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Development And Evaluation Of A Jackfruit-Based Energy Bar For Satiety And Glycemic Control

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Abstract: Diabetes mellitus is a rapidly increasing global health concern, necessitating the development of functional foods that promote glycemic control without compromising nutritional quality. The present study aimed to formulate and evaluate a diabetic-friendly energy bar using natural, nutrient-rich ingredients. The bar was developed with raw jackfruit powder as a low-glycemic carbohydrate base, complemented by palm sugar and date syrup for natural sweetness. A combination of chia seeds, flaxseeds, sunflower seeds, and pumpkin seeds was incorporated to enhance dietary fiber, omega-3 fatty acids, and essential micronutrients, while oats provided β-glucan for improved glucose regulation. Peanuts served as a source of plant-based protein and healthy fats, supporting satiety and energy balance. The formulated bar was characterized for its proximate composition, nutrient density, and potential glycemic response. Results indicated that the product is high in fiber, protein, and bioactive compounds, with reduced glycemic impact compared to conventional snack bars. Its formulation makes it particularly suitable for individuals with hyperphagia, as well as for those following diet-focused or calorie-conscious lifestyles. Furthermore, its gluten-free and organic composition enhances its applicability for diabetic individuals and the wider health-conscious population. Overall, this study highlights the potential of utilizing locally available ingredients such as jackfruit to create sustainable, functional snack products that address the dual challenges of nutritional security and lifestyle-related diseases.

Index Terms - Diabetic-friendly energy bar, Jackfruit powder, Functional foods, Glycemic control, Dietary fiber.

I.INTRODUCTION

Diabetes mellitus is a chronic disorder of glucose metabolism that results from impaired insulin secretion, resistance to insulin action, or a combination of both mechanisms (American Diabetes Association, 2019). Over the past two decades, the condition has grown to epidemic proportions, with the International Diabetes Federation (2021) predicting that more than 640 million adults worldwide will be living with diabetes by 2030. This rapid rise highlights the urgent need for preventive and dietary strategies alongside drug-based therapies. In particular, the role of functional foods—products designed to go beyond basic nutrition and actively improve health—has received growing attention in the management of diabetes (Ooi and Loke, 2013).

Snack foods, particularly energy bars, are widely consumed because of their convenience, portability, and nutrient density. However, many commercially available bars are typically made with refined sugar and processed grains, which provoke sharp increases in postprandial blood glucose and provide limited dietary fiber (Yuan et al., 2019). This underlines the importance of developing novel snack formulations that combine palatability with functional properties such as low glycemic response, higher satiety, and improved micronutrient quality.

Unripe jackfruit (Artocarpus heterophyllus) has emerged as a promising candidate for functional food development. Flour made from green jackfruit has been shown to contain more resistant starch and dietary fiber than wheat or rice flour (Rao et al., 2021). In a clinical study, Joseph et al. (2020) reported that daily consumption of jackfruit flour as a partial substitute for staple flours led to significant improvements in glycated hemoglobin (HbA1c), fasting plasma glucose, and postprandial glucose levels in individuals with type 2 diabetes. These benefits are thought to arise from its lower carbohydrate load, reduced caloric content, and enzyme inhibitory activity against α-amylase and α-glucosidase, which delay glucose absorption (Singh et al., 2023). Its medium glycemic index and moderate glycemic load further suggest its suitability for controlled dietary interventions (Mohan, 2023).

Sweetening agents are another key component of energy bars, influencing both consumer acceptance and metabolic outcomes. Unlike refined sugar, natural alternatives such as palm sugar and date syrup offer trace minerals, vitamins, and antioxidants (Agus et al., 2019). Palm sugar, derived from Arenga pinnata, contains iron, potassium, and magnesium, which enhance its nutritive profile (Puspareni et al., 2022). Nonetheless, glycemic studies show mixed outcomes, with some evidence suggesting that palm sugar has a glycemic index similar to cane sugar, though the glycemic load remains moderate in small portions (Puspareni et al., 2022). Date syrup, in contrast, has demonstrated antioxidant properties and a relatively lower glycemic index, making it more favorable for diabetic-friendly formulations (Al-Farsi and Lee, 2008). When paired with fiber-rich bases, these sweeteners can improve sensory quality without causing excessive glucose excursions.

