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Development and Quality Assessment of Nutrient-enriched Value-added Energy Balls and Cookies

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Value-added food products represent an emerging approach in food science aimed at improving both sensory quality and nutritional value. Such products are formulated using functional ingredients that not only enhance patability but also provide additional health benefits, responding to the increasing consumer demand for nutritious alternatives to conventional foods.
Objective: This study aimed to develop value-added products—specifically energy balls and cookies—using almond milk, wheat germ flour, dates, and makhana powder, and to evaluate their sensory and nutritional qualities compared to non-value-added controls.
Methods: Both control and incorporated products were prepared following standardized procedures and subjected to sensory evaluation for colour, flavour, texture, taste, and overall acceptability. The most acceptable formulations were identified through hedonic scoring. Nutritional

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composition of the selected products was determined, including proximate analysis (moisture, ash, fat, dietary fibre, protein, carbohydrates), caloric value, and mineral content (Ca, Fe, Zn, Mg, K, Na).

Results: Sensory analysis revealed that all incorporated products were superior to control samples, with treatment T2 for both energy balls and cookies achieving the highest overall acceptability. Nutritional analysis of value-added energy balls demonstrated 22.01% moisture, 4.9% ash, 8.4% fat, 6.1% dietary fibre, 10.53% protein, and 48.05% carbohydrates, corresponding to an energy value of 309.92 kcal. Mineral analysis indicated appreciable levels of calcium (0.02%), iron (0.39%), zinc (0.95%), magnesium (0.12%), potassium (0.30%), and sodium (0.43%). Value-added cookies showed 14.5% moisture, 2.78% ash, 12.5% fat, 6.5% dietary fibre, 8.24% protein, and 49.98% carbohydrates, yielding 345.38 kcal, along with significant amounts of calcium (0.03%), iron (0.38%), zinc (0.91%), magnesium (0.12%), potassium (0.43%), and sodium (0.29%).

Conclusion: The incorporation of wheat germ flour, dates, and makhana powder significantly enhanced both the sensory attributes and nutritional value of developed products compared to controls. These findings highlight the potential of formulating functional food products such as energy balls and cookies to deliver improved health benefits and consumer acceptability.

Keywords: Value addition; functional foods; sensory evaluation; nutritional enhancement; health benefits.

1. INTRODUCTION

In recent years, increased consumer awareness regarding the complex link between dietary habits and health outcomes has significantly increased the demand for functional foods those that deliver additional health benefits beyond basic nutrition. This type of conceptual structure shift has guided scientific and industrial efforts toward the development of food products enriched with bioactive components to address micronutrient deficiencies, support metabolic well-being, and simultaneously enhance sensory qualities. Within this context, almonds (*Prunus dulcis*) have emerged as a highly valuable ingredient due to their exceptional nutritional profile. Rich in monounsaturated fatty acids, high-quality plant proteins, dietary fiber, and bioavailable micronutrients including vitamin E, calcium, magnesium, and zinc. Almonds offer a multifaceted platform for the formulation of health-promoting food products (Javaid et al*.,* 2019). Their wide consumer acceptability, favorable taste profile, and adaptability in various food systems further shows significance in their potential in functional food innovation.

Micronutrient fortification represents a strategically significant approach in the formulation of value-added food products. By enhancing the nutritional density of widely consumed items, fortification seeks to improve their health efficacy without compromising sensory characteristics. Almond milk, a plant-based alternative to dairy, has gained prominence due to its lactose-free nature, low cholesterol content, and compatibility with vegan, lactose-intolerant, and allergen-conscious diets (Mannar et al*.,* 2024). However, plant-based beverages have also lack of some nutrients, particularly when compared to animal-derived products, thereby necessitating deliberate fortification to enhance their micronutrient profile.

