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Original Research Article

Development and Evaluation of Foxnut and Pea Based Functional Biscuits: Nutritional and Organoleptic Perspective

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Abstract: *The growing consumer interest in nutritious and functional snacks has driven innovation in bakery products using unconventional, nutrient-dense ingredients. Foxnut and pea flour are promising plant-based sources of protein, fibre, and antioxidants that can enhance the nutritional profile of bakery products.* ***Objective:*** *To develop and evaluate functional biscuits (fox pea sticks) fortified with foxnut and pea flour, assessing their nutritional, physicochemical, and sensory characteristics.* ***Methods:*** *Three biscuit formulations were prepared: T_0 (control, 100% wheat flour), T_1 (5% foxnut + 5% pea flour), and T_2 (10% foxnut + 10% pea flour), sweetened with 1.5% stevia as a sugar substitute. Proximate composition, texture profile (hardness, chewiness, springiness, cohesiveness, resilience), antioxidant activity, and sensory attributes were analyzed over a 14-day storage period. Data were statistically evaluated using ANOVA, with significance set at $p < 0.01$.* ***Results:*** *Substitution with foxnut and pea flour significantly improved the nutritional quality of the biscuits. Protein, dietary fibre, and antioxidant activity were notably higher in T_1 and T_2 compared to T_0. Texture profiling showed a significant ($p < 0.01$) increase in hardness, chewiness, and springiness in T_2, reflecting enhanced structural integrity. Sensory evaluation revealed that T_2 achieved the highest scores for appearance, texture, taste, and overall acceptability, indicating superior consumer preference. The T_2 formulation maintained its quality and palatability throughout storage.* ***Conclusion:*** *Incorporation of foxnut and pea flour into wheat-based biscuits successfully enhanced nutritional and functional properties without compromising sensory appeal. The optimized T_2 formulation demonstrated the best balance of texture, nutrition, and acceptability, establishing foxnut and pea flour as sustainable, functional ingredients for health-oriented bakery products.*

Keywords: Dietary Fiber Antioxidants Food, Fortified Cookies Sensory Evaluation

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Introduction

In accordance with rising health concerns such as obesity, diabetes, and heart disease, the food industry is progressively transitioning to healthier and more functional ingredients. Among the most promising solutions for sugar reduction and nutritional enhancement are stevia, foxnuts (makhana), peas, wheat, eggs, and butter, all of which have distinct health advantages and functional features. When used together, particularly in baked goods such as biscuits, they provide a potent mix of nutrition, flavor, and improved health outcomes (1–4).

Stevia stands out as a natural, zero-calorie sweetener that is significantly sweeter than regular sugar. It has proven to be a viable sugar substitute not only for diabetics, but also for consumers who want to cut calories without sacrificing sweetness. Stevia's nutritional profile—rich in steviol glycosides and antioxidant potential—makes it an important element in functional foods. Furthermore, its use in biscuits need not adversely alter appetite responses and can support glycaemic control and insulin regulation in appropriate contexts (1,5–7).

Foxnuts (makhana) have their own set of impressive nutritional benefits. They are nutrient-dense—supplying protein, fiber, and essential minerals—and suit vegetarian diets. Although cultivation/processing can be labor-intensive, roasted makhana develops a distinctive crunch. It may show higher phenolics/antioxidant activity with a favourable glycaemic profile, making it well-suited to healthier snack formulations and increasingly popular globally (8–11).

Pea protein is also gaining popularity in culinary innovation. It is a high-quality plant protein that is generally hypoallergenic and provides proper levels of fiber and carbohydrates. Pea flours/protein isolates exhibit valuable techno-functional traits (water/oil binding, solubility, emulsification, foaming) that help formulate improved biscuit textures while contributing antioxidant activity and overall nutritional value (3,12–14).

Wheat remains a cornerstone of biscuit production and contributes substantially to global calorie and protein intake. Whole-wheat flours offer dietary fibre, minerals, and vitamins; however, bran can challenge dough handling and product texture. Combining wheat with complementary ingredients such as eggs and butter can balance processing behaviour and product quality while retaining nutritional benefits (15–17).

Eggs play dual roles in biscuit systems—improving structure/aeration and acting as natural emulsifiers—while supplying complete proteins to complement cereal amino acid profiles. They can reduce the need for hydrogenated fats, although lipid management during processing is important to limit oxidation. Butter contributes characteristic flavour, tenderness, and spread, with performance influenced by fat content, processing, and storage; careful control optimizes mouthfeel and softness in baked products (18–24).

When stevia, foxnuts, pea protein, wheat, eggs, and butter are intelligently blended, they not only enhance the nutritional value of biscuits but also support desirable sensory qualities and consumer acceptance—paving the way for lower-sugar, functionally enriched biscuits without compromising taste or quality (25–32).

Aims and Objectives

Development and characterization of foxpea sticks by using foxnut and pea powder.

Evaluation of shelf stability of baked foxpea sticks by analyzing physicochemical properties, antioxidant capacity, and sensory characteristics.

Methodology

Procurement of raw material for foxpea sticks production:

Peas and milk were sourced from local market in Lahore, Pakistan. Baking powder, eggs, butter, wheat flour, stevia and foxnuts were sourced from Al-Fateh Lahore.

Powder preparation of peas:

Extraction of peas from their pods and preparing pea powder was done by using method defined by Senapati *et al.* (33). Fresh peas were ground and dried during the preparation process. First, the peas were entirely separated from their pod. The peas were then cleaned with tap water, blanched, and spread on aluminum foil. These peas were dehydrated in a dehydrator at 50°C for 12 hours. Afterward drying, the samples were removed and allowable to cool to room temperature. Dried peas were pulverized hooked on a fine powder using a heavy-duty blender. The produced powder was then securely wrapped in polypropylene pouches.