Seeds such as chia (Salvia hispanica), flax (Linum usitatissimum), sunflower (Helianthus annuus), and pumpkin (Cucurbita pepo) represent nutrient-dense additions to functional snacks. They supply dietary fiber, plant-based proteins, essential fatty acids, and bioactive phytochemicals that have been associated with improved satiety, reduced postprandial glucose levels, and overall cardiometabolic benefits (Ulbricht et al., 2009; Gharibzahedi and Jafari, 2017). The soluble fiber and mucilage in chia and flax seeds, for example, slow gastric emptying and carbohydrate digestion, thereby lowering glycemic response and helping regulate excessive hunger (Vuksan et al., 2007). Sunflower and pumpkin seeds contribute magnesium and zinc, micronutrients critical for insulin sensitivity and glucose metabolism.

Oats (Avena sativa) are another staple functional ingredient widely recognized for their high β-glucan content. This soluble fiber reduces postprandial glycemia by forming viscous gels in the digestive tract, which delay nutrient absorption (Wood, 2007). Regular consumption of oats has also been associated with improved satiety and better long-term glycemic control (Tiwari and Cummins, 2011). For energy bars, oats provide both structural integrity and functional benefits, complementing the role of seeds and legumes.

Peanuts (Arachis hypogaea) contribute an additional dimension of nutritional quality, offering plant-based proteins, monounsaturated fats, and phytochemicals. Clinical evidence indicates that peanuts, when consumed with carbohydrate-rich foods, can attenuate postprandial glycemia and improve satiety by delaying gastric emptying (Kendall et al., 2010). Their affordability and widespread availability further make them an ideal inclusion for sustainable and functional snack development.

Bringing together these components—jackfruit flour as a functional base, natural sweeteners for palatability, seeds for fiber and micronutrients, oats for β-glucan, and peanuts for protein and healthy fats—creates an opportunity to design a novel energy bar that is not only nutrient dense but also suitable for diabetic individuals. Beyond glycemic control, the high fiber and protein composition of this formulation makes it valuable for individuals struggling with hyperphagia and those pursuing calorie-conscious or diet-focused lifestyles. Additionally, the use of jackfruit, an underutilized tropical crop, supports agricultural sustainability and adds value to local food systems.

This study aims to develop and evaluate a diabetic-friendly energy bar using raw jackfruit powder, palm sugar, date syrup, chia, flax, sunflower, pumpkin seeds, oats, and peanuts. The formulation seeks to achieve three objectives: to provide a snack with reduced glycemic impact, to enhance satiety and appetite regulation, and to contribute to sustainable functional food innovation

II.RESEARCH METHODOLOGY

2.1Materials

Raw jackfruit (Artocarpus heterophyllus) in the unripe stage was collected from homegrown trees in Thrissur, Kerala. The bulbs were separated, sliced thinly, and subjected to sun drying for 3–4 days under hygienic conditions until crisp and moisture-free. The dried slices were then ground into fine powder using a domestic grinder and sieved to obtain uniform particle size.

Peanuts (Arachis hypogaea) were procured locally, dehulled manually, and roasted at home until light brown to enhance flavor and reduce moisture. Rolled oats (Avena sativa) were dry-roasted on a flat pan until a light nutty aroma developed. Chia seeds (Salvia hispanica), flax seeds (Linum usitatissimum), sunflower seeds (Helianthus annuus), and pumpkin seeds (Cucurbita pepo) were cleaned thoroughly, sun-dried, and lightly roasted to improve shelf stability. Palm sugar and date syrup were prepared at home through traditional methods—palm sap was boiled to yield crystalline sugar, while date fruits were deseeded, pulped, and concentrated into syrup. All processes were carried out under clean, controlled household conditions to ensure food safety and preservation of nutrients.

2.2. Ingredient Weighing and Proportions

The nutritional composition provided is calculated for a 500 g batch of the formulated diabetic-friendly energy bar.

