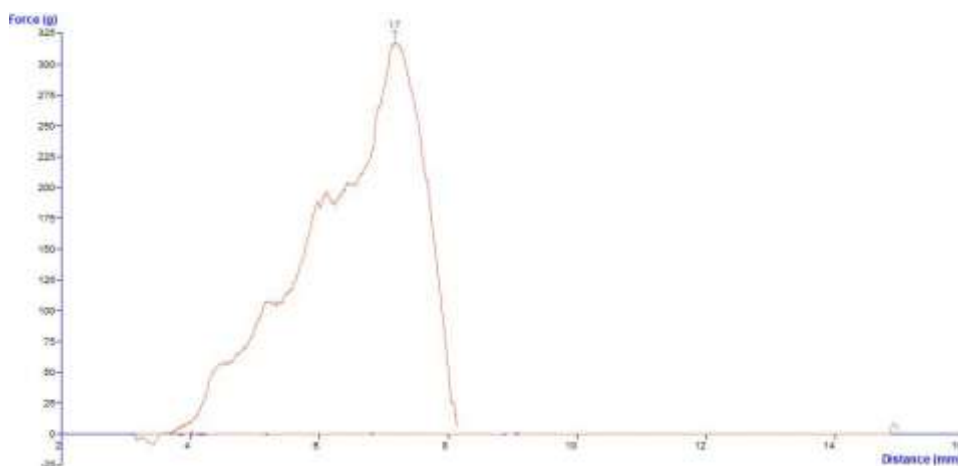
- Values are expressed as mean ± SD (n = 3). Means with different superscripts within a row differ significantly (p < 0.05) as determined by one-way ANOVA followed by the LSD test.



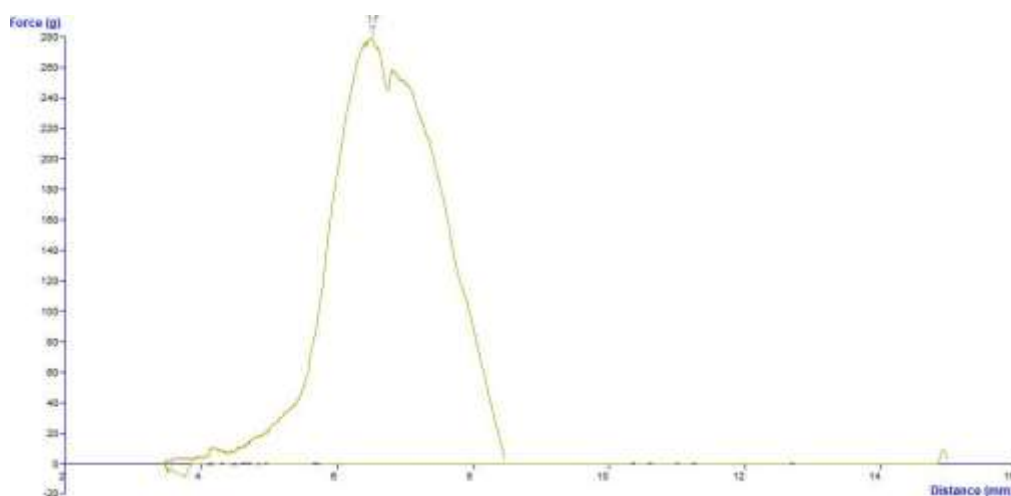
Graph 1: Texture profile curve of control (CC) cookie showing the maximum hardness



Graph 2: Texture profile curve of KC-5% cookie showing reduced hardness compared with the control.



Graph 3: Texture profile curve of KC-7.5% cookie showing a further reduction in hardness



Graph 4: Texture profile curve of KC-10% cookie showing the lowest hardness among the formulations

Table 5. Nutritional composition of baked control and Kachri-incorporated cookies (per 100 g)

Parameter	Control cookies	KC-5%	KC-7.5%	KC-10%
Moisture (%)	4.50 ± 0.12 ^d	4.90 ± 0.14 ^c	5.12 ± 0.15 ^b	5.35 ± 0.16 ^a
Protein (%)	5.20 ± 0.15 ^a	4.90 ± 0.14 ^b	4.75 ± 0.13 ^c	4.60 ± 0.12 ^d
Fat (%)	21.00 ± 0.25 ^d	21.60 ± 0.27 ^c	21.80 ± 0.28 ^b	22.00 ± 0.30 ^a
Ash (%)	2.10 ± 0.05 ^d	2.90 ± 0.06 ^c	3.10 ± 0.07 ^b	3.25 ± 0.08 ^a
Crude fiber (%)	2.40 ± 0.07 ^d	4.10 ± 0.09 ^c	4.85 ± 0.10 ^b	5.50 ± 0.12 ^a
Carbohydrates (%)	64.80 ± 0.30 ^a	60.70 ± 0.32 ^b	59.40 ± 0.35 ^c	58.20 ± 0.38 ^d
Energy (kcal/100 g)	472.00 ± 3.1 ^a	470.00 ± 3.3 ^a	468.00 ± 3.5 ^a	466.00 ± 3.7 ^a
Minerals (mg/100gm)				
Calcium	30.54 ± 1.43 ^d	62.37 ± 2.16 ^c	106.21 ± 1.58 ^b	123.25 ± 1.43 ^a
Iron	0.62 ± 0.01 ^d	0.97 ± 0.03 ^c	1.21 ± 0.01 ^a	1.17 ± 0.02 ^b
Zinc	1.05 ± 0.02 ^d	1.46 ± 0.03 ^c	2.23 ± 0.05 ^a	1.72 ± 0.01 ^b

- Values are expressed as mean ± SD (n = 3). Means with different superscripts within a row differ significantly (p < 0.05), as determined by one-way ANOVA followed by LSD test.