Powder preparation of foxnuts:

After learning about the nutritional value and advantages of roasted foxnuts (9), we came up with the concept of incorporating roasted foxnut powder into our creative FoxPea Sticks. The powder was created by roasting foxnuts over low to medium heat until they became slightly darker and crispier, then removing them from the heat and letting them cool to room temperature before grinding them in a grinder to a fine powder. At 27°C, the produced powder was thereafter correctly sealed in polypropylene pouches.

Flour blend preparation

To assess the physicochemical and antioxidant properties of Stevia based FoxPea sticks made with incorporation of pea powder, foxnut powder, butter, egg, baking powder and wheat flour, various formulations of these ingredients were created and compared to the control group across several parameters. The treatment plan is as follows:

Control T0 = 100% wheat flour

Treatment 1 T1 = 5% foxnut powder, 5% pea powder

Treatment 2 T2 = 10% foxnut powder, 10% pea powder

Formulation of Foxnut and pea powder incorporated stevia based FoxPea sticks

Table 1. Foxnut and pea powder incorporated stevia based FoxPea sticks

Samples	Flours blend (g) Wheat flour: Foxnut powder: Pea powder			Stevia (g)	Butter (g)	Baking powder (g)	Egg
	WF	FP	PP				
To	82g	0g	0g	2g	25g	0.37g	1
T1	72g	5g	5g	2g	25g	0.37g	1
T2	62g	10g	10g	2g	25g	0.37g	1

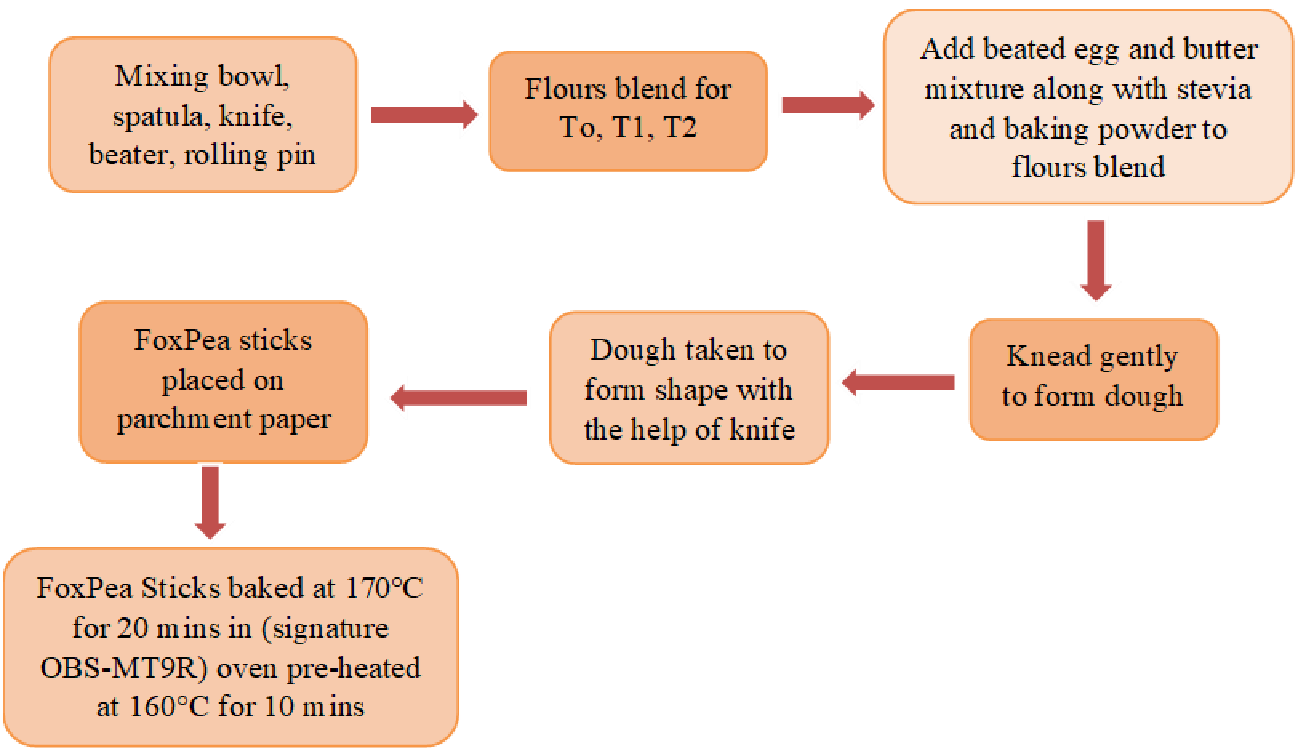

Figure 1. Flowline of Foxnut and pea powder incorporated stevia based FoxPea sticks

Following the above flowchart, FoxPea sticks were made using each flour blend: wheat flour, Pea powder, and Foxnut powder. The proportions of wheat flour, Pea powder, and Foxnut powder were altered, but the other ingredients stayed the same.

Proximate analysis of foxpea sticks

Determination of the Moisture content

Moisture content of biscuit samples were tested using the AOAC international technique, which involved drying 3g sample in the hot air oven at 104 °C for 3 hours which was described by (AÇARI. 2021). Weighing values of the samples were taken at regular intervals. The weighing process continued until the difference between the two weightings was 0.50%. The moisture content in biscuit samples was estimated using the method below:

$$\textbf{Moisture (\%)} = \frac{\textit{final weight of the sample}}{\textit{initial weight of the sample}} \times 100$$

Determination of ash content

Ash content of the FoxPea Sticks samples were determined as described by AOAC and Ajayi and Oyetayo (34). The dry crucibles were weighed