This study explores the development and sensory enrichment of almond milk through the incorporation of three complementary plant-based ingredients: wheat germ flour, dates, and makhana (*Euryale ferox*). Wheat germ, the nutrient-rich germinal part of the wheat kernel, is a concentrated source of vitamin E, B vitamins, protein, and essential minerals, contributing both functional and sensory enhancements. Dates (*Phoenix dactylifera*), known for their naturally high carbohydrate content, dietary fiber, potassium, and polyphenolic compounds, are traditionally valued for their energy-enhancing and digestive properties. Makhana, also referred to as fox nut, is an underutilized aquatic crop distinguished by its low-fat composition, high fiber content, and mineral richness, particularly in magnesium, potassium, and phosphorus.

The incorporation of these nutrient-dense ingredients into almond milk aims to significantly improve its nutritional quality, texture, flavor, and overall sensory acceptance. The study applies on a comprehensive sensory evaluation to assess consumer acceptability based on key organoleptic parameters such as appearance, taste, aroma, mouthfeel, and overall satisfaction. Through this multidimensional approach, the research contributes to the formulation of clean-label, nutrient-enriched functional beverages that align with modern health and wellness.

1.1 Nutritional Composition and Health Benefits of Selected Functional Ingredients

Almond Milk Nutritional Composition: Almond milk is a plant-derived beverage produced by blending ground almonds with water, followed by filtration to obtain a smooth emulsion. It is naturally low in energy and saturated fat, providing approximately 15–25 kcal and 1–2 g of fat per 100 mL. The protein and dietary fiber content is in almond milk is minimal, commercially fortified variants serve as valuable sources of calcium, vitamin D, and vitamin B12 (Hasan et al*.,* 2012). Naturally occurring vitamin E is present in almond milk and ranges between 6–8 mg per 100 mL, contributing significantly to its antioxidant properties.

Nutritional Benefits of Almond Milk: Due to its lactose-free and cholesterol-free nature, almond milk is well-suitable for individuals with lactose intolerance, as well as those who wants to consume vegan or plant-based diets. The high vitamin E content contributes to cellular antioxidant defense mechanisms, supports skin integrity, and enhances immune function (Vashisht et al*.,* 2024). Fortified almond milk formulations may help in preserving bone mineral density and promoting metabolic health.

Almonds Nutritional Composition: Almonds (*Prunus dulcis*) are nutrient-dense nuts comprising approximately 20–22% protein, 50–55% monounsaturated and polyunsaturated fats, and 12–14% dietary fiber. They are rich in micronutrients such as vitamin E (25.6 mg/100 g), magnesium (270 mg/100 g), calcium, and iron (Yada & Huang 2011). Furthermore, almonds contain a range of bioactive phytochemicals, including flavonoids, polyphenols, and phytosterols, all of which contribute to their functional health properties.

Nutritional Benefits: Regular consumption of almonds has been associated with improvements in lipid metabolism, including reductions in low-density lipoprotein (LDL) cholesterol and elevations in high-density lipoprotein (HDL) cholesterol. Their high fiber and protein content enhance satiety, which support weight management (Lapsley & Huang 2004). The antioxidant components help attenuate oxidative stress, while the low carbohydrate content combined with high micronutrient density supports glycemic regulation and overall metabolic balance.

Wheat Germ Flour Nutritional Composition: Wheat germ flour is extracted from the embryonic part of the wheat kernel and is known for its high nutrient density. It contains 25–28% protein, 10–13% unsaturated fats, and 15–18% complex carbohydrates. It is also a significant source of dietary fiber, vitamin E (up to 149 mg/kg), B-complex vitamins, and essential minerals such as magnesium, zinc, and iron (Ghafoor et al*.,* 2017). Moreover, it provides essential fatty acids and phytosterols, enhancing its functional food potential.

Nutritional Benefits: The presence of high concentrations of B-vitamins and vitamin E enhances immune function and supports energy metabolism. Its antioxidant properties contribute to cellular protection from oxidative damage. The combined presence of protein and fiber helps in muscle maintenance and promotes digestive health (Awulachew et al*.,* 2020).

