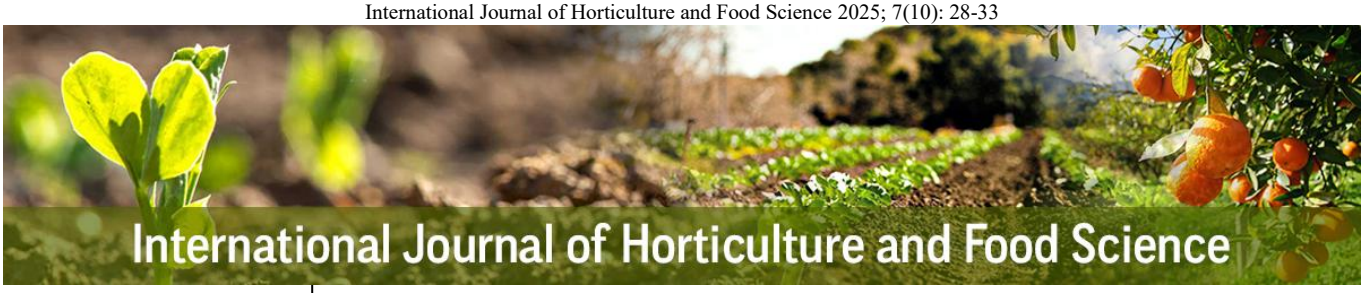

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Aditya Sharad Kuyate
Student, Department of Food Plant Operation, K. K. Wagh College of Food Technology, Nashik, MPKV Rahuri University, Maharashtra, India

Prachi Sardarsing Rajput
Student, Department of Food Plant Operation, K. K. Wagh College of Food Technology, Nashik, MPKV Rahuri University, Maharashtra, India

Khushi Chandan Ghule
Student, Department of Food Plant Operation, K. K. Wagh College of Food Technology, Nashik, MPKV Rahuri University, Maharashtra, India

Shembade Pratiksha Shivaji
Student, Department of Food Plant Operation, K. K. Wagh College of Food Technology, Nashik, MPKV Rahuri University, Maharashtra, India

Shruti Ravindra Tanpure
Student, Department of Food Plant Operation, K. K. Wagh College of Food Technology, Nashik, MPKV Rahuri University, Maharashtra, India

Neha Pravin Deshmukh
Student, Department of Food Plant Operation, K. K. Wagh College of Food Technology, Nashik, MPKV Rahuri University, Maharashtra, India

Saurabh Sanjay Bankar
Professor, Department of Food Plant Operation, K. K. Wagh College of Food Technology, Nashik, MPKV Rahuri University, Maharashtra, India

Nitin Nivrutti Talpade
Professor, Department of Food Chemistry & Nutrition, K. K. Wagh College of Food Technology, Nashik, MPKV Rahuri University, Maharashtra, India

Kumargaurav Prakash Tayade
Professor, Department of Food Engineering, K. K. Wagh College of Food Technology, Nashik, MPKV Rahuri University, Maharashtra, India

Corresponding Author:
Aditya Sharad Kuyate
Student, Department of Food Plant Operation, K. K. Wagh College of Food Technology, Nashik, MPKV Rahuri University, Maharashtra, India

Studies on standardization, sensory evaluation, chemical and microbial analysis of Greek stick incorporated with fenugreek (*Trigonella foenum-graecum*), Moong Bean and Red lentils

Aditya Sharad Kuyate, Prachi Sardarsing Rajput, Khushi Chandan Ghule, Shembade Pratiksha Shivaji, Shruti Ravindra Tanpure, Neha Pravin Deshmukh, Saurabh Sanjay Bankar, Nitin Nivrutti Talpade and Kumargaurav Prakash Tayade