(W1). After cleaning, drying, and weighing the crucibles, approximately 3g of each sample was added and weighed again (W2). The containers were heated in a muffle furnace for 3 hours at 550℃. The heating was maintained until a light grey or white ash was created. The containers were removed from the furnace, warmed to area temperature using desiccators, and weighed. After achieving a stable weight, cooling and weighing were maintained. The ash content was designed with the formula below;

$$\textbf{\% Ash content} = \frac{W1 - W3}{W2 - W1} \times 100$$

Determination of the Crude Fat

Dry and finely grounded feed when mixed with diethyl ether dissolves fats and fat-soluble materials at a temperature of 200℃ as the boiling point of Diethyl ether is 300℃. Subsequently evaporation of ether from the fat solution leaves the resulting rest referred to as crude fat. Approximately 2g of feed is weight and grinded to fine powder. In a conical flask finely, grounded feed is mixed with 10ml of Diethyl Ether and boiled at temperature of 200℃ on a heating layer for 20 minutes. Prior to extraction a petri dish is weight and after boiler the supernatant is poured on the pre-weighted the petri dish and weight is taken. The difference in heaviness of the petri dish indicates the quantity of the fats. For validation of fats in the sample Sudan III test 9–11 was done which gives a positive result (Das and Biswas., 2019).

$$\text{Fat content \%} = \frac{weight\ of\ fat\ in\ sample}{weight\ of\ dried\ sample} \times 100$$

Determination of Crude Fiber

The crude fiber content of the nachos samples was determined using the AOAC and Imoisi *et al.*, (2020). Two grams of each sample were boiled under reflux in a fume cupboard for thirty minutes with 200 mL of 15% H2SO4 solution. The resulting mixture was then filtered through filter paper in a Buchner funnel using a vacuum pump and washed with distilled water until neutrality was achieved. The residue was transferred to a round-bottom flask and boiled for another thirty minutes with 100 mL of 5% NaOH solution. Afterward, the final residue was filtered into a crucible, washed with distilled water and ethanol until neutrality was reached. The residue was then dried in an oven and weighed. Finally, the dried residue was incinerated in a muffle furnace, cooled, and weighed again.

$$\textbf{Crude fiber\%} = \frac{\boldsymbol{W2 - W3}}{\boldsymbol{W1}} \times \mathbf{100}$$

Where;
W1 = weight of sample used
W2 = weight of crucible + oven dried sample
W3 = weight of crucible + ash

Figure 2. Determination of crude fibre of products To, T1, and T2 performed in Lab II at the University of Central Punjab, Lahore

Determination of crude protein The crude protein content of the nachos sample was determined using the Kjeldahl method described by Imoisi et al., (2020). 1g of the sample was placed into a digestion flask. 10mL of nitric acid (HNO3) was added, and the mixture was heated and filtered before being made up to a final volume of 100mL. Next, 10mL of the digest was transferred into a 500mL flask and diluted with 40 milliliters of distilled water. A 40% sodium hydroxide (NaOH) solution was then added, and the flask was securely stopped and connected to a 250mL conical flask. In the conical flask, 50mL of 4% boric acid was added. The mixture was heated to collect the distillate. The distillate was then titrated with 0.1N hydrochloric acid (HCl) until a faint pink color was achieved. The initial and final titration results were recorded, and the average titer value was calculated. Finally, the percentage of protein in the samples was determined based on this analysis. Wet nitrogen% = ((A-B)×1.4007)/(Weight of sample)×100 Where; A = Vol (mL) Std HCl × Normality of Std HCl B = Vol (mL) Std NaOH × Normality of Std NaOH Dry nitrogen % = (Wet moisture%)/(100-moisture%) Protein%= dry nitrogen% × 6.25 (protein nitrogen conversion factor) Textural Determination of FoxPea Sticks Whole tasters of foxpea biscuits were subjected to a unidirectional compression test to measure fractur ability parameters: force at which the food started to disruption (kg. m2 s-2); and hardness: extreme force at which the product completely broke (kg. m2 s-2). A TA. TX2i® texture analyzer was used. Stable Micro System, coupled with the Texture Expert Exceed version 2.64 software; equipped with an aluminum platform on which the trials were placed, with a load cell of up to 500 N; the processing rapidity was determined utilizing preceding tests and set at 5 mm/sec (González et al., 2018). The color indices of FoxPea sticks were measured using a handheld spectrocolorimeter (Lovibond, LC-400) and the CIE L a b scale, following Ho and Dahri's (2016) approach. Before analysis, the device was calibrated using white reference tiles. The FoxPea stick samples (T_o, T1, and T2) were evaluated after being placed on a petri dish. Color parameters counting brightness (L), redness (a), and yellowness (b) was recorded. The letter L represents lightness (0º = black, 100º = white), while the letters "a" denotes redness and greenness and 'b" denotes yellowness and blueness, respectively.

Microbial evaluation of FoxPea Sticks

To homogenize, 3 grams of each trials were mixed with 9ml sterile peptone marine and firmly shaken. Each sample was serially diluted tenfold, and an aliquot was obtained from the appropriate dilution. The aliquot was then placed in petri plates with sterilized agar material. The plates were incubated at 37°C for 24 hours as described by (I. C. *et al.*, 2022).

The sensory Evaluation of FoxPea Sticks

The sensory evaluation was conducted using a 9-point hedonic ruler to determine the sensory acceptability of FoxPea Sticks. A panel of evaluators assessed key sensory factors, the attendance or lack of distinctive flavor or discrimination, colour, texture, appearance, and general acceptability were used to assess the samples' freshness. A renewed sample of biscuits should taste and taste like the benchmark for those without accelerated storage. As a result, flavor and taste were rated above the normal value, with severely baked or burnt being at the upper end of the scale. In contrast, the absence of distinctive flavor and palate was rated below the standard value (Jose *et al.*, 2018).

Shelf life evaluation of FoxPea Sticks

Value-addition items were stored at the room temperature in a polythene zipper bag (LD-PE, clear zip lock, thickness 0.11mm) with 7-day intervals for2 weeks. A board of 5 semi-judges from the Department of Food and Nutritional Sciences UCP, evaluated the sensory features (color, appearance, scent, texture, taste, and overall acceptability) on a 9-point hedonic scale. The peroxide price was measured using the AOAC method.