Dates Nutritional Composition: Dates (*Phoenix dactylifera*) are naturally energy-rich fruits, containing approximately 70–75% natural sugars (primarily glucose and fructose), 2–3% protein, and 6–8% dietary fiber. They are abundant in potassium (600–700 mg/100 g), magnesium, iron, calcium, and vitamin B6. Additionally, dates are rich in bioactive compounds such as flavonoids, polyphenols, and phenolic acids, this all bioactive compounds contains various health promoting benefits (Amadou et al*.,* 2016).

Nutritional Benefits: Dates serve as a natural sweetener and provide significant nutritional advantages due to their high fiber content and low glycemic index, which assist in digestive health and glycemic regulation. The antioxidant constituents help protects against cellular oxidative stress and are linked to potential reductions in the risk of cardiovascular diseases, neurodegenerative conditions, and metabolic syndromes (Jain et al*.,* 2013).

Makhana (Fox Nuts) Nutritional Composition: Makhana (*Euryale ferox*), commonly referred to as fox nut or lotus seed, is an underutilized aquatic crop with substantial nutritional potential. It comprises approximately 9–10% protein, 75–78% carbohydrates—predominantly complex starches and a very low-fat content (0.1–0.5%). It is also a valuable source of dietary fiber (14–15 g/100 g), and minerals such as magnesium (140 mg/100 g), potassium (500 mg/100 g), calcium (60 mg/100 g), and phosphorus (Islam et al*.,* 2023). The seed also contains bioactive constituents including flavonoids, alkaloids, and saponins.

Nutritional Benefits: Makhana's low-calorie, gluten-free profile, with its high fiber and mineral content, makes it particularly suitable for individuals managing diabetes, obesity, or cardiovascular health issues. Its high potassium and low sodium levels support heart health, while its antioxidant components contribute to the reduction of oxidative damage (Garg et al*.,* 2021).

2. MATERIALS AND METHODS

2.1 Primary Materials for Study

The raw ingredients, including almond, almond milk, wheat germ flour, dates and makhana powder were procured from the local market. All the chemicals and glassware used in this research work were of analytical grade (AR) and were used from the PG laboratory in the Department of Food Science and Nutrition. Equipment required in the present investigation was available at the College of Community Science, Chandra Shekhar Azad Agriculture University, Kanpur. Procedures recommended by the Association of Official Analytical Chemists (AOAC, 1990) were used for this research work.