Table 6. Physical and color characteristics of control cookies and Kachri cookies

Parameters	Control (CC)	KC-5%	KC-7.5%	KC-10%
Diameter (mm)	56.20 ± 0.21 ^a	55.80 ± 0.18 ^b	55.20 ± 0.20 ^c	54.50 ± 0.22 ^d
Thickness (mm)	8.40 ± 0.10 ^d	8.60 ± 0.12 ^c	8.70 ± 0.14 ^b	9.00 ± 0.16 ^a
Spread Ratio	6.69 ± 0.08 ^a	6.49 ± 0.07 ^b	6.34 ± 0.09 ^c	6.05 ± 0.11 ^d
Weight (g)	9.20 ± 0.15 ^d	9.40 ± 0.18 ^c	9.60 ± 0.20 ^b	9.80 ± 0.21 ^a
Spread Factor	100.0 ± 0.00 ^a	96.90 ± 0.90 ^b	94.80 ± 0.85 ^c	90.50 ± 0.95 ^d
Bulk density (g/cm ³)	0.46 ± 0.01 ^d	0.49 ± 0.02 ^c	0.51 ± 0.02 ^b	0.54 ± 0.02 ^a
Volume (mL)	19.80 ± 0.35 ^a	19.20 ± 0.32 ^b	18.90 ± 0.30 ^c	18.10 ± 0.28 ^d
Water activity (a _w)	0.47 ± 0.03 ^d	0.49 ± 0.03 ^c	0.51 ± 0.04 ^b	0.53 ± 0.04 ^a
Color				
L*	58.54 ± 0.83 ^a	56.20 ± 0.80 ^b	54.75 ± 0.78 ^c	51.10 ± 0.75 ^d
A*	8.13 ± 0.12 ^a	7.85 ± 0.14 ^b	6.40 ± 0.16 ^c	5.10 ± 0.18 ^d
B*	32.86 ± 0.26 ^a	30.20 ± 0.35 ^b	28.80 ± 0.40 ^c	25.00 ± 0.45 ^d

- Values are expressed as mean ± standard deviation (n = 3). Means within a column bearing different superscripts differ significantly (p < 0.05), as determined by one-way analysis of variance (ANOVA) followed by the Least Significant Difference (LSD) test.

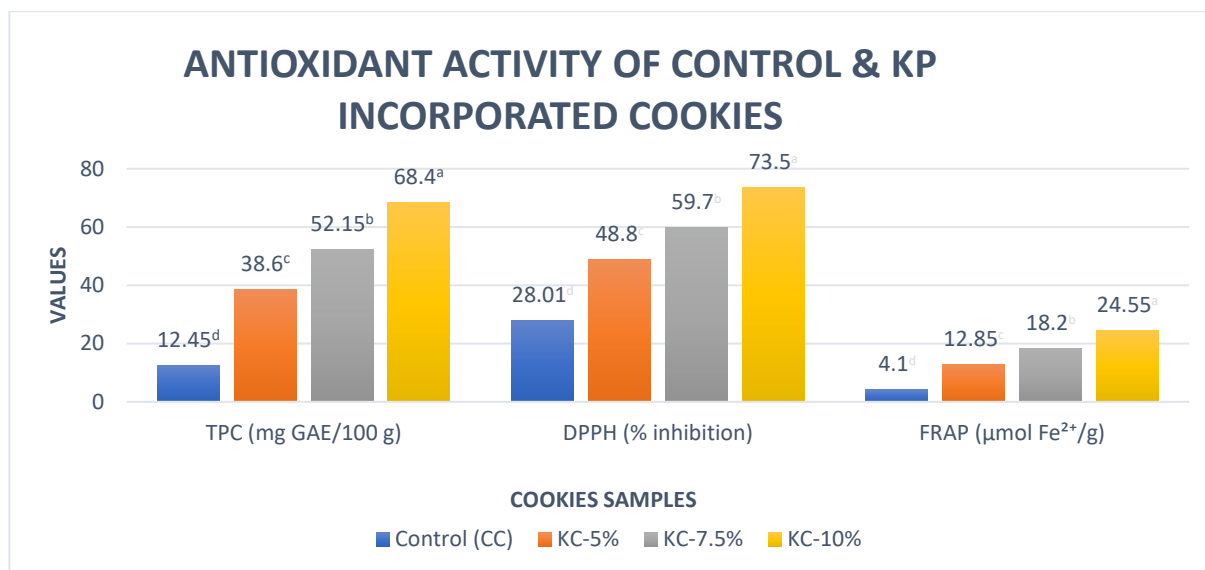


Figure 5. TPC, DPPH, and FRAP activity of baked control cookies and Kachri cookies

- TPC, DPPH, and FRAP values showed a strong positive correlation with increasing Kachri incorporation ($R^2 \approx 0.96-0.99$), indicating enhanced antioxidant activity.
- One-way ANOVA revealed significant differences ($p < 0.05$) among treatments, while low SD values indicated good precision and repeatability.
- Values are expressed as mean $\pm$ SD ($n = 3$). Means with different superscripts within a column differ significantly ($p < 0.05$) using one-way ANOVA followed by the LSD test.



Figure 6: The Salkowski test indicated the presence of phytosterols in Kachri-incorporated cookies.

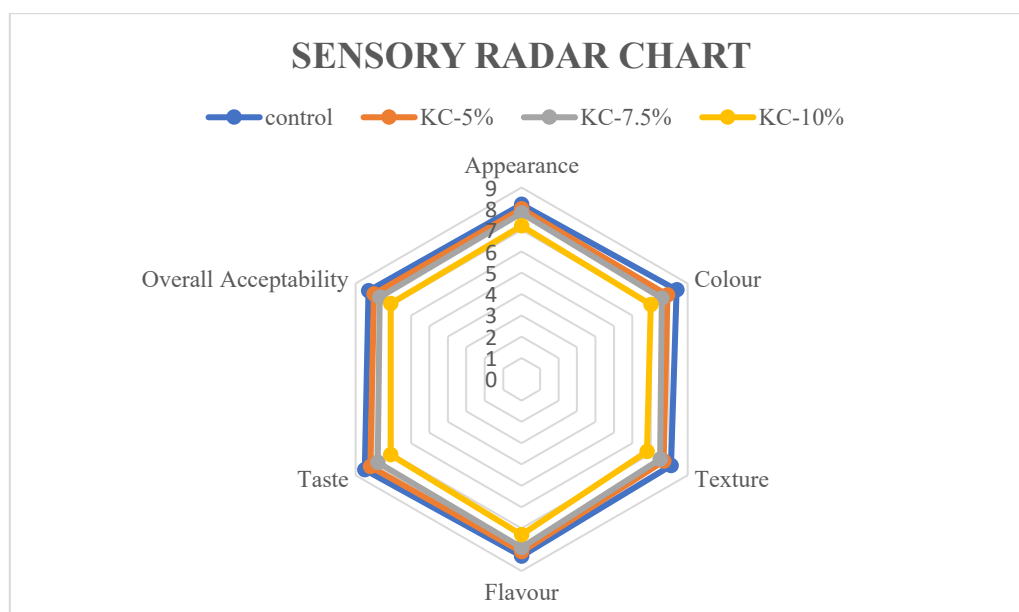


Figure 7: Radar chart representing sensory evaluation of control and Kachri-incorporated cookies (5%, 7.5%, and 10%) based on a nine-point hedonic scale.