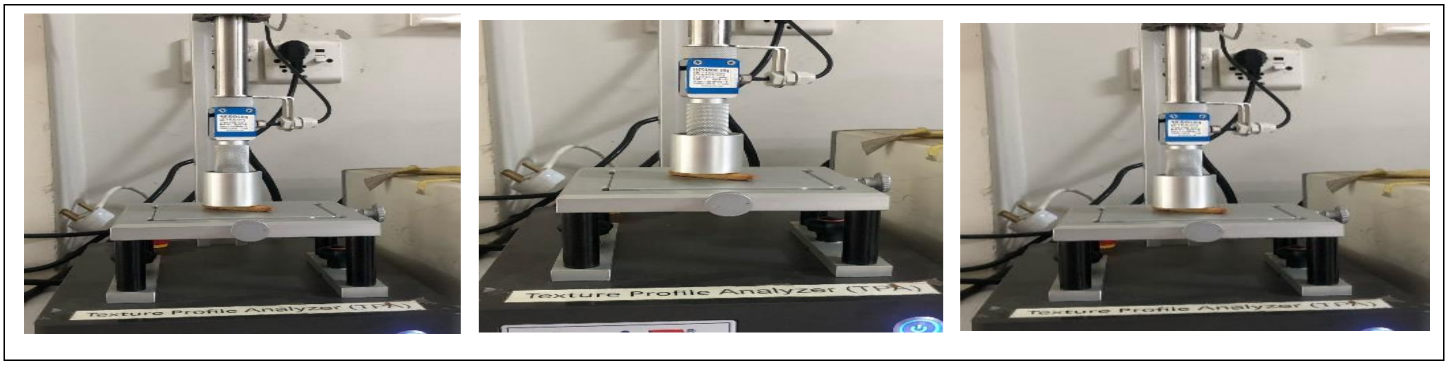

Figure 3. Textural analysis of products To, T1, and T2 performed in Lab II at the University of Central Punjab, Lahore

Color analysis of FoxPea Sticks

Figure 4. Color analysis of products To, T1, and T2 performed in Lab II at the University of Central Punjab, Lahore

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Result & Discussion

Physiochemical analysis of fox nut and pea based functional sticks

The moisture content fox pea sticks sample showed that the minimum mean value (3.37± 0.21) was observed inT2, which contained the highest proportion of fox nut and pea flour while the maximum mean value (3.43± 0.01%) was recorded in T0 (control) made from refined flour alone. These values indicated that addition of fibre rich ingredients like fox nut and pea flour contributed to decrease in moisture content due to their lower water holding capacity and the binding of water within the matrix. During the 14 days storage period, moisture content decreased slightly from 3.47± 0.01% to 3.37 ± 0.021%, a trend consistent with previous studies that showed moisture loss due to environment temperature fluctuation and water migration, thus improving the product shelf stability. The ash content of fox pea sticks sample demonstrated a noticeable increase with the incorporation of fox nut and pea flour. The highest mean ash value (1.67 ± 0.01) was found in T2, while the lowest (1.17 ± 0.01) was observed in T0. This increase is attributed to mineral rich natural of both fox nut and pea flours, which enhanced the nutritional profile of product. Over the intense period, the ash content increased consistently, a pattern documented in food science literature, where moisture loss lead to relative concentration of solid component including minerals, thereby improving mineral availability in final product.

The fat content of fox pea sticks samples ranged from 3.52 ± 0.01% in T0 to 3.9533 ± 0.01% in T2. The gradual increase in fat content during the 14 days storage period may be attributed to moisture reduction and lipid redistribution. Additionally, fox nut and pea flour contribution natural fats, which can become more prominent with results from (fasolin *et al*.,2017), where baked snacks shored similar trend in fat behaviour during storage, without necessarily indicating rancidity. Fibre content was highest in T2 (8.4767 ± 0.02%) and lowest in T0 (6.2833 ± 0.25), highlighting the role of fox nut and pea flour in boosting dietary fibre. However, fibre content slightly decreased over storage, likely due to degradation of certain unstable fibre component under prolonged storage conditions. Similar to observation by (bashir *et al*.,2023), this reduction may also be linked to oxidative and enzyme reactions. However, the overall fibre content remained higher than in control samples, supporting the sticks functional benefit. Protein content also increased with addition of fox nut and pea flour with T2 exhibiting the highest value (9.8733 ± 0.015%) and T0 the lowest (9.64 ± 0.02%). The apparent rise in protein content during storage is primarily a result of moisture reduction, concentrating the solid matter including proteins. Additionally, fox nut and pea are both rich sources of plant based protein contributing to enhanced nutritional profile. As in previous studies this relative increase in not due to additionally protein but due to composition concentration during storage. In conclusion, T2 (20% fox nut and pea flour) exhibited superior nutritional properties across all tested parameters. Moisture reduction enhanced shelf life, while protein, ash, fat, and fibre content increased or were well retained demonstrating the potential of fox nut pea flour as visible functional ingredients in the development of nutritious, gluten free baked snacksColor analysis of Fox Pea sticks The result show that the L (lightness) value of sample T0 (made up of only 1.5% stevia), T1 (containing 5% fox nut powder, 5% pea powder, and 1.55 stevia), and T2 (with higher 64.367± 0.06%, and 59.400 ± 0.15%, respectively. These values indicates a significant variation in lightness among the samples, with T2 being visibly darker than T0 and T1. This reduction in L value may be attributed to increased level of natural pigments and Millard browning during baking due to presence of protein and carbohydrates interaction from pea and fox nut powder. The (redness) value of sample also varied considerably. T0 exhibited a value of 2.2000± 0.01%,T1 recorded 1.5000± 0.1%,while T2 showed the highest redness at 5.8000± 0.1%.This reflect a clear shift in red green axis particularly in T2, Likely due to pigment concentration from fox nut and pea flours as well as potential browning reaction during heat treatment. Similarly, the b(yellowness) value of sample T0, T1 and T2 were 13.200± 0.1%,13.500± 0.1% and 11.200± 0.1%, respectively, showing a decrease in yellowness in T2 compared to the others. This trend suggest that the inclusion of legume and seed powder affects not only the overall brightness but also the warm colour tones of the product.

