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Development and nutritional evaluation of a chocolate-based functional yoga nutrition bar

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Abstract
The present study was undertaken to develop and evaluate a chocolate-based functional yoga nutrition bar formulated with nutrient-dense ingredients including oats, nuts, seeds, dates, honey, and natural peanut butter. Three formulations (T_1, T_2, T_3) were prepared and assessed for sensory quality, proximate composition, vitamin and mineral content, antioxidant potential, and microbial safety. Sensory analysis using a 9-point hedonic scale revealed high acceptability across all samples, with T_2 scoring highest in overall preference. Proximate analysis demonstrated a well-balanced nutritional profile, offering 437.8 Kcal energy, 12 g protein, 23 g fat, 45.7 g carbohydrates, and 5 g dietary fiber per 100 g. The bar also provided essential micronutrients such as 3 mg vitamin E, 0.6 mg vitamin C, 2.3 mg iron, and 70 mg calcium. Microbial analysis confirmed the product's safety and shelf stability, showing compliance with food safety norms. The findings support the potential of a chocolate-based yoga nutrition bar as a functional, clean-label snack option for wellness-focused individuals.

Keywords: Yoga nutrition bar, functional food, sensory evaluation, proximate analysis, antioxidant nutrients, clean-label snack

1. Introduction
In recent decades, the global shift towards health-conscious consumption patterns has significantly impacted the food industry, particularly the functional food sector. Consumers are increasingly seeking convenient snack options that align with active lifestyles, holistic wellness, and preventive health. Functional snack bars especially those enriched with plant-based ingredients have gained widespread popularity due to their portability, nutrient density, and versatility in formulation. Among these, nutrition bars tailored for fitness enthusiasts and yoga practitioners offer a valuable platform to deliver balanced macronutrients along with vitamins, minerals, fiber, and bioactive compounds.

Yoga-based nutrition, rooted in ancient wellness principles, emphasizes sattvic, plant-based, and minimally processed foods that not only nourish the body but also support mental clarity and energy balance. In this context, the development of chocolate-based yoga bars presents a modern nutritional solution that combines the ancient wisdom of balanced diets with contemporary functional ingredients. Such bars aim to provide sustained energy, muscle repair support, digestive health, and antioxidant protection core needs for individuals engaged in regular physical activity and mindful living.

Key ingredients used in the formulation of functional bars such as oats, almonds, cashews (kaju), pistachios (pista), walnuts (akhrot), pumpkin seeds, and dates are renowned for their roles in delivering plant-based protein, dietary fiber, healthy fats (including omega-3 and monounsaturated fatty acids), and essential micronutrients (Gopalan *et al*., 2004; Slavin, 2005) [6, 16]. Oats are a rich source of beta-glucans that help regulate blood sugar and lipid levels, while nuts and seeds contribute significantly to cardiovascular and metabolic health (Lapsley & Geisler, 2005; Sathe & Venkatachalam, 2007) [8, 13].

The inclusion of chocolate particularly dark chocolate or cocoa further enhances antioxidant potential due to the presence of flavonoids, catechins, and polyphenols (Micha *et al*., 2017) [9]. Beyond its health benefits, chocolate contributes to palatability, thus improving sensory acceptability. Natural sweeteners like dates and honey not only eliminate the need for refined sugar but also add dietary fiber, minerals, and a low glycemic load, making the formulation suitable for health-focused consumers.

Previous studies have established the feasibility and nutritional promise of cereal and nut-based snack bars (Srinivasan & Rani, 2014; Semwal *et al*., 2018) [17, 14]. For example, Semwal *et al*. (2018) [14] developed quinoa-based choco-nutri bars and highlighted their sensory and nutritional advantages. Similarly, Kumar & Yadav (2017) [7] reported the value of dried fruits and cereals in enhancing energy density and micronutrient content in energy bars. The integration of these findings has laid the foundation for advancing the science of snack formulations that bridge the gap between nutrition and sensory appeal.

However, despite the growing availability of snack bars in the market, there is a paucity of standardized formulations that are both nutritionally optimized and microbiologically safe for yoga and wellness-oriented consumers. Most commercial products still rely on added sugars, preservatives, and synthetic flavors. Therefore, developing a clean-label, minimally processed, chocolate-based yoga bar with scientifically validated nutritional and sensory attributes represents a valuable contribution to functional food science. Hence the study was framed to develop a standardized chocolate-based Yoga Nutrition Bar using nutrient-dense ingredients such as nuts, seeds, oats, dates and natural sweeteners. Additionally, the study aimed to evaluate its proximate composition, micronutrient content, antioxidant and microbial properties.