- A strong negative correlation ($R^2 \approx 0.94\text{--}0.97$) was observed between the level of Kachri incorporation and sensory scores, indicating a decline in sensory acceptability at higher substitution levels.
- Values are expressed as mean $\pm$ standard deviation ($n = 70$ panelists). Means within a column bearing different superscripts differ significantly ($p < 0.05$), as determined by one-way ANOVA followed by the Least Significant Difference (LSD) test.

Table 7. Effect of storage on proximate composition and overall acceptability of control and Kachri-incorporated cookies.

Storage Period (Days)	Sample	Moisture (%)	Protein (%)	Fat (%)	Crude fiber (%)	Carbohydrate (%)	Overall Acceptability (9-point scale)
0	Control	4.50 $\pm$ 0.12 ^d	5.20 $\pm$ 0.15 ^a	21.00 $\pm$ 0.25 ^a	2.40 $\pm$ 0.07 ^d	64.80 $\pm$ 0.30 ^a	8.30 $\pm$ 0.11 ^a
	KC-5%	4.90 $\pm$ 0.14 ^c	4.90 $\pm$ 0.14 ^b	21.60 $\pm$ 0.27 ^a	4.10 $\pm$ 0.09 ^c	60.70 $\pm$ 0.32 ^b	8.00 $\pm$ 0.13 ^b
	KC-7.5%	5.12 $\pm$ 0.15 ^b	4.75 $\pm$ 0.13 ^c	21.80 $\pm$ 0.28 ^a	4.85 $\pm$ 0.10 ^b	59.40 $\pm$ 0.35 ^c	7.70 $\pm$ 0.16 ^c
	KC-10%	5.35 $\pm$ 0.16 ^a	4.60 $\pm$ 0.12 ^d	22.00 $\pm$ 0.30 ^a	5.50 $\pm$ 0.12 ^a	58.20 $\pm$ 0.38 ^d	7.10 $\pm$ 0.18 ^d
15	Control	4.68 $\pm$ 0.13 ^d	5.15 $\pm$ 0.14 ^a	20.70 $\pm$ 0.27 ^a	2.40 $\pm$ 0.07 ^d	64.30 $\pm$ 0.35 ^b	8.10 $\pm$ 0.12 ^a
	KC-5%	5.08 $\pm$ 0.14 ^c	4.85 $\pm$ 0.13 ^b	21.30 $\pm$ 0.29 ^a	4.10 $\pm$ 0.09 ^c	60.20 $\pm$ 0.38 ^b	7.80 $\pm$ 0.14 ^b

	KC-7.5%	5.31 ± 0.16 ^b	4.70 ± 0.12 ^c	21.50 ± 0.30 ^a	4.85 ± 0.10 ^b	58.90 ± 0.40 ^b	7.30 ± 0.17 ^c
	KC-10%	5.58 ± 0.17 ^a	4.55 ± 0.11 ^d	21.70 ± 0.32 ^a	5.50 ± 0.12 ^a	57.70 ± 0.42 ^b	6.80 ± 0.19 ^d
30	Control	4.85 ± 0.14 ^d	5.10 ± 0.13 ^a	20.30 ± 0.30 ^a	2.40 ± 0.07 ^d	63.80 ± 0.40 ^c	7.70 ± 0.13 ^a
	KC-5%	5.26 ± 0.15 ^c	4.80 ± 0.12 ^b	21.00 ± 0.32 ^a	4.10 ± 0.09 ^c	59.60 ± 0.42 ^c	7.20 ± 0.15 ^b
	KC-7.5%	5.50 ± 0.17 ^b	4.65 ± 0.11 ^c	21.20 ± 0.34 ^a	4.85 ± 0.10 ^b	58.30 ± 0.45 ^c	6.70 ± 0.18 ^c
	KC-10%	5.80 ± 0.18 ^a	4.50 ± 0.10 ^d	21.40 ± 0.36 ^a	5.50 ± 0.12 ^a	57.10 ± 0.48 ^c	6.10 ± 0.20 ^d
45	Control	5.06 ± 0.15 ^d	5.05 ± 0.12 ^a	19.90 ± 0.32 ^a	2.40 ± 0.07 ^d	63.20 ± 0.45 ^c	7.10 ± 0.14 ^a
	KC-5%	5.48 ± 0.16 ^c	4.75 ± 0.11 ^b	20.60 ± 0.35 ^a	4.10 ± 0.09 ^c	59.00 ± 0.48 ^c	6.70 ± 0.16 ^b
	KC-7.5%	5.73 ± 0.18 ^b	4.60 ± 0.10 ^c	20.80 ± 0.37 ^a	4.85 ± 0.10 ^b	57.70 ± 0.50 ^c	6.20 ± 0.19 ^c
	KC-10%	6.05 ± 0.19 ^a	4.45 ± 0.09 ^d	21.00 ± 0.40 ^a	5.50 ± 0.12 ^a	56.50 ± 0.52 ^c	5.60 ± 0.21 ^d
60	Control	5.28 ± 0.16 ^d	5.00 ± 0.11 ^a	19.50 ± 0.35 ^a	2.40 ± 0.07 ^d	62.60 ± 0.50 ^c	6.30 ± 0.15 ^a
	KC-5%	5.72 ± 0.17 ^c	4.70 ± 0.10 ^b	20.20 ± 0.38 ^a	4.10 ± 0.09 ^c	58.40 ± 0.52 ^c	5.90 ± 0.17 ^b
	KC-7.5%	5.98 ± 0.19 ^b	4.55 ± 0.09 ^c	20.40 ± 0.40 ^a	4.85 ± 0.10 ^b	57.10 ± 0.55 ^c	5.30 ± 0.20 ^c
	KC-10%	6.32 ± 0.20 ^a	4.40 ± 0.08 ^d	20.60 ± 0.42 ^a	5.50 ± 0.12 ^a	55.90 ± 0.58 ^c	4.80 ± 0.22 ^d

- Moisture content and peroxide value exhibited a strong positive correlation with storage time ($R^2 \approx 0.92-0.96$), whereas overall acceptability showed a strong negative correlation ($R^2 \approx 0.85-0.91$), indicating a decline in sensory quality with prolonged storage.
- Values are expressed as mean ± SD (n=3). Means within each storage interval and parameter bearing different superscript letters differ significantly ($p < 0.05$), as determined by one-way ANOVA followed by the LSD test.