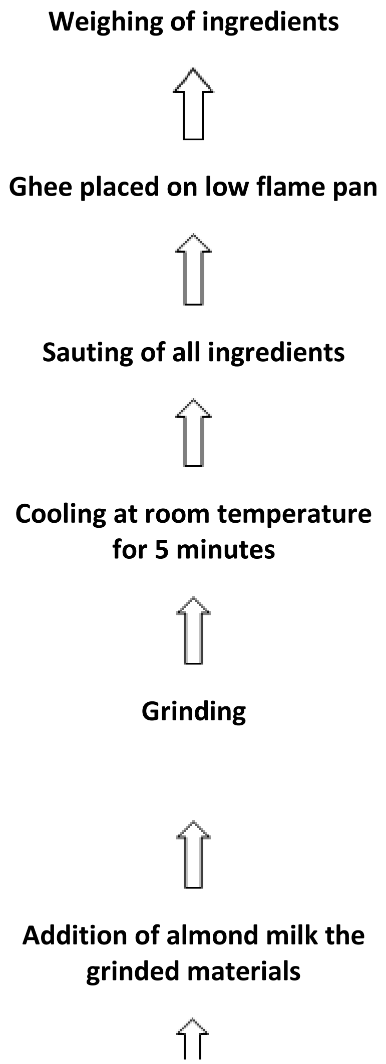

Fig. 1. Flow sheet for the preparation of energy balls

Ingredients were weighed accurately

⇧

Butter, dates and jaggery powder and grinded materials were mixed well

⇧

Almond milk added to batter and batter was beaten

⇧

Cutting were cut out with cookies cutter

⇧

Baking at 180°C for 25 min

⇧

Cooling at room temperature

Fig. 2. Flow sheet for the preparation of cookies

2.2 Methodology for Preparation of Value-added Energy Balls

The energy balls were prepared through a standardized procedure involving the sequential incorporation of both dry and wet ingredients. Initially, the dry components—including wheat flour, wheat germ flour, makhana powder, jaggery, and crushed nuts—were weighed accurately and thoroughly blended in a mixing bowl to ensure homogeneity. In a separate step, jaggery was gently heated on a low flame to form a syrup, into which ghee was gradually incorporated and stirred until a uniform mixture was obtained. This jaggery-ghee solution was then added to the dry mixture along with a measured quantity of almond milk to facilitate dough formation. The resulting dough was kneaded until it reached a cohesive, consistency. Portions of the dough were manually shaped into uniformly sized balls. The formed energy balls were allowed to cool at ambient temperature and subsequently stored in airtight containers under hygienic conditions for further physicochemical and sensory evaluation.

2.3 Methodology for Preparation of Value-added Cookies

Cookies were developed based on the standardized formulation and process flow outlined in Fig. 2, incorporating both conventional and nutrient-dense functional ingredients. The dry ingredients wheat flour, wheat germ flour, makhana powder, jaggery, and baking powder were precisely weighed and thoroughly mixed to ensure homogeneity. In a separate mixing bowl, softened butter was creamed with jaggery until a smooth, uniform texture was achieved. Almond milk and vanilla essence were gradually added to this mixture and blended to form a stable emulsion. The resulting wet mixture was then incorporated into the dry ingredient blend and kneaded gently to obtain a cohesive, pliable dough. The prepared dough was rolled out and portioned into uniform shapes using a standard cookie cutter. The shaped cookies were placed on a greased baking tray with adequate spacing to facilitate even heat distribution. Baking was carried out in a preheated oven at 180 ± 5°C for 12 to 15 minutes, until a light golden-brown colour indication observed. Upon removal from the oven, the cookies were allowed to cool at room temperature.

2.4 Quality Attributes

The developed value-added samples were evaluated for their chemical analysis such as moisture content, protein content, crude fat content, ash content, carbohydrate content and also for the sensory evaluation. The procedures used for the determination of these parameters are given below.

2.4.1 Moisture content

Moisture content was determined using the (A.O.A.C., 1990) method. The following formula was used to measure the moisture content.

% Moisture = Initial weight – Final weight / Weight of sample X 100

2.4.2 Fat content

Fat content was determined using the (A.O.A.C., 1990) method. Soxhlet apparatus was used to determine the crude fat content of samples.

% Crude fat = Final weight of flask – Empty weight of the flask / Weight of sample X 100

2.4.3 Protein content

Protein content was determined using the (A.O.A.C., 1990) method. Kjeldahl apparatus was used to determine the crude protein content of samples. Micro- Kjeldahl steam distillation unit was used for distillation purposes.

Per cent nitrogen and per cent protein was calculated by using the following formula.

% Nitrogen = CBR X Normality of H_2So_4 X Moles of nitrogen X D.F / Weight of sample X 100

Where,

CBR= Corrected Burette Reading
Normality of Acid (H_2So_4) = 0.01
Moles of Nitrogen = 0.014
D.F. = Dilution Factor

Total protein = % Nitrogen X Protein factor [for cereals 5.7 & for Sorghum 6.25]

2.4.4 Ash content

Ash content was determined using the (A.O.A.C., 1990) method. A muffle furnace was used to determine the ash content of the samples. The per cent ash was calculated using the following formula.

% Ash = Weight of crucible with ash – weight of empty crucible / Total weight of the sample X 100

2.4.5 Total Carbohydrate

The modified phenol sulphuric acid method was used to determine the total carbohydrate content of the samples. The standard graph was plotted using standard glucose solution and a comparison was done with the standard curve obtained using a graph. The graph was plotted as absorbance on the Y axis and concentration on the X axis.