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Abstract
The formulation for preparation of Greek sticks was carried out by using different variation in moong bean flour and red lentils flour whereas rice flour, semolina, and fenugreek which are constant T0, T1, T2, T3, T4 *viz,* 100:00, 30:30:15:15:5, 40:20:15:15:5, 20:35:20:15:5, 25:25:15:15:5, respectively. Further Greek sticks were prepared and it then allow for organoleptic evaluation with semi trained panel in that T2 got more score in terms of taste, flavour, crispiness and texture received highest sensory score (9). Chemical properties of Greek sticks *viz,* moisture, fat, protein, carbohydrate, fibre, ash was analysed. Results obtained for chemical composition of Greek sticks revealed that moisture content 4.90%, fat 16.10%, protein 18.20%, carbohydrates 49.20%, crude fibre 9.80%, ash 1.70% and the energy value of 415.15 kcal; indicating a nutrient-dense, balanced snack suitable for health-conscious consumers. The product was further evaluated for microbial safety during storage at 1, 4, 8, 12, 16, 20 and 24 days, showing Total Plate Counts of 3.2×10^3, 3.6×10^3, 4.0×10^3, 5.2×10^3, 6.0×10^3, and 7.1×10^3 CFU/g, the Yeast & Mold counts of 1.6×10^3, 2.1×10^2, 3.5×10^2, 5.8×10^2, 7.5×10^2, 9.8×10^2, and 1.3×10^2 CFU/g, and the coliform counts <10 CFU/g, confirming the microbiological safety of the ready-to-eat snack. Overall, Greek Sticks provide a convenient, nutrient-rich, and ready to eat snack that delivers protein, carbohydrates, fibre from legumes and fenugreek, making it suitable for modern lifestyles and health-conscious consumers seeking ready-to-eat options.

Keywords: Greek sticks, moong bean flour, red lentils, semolina, sensory evaluation, microbial analysis, ready-to-eat

Introduction
Customers' increased awareness of health and wellness is driving up demand for nutrient-dense and useful snack options. Products that support digestive health, immunity, and overall well-being have garnered the most attention among these. A new snack product called Greek Sticks was developed using a combination of rice flour, red lentil flour, whole moong flour, semolina, and fenugreek leaves to satisfy both nutritional and sensory needs. These ingredients were selected for their attractiveness, digestibility, and health-promoting properties in accordance with modern consumer preferences for foods that are practical and convenient. Vitamins, vital minerals, dietary fibre, and plant-based protein are all abundant in whole moong bean flour (*Vigna radiata*). Both soluble and insoluble fibre promote a balanced gut microbiota and aid in healthy digestion. Additionally, moong beans contain bioactive substances like polyphenols that support the immune system and act as antioxidants. Greek sticks with moong flour have higher protein and fibre content, which encourages fullness and nutritional balance. Red Lentil Flour (*Lens culinaris*) adds complementary nutritional value to the formulation. Red lentils are high in protein, complex carbohydrates, dietary fibre, and essential micronutrients like iron, folate, and magnesium. The soluble fibre in red lentils acts as a prebiotic, supporting the growth of beneficial gut bacteria and improving digestive health.

Red lentil flour also contributes to the product's structural integrity and texture, allowing for crisp yet light sticks that are appealing to consumers. In Greek sticks, semolina (*Triticum durum)* and rice flour (*Oryza sativa*) enhance the dough's textural consistency and binding qualities. Because rice flour is gluten-free and easily digested, it guarantees that the sticks are crisp and light. The overall sensory appeal is improved by the firmness and faintly nutty flavour that semolina's coarse granules provide. A balanced macronutrient profile that is appropriate for a variety of consumers, including those with mild gluten sensitivity, is produced by combining these flours. (*Trigonella foenum-graecum)*, or fenugreek leaves, are added for their flavour and practical advantages. Fenugreek, which has long been used in Indian medicine and food, is high in soluble fibre, antioxidants, and bioactive substances that aid in digestion, control blood sugar, and reduce inflammation. Greek Sticks are a useful snack choice because the addition of fenugreek improves the flavour profile while having health-promoting benefits. In addition to enhancing palatability, the addition of spices and a small amount of oil to the formulation offers antimicrobial and antioxidant properties that support shelf-life stability. Greek sticks are a nutrient-dense, convenient snack that is ideal for consumers who are health-conscious thanks to the combination of these ingredients. Greek sticks are adaptable to a variety of dietary requirements and contemporary lifestyles because they can be eaten as a ready-to-eat snack or combined with dips, soups, or salads. Overall, Greek Sticks represent an innovative approach to functional snacking, integrating plant-based protein, fibre, and bioactive compounds in a convenient, tasty format. By leveraging the nutritional and functional properties of moong, red lentils, rice flour, semolina, and fenugreek, this product aligns with the global trend of health-oriented, functional foods that promote digestive health, satiety, and overall wellness.