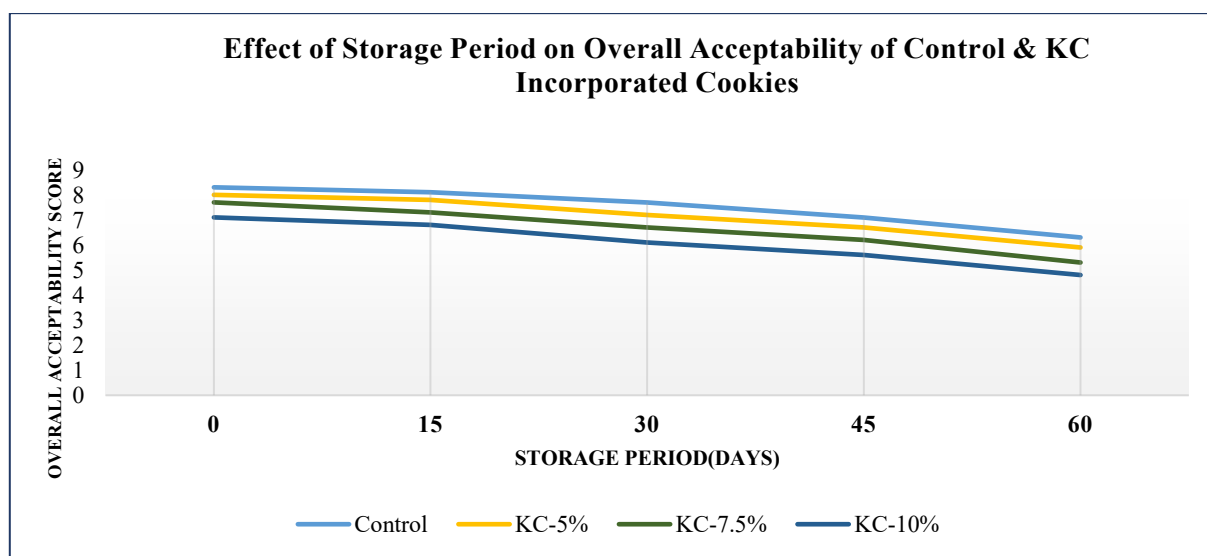


Figure 8: Effect of Storage Period on Overall Acceptability of Control and KC Incorporated Cookies

Table 8: Storage stability of cookies

Storage Period (Days)	Sample	Peroxide value (meq/kg fat)	Total plate count CFU/g	Yeast and Mould CFU/g
0	Control	1.85 ± 0.05 ^d	ND	ND
	KC-5%	1.92 ± 0.06 ^c	ND	ND
	KC-7.5%	1.98 ± 0.06 ^b	ND	ND
	KC-10%	2.05 ± 0.07 ^a	ND	ND
15	Control	2.40 ± 0.08 ^d	1.2 × 10 ³	3.2 × 10 ¹
	KC-5%	2.45 ± 0.09 ^c	1.1 × 10 ³	3.5 × 10 ¹
	KC-7.5%	2.50 ± 0.10 ^b	1.0 × 10 ³	4.0 × 10 ¹
	KC-10%	2.55 ± 0.10 ^a	9.5 × 10 ²	4.5 × 10 ¹
30	Control	3.10 ± 0.10 ^a	2.5 × 10 ³	6.5 × 10 ¹
	KC-5%	3.05 ± 0.11 ^b	2.3 × 10 ³	7.0 × 10 ¹
	KC-7.5%	3.00 ± 0.12 ^c	2.1 × 10 ³	7.8 × 10 ¹
	KC-10%	2.95 ± 0.12 ^d	2.0 × 10 ³	8.5 × 10 ¹
45	Control	4.35 ± 0.12 ^a	4.2 × 10 ³	1.1 × 10 ²
	KC-5%	4.25 ± 0.13 ^b	3.9 × 10 ³	1.18 × 10 ²
	KC-7.5%	4.18 ± 0.14 ^c	3.6 × 10 ³	1.25 × 10 ²
	KC-10%	4.15 ± 0.15 ^c	3.3 × 10 ³	1.35 × 10 ²
60	Control	5.10 ± 0.14 ^a	6.5 × 10 ³	1.9 × 10 ²

	KC-5%	4.95 ± 0.15^b	5.9×10^3	2.1×10^2
	KC-7.5%	4.82 ± 0.16^c	5.3×10^3	2.3×10^2
	KC-10%	4.10 ± 0.17^d	4.9×10^3	2.5×10^2

- ND: Not detected
- Values are expressed as mean $\pm$ SD of triplicate determinations.
- Means within each storage interval followed by different superscript letters differ significantly ($p < 0.05$) according to one-way ANOVA followed by the Least Significant Difference (LSD) test.
- Peroxide value, total plate count, and yeast and mould count showed strong positive correlations with storage duration ($R^2 \approx 0.88\text{--}0.96$), indicating progressive oxidative and microbiological deterioration during storage.

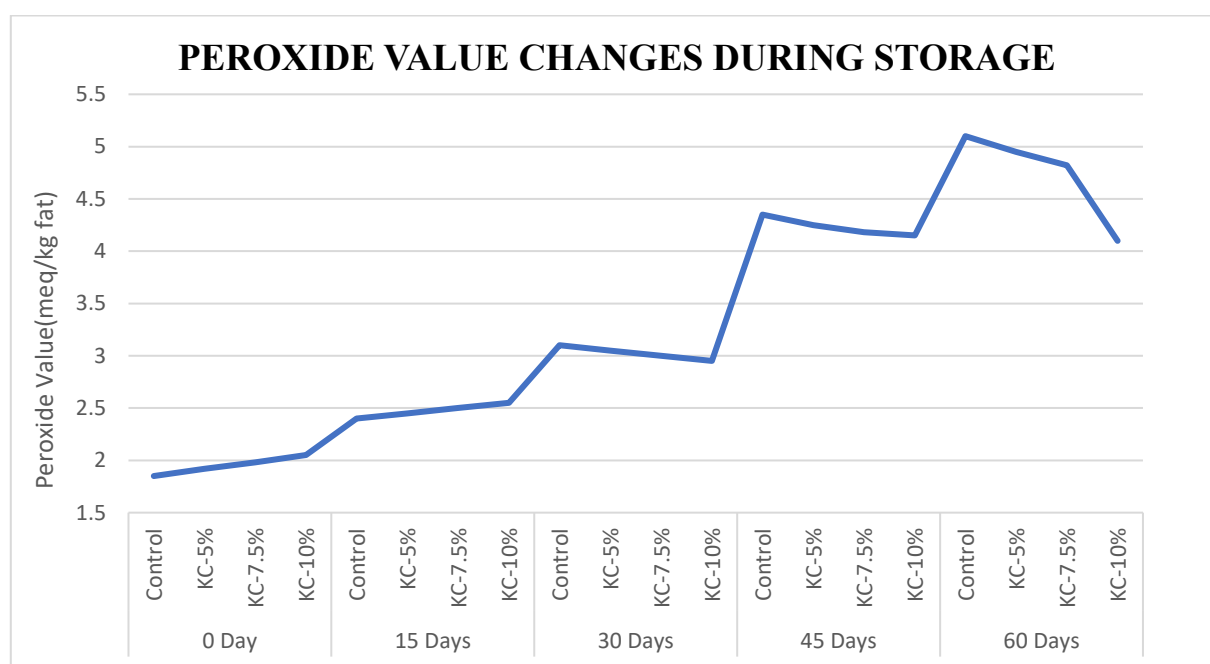


Figure 9: Effect of storage duration on peroxide value (meq/kg fat) of control and Kachri-incorporated cookies during 60 days of storage. Values are expressed as mean $\pm$ SD ($n = 3$)