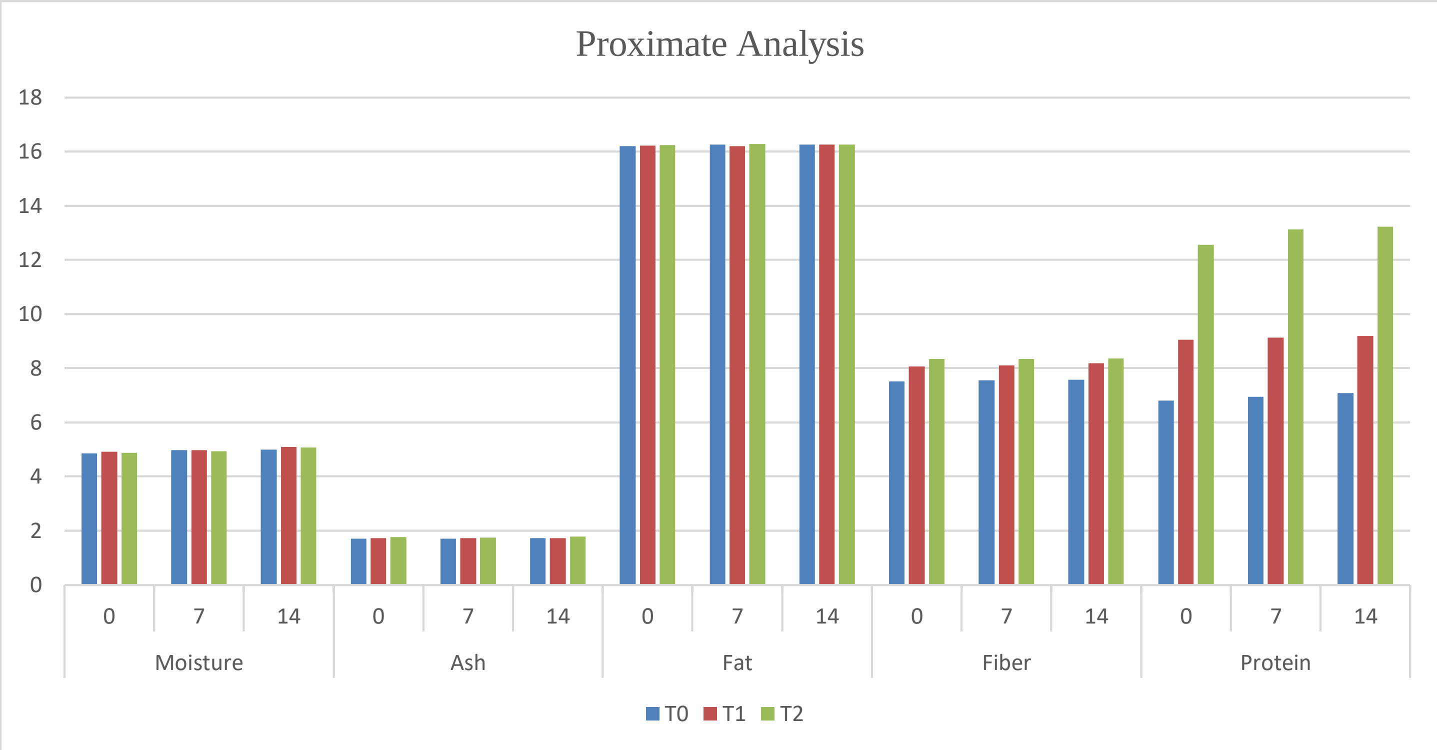

Figure 5. Present the physicochemical analysis of FoxPea Sticks T0 (100% wheat flour), T2 (5% pea powder, 5% foxnut powder and 1.5% stevia), T3 (10% pea powder, 10% foxnut powder and 1.5% stevia) with storage of 0,7,14 days.