Materials and Methods

The study was conducted in the Department of Food Plant Operation, Food Chemistry and Nutrition, Food Microbiology at K. K. Wagh College of Food Technology, affiliated with Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra. The research focused on the development of a novel ready-to-eat snack, Greek Sticks, prepared using a composite blend of whole moong bean flour, red lentils flour, rice flour, semolina and fenugreek leaves. All raw materials were procured from local markets and confectionery outlets in Nashik, ensuring freshness and quality.

Proximate Analysis

Different chemical properties of samples were analysed for moisture content, ash, fat, protein and total carbohydrate. All the determinations were done in triplicate and the results were expressed as the average value.

Moisture content

Moisture content was determined adopting [1] method as following:

$$\% \text{ Moisture content} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

Fat

(AOAC, 2005) [1] Method using Soxhlet apparatus was used to determined crude fat content of the sample. The percent of crude fat was expressed as follows:

$$\% \text{ Crude Fat} = \frac{\text{Weight of dried ether soluble material}}{\text{Weight of sample}} \times 100$$

Protein

Protein content was determined using (AOAC, 2005) [1] method. Percentage of nitrogen and protein calculated by the following equation:

$$\% \text{ Nitrogen} = \frac{T_S - T_B \times \text{Normality of acid} \times 0.014}{\text{Weight of sample}} \times 100$$

Where, Ts = Titre volume of the sample (ml), TB = Titre volume of Blank (ml), 0.014= M eq. of N_2.
% Protein = Nitrogen × 6.25

Total carbohydrate

Total carbohydrate content of the samples was determined as total carbohydrate by difference, that is by subtracting the measured protein, fat, ash and moisture from 100 phenol sulphuric acid method as given by (AOAC, 2005) [1].

Ash

Drying the sample at 100^0 C and churned over an electric heater. It was then ashes in muffle furnace at 550^0 C for 5 hrs.
It was calculated using the following formula:

$$\% \text{ Ash content} = \frac{AW}{IW} \times 100$$

Where, AW = Weight of Ash and IW= Initial weight of dry matter

Methodology

Recipe Standardization for Greek Sticks

For recipe standardization of Greek sticks various proportion were taken with ingredients, including whole moong bean flour, red lentil flour, rice flour, semolina, and fenugreek leaves. Whole moong bean and red lentil seeds were cleaned, roasted to enhance flavour and digestibility at temperature of 120^0 C, and then ground into fine powders with the help of grinder. Rice was cleaned, partially milled into fine rice flour, while semolina was sieved to ensure uniform particle size. Fenugreek leaves were washed and steam blanched at temperature of 80^0 C to reduce bitterness, later it is been dried mechanical with the help of tray dryer and powdered by the use of grinder. All powdered ingredients were accurately weighed according to the optimized formulation as per shown in Table No. 01 mixed thoroughly using a planetary mixer to achieve a uniform distribution.

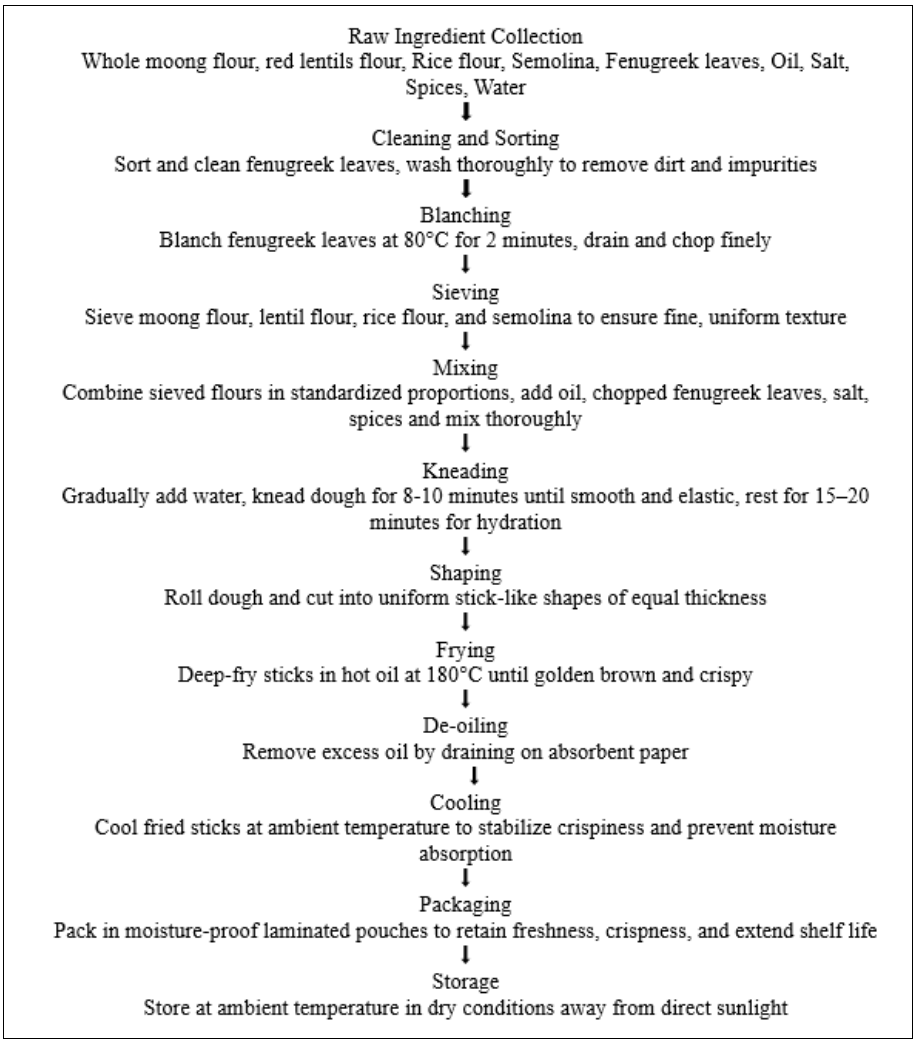
Table 1: Recipe Standardization for Greek Sticks