5. DISCUSSION

Table 3 presents the physicochemical composition of the raw materials, namely refined wheat flour and Kachri powder, used in cookie formulation. These values represent the characteristics of the ingredients prior to cookie preparation and were used to assess the nutritional contribution of Kachri powder to the developed products. Overall, the results indicate that Kachri powder is a rich source of dietary fiber and minerals, making it a promising functional ingredient for enhancing the nutritional quality of bakery products when incorporated into formulations.

As per results shown in table 4, the observed modifications in hydration, pasting, and textural properties indicate that Kachri powder substantially altered the functionality of the flour matrix. The increase in water absorption and oil holding capacities can be attributed to the high dietary fiber content of Kachri powder, which contains numerous hydrophilic sites capable of binding water and lipids (Zheng et al., 2023). Enhanced hydration properties are technologically important because they influence dough consistency, processing behavior, and final product texture (Guardianelli et al., 2021). These findings are consistent with earlier reports where the incorporation of plant-based fiber sources improved hydration properties in bakery products (Ahmad et al., 2016).

The reduction in peak viscosity and breakdown values suggests dilution of starch and restricted starch granule swelling in the presence of dietary fiber (Singh et al., 2003). Conversely, higher final viscosity and setback values indicate stronger gel formation during cooling, likely resulting from interactions among starch, fiber, and other non-starch polysaccharides.

Hardness decreased significantly as also shown in graphs, indicating that increasing Kachri powder incorporation produced a comparatively softer cookie structure. Fracturability increased progressively, demonstrating that Kachri powder significantly altered the breaking characteristics of the cookies.

As shown in table 5, the nutritional modifications observed in Kachri-enriched cookies are directly attributable to the compositional characteristics of Kachri powder, particularly its high dietary fiber and mineral content. The increase in ash and fiber levels indicates successful nutritional enrichment and suggests that Kachri powder may contribute to improved digestive health and enhanced micronutrient intake. From a product development perspective, these changes are desirable because they improve nutritional density without substantially altering the caloric value of the final product, thereby supporting the formulation of functional bakery products with enhanced health-promoting attributes.

The physical changes observed in Kachri-enriched cookies reflect the influence of dietary fiber on dough rheology and baking performance as shown in Table 6. Increased water absorption by fiber components reduced dough flow during baking, resulting in lower spread ratio and greater cookie thickness. Similar responses have been reported in cookies enriched with fiber-rich plant materials, where competition for available water limits expansion during thermal processing (Masoud et al., 2024).

The increase in bulk density and reduction in cookie volume indicate the formation of a more compact structure, which may be attributed to reduced gas retention and altered gluten–starch interactions. Despite these changes, the physical dimensions remained within acceptable limits for cookie products, suggesting that Kachri powder can be incorporated without compromising structural quality (Masoud et al., 2024).

The progressive reduction in lightness (L^*), redness (a^*) and yellowness (b^*) indicates darker coloration with increasing Kachri powder incorporation. These changes may be attributed to natural pigments and browning reactions during baking. However, moderate Kachri incorporation maintained acceptable visual quality while enhancing nutritional value.

As per results presented in Figure 5, the marked improvement in antioxidant activity confirms that Kachri powder functions as an effective source of bioactive compounds in baked products. The strong association between total phenolic content and antioxidant assays suggests that phenolic constituents retained sufficient stability during baking to contribute to the antioxidant potential of the final product. This finding is particularly relevant for functional food development because thermal processing often reduces phytochemical activity (Toydemir et al., 2022). The presence of antioxidant activity in the baked cookies indicates that antioxidant constituents of Kachri remained detectable after baking; however, the extent of their retention or thermal degradation could not be quantified in the present study.

The control cookies recorded the highest overall acceptability score (8.3), followed closely by KC-5% cookies (8.0) as shown in Figure 7. Cookies containing 7.5% Kachri powder showed slightly lower scores (7.7), while KC-10% cookies recorded the lowest acceptability score (7.1) among the treatments.

Sensory evaluation revealed a gradual decline in overall acceptability scores with increasing storage duration, as shown in Figure 8. This decline may be attributed to moisture gain, loss of crispness, slight flavor deterioration, and changes in other sensory attributes over time. The gradual decrease in sensory scores with increasing levels of Kachri powder may also be associated with the stronger characteristic flavor and darker color imparted by Kachri powder at higher incorporation levels, along with increased hardness. Among the samples, control and 5% Kachri cookies retained relatively higher acceptability, whereas higher incorporation levels (7.5% and 10%) showed a more pronounced decline in sensory scores. However, all cookie samples received scores above 7 on the hedonic scale, indicating favorable responses during sensory evaluation by the semi-trained panel. Among the developed formulations, KC-5% cookies were found to be the most acceptable, suggesting that moderate incorporation of Kachri powder (5%) provided the most favorable balance between nutritional enhancement and sensory quality, while higher incorporation levels negatively influenced sensory attributes. Similar results have been reported in previous studies, where moderate substitution levels of functional plant ingredients improved nutritional quality while maintaining sensory acceptability (Batoool et al., 2024).

The changes observed during storage as shown in Table 7 were primarily driven by moisture migration and associated physicochemical reactions occurring under ambient conditions. From a shelf-life and packaging perspective, the progressive increases in moisture content, peroxide value, and microbial counts observed during storage highlight the importance of moisture and oxygen control in the packaging of Kachri-enriched cookies. Moisture uptake is particularly relevant because the dietary fiber contributed by Kachri powder may increase the hygroscopicity of the product, thereby accelerating loss of crispness and deterioration of sensory quality. The increase in peroxide value indicates gradual lipid oxidation during storage, although the values remained below the acceptable limit throughout the 60-day evaluation period. The gradual increase in total plate count and yeast and mould counts further indicates that prolonged storage under ambient conditions can contribute to microbiological deterioration. Nevertheless, the microbial counts remained within the acceptable limits throughout the evaluated storage period, supporting the microbiological stability of the products under the conditions used in this study.