Table 1. Formulation details for the preparation of energy balls per 100g

Ingredients	T_0	T_1	T_2	T_3
Wheat germ flour	-	40	50	60
Dates	-	20	10	15
Makhana powder	-	10	10	5
Almond milk	-	10	10	5
Wheat flour	60	-	-	-
Jaggery	20	5	5	5
Nuts	10	10	5	5
Ghee	10	5	5	5

Table 2. Formulation details for the preparation of cookies per 100g

Ingredients	T_0	T_1	T_2	T_3
Wheat germ flour	-	30	40	50
Dates	-	20	10	20
Makhana powder	-	20	10	10
Almond milk	-	5	15	10
Wheat flour	70	5	10	5
Jaggery	20	10	5	5
Butter	9	9	9	9
Baking powder	0.5	0.5	0.5	0.5
Vanilla essence	0.5	0.5	0.5	0.5

2.4.6 Crude fibre

The crude fibre content was determined using the (A.O.A.C., 1990) method.

% Crude fibre = $(W_2 – W_1) – (W_3 – W_1) / W \times 100$

Where,

W = weight of the sample.
W_1 = weight of ashing dish.
W_2 = weight of sample before ignition.
W_3 = weight of sample after ignition.

2.4.7 Determination of minerals

The mineral content of food was determined by the method given by (Ranganna, 1986).

3. RESULTS AND DISCUSSION

3.1 Sensory Evaluation of Control and Value-added Energy Balls

The sensory evaluation of control and value-added energy balls are summarized in Table 3. The sensory scores are given according to the scores given by the panel.

The sensory evaluation results summarized in Table 3 demonstrate that all energy ball formulations, including the control (T_0) and the treated samples (T_1, T_2, and T_3), were generally well-received across the assessed sensory parameters. Among the formulations, T_2 (50:15:10) consistently achieved the highest mean scores for appearance (8.6), colour (8.4), taste (8.4), flavour (8.2), texture (8.4), and overall acceptability (8.4), indicating a significant favorable sensory profile. In contrast, the control sample exhibited comparatively lower scores across most attributes, while T_1 and T_3 displayed moderate levels of acceptability. Despite the observed numerical differences among treatments, statistical analysis confirmed that these variations were not significant ($p > 0.05$). This suggests that the incorporation of wheat germ flour, dates, and makhana powder at varying levels did not adversely impact the sensory characteristics of the energy balls.

3.2 Sensory Evaluation of Control and Value-added Cookies

The sensory evaluation data of the control and treated cookies formulations, as presented in the Table 4, demonstrate different variations across all assessed attributes. Among the formulations, treatment T_2 (40:10:15) consistently revealed the highest mean scores for appearance (8.4), colour (8.4), taste (8.4), flavour (8.6), texture (8.8), and overall acceptability (8.6), reflecting its superior sensory profile. Treatment T_3 (50:10:10) also exhibited good sensory performance, with values slightly lower than T_2 across most parameters. In contrast, T_1 (30:20:5) showed moderate acceptability, while the control sample (T_0) received the lowest ratings, particularly in flavour (7.2), texture (7.4), and overall acceptability (7.2).

Table 3. Sensory evaluation of control and incorporated energy balls

Parameter	Control T_0	T_1(40:20:10)	T_2(50:15:10)	T_3(60:15:5)	CD (5%)	S. E
Appearance	7.6	7.8	8.6	7.8	0.3368	0.1121
Colour	7.8	8	8.4	8	0.2698	0.0954
Taste	7.8	8.2	8.4	8	0.3693	0.1217
Flavour	7.8	8.0	8.2	8.0	0.2830	0.0933
Texture	8	8.2	8.4	7.2	0.5278	0.1751
Overall acceptability	7.8	8	8.4	8	0.2568	0.0827