Ingredients (100 gm)	Treatments				
	T0	T1	T2	T3	T4
Refined wheat Flour	90	00	00	00	00
Fenugreek	05	05	05	05	05
Moong Bean Flour	-	30	40	20	25
Red Lentils Flour	-	30	20	35	25
Rice Flour	-	15	15	20	25
Semolina	-	15	15	15	15

Where, T0: Control and T1, T2, T3, and T4: Trials

Preparation of Greek Sticks

The preparation of Greek sticks involves a systematic process starting with the selection of good-quality ingredients such as whole moong flour, red lentils flour, rice flour, semolina, and fenugreek leaves. Each of these ingredients is first cleaned and pre-processed to ensure safety and quality. Whole moong, red lentils and rice are milled into fine flours, while semolina has procured and sieved to remove lumps or coarse particles. Fenugreek leaves are sorted, washed thoroughly to remove dirt and adhering impurities, and then blanched at 80°C for about 2minutes to minimize bitterness and retain chlorophyll content, after which they are drained and chopped finely. In the preparation stage, all the flours were mixed in standardized proportions to obtain a balanced blend. To this mixture, oil is incorporated gradually, which not only improves binding but also enhances the mouthfeel and crispiness of the final product. Finely chopped fenugreek leaves are then added, followed by gradual addition of water to form a homogenous dough. The dough is kneaded thoroughly for 8–10 minutes until it achieves a smooth, elastic texture and is then covered and rested for about 15–20 minutes to allow proper hydration and development of structure. After resting, the dough is portioned and rolled into uniform cylindrical shapes resembling sticks, ensuring equal thickness for even cooking. These sticks are then carefully deep-fried in hot oil maintained at 180°C until they acquire a golden-brown colour, crispy texture, and characteristic aroma. Once fried, the sticks are removed and excess oil is drained using absorbent paper to enhance product quality and shelf stability. The fried Greek sticks are then allowed to cool at ambient temperature, which stabilizes their crunchiness and prevents condensation during storage. After cooling, they are packed in airtight, moisture-proof, and food-grade laminated pouches to retain their freshness, crispness, and flavour while protecting them against rancidity and moisture uptake. This method results in a protein-rich, fibre-enriched, and nutrient-dense fried snack with distinct flavour contributed by fenugreek leaves and the wholesome combination of cereals.