The use of metallized polyester–polyethylene pouches provided a suitable packaging system for the storage evaluation; however, the observed moisture uptake and oxidative changes suggest that packaging with optimized moisture- and oxygen-barrier properties may be necessary for extending the commercial shelf life of the product. Effective heat sealing and protection from temperature and humidity fluctuations may further reduce moisture migration and oxidative deterioration. Based on sensory acceptability, peroxide value, and microbiological quality, the practical shelf life of the control and KC-5% cookies were estimated to be approximately 45 days under the ambient conditions evaluated. Although the products remained within acceptable oxidative and microbiological limits at 60 days, the decline in sensory acceptability indicates that sensory quality may become the limiting factor for practical shelf life. Therefore, longer-term studies under controlled temperature and relative-humidity conditions, together with comparative evaluation of high-barrier packaging materials, are recommended to establish a more robust commercial shelf-life estimate. Such studies should also evaluate packaging integrity, water-vapor and oxygen transmission, microbial safety, sensory quality, and oxidative stability under different storage environments.

The relatively minor changes in protein, fat, and carbohydrate contents indicate that the nutritional composition of the cookies remained largely stable throughout storage. The stability of crude fiber content further confirms the resistance of fiber components to degradation under normal storage conditions.

As shown in Table 8, the gradual increase in peroxide value (PV) during storage indicates progressive lipid oxidation, a common phenomenon in bakery products containing fat. However, the lower peroxide values observed in Kachri-enriched cookies, as shown in Figure 9, suggest that naturally occurring phenolic compounds and other antioxidant constituents may have slowed oxidative deterioration. This finding is particularly important because oxidative stability directly influences shelf life, flavor preservation, and overall product quality. The gradual increase in PV during storage agrees with the findings of Patil et al. (2020), who observed similar oxidative changes in bakery products during ambient storage. However, all peroxide values remained below the acceptable limit of 10 meq/kg fat recommended for bakery products by FSSAI (2016), indicating good oxidative stability throughout the 60-day storage period. In addition, Najjar et al. (2022) noted that fiber-rich bakery products tend to absorb more moisture during storage, thereby influencing microbial stability, which may also contribute to changes in product quality during prolonged storage.

Microbial populations increased gradually during storage, primarily due to moisture absorption and prolonged exposure to ambient conditions. Similar storage-related changes in bakery products have also been reported by Patil et al. (2020), and Najjar et al. (2022). Nevertheless, microbial counts remained within acceptable safety limits throughout the study period. The relatively lower bacterial counts observed in Kachri-containing cookies may indicate the presence of phytochemicals with mild antimicrobial activity. Similar antimicrobial effects of plant-derived phenolic compounds in bakery products have been reported in previous studies (Singh et al., 2026). Deepika et al. (2023) also reported that phenolic-rich plant materials exhibit antioxidative activity capable of improving oxidative stability in food products. These results further support the potential application of Kachri as a functional ingredient in commercial bakery products.

Correlation Analysis of Storage Parameters

Regression analysis revealed a strong positive correlation ($R^2 = 0.92\text{--}0.96$) between storage duration and moisture content in all cookie samples, indicating progressive moisture uptake during storage under ambient conditions. Similarly, peroxide value showed a strong positive correlation ($R^2 = 0.88\text{--}0.96$) with storage time, confirming gradual lipid oxidation throughout the storage period.

Microbial counts, including TPC and yeast and mould counts, also exhibited positive correlations with storage duration, demonstrating progressive microbial growth during storage. However, all microbial counts remained within acceptable safety limits for bakery products throughout the 60-day storage period.

In contrast, overall sensory acceptability showed a strong negative correlation ($R^2 = 0.85\text{--}0.91$) with storage duration, indicating gradual deterioration in sensory quality over time. The decline in sensory scores may be attributed to moisture absorption, loss of crispness, oxidative changes, and slight flavor deterioration during storage. Further large-scale consumer studies are recommended to validate the sensory acceptability of Kachri-enriched cookies.

Among the developed formulations, cookies containing 5% Kachri powder exhibited comparatively better storage stability and sensory retention than higher incorporation levels. Overall, the regression analysis confirmed that storage-related physicochemical, microbiological, and sensory changes followed predictable trends under ambient storage conditions.

Shelf-Life Prediction

Based on the sensory acceptability threshold, peroxide value, and microbiological quality, the practical shelf-life of the developed cookies was estimated under ambient storage conditions. Control cookies and KC-5% cookies maintained acceptable sensory scores up to approximately 45 days of storage, whereas KC-7.5% and KC-10% cookies showed a comparatively faster decline in sensory acceptability due to gradual moisture uptake, loss of crispness, and development of stronger flavor notes associated with higher Kachri incorporation.

Peroxide values of all cookie samples remained well below the acceptable limit of 10 meq/kg fat throughout the 60-day storage period, indicating satisfactory oxidative stability. Similarly, total plate count and yeast and mold counts remained within acceptable microbiological limits for bakery products during storage. The comparatively lower peroxide values observed in Kachri-incorporated cookies suggest that phenolic compounds and antioxidant constituents present in Kachri powder contributed to improved oxidative stability.

Regression analysis demonstrated strong positive correlations between storage duration and peroxide values and microbial counts ($R^2 \approx 0.88\text{--}0.96$), while sensory scores exhibited a negative correlation with storage time ($R^2 \approx 0.85\text{--}0.91$). These findings indicate that storage-related quality deterioration occurred progressively and predictably under ambient conditions.

Overall, the results suggest that cookies formulated with 5% Kachri powder possessed the most desirable balance between nutritional enhancement, sensory acceptability, and storage stability. The developed cookies remained microbiologically acceptable under the conditions evaluated and organoleptically acceptable for up to 45 days under ambient storage conditions when packaged in metallized polyester–polyethylene pouches. Further large-scale consumer studies are recommended to validate market acceptability and commercial shelf-life under different storage environments.

6. CONCLUSION

The present study demonstrated the feasibility of incorporating *Cucumis callosus* (Kachri) powder into cookies as a value-added functional ingredient. The progressive incorporation of Kachri powder resulted in improvements in several nutritional and functional attributes of the cookies, particularly dietary fiber, ash, calcium, iron, zinc, total phenolic content, DPPH radical-scavenging activity, and FRAP values. The incorporation of Kachri also modified the functional properties of the flour, including water absorption and oil-holding capacity, while producing measurable changes in the physical, textural, and color characteristics of the cookies.