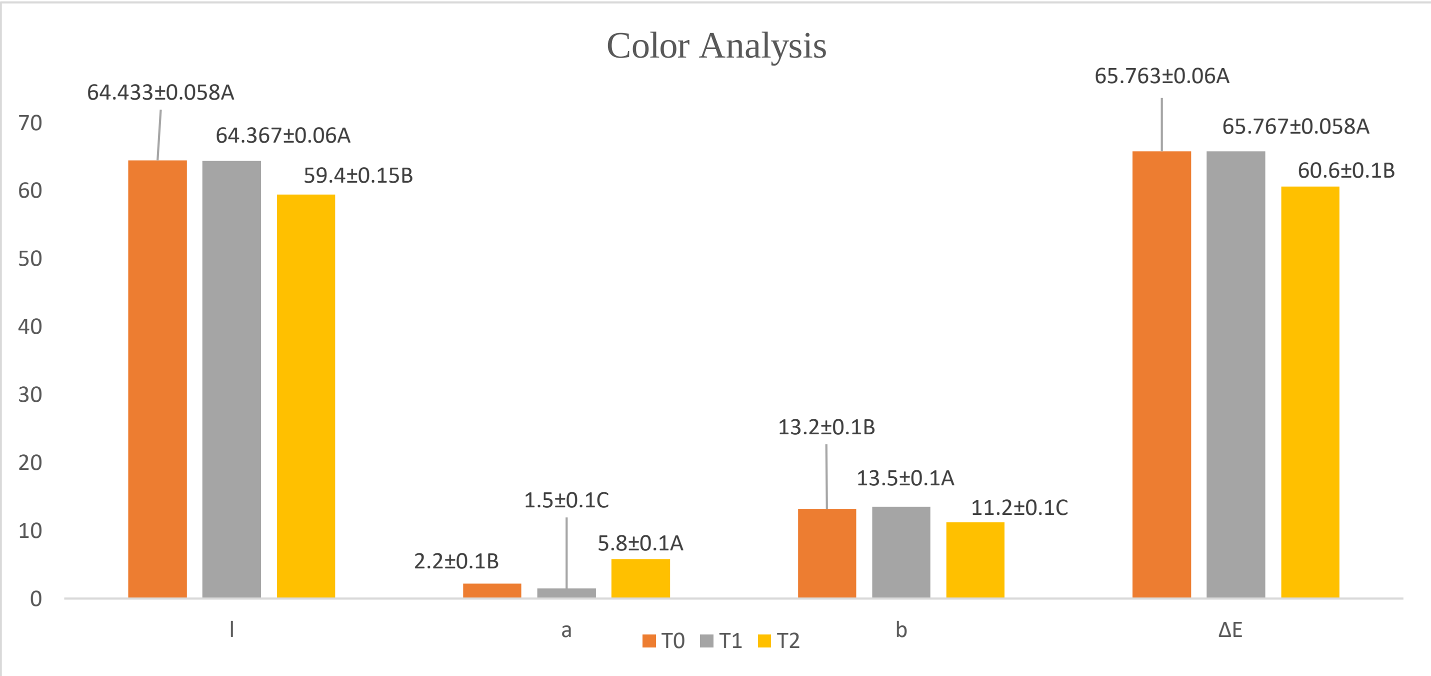

Figure 6. Present the color analysis of FoxPea Sticks T0 (100% wheat flour), T2 (5% pea powder, 5% foxnut powder and 1.5% stevia), T3 (10% pea powder, 10% foxnut powder and 1.5% stevia) with storage of 0,7,14 days

Textural analysis of fox pea sticks Enriched with fox nut and pea powder

This study demonstrated that the incorporated of fox nut and pea powder significantly influenced the textural attributes of stevia-based fox pea sticks. Among the evaluated parameters, chewiness was marked enhanced in the T2 formulation (10% pea powder and 10% fox nut powder). Which recorded the highest value of 3346.6± 12.29%, compared to T1 (5%pea powder and 5% fox nut powder) at 2593.1± 3.17% and the control of T0 (100% wheat flour) at 2098.0± 25.35%. The increase in chewiness can contributed to high fibre and protein content of the legumes based powder which provide a denser and more cohesive texture prolonging mastication and flavour release.

The cohesiveness of fox pea sticks was also significantly improved by the addition of fox nut and pea powder. The T2 sample exhibited the highest cohesiveness (0.5939± 0.005), while the lowest was found in T0 control(0.5263± 0.005). This enhancement is likely due to binding capacity of the functional ingredients, which strengthen the internal structure of biscuits and reducing crumbling, resulting in better inter digit during handling and consumption. In contrast to some fibre application that reduce product firmness, hardness increased with the addition of fox nut and pea powders.T2 demonstrated the highest hardness (14519± 17.9%) compared to T1 (13720 ± 58.9%) and T0 (10639± 199.5%). The increased hardness may be due to the reduced starch content and increased solid mass provided by the functional flour, contributing to a firmer and more robust matrix. The inclusion of fox nut and pea powder significantly enhanced the resilience of fox pea sticks. The T2 sample showed the highest resilience (0.4490± 0.006), followed by T1 (0.4460± 0.03) and T0 (0.2273± 0.01). This increase can be attributed to moisture retention and structural reinforcement provided by the dietary fibres, which allow the product to recover its shape after compassion, improving its chew profile and durability.