Flow Chart N0 1: Processing Technology for Preparation of Greek Sticks

Results and Discussion

Sensory evaluation of Greek Sticks

The sensory evaluation of Greek sticks was carried out with respect to taste, flavour, crispiness, texture, appearance, and overall acceptability, as shown in Table No. 3. It was observed that the incorporation of fenugreek leaves, along with a balanced combination of moong bean flour, red lentil flour, rice flour, and semolina, had a significant influence on the sensory attributes of the product. The scores indicated that colour and appearance were uniform and highly acceptable in the control sample and treatment T1, while slight variation in colour intensity was noted in samples with higher fenugreek incorporation. Taste and flavour scores were highest for sample T2, as the blend of pulses and fenugreek imparted a characteristic, mildly bitter yet appealing flavour that was appreciated by the panellists. Textural scores revealed that frying resulted in a crispy and crunchy product, with T1 and T2 maintaining the most desirable texture, whereas higher moisture retention in T3 slightly reduced crispiness. Overall acceptability scores showed that sample T2 was significantly superior to other treatments, due to its balanced combination of colour, flavour, texture, and mouthfeel. Statistical analysis of the data further confirmed that T2 had a highly significant effect ($p<0.05$) on sensory quality compared to control and other treatments.

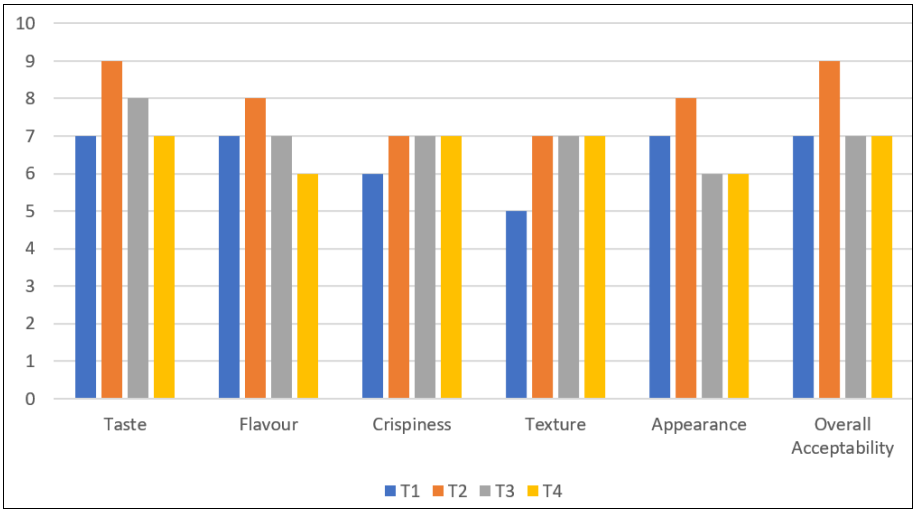
Table 2: Nine-point hedonic liking preference scale

Dislike extremely	Dislike very much	Dislike moderately	Dislike Slightly	Neither like nor dislike	Like slightly	Like Moderately	Like very much	Like extremely

Table 3: Mean sensory values for the Greek Sticks

Sample	Taste	Flavour	Crispiness	Texture	Appearance	Overall Acceptability
T0	7	6	7	7	6	7
T1	7	7	6	5	7	7
T2	**9**	**8**	**7**	**7**	**8**	**9**
T3	8	7	7	7	6	7
T4	7	6	7	7	6	7

*Each Value is average of three determinants



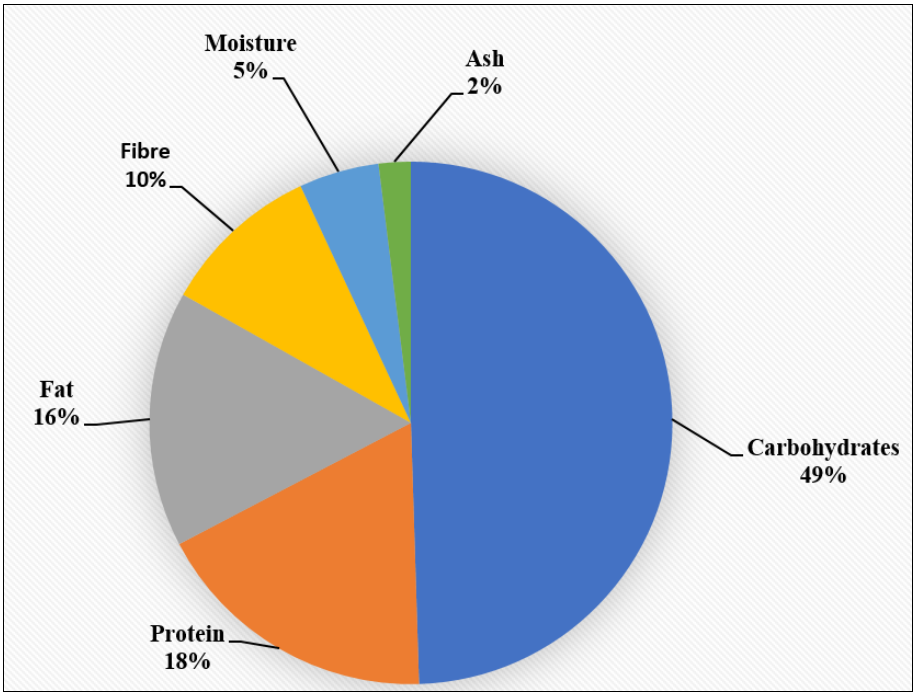
Graph 1: Graphical Representation of Sensory evaluation chart