Although increasing Kachri incorporation enhanced the antioxidant and nutritional properties, higher substitution levels resulted in darker cookies and a progressive reduction in sensory scores. Among the Kachri-enriched formulations, KC-5% showed the highest overall sensory acceptability, with an overall acceptability score of 8.0, compared with 7.7 and 7.1 for KC-7.5% and KC-10%, respectively. Thus, the 5% incorporation level provided a suitable balance between nutritional enhancement and sensory quality.

The storage study further indicated that the developed cookies retained acceptable quality during the evaluated storage period, although moisture content, peroxide value, microbial counts, and other quality changes increased progressively with storage

duration, accompanied by a decline in overall acceptability. These findings demonstrate the potential of Kachri powder for improving the nutritional and antioxidant characteristics of bakery products while maintaining satisfactory product quality.

Overall, the study supports the utilization of Kachri, an underutilized plant resource, for the development of nutritionally enriched cookies and provides a basis for its further application in functional bakery products. However, the antioxidant evaluation was performed only on baked cookies, and the study did not quantify the retention or thermal degradation of bioactive compounds during baking. Future investigations should therefore focus on the identification of individual bioactive compounds, their stability and bioaccessibility after processing, consumer-level acceptance, optimization of processing and packaging conditions, and evaluation of the commercial feasibility of Kachri-enriched bakery products.

7. DECLARATIONS

Ethics approval and consent to participate:

The plant material used in this study, *Cucumis callosus*, was procured as cultivated produce from a local farmer in Kalyanpur, Kanpur, Uttar Pradesh, India. The collection and use of plant material complied with applicable institutional guidelines for the use of plant resources. No wild collection was involved in this study; therefore, no specific permits or licenses were required. The study adhered to standard ethical practices for plant-based research.

The study protocol involving human participants for sensory evaluation was reviewed and approved by the Institutional Ethics Committee of CSJMU, Kanpur. The research was conducted in accordance with the guidelines and regulations prescribed by the committee and adhered to the principles of the Declaration of Helsinki.

Data availability

The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

Generative AI and AI-assisted technologies:

During the preparation of this manuscript, the authors used generative artificial intelligence (AI)-based tools solely for language improvement, grammar correction, and editorial assistance. The authors reviewed and verified all AI-assisted content and take full responsibility for the accuracy, originality, and integrity of the final manuscript.

Funding

No funding was received for this research.

Acknowledgement

The authors are grateful to the CSJM University, Kanpur, India.

REFERENCES

- [1] Ahmad, M., Wani, T. A., Wani, S. M., Masoodi, F. A., & Gani, A. (2016). Incorporation of carrot pomace powder in wheat flour: effect on flour, dough and cookie characteristics. *Journal of Food Science and Technology*, 53(10), 3715-3724. <https://doi.org/10.1007/s13197-016-2345-2>.
- [2] Alshammari, J. M., Waseem, M., & Mugabi, R. (2026). Valuation of nutritional, antinutritional, antioxidant and sensorial characteristics of thermal and non-thermal processed *Cucumis callosus* L. powder. *Discover Food*. <https://doi.org/10.1007/s44187-026-00879-z>
- [3] AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1983. Approved Methods of the AACC. Methods 8-01 and 44-16, approved April 1961; Method 10-IOB, approved January 1983; Method 10-52, approved September 1985; Method 46-12, approved October 1976; and Method 54-30, approved October 1984. The Association: St. Paul, MN.

- [4] AOAC. Official Methods of Analysis. 18th edn. Association of Official Analytical Chemists; Arlington, VA, USA: 2005.
- [5] Bakir, S. (2026). Bakery Products Enriched With Fruit and Vegetable Wastes: A Functional Approach. *AgriFood Journal of Agricultural Products for Food*, 2(1), 47–56. <https://doi.org/10.1002/agf2.70011>
- [6] Batool, R., Ramzan, R., Raza, A., Aziz, M., Rohi, M., Naeem, A., Nusrat, W., Razi, A., Saleem, B., Batool, W., Bilal, A., & Khadijah, B. (2024). Dietary supplementation of black cumin (*Nigella sativa*) meal in the formulation of protein-enriched cookies, further in vivo evaluation of protein quality with physicochemical and organoleptic characterization. *Food Science & Nutrition*, 12(10), 7405. <https://doi.org/10.1002/fsn3.4016>
- [7] BENAM, N. S., Goli, M., Ardebili, S. M. S., & VAEZSHOUSHTARI, N. (2021). The quality characteristics of dough and toast bread prepared with wheat flour containing different levels of *Portulaca oleracea* leaf powder. *Food Science and Technology*, 42. <https://doi.org/10.1590/fst.60820>
- [8] Benzie, I. F., & Strain, J. J. (1996). The ferric reducing ability of plasma (FRAP) as a measure of “antioxidant power”: the FRAP assay. *Analytical biochemistry*, 239(1), 70–76. <https://doi.org/10.1006/abio.1996.0292>
- [9] Boora, N., Singh, J. P., Gunjal, M., Assouguem, A., Ercisli, S., & Rasane, P. (2025). *Cucumis callosus* : A valuable neglected crop as an alternative source of nutrition. *CABI Reviews*. <https://doi.org/10.1079/cabireviews.2025.0056>
- [10] Chau, C. F., & Huang, Y. L. (2003). Comparison of the chemical composition and physicochemical properties of different fibers prepared from the peel of *Citrus sinensis* L. Cv. Liucheng. *Journal of agricultural and food chemistry*, 51(9), 2615–2618. <https://doi.org/10.1021/jf025919b>
- [11] Chaudhary, P., & Gupta, K. (2025). Comprehensive analysis of nutritional and antioxidant properties of *Cucumis callosus* peel. *Current Botany*, 186–192. <https://doi.org/10.25081/cb.2025.v16.9515>
- [12] Deepika, D., Kumari, A., Prajapati, P., Sarita, S., Kumar, S., Aluko, R. E., Singh, S., & Garg, M. (2023). Pharmacological and Therapeutic Potential of *Cucumis callosus*: a Novel Nutritional Powerhouse for the Management of Non-communicable Diseases. *Plant Foods for Human Nutrition*, 78(4), 630. <https://doi.org/10.1007/s11130-023-01098-y>
- [13] FSSAI. (2016). Food Safety and Standards (Food Products Standards and Food Additives) Regulations. Food Safety and Standards Authority of India, New Delhi, India.
- [14] Guardianelli, L. M., Puppo, M. C., & Salinas, M. V. (2021). Influence of pistachio by-product from edible oil industry on rheological, hydration, and thermal properties of wheat dough. *LWT*, 150, 111917–111917. <https://doi.org/10.1016/j.lwt.2021.111917>
- [15] Guiné, R. P. F., & Florença, S. G. (2024). Development and Characterisation of Functional Bakery Products. *Physchem*, 4(3), 234–257. <https://doi.org/10.3390/physchem4030017>
- [16] Harborne, A. J. (1998). *Phytochemical methods a guide to modern techniques of plant analysis*. springer science & business media.
- [17] Herzi, N., Bouajila, J., Camy, S., Romdhane, M., & Condoret, J. (2013). Comparison of different methods for extraction from *Tetralinis articulata*: Yield, chemical composition and antioxidant activity. *Food Chemistry*, 141(4), 3537. <https://doi.org/10.1016/j.foodchem.2013.06.065>
- [18] Irondi, E. A., Olatoye, K. K., Abdulameed, H. T., Aliyu, O. M., Ajani, E. O., & Ogbebor, O. F. (2024). Physicochemical, in vitro starch digestibility and sensory characteristics of biofortified yellow maize-cowpea composite flours and biscuits. *Food Production Processing and Nutrition*, 6(1). <https://doi.org/10.1186/s43014-023-00201-9>
- [19] Kaushik, I., Khedkar, R., & Saini, A. K. (2025). Process Innovation and Industrial Insights in India’s Biscuit Sector. *BIO Web of Conferences*, 178, 3013–3013. <https://doi.org/10.1051/bioconf/202517803013>
- [20] Krajewska, A., & Dziki, D. (2023). Enrichment of Cookies with Fruits and Their By-Products: Chemical Composition, Antioxidant Properties, and Sensory Changes. *Molecules*, 28(10), 4005–4005. <https://doi.org/10.3390/molecules28104005>