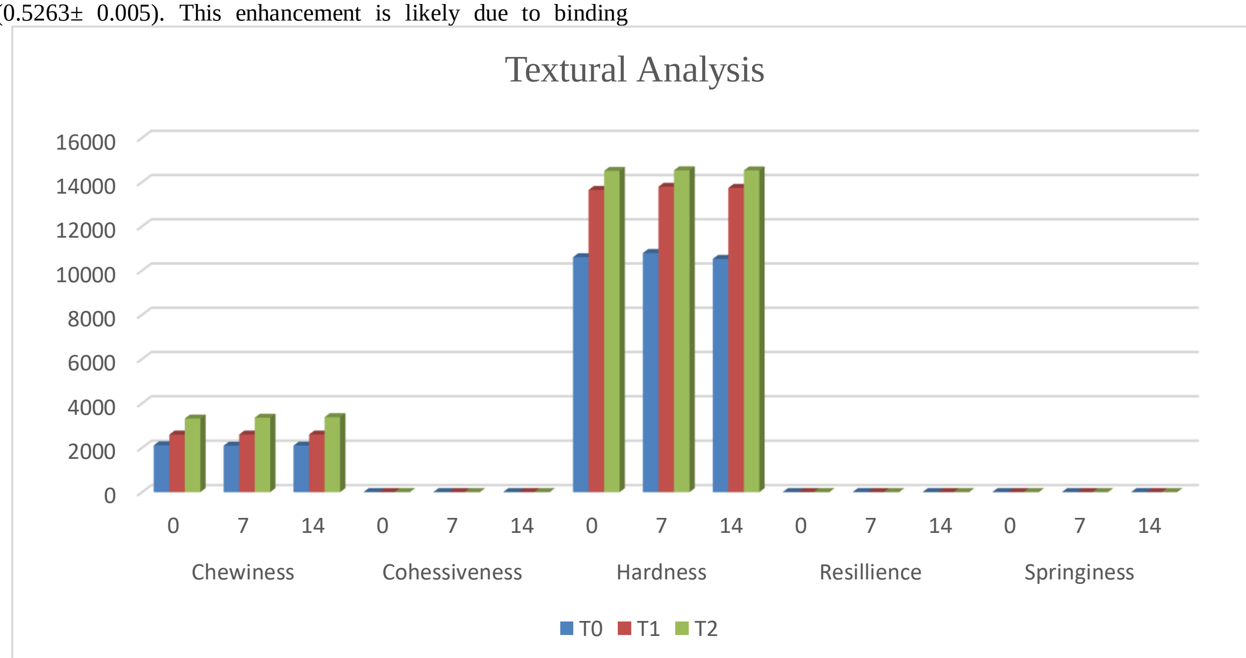

Figure 7. Present the textural analysis of FoxPea Sticks T0 (100% wheat flour), T2 (5% pea powder, 5% foxnut powder and 1.5% stevia), T3 (10% pea powder, 10% foxnut powder and 1.5% stevia) with storage of 0,7,14 days

Sensory analysis of fox nut and pea powder incorporated stevia based fox pea sticks The appearance score of fox pea sticks made with fox nut and pea powder shows that the maximum mean value (8.3333± 0.58%) was observed in case of T2 fox pea sticks sample made from 10% pea powder and 10% fox nut powder. In comparison, the minimum mean value (6.6667± 0.58%) was observed in case of T1 made from 5% pea powder and 5% fox nut powder. The mean value showed that the appearance score decreased from 8.333± 0.58% to 6.6667± 0.58% during the storage period. This decline in appearance score may be attributed to enzymatic browning, chlorophyll degradation, and reduction in moisture levels. These results are support by (zbikowska et al., 2020), who reported similar finding in biscuits storage. The aroma score of fox pea sticks revealed that the highest mean value (8.3333± 0.58%) was recorded in T2 (10% pea and 10% fox nut powder), whereas the lowest mean value (6.000+1%) was found in T1 (5% pea and 5% fox nut powder). Aroma score decreased significantly during storage, ranging from 8.3333± 0.58% to 6.000± 1%. This reduction is likely due to flavour deterioration, moisture loss, or absorption of external odours, corroborating the study conduct by (Rameriez et al., 2021), which observed aroma similar loss in nachos during storage. Taste score analysis also indicated that T2 treatment achieved the highest mean value 98.66667± 0.58) and T1 the lowest (5.6667± 1.53%) over the 14 days storage period. Taste score declined over time due to flavour degradation, staling, and possible odour absorption from surroundings. These findings are consistent with (Du and Ramirez. 2020), who observed taste deterioration in stored baked snacks. The texture score was highest for T2 (8.333± 1.15%) and lowest for T1 (6.3333± 0.58%), with a general decreasing trend from 0 to day 14. The decline in texture may be linked to moisture loss, oxidative changes, and microbial activity during storage. The study by (Zbikowla et al., 2020) also observed that snack texture significantly worsens over time due to these factors. Overall acceptability score was also highest (8.333± 1.15%) and lowest for T1 (6.3333± 0.58%), with a study decline across the storage period. This decrease is attributed todeterioration in taste, texture and appearance, which reduced the appeal of the product. Similar finding were reported by (Zbikowska et al., 2020), confirming that these sensory parameters directly impact costumer acceptability over time. +The total plate count TPC of fox pea sticks sample made from fox nut and pea powder shows that the maximum mean value of 98.000± 0.01(log_{10}dfu/g) was observed in T1 samples made from 5% pea powder and 5% fox nut powder, while minimum mean value of 35.667± 0.58(log_{10}dfu/g) was observed in T0 sample made from 100% wheat flour. The mean value indicate that the TPC increased progressively from 35.667± 0.58 to 98.000± 1(log_{10}dfu/g) over the 14 day storage period. This increased in TPC can be attribute to several factors such as prolonged storage time, ambient temperature, relative humidity, and the nature of packaging material used. These finding are consistent with those observed in previous research conducted on baked snacks (criitoru *et al*., 2018), where TPC increased significantly during storage. The total mould and yeast count of fox pea sticks samples also showed a rising trend during storage. The highest mean value of 51.333± 1.53(log_{10}dfu/g) was observed in T2 samples made from 10% pea powder and 10 % foxnut powder, while the lowest mean value of 26.000± 0.01 (log_{10}dfu/g) was found in T0 samples (100% wheat flour). Studies show that initially, at day 0 the mould and yeast counts were relatively low, but they increased gradually during the 14 days storage, ranging from 26.000± 1 to 51.333± 1.53(log_{10}dfu/g). This microbial increased in linked to favourable environment condition for fungal growth, particularly elevated storage temperature, high moisture content, and exposure to oxygen.