Table 4. Sensory evaluation of control and incorporated cookies

Parameter	Control T_0	T_1(30:20:5)	T_2(40:10:15)	T_3(50:10:10)	CD (5%)	S. E
Appearance	7.6	8.2	8.4	8.4	0.1323	0.0436
Colour	7.8	8	8.4	8	0.1219	0.03978
Taste	7.8	8	8.4	8.2	0.1392	0.4178
Flavour	7.2	7.8	8.6	8.4	0.0866	0.0285
Texture	7.4	8.2	8.8	8.4	0.1937	0.0690
Overall acceptability	7.2	7.8	8.6	8.4	0.1536	0.0509

Table 5. Nutritional composition of control and value-added energy balls (in 100g)

Nutrients	Control T_0	T_1(40:20:10)	T_2(50:15:10)	T_3(60:15:5)	CD (5%)	S.E
Moisture	27.5	24.1	22.01	20.5	0.4156	0.1370
Ash	3.2	4.5	4.9	3.7	0.2237	0.0737
Fat	4.9	7.6	8.4	7.9	0.4260	0.1404
Fibre	3.8	5.2	6.1	5.3	1.8607	0.6134
Protein	8.1	9.7	10.53	10.0	0.8112	0.2674
Carbohydrate	52.5	48.9	48.05	52.6	0.3866	0.1274
Energy	286.5	302.8	309.92	321.5	0.1568	0.0521
Calcium	0.015	0.018	0.02	0.019	0.1276	0.0352
Iron	0.31	0.35	0.39	0.37	0.1288	0.0423
Zinc	0.82	0.85	0.95	0.93	0.0692	0.0228
Magnesium	0.09	0.10	0.12	0.11	0.0152	0.0051
Potassium	0.24	0.27	0.30	0.29	0.1608	0.0533
Sodium	0.38	0.41	0.43	0.42	0.0104	0.0352

Table 6. Nutritional composition of control and value-added cookies (in 100g)

Nutrients	Control T_0	T_1(30:20:5)	T_2(40:10:15)	T_3(50:10:10)	CD (5%)	S. E
Moisture	16.01	15.3	14.5	12.9	0.3676	0.1212
Ash	1.88	2.34	2.78	2.59	0.3088	0.1026
Fat	8.3	10.7	12.5	11.4	0.2776	0.0921
Fibre	3.8	5.2	6.5	6.0	0.4842	0.1610
Protein	5.2	7.1	8.24	7.8	0.1145	0.0377
Carbohydrate	61.4	55.2	49.98	51.1	0.4080	0.1358
Energy	298.2	323.6	345.38	336.0	0.1296	0.0432
Calcium	0.017	0.026	0.03	0.028	0.0969	0.0321
Iron	0.24	0.33	0.38	0.36	0.1687	0.0578
Zinc	0.68	0.82	0.91	0.88	0.1841	0.0610
Magnesium	0.07	0.10	0.12	0.11	0.0330	0.0098
Potassium	0.29	0.38	0.43	0.41	0.1248	0.0417
Sodium	0.21	0.27	0.29	0.28	0.6996	0.0238

These results suggest that the incorporation of functional ingredients which are used in value-added products positively influenced the sensory characteristics of incorporated cookies.

3.3 Nutritional Evaluation of Control and Value-added Energy Balls

Data from Table 5 reveals the analysis of the nutritional composition of the control (T_0) and the value-added energy ball formulations (T_1, T_2, and T_3) demonstrated statistically significant differences across various parameters. Moisture content was found to be highest in the control sample (27.5%), with a consistent decrease observed in the treated samples, observed the lowest level in T_3 (20.5%), suggesting improved shelf-life potential. Ash content, indicative of total mineral presence, was high in T_2 (4.9%), followed by T_1 (4.5%), reflecting enhanced mineral fortification. The fat content showed significant rise in all value-added samples, with

T_2 having the highest fat content value (8.4%) in contrast to the control (4.9%). Similarly, dietary fiber and protein content exhibited considerable enhancement, peaking in T_2 at 6.1% and 10.53%, respectively, indicating a substantial improvement in nutritional quality through the incorporation of functional ingredients (Gomathi & Parameshwari 2022). Although carbohydrate levels declined slightly in T_1 (48.9%) and T_2 (48.05%), T_3 surpassed both the control and other treatments at 52.6%. Energy content increased in all experimental variants, with T_3 achieving the highest caloric value (321.5 kcal/100g).