2. Materials and Methods

2.1 Ingredient Purchase

The primary ingredients used in the formulation of the chocolate-based yoga nutritive bar included almonds (*Prunus dulcis*), cashew nuts (*Anacardium occidentale*), pistachios (*Pistacia vera*), walnuts (*Juglans regia*), pumpkin seeds, rolled oats (*Avena sativa*), dried dates (*Phoenix dactylifera*), honey, natural peanut butter, and dark chocolate flavoring. All ingredients were sourced from certified organic and food-grade suppliers in Hyderabad, India, ensuring quality, safety, and traceability. Each ingredient was selected for its specific nutritional contribution-providing protein, fiber, essential fatty acids, and bioactive compounds (Gopalan *et al*., 2004; Slavin, 2005; Sathe & Venkatachalam, 2007) [6, 16, 13].

2.2 Preparation of Product

The preparation began with the hygienic cleaning and sorting of all dry ingredients

Collection of Ingredients
↓
Cleaning and Sorting (Oats, Dates, Almonds, Pumpkin Seeds)
↓
Roasting (Oats, Almonds, Pumpkin Seeds)
↓
Deseeding & Chopping (Dates)
↓
Grinding / Powdering (Oats, Almonds, Seeds)
↓
Melting Chocolate / Sifting Cocoa Powder
↓
Measuring Peanut Butter, Salt, Natural Sweeteners
↓
Weighing All Ingredients

Fig 1: Flowchart of yoga nutrition bar

Dates were deseeded and chopped into small pieces. Nuts and seeds were dry-roasted at 120 °C for 5-7 minutes to enhance flavor and reduce moisture content. Rolled oats were also lightly roasted to improve their texture and digestibility. Roasted ingredients were then cooled, chopped or powdered as per formulation requirements.

2.3 Procedure

The standardized procedure involved blending the powdered oats, roasted nuts and seeds in a mixing bowl. Chopped dates and peanut butter were added as natural binders, along with honey for sweetness and additional stickiness. Chocolate flavoring was either added in powder form or melted dark chocolate was incorporated at low heat (not exceeding 45 °C to preserve antioxidant integrity). The mixture was evenly pressed into a tray lined with parchment paper and refrigerated for 4-6 hours to set. Once firm, the bars were cut into uniform pieces (40g each), wrapped in food-grade packaging, and stored at room temperature.

Table 1: Composition of yoga nutrition bar (T_1, T_2 and T_3)

Ingredients	T_1	T_2	T_3
Kaju	100 g	75 g	50 g
Almonds	50 g	25 g	15 g
Pista	35 g	25 g	15 g
Akhrot	15 g	10 g	5 g
Pumpkin Seeds	20 g	10 g	5 g
Oats	40 g	40 g	25 g
Dates	30 g	30 g	20 g
Chocolate Flavour	10 g	10 g	10 g
Honey	15 g	10 g	10 g

2.4 Sensory Evaluation: 9-Point Hedonic Scale

Sensory analysis was conducted using a 9-point hedonic scale (Peryam & Pilgrim, 1957) ranging from 1 ("dislike extremely") to 9 ("like extremely"). A panel of 20 semi-trained individuals (aged 20-40 years) was selected to evaluate the sensory parameters-color, texture, aroma, taste, and overall acceptability. All samples (T_1, T_2, T_3) were coded and presented in random order under controlled laboratory conditions. Water was provided to cleanse the palate between samples. Mean scores and standard deviations were calculated to assess preference.

2.5 Nutritional Analysis

The proximate composition of the formulated bar-including moisture, protein, fat, carbohydrate, fiber, and ash-was determined using standardized AOAC methods (AOAC, 2005) [1]. Moisture content was measured by oven drying at 105 °C to constant weight (AOAC 925.10). Crude protein was assessed via the Kjeldahl method (AOAC 990.03), where nitrogen content was multiplied by a conversion factor of 6.25. Total fat was extracted using the Soxhlet method (AOAC 963.15), and dietary fiber was measured using acid and alkali digestion followed by gravimetric analysis (AOAC 985.29). Carbohydrates were estimated by difference:

% Carbohydrates = 100 − (Moisture + Protein + Fat + Fiber + Ash).