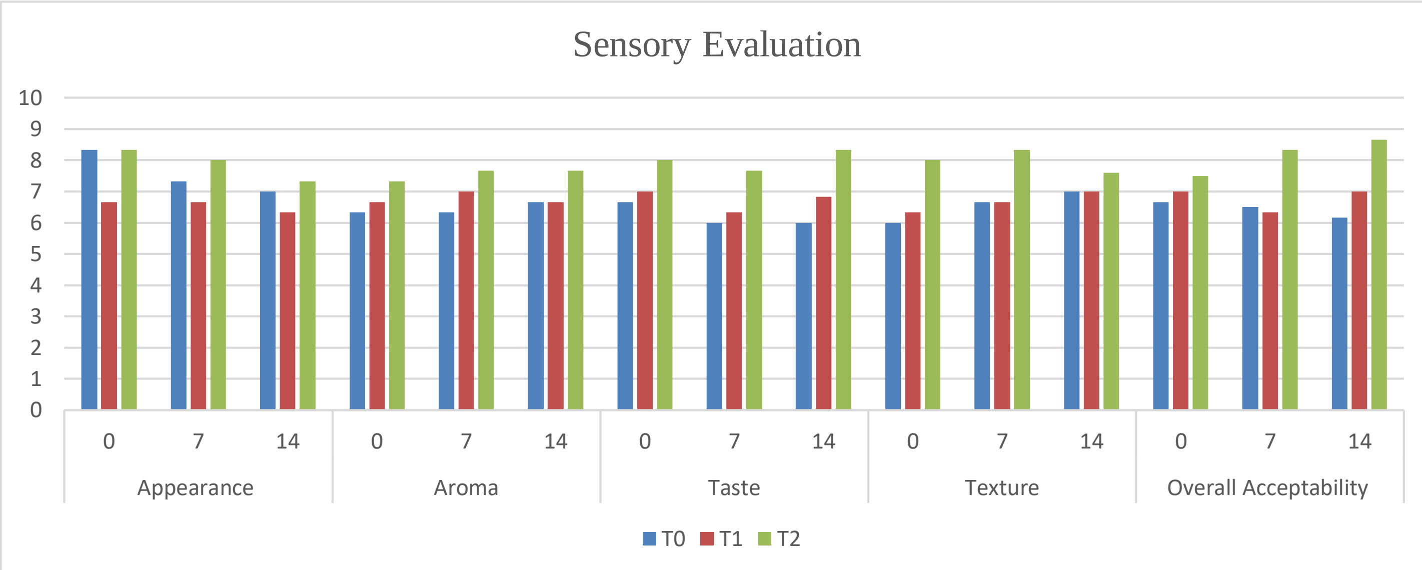

Figure 8. Present the Sensory evaluation of FoxPea Sticks T0 (100% wheat flour), T2 (5% pea powder, 5% foxnut powder and 1.5% stevia), T3 (10% pea powder, 10% foxnut powder and 1.5% stevia) with storage of 0,7,14 days

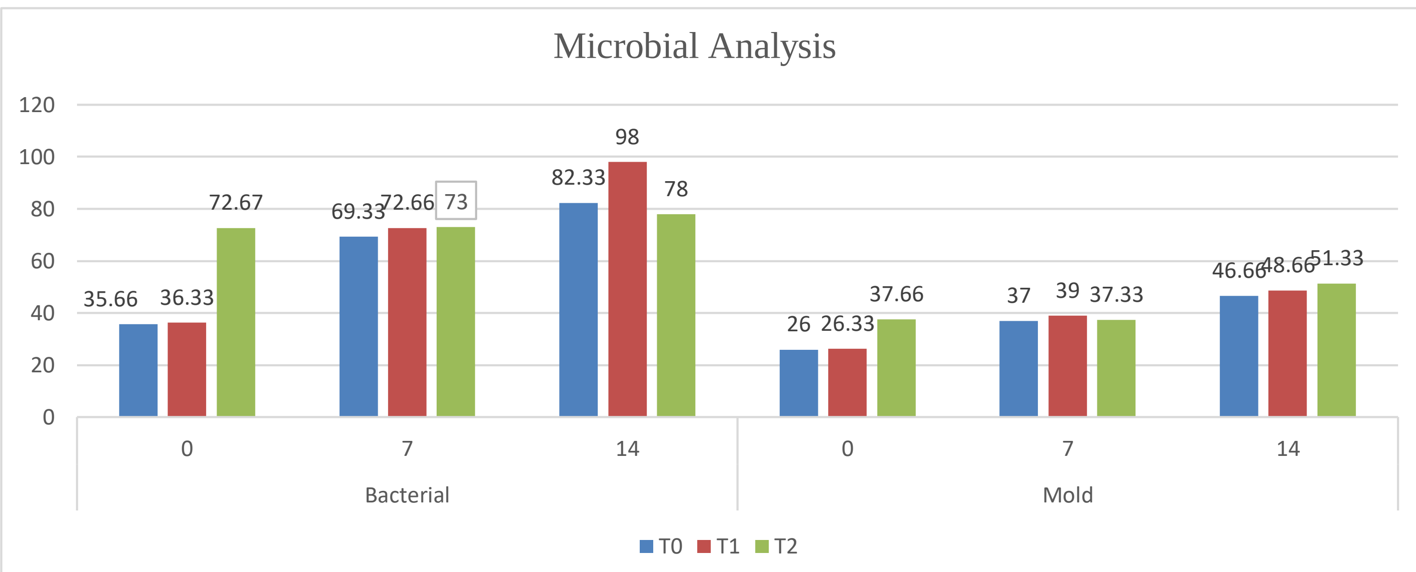

Figure 9. Present the microbial analysis of FoxPea Sticks T0 (100% wheat flour), T2 (5% pea powder, 5% foxnut powder and 1.5% stevia), T3 (10% pea powder, 10% foxnut powder and 1.5% stevia) with storage of 0,7,14 days

Conclusion

This research successfully demonstrated that functional biscuits enriched with foxnut and pea can formulate to provide enhanced nutritional and organoleptic qualities. Both ingredients supported the development of nutritionally superior snack that caters to modern dietary preferences and health condition, especially for diabetic, obese, or cardiovascular-compromised population. The literature reviewed support the formulation of food products that delivered enhanced protein, fiber, antioxidant, and essential micronutrients. This study contributed to food innovation by providing a scientifically baked model for formulating bakery products using underutilized functional ingredients.it also align with global goals for sustainable nutrition and reduced reliance on refined sugar and fats. In conclusion, this research lays the foundation for functional biscuits developing using plant-based ingredients with therapeutic potential. The finding suggest that such biscuits can appeal to health-conscious consumer while maintain sensory satisfaction. This work encourages further exploration into scaling the production of function snacks using alternatives protein and fibre sources, and sets a benchmark for future innovation in health focused bakery products.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-MMNCS-0331d-24)

Consent for publication

Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

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Manuscript drafting, Study Design,

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SF

Review of Literature, Data entry, Data analysis, and drafting article.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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