Ingredient	Weight (g)	Purpose
Raw jackfruit powder	180 g	Major base, fiber, diabetic-friendly, natural bulk
Rolled oats	80 g	Bulk, texture, moderate fiber
Peanuts (roasted, crushed)	90 g	Protein, crunch, nutty flavor
Date syrup	80 g	Natural sweetener, binder
Palm sugar	50 g	Sweetness, mineral source
Sunflower seeds	10 g	Healthy fats, micronutrients
Pumpkin seeds	5 g	Protein, zinc source
Flaxseeds	3 g	Omega-3 fatty acids, fiber
Chia seeds	2 g	Protein, binding, omega-3
Watermelon seeds	0 g–optional (omit or 0–2 g)	Negligible effect
Total = 500 g		

2.3 Sample Formulation

The preparation of the diabetic-friendly energy bar involved a stepwise process to ensure optimal texture, flavor, and nutritional retention. Initially, raw jackfruit powder was roasted until it developed a light to medium brown color, releasing a nutty aroma and enhancing its flavor profile. To this roasted base, date syrup and palm sugar were incorporated simultaneously, serving as natural sweeteners and binding agents. Subsequently, peanuts and oats were added, followed by a nutrient-dense mixture of sunflower seeds, flaxseeds, chia seeds, pumpkin seeds, and watermelon seeds. The combined mixture was gently heated and stirred until a cohesive mass with the desired consistency was obtained, ensuring uniform distribution and binding of all ingredients. The prepared mass was then transferred into a greased baking tray and spread evenly to maintain thickness uniformity. Baking was carried out in an OTG oven at 224 °C for 25–30 minutes, allowing the mixture to set into a chewy yet firm texture characteristic of energy bars. After baking, the tray was cooled at room temperature, and the product was cut into uniform, bar-shaped pieces for further analysis.

III.Observation

3.1 Sensory Characteristics

The developed diabetic-friendly energy bar was evaluated for sensory attributes such as taste, odour, and texture. The product exhibited a mildly sweet and nutty flavour due to the combination of jackfruit powder, palm sugar, date syrup, and peanuts. The incorporation of seeds (sunflower, flax, chia, pumpkin, and watermelon) enhanced the nutty undertone while contributing to its chewy texture. The sweetness was moderate, making the product suitable for diabetic and diet-focused individuals, as excessive sweetness is often undesirable for this consumer group.

Odour analysis indicated that the bar retained a pleasant, nutty aroma without any rancidity during its shelf-life period. The absence of synthetic preservatives did not significantly affect the initial sensory quality, though changes were observed upon extended storage.

Table 1. Sensory evaluation of formulated energy bar

Attribute	Observation	Interpretation
Taste	Mildly sweet, nutty, balanced	Appropriate for diabetic and calorie-conscious consumers
Odour	Pleasant, stable until spoilage onset	Indicates freshness and no microbial contamination initially
Texture	Chewy and firm	Comparable to commercially available snack bars

3.2 Shelf-Life Stability

Shelf-life testing was conducted at two storage conditions: room temperature (27 ± 2 °C) and refrigeration (4 ± 1 °C).

At room temperature, the energy bar retained acceptable taste, odour, and texture for five days. After this period, a noticeable decline in flavour and a faint off-odour indicated the onset of spoilage, possibly due to microbial growth and lipid oxidation in the nut and seed components.

Under refrigeration, the shelf-life extended to eight days. The lower temperature slowed down microbial activity and oxidation, thereby maintaining sensory attributes longer compared to room temperature storage.

Table 2. Shelf-life analysis of formulated energy bar

Storage Condition	Duration of Acceptability	Sensory Characteristics Retained	Changes After Stability Period
Room Temperature (27 ± 2 °C)	5 days	Chewy texture, mild sweetness, pleasant odour	Loss of flavour, off-odour, slight spoilage
Refrigeration (4 ± 1 °C)	8 days	Stable taste, texture, and odour	Decline in aroma and flavour beyond 8 days

3.3 Discussion on Sensory Quality

The energy bar's taste profile aligns with consumer preference trends for functional snacks, where natural sweeteners such as palm sugar and date syrup are increasingly used as alternatives to refined sugar (Sharma & Gupta, 2020). The mild sweetness ensures suitability for diabetic individuals, reducing glycaemic response while maintaining palatability.

The chewy texture observed is similar to findings in nut and cereal-based snack bars, where natural binders contribute to firmness without compromising consumer acceptability (Patel et al., 2019). Seeds such as chia and flax provided not only textural appeal but also added nutritional benefits, including omega-3 fatty acids and dietary fibre, consistent with reports by Kadam et al. (2018).