The mineral composition analysis reveals that calcium content increased from 0.015 g in the control to 0.02 g in T2, while iron content improved from 0.31 mg to 0.39 mg. Zinc content also rose, with T2 exhibiting the highest level (0.95 mg), followed by T3 (0.93 mg), compared to 0.82 mg in the control. Magnesium levels improved from 0.09 mg to 0.12 mg, and potassium content increased from 0.24 mg to 0.30 mg in T2. Sodium content showed a marginal increase across treatments, from 0.38 mg in the control to 0.43 mg in T2.

3.4 Nutritional Evaluation of Control and Value-added Cookies

The nutritional assessment of the control (T_0) and the value-added cookie formulations (T_1, T_2, and T_3), enriched with wheat germ flour, dates, and makhana powder, demonstrated statistically significant variations across all evaluated parameters, as presented in Table 6 (Shivangi & Ritu 2025). Moisture content was highest in the control sample (16.01%) and exhibited a gradual decline across the fortified samples, with T_3 exhibiting the lowest moisture level (12.9%), which may contribute to better shelf life.

Ash content, indicative of total mineral presence, increased across all treated samples, with the highest value observed in T_2 (2.78%), followed by T_3 (2.59%) and T_1 (2.34%), compared to 1.88% in the control. Fat content showed a substantial increase in all fortified formulations, with T_2 recording the maximum value (12.5%), in contrast to 8.3% in the control. Enhancements in dietary fibre and protein were also noted, with T_2 again exhibiting the highest concentrations (6.5% fibre and 8.24% protein), underscoring the nutritional contribution of the added functional ingredients. In contrast, carbohydrate content declined in the value-added cookies, with T_2 showing the lowest level (49.98%) compared to the control (61.4%). The energy value increased in all enriched samples, ranging from 323.6 kcal (T_1) to 345.38 kcal (T_2), indicating improved energy density relative to the control (298.2 kcal). Mineral analysis revealed that the T2 sample had the highest levels of calcium (0.030%), iron (0.38%), zinc (0.91%), magnesium (0.12%), potassium (0.43%), and sodium (0.29%) compared to the control values of 0.017%, 0.24%, 0.68%, 0.07%, 0.29%, and 0.21%, respectively. Overall, the inclusion of wheat germ flour, dates, and makhana powder significantly improved the nutritional characteristics of the cookies (Hawa et al*.,* 2018), with T_2 emerging as the most nutritionally enhanced and balanced formulation among the treatments.

4. CONCLUSION

In summary, the present study highlights the development of value-added products by incorporating diverse functional ingredients into value-added food formulations. Developing and quality analysis of nutrient-rich energy balls and cookies is important because they help fill nutritional gaps, give people healthier snack choices, make good use of food resources and create new opportunities for the functional food industry. Ingredients such as almond, wheat germ flour, dates, and makhana were effectively utilized due to their rich content of high-quality protein, dietary fiber, and essential minerals. The sensory evaluation of the developed products demonstrated that these components significantly enhance the overall nutritional value. Among the various formulations evaluated, Treatment T2 for energy balls and T2 for value-added cookies, prepared using wheat germ flour, dates and makhana powder in the ratio of 50:15:10, 40:10:15, 60:5:5 and 25:18:5 respectively was the most acceptable based on sensory analysis. The findings indicate that the developed value-added products are not only nutritionally balanced but also offer promising sources of plant-based protein, complex carbohydrates, and dietary fiber, making them suitable candidates for functional food development aimed at improving public health and dietary quality.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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