2.6 Vitamin Analysis

Vitamin E content was estimated using the AOAC 992.03

method; Vitamin C was determined using the AOAC 984.26 method through titrimetric analysis with 2,6-dichlorophenolindophenol dye. These vitamins were selected due to their antioxidant and immune-supporting properties, relevant to the functional food claim (Gonçalves & Silva, 2021) [5].

2.7 Mineral Analysis
Calcium and iron contents were analyzed according to AOAC 984.27 and AOAC 967.22, respectively.

2.8 Microbial Analysis
Microbiological safety was assessed using standard AOAC procedures: Total Plate Count (TPC): AOAC 990.12; Yeast and Molds: AOAC 997.02; Enterobacteriaceae: AOAC 2018.05; *Staphylococcus aureus*: AOAC 2003.07
Samples were incubated on selective media, and colony-forming units (CFU/g) were enumerated. Absence of pathogenic organisms confirmed the product's microbiological safety for human consumption (FAO/WHO, 2003) [4].

3. Results and Discussion
3.1 Sensory evaluation of chocolate-based yoga nutritive value-added Bars
The sensory characteristics of the three developed chocolate yoga bar formulations-T_1, T_2, and T_3-were evaluated using a 9-point hedonic scale for parameters including color, texture, aroma, taste, and overall acceptability. The results are presented in Table 2. The sensory evaluation of the three chocolate yoga bar formulations (T_1, T_2 and T_3) was carried out using a 9-point hedonic scale, assessing parameters such as color, texture, aroma, taste, and overall acceptability. All formulations received favorable scores, with values above 7.5 in all categories, indicating general consumer acceptance. T_2 showed the highest overall acceptability (8.25±0.64), followed by T_3 (8.20±0.62), likely due to its well-balanced ingredient composition and favorable texture. T_3 scored the highest in taste (8.25±0.64), suggesting a preferred flavor profile, possibly due to optimal sweetness and nutty undertones. Texture was best rated in T_2 (8.00±0.65), indicating a desirable chewy yet firm consistency attributed to the ratio of oats, dates, and honey. Color scores varied slightly, with T_1 rated highest (8.05±0.89), possibly due to a visually rich nut content. Aroma scores remained consistent across samples, with T_2 slightly ahead. These results align with previous studies highlighting the importance of texture and flavor in consumer acceptance of nutrition bars (Semwal *et al*., 2018; Srinivasan & Rani, 2014) [14, 17]. Statistical analysis further confirmed significant differences (p<0.05) among the samples, supporting the conclusion that ingredient variation impacts sensory quality.

Table 2: Sensory parameters of tested sample (T_1, T_2, T_3) of chocolate yoga nutritive bar

Sample	Color	Texture	Aroma	Taste	Overall Acceptability
T_1	8.05+0.89	7.70±0.55	7.70±0.66	8.10±0.55	8.05±0.60
T_2	7.95±0.60	8.00±0.65	7.80±0.52	8.05±0.60	8.25±0.64
T_3	7.90±0.64	7.80±0.52	7.75±0.72	8.25±0.64	8.20

3.2 Proximate composition of the chocolate-based yoga nutritive value-added bar: The proximate analysis of the developed chocolate yoga bar revealed a balanced nutritional profile suitable for functional snacking. The energy content was measured at 437.8 Kcal per 100 g**,** making it a high-energy food ideal for physically active individuals and those seeking nutrient-dense meal replacements. The protein content, determined using the AOAC 990.03 method, was 12 g/100 g, primarily contributed by the inclusion of nuts (almonds, cashews, pistachios, and walnuts), seeds, and oats. The bar also contained 45.7 g of carbohydrates, providing both immediate and sustained energy, while total fat content was found to be 23 g/100 g (AOAC 963.15), (Table 3), largely derived from healthy fats present in nuts and seeds. This fat content supports the absorption of fat-soluble vitamins and contributes to satiety and mouth feel (Rebello, Greenway, & Finley, 2014) [12]. The dietary fiber, assessed using AOAC 925.10, was 5 g/100 g, offering digestive health benefits and contributing to glycemic control, as supported by Slavin (2005) [16], who emphasized the role of fiber in functional foods. The moisture content was relatively high at 22%, which, while aiding in chew ability, also underscores the need for proper packaging and storage to ensure microbial safety and shelf stability. The ash content, measured via AOAC 942.05, indicates the presence of essential minerals, although specific values were not recorded in this dataset. Overall, the bar demonstrates a nutrient-rich composition in line with the objectives of functional snack development, supporting both energy and micronutrient requirements.