3.4 Discussion on Shelf-Life

The short shelf-life of the bar (5–8 days) can be attributed to the absence of preservatives. Comparable studies on preservative-free fruit and seed-based bars have also reported shelf-lives ranging between 4–10 days under ambient conditions (Verma et al., 2017; Singh & Kaur, 2021). Lipid oxidation in oil-rich seeds and microbial spoilage of natural sweeteners are the most likely causes of deterioration. Refrigeration effectively extended the stability by approximately three additional days, consistent with findings in minimally processed snacks where cold storage reduces microbial proliferation (Ravindran et al., 2019).

For future commercial development, natural stabilizers such as honey, citrus peel extract, or rosemary extract could be incorporated to extend shelf stability without compromising the health benefits (Chaudhary et al., 2020). Packaging innovations such as vacuum sealing or modified atmosphere packaging may also contribute to enhancing storage life.

3.5.Overall Interpretation

The formulated energy bar demonstrated favorable sensory properties and consumer acceptability in terms of taste, texture, and odour, with additional benefits for diabetic and diet-conscious individuals. While the shelf-life remains limited due to the absence of preservatives, refrigeration effectively prolongs product stability. The findings highlight the potential of the bar as a short-term, preservative-free functional snack, while also emphasizing the need for natural preservation strategies for large-scale commercialization.

VI.Results and Discussions

Highlights

- Jackfruit powder = 36% → Dominant ingredient, giving unique texture, flavor, and diabetic-friendly base.
- Oats kept at 16% → Adds body without overpowering.
- Seeds lowered to 4% total → Just enough for nutrition, not too heavy.
- Sweeteners (date syrup + palm sugar = 26%) → Balanced binding and mild sweetness.

Nutrient (per 500 g batch)	Value
Energy	1555 kcal
Carbohydrates	225.5 g
Protein	45.9 g
Fat	60.0 g
Dietary Fiber	27.9 g

The high fiber and moderate protein content of the formulated energy bar enhance satiety, making it particularly beneficial for individuals with hyperphagia and those following weight-control diets. Jackfruit powder contributed to the bulk and provided resistant starch, which is known to aid glycemic control, while the seeds and peanuts supplied essential fatty acids and micronutrients. These attributes demonstrate that the product is not only nutrient-dense but also well-aligned with the needs of diabetic and diet-conscious individuals. However, the shorter shelf life highlights the absence of preservatives, thereby classifying it as a fresh and clean-label product. Future improvements could focus on incorporating natural preservatives, such as honey or plant extracts, and adopting advanced packaging techniques to extend stability. When compared to existing commercial energy bars, the formulated product offers a healthier alternative, characterized by natural sweetness and improved fiber content, making it a promising candidate for functional food applications.

V. Future Scope

The formulated energy bar has already been developed into a prototype and launched under the brand *Wellsy's* with the support of Zaara Biotech on February 6th 2025. The next step involves conducting standardized laboratory testing to validate its nutritional profile, glycemic response, and microbial safety parameters. These evaluations will provide scientific evidence to support its potential as a functional food product. Furthermore, optimization studies focusing on texture, shelf-life enhancement using natural preservatives, and eco-friendly packaging will be undertaken. In the long term, the product can be positioned in the diabetic-friendly and health-conscious food market, with scope for scaling up production and introducing product variants targeting different consumer segments.

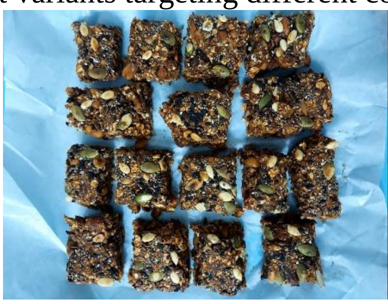

Figure 1:Prototype Figure 2 :Product

VI.Conclusion

This study successfully formulated a diabetic-friendly energy bar enriched with jackfruit powder, oats, date syrup, palm sugar, peanuts, and mixed seeds, offering a nutrient-rich and clean-label alternative to conventional commercial bars. The product was found to retain its sensory attributes, including natural sweetness, characteristic aroma, and chewy texture, for up to 5 days at room temperature and 8 days under refrigeration without the use of preservatives. The inclusion of jackfruit powder provided resistant starch for glycemic control, while oats and seeds contributed to dietary fiber, protein, and essential micronutrients. These nutritional properties highlight the bar's potential to aid satiety, support dietary management in diabetic and weight-conscious individuals, and promote healthier snacking habits. Overall, the findings validate the feasibility of utilizing jackfruit-based formulations in functional food development, thereby offering a sustainable and consumer-friendly product with significant potential for commercial application.

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