- [21] Masoud, N. A., Hassan, S. A., Alomar, T. S., Mujahid, W., & Aadil, R. M. (2024). Enhancing biscuits with muskmelon seed flour: a study of physicochemical, textural, and nutritional characteristics. *Quality Assurance and Safety of Crops & Foods*, 16(3), 139–151. <https://doi.org/10.15586/qas.v16i3.1503>
- [22] Meena, S., Singh, R., Sharma, B., & Singh, D. (2016). *Most favourite traditional cucurbitaceous vegetables and their utilization pattern in Thar desert of the western Rajasthan, India*.
- [23] Najjar, Z., Alkaabi, M., Alketbi, K., Stathopoulos, C. E., & Ranasinghe, M. (2022). Physical Chemical and Textural Characteristics and Sensory Evaluation of Cookies Formulated with Date Seed Powder. *Foods*, 11(3), 305. <https://doi.org/10.3390/foods11030305>
- [24] Nawabueze, T. (2006). Water/oil absorption and solubility indices of extruded African bread fruit blends. *J Food Technol*, 4(1), 64-69.
- [25] Pathare, P.B., Opara, U.L. & Al-Said, F.AJ. Colour Measurement and Analysis in Fresh and Processed Foods: A Review. *Food Bioprocess Technol* 6, 36–60 (2013). <https://doi.org/10.1007/s11947-012-0867-9>
- [26] Patil, A., Chogale, N. D., Pagarkar, A., Koli, J., Bhosale, B., Pathan, D., Sawant, S., & Sarang, S. S. (2020). Biochemical and shelf life characteristics of air packed pangasius (*Pangasianodon hypophthalmus*) during chill storage. *International Journal of Fisheries and Aquatic Studies*, 8(6), 34. <https://doi.org/10.22271/fish.2020.v8.i6a.2358>
- [27] Ribeiro, E. F., Luzia, D. M. M., & Jorge, N. (2019). Antioxidant compounds extraction from coffee husks: the influence of solvent type and ultrasound exposure time. *Acta Scientiarum. Technology/Acta Scientiarum. Technology*, 41(1), 36451. <https://doi.org/10.4025/actascitechnol.v41i2.36451>
- [28] Salfinger, Y., & Tortorello, M. L. (Eds.). (2015). *Compendium of methods for the microbiological examination of foods*. American Public Health Association. <http://dx.doi.org/10.2105/MBEF.0222>
- [29] Samadia, D., SM, H., Ram, H., Verma, A., & Gurjar, P. (2024). Kachri melon (a non-dessert form of *Cucumis melo*) diversity, germplasm utilization and varietal development under hot arid climate: Approaches and realization. *Journal of Agriculture and Ecology*, 18, 14–27. <https://doi.org/10.58628/jae-2418-103>
- [30] Singh KK, Singh P, Rajput H, Kumar S, Gupta A. (2026). *Cucumis callosus—A neglected cucurbit of the Indian subcontinent: Taxonomy, phytochemistry, health benefits, and value addition: A review*. *International Journal of Drug Delivery Technology*, 16(28s), 956–983. DOI: 10.25258/ijddt.16.28s.114
- [31] Singh, N., Singh, J., Kaur, L., Sodhi, N. S., & Gill, B. S. (2003). Morphological, thermal and rheological properties of starches from different botanical sources. *Food chemistry*, 81(2), 219-231. [https://doi.org/10.1016/S0308-8146\(02\)00416-8](https://doi.org/10.1016/S0308-8146(02)00416-8)
- [32] Toydemir, G., Subaşı, B. G., Hall, R. D., Beekwilder, J., Boyacıoğlu, D., & Çapanoğlu, E. (2022). Effect of food processing on antioxidants, their bioavailability and potential relevance to human health. *Alanya Alaaddin Keykubat University Institutional Repository*, 14, 100334–100334. <https://doi.org/10.1016/j.fochx.2022.100334>
- [33] Vaghasiya, S., & Ishnava, K. B. (2024). Biological Activity and Phytochemical Analysis of *Cucumis callosus* (Rottl.) Cong Underutilization Vegetable. In *Research Square*. <https://doi.org/10.21203/rs.3.rs-5393375/v1>
- [34] Zheng, H., Sun, Y., Zheng, T., Zeng, Y., Fu, L., Zhou, T., Fan, J., Xu, Y., He, K., & Yang, Y. (2023). Effects of shear emulsifying/ball milling/autoclave modification on structure, physicochemical properties, phenolic compounds, and antioxidant capacity of lotus (*Nelumbo*) leaves dietary fiber. *Frontiers in Nutrition*, 10. <https://doi.org/10.3389/fnut.2023.1064662>