Table 3: The proximate analysis of the formulation nutritive chocolate yoga bar

Test Parameter	Unit	Results
Energy	K/cal	437.8
Protein	g/100 gm	12
Carbohydrates	g/100 gm	45.7
Total Fat	g/100 gm	23
Dietary fibre	g/100 gm	5
Ash	%	-
Moisture content	%	22

3.3 Vitamin and mineral composition of the chocolate-based yoga nutritive value-added bar
The vitamin and mineral analysis of the chocolate yoga bar revealed its potential contribution to meeting daily micronutrient needs, especially for health-conscious and active consumers. The bar contained 3 mg of Vitamin E per 100 g (AOAC 992.03), attributed to the inclusion of nuts and seeds such as almonds, walnuts, and pumpkin seeds, which are naturally rich in tocopherols. Vitamin E is a key antioxidant that protects cell membranes from oxidative stress and supports immune and cardiovascular health (Micha *et al*., 2017) [9]. The Vitamin C content was 0.6 mg/100 g (AOAC 984.26), (Table 4), a modest but beneficial addition, likely contributed by dates and honey. While not a major source, its presence can aid in non-heme iron absorption and antioxidant defense (FAO/WHO, 2003) [4]. In terms of minerals, the bar provided 2.3 mg of iron and 70 mg of calcium per 100 g, both essential for metabolic and structural functions. The iron content supports oxygen transport and energy metabolism, particularly important for individuals with increased physical demands, while the calcium contributes to bone health and neuromuscular function. These values are consistent with those found in nut- and seed-based formulations reported in earlier studies

(Rebello *et al*., 2014) [12]. The inclusion of these micronutrients enhances the functional quality of the bar, aligning it with the principles of functional foods that aim to offer both nutritional and physiological benefits beyond basic nutrition (Siro *et al*., 2008) [15].

Table 4: Vitamin and mineral analysis of chocolate yoga bar

Test Parameter	Unit	Results
Vitamin E	mg/100 gm	3
Vitamin C	mg/100 gm	0.6
Iron	mg/100 gm	2.3
Calcium	mg/100 gm	70

3.4 Microbial quality of the chocolate-based yoga nutritive bar

The microbial analysis of the developed chocolate yoga bar demonstrated excellent microbiological safety and stability. As shown in Table 5, the aerobic plate count was found to be < 10 CFU/g**,** well within the acceptable limits as per AOAC 990.12, indicating minimal bacterial load and effective hygiene practices during processing. Similarly, yeast and mold counts were also < 10 CFU/g (AOAC 997.02), reflecting good moisture control and proper storage conditions, which are critical for preventing fungal spoilage in moisture-containing products like nutrition bars. Notably, Enterobacteriaceae and *Staphylococcus aureus* were absent in 25 g samples**,** conforming to food safety standards outlined in AOAC 2018.05 and AOAC 2003.07, respectively. The absence of these pathogens confirms that the product was processed under sanitary conditions and is safe for consumption. These findings are crucial, as microbial quality directly impacts the shelf life, safety, and commercial viability of ready-to-eat functional foods (FAO/WHO, 2003) [4]. Overall, the microbial profile of the bar indicates strong compliance with food safety norms and suggests that the product is microbiologically stable under standard storage conditions.

Table 5: Microbial activity of chocolate-based yoga nutritive bar

Test Parameter	Unit	Result	Limits
Aerobic plate count	CFU/g	< 10	1*10
Yeast & molds	CFU/g	< 10	1*10
Enterobacteriaceae	CFU/g	Absent	Absent/25 g
S. aureus	CFU/25 g	Absent	Absent/25 g

4. Conclusion

The development and nutritional evaluation of the chocolate-based functional yoga nutrition bar highlight its suitability as a health-oriented snack that aligns with the principles of yoga-based nutrition. The incorporation of minimally processed, plant-based ingredients not only enhanced the sensory appeal but also ensured a balanced supply of macronutrients, essential vitamins, and minerals. The bar demonstrated excellent microbial safety and acceptability among consumers, confirming its viability for commercial application in the functional food sector. This study underscores the potential of formulating clean-label, antioxidant-rich snack bars that support energy, muscle repair, and overall wellness in physically active and health-conscious populations.

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