Chemical Analysis

Table 4: Tabular Representation of Proximate Analysis

Proximate Analysis	
Parameter	Mean Value*
Moisture	4.90%
Fat	16.15%
Protein	18.25%
Carbohydrate	49.20%
Fiber	9.80%
Ash	1.80%
Calorific Value	415.15 kcal
SE±@5%	0.50
CD±@5%	2.50

*Each value is average of three determinants



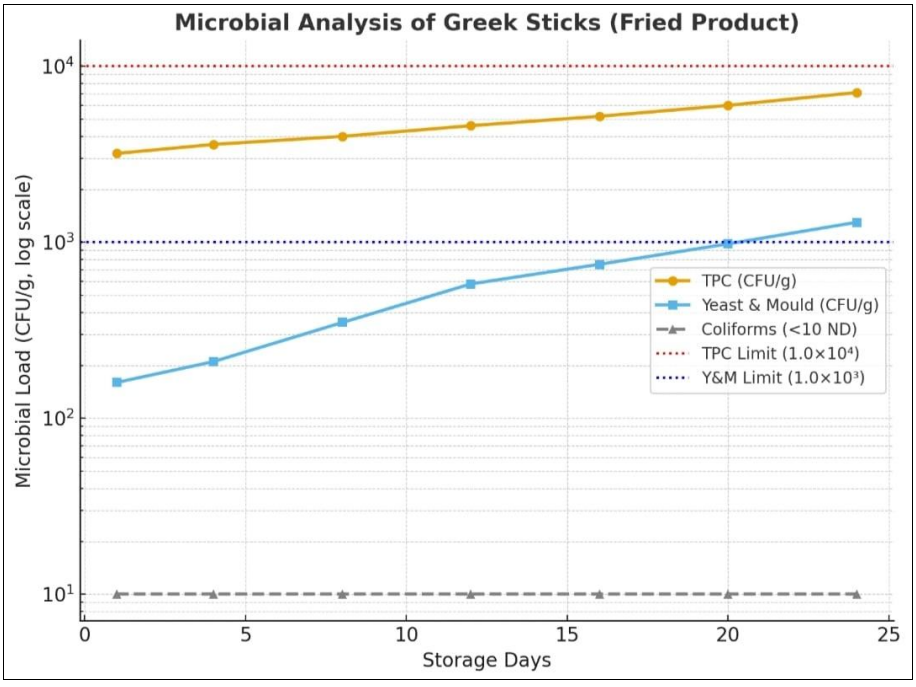
Graph 2: Graphical Representation of Chemical Analysis

The chemical composition of the sample was analysed for major nutritional constituents, including moisture, fat, protein, carbohydrates, ash, and crude fibre. Revealed that moisture content was 4.90%, fat 16.10%, protein 18.20%, carbohydrates 49.20%, crude fibre 9.80%, and ash 1.70%. with calories of 415.15 kcal.

Microbial Analysis

Table 5: Tabular Representation of Microbial Analysis

Storage Days	TPC	Yeast & Mould (CFU/g)	Coliforms	Desirable Limits
1	3.2 x 10^3	1.6 x 10^3	<10(ND)	TPC<1.0 x 10^4
4	3.6 x 10^3	2.1 x 10^2	<10(ND)	Y&M<1.0 x 10^3
8	4.0 x 10^3	3.5 x 10^2	<10(ND)	Coliforms<1.0 x 10^2
12	4.6 x 10^3	5.8 x 10^2	<10(ND)	
16	5.2 x 10^3	7.5 x 10^2	<10(ND)	
20	6.0 x 10^3	9.8 x 10^2	<10(ND)	
24	7.1 x 10^3	1.3 x 10^2	<10(ND)	



Graph 3: Graphical Representation of Microbial Analysis

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