**Development and Evaluation of a Functional Fiber-Rich Bar Incorporating Lotus Stem and Carrot Pomace**

**ABSTRACT**

The aim of this study was to create an energy bar high in fiber using carrot pomace powder and lotus stem powder, both of which are rich in essential nutrients such as protein, fat, carbohydrates, dietary fiber, and minerals. Dietary fiber bars were formulated utilizing carrot pomace, Lotus stem powder, oats, date puree, honey, pumpkin seeds, almonds, cashews, sesame seeds, and dark chocolate. The consumption of dietary fiber may diminish appetite and lead to an extended sensation of satiety following ingestion. Four distinct formulations of the bar were developed, referred to T0, T1, T2, and T3, incorporating 10 grams, 15 grams, and 20 grams of Fibre Rich Powder, derived from lotus stem and carrot pomace. The formulation deemed optimal, T1 (15 g), was chosen based on sensory evaluations including color, texture, flavor, and overall acceptability.These bars were assessed for their physical characteristics (such as colour, water activity, and hardness) as well as their organoleptic properties. The final composition comprised 437.17 kcal of energy, with a distribution of 23.7% total protein, 47.23% total carbohydrates, 17.05% total fat, 9.48% dietary fiber, 9.88% moisture, and 2.08% total ash. The formulation with 15 g of the fiber-rich powder (T1) exhibited the best overall sensory qualities, making it the most appealing choice for consumers. This study addresses the gap in functional food development by leveraging agricultural by-products to enhance nutritional value. These fiber bars present a convenient option for those seeking to maintain fullness and occasionally skip meals.

**Keywords:** Bar, Carrot pomace powder, Dietary fiber, Lotus stem powder.

**1 - Introduction**

Consumers are increasingly seeking health foods that are easy to carry, convenient, and appropriately portioned (Sloan 2005). Many of these options are lightly processed, nutrient-dense, and have a pleasant taste. Energy bars, which meet these criteria, have seen a rise in sales, as reported by the ACNielsen Market Track (Burn, 2007). Due to the rising demand for healthy, natural, snacks and convenient foods, efforts are underway to dehull flaxseed (Zhang *et al*. 2009). They can be reformulated to make better ones having more nutrients than conventional approaches. These strategies can greatly improve individual health and the global market (Manzoor *et al.* 2025). Vegetable juices and powders are gaining significant attention for their high nutritional content and appealing taste (Song *et al*. 2007; Zhang *et al*. 2004). Among these, lotus root beverages are popular for their positive effects on heart and lung health (Fan *et al*. 2006). Besides juice, lotus root starch, also known as lotus root powder, is a traditional Chinese food. It is derived from lotus roots, which are abundant in starch, protein, amino acids, reducing sugars, dietary fibers, minerals, beta-carotene, and vitamins (Sun *et al*. 2009). This food is commercially available in China and is consumed as breakfast, fast food, traditional sweets, and food additives, making it particularly suitable for children, the elderly, and some patients due to its digestibility and nutritional value (Min *et al*., 2007; Zhong *et al*., 2007). The production of lotus root powder has been on the rise annually due to market demand, and with the swift growth in consumer interest in health, many manufacturers have recently developed sugar-free lotus root powder. However, many of these products labeled as "sugar-free" only exclude sucrose and still contain other sugars like glucose and fructose to cut processing costs and maintain flavor (Niu *et al*. 2012). Additionally, some lotus plants have also been found in India.

Lotus Stem, scientifically known as Nelumbo Nucifera Garten, is commonly referred to as the Indian Lotus. This aquatic plant features a thick, creeping rhizome that is yellowish-white in color. The rhizomes of Nelumbo nucifera are known for their anti-inflammatory and anti-diabetic effects. Additionally, its seeds possess hepatoprotective and free radical-scavenging properties, while its extracts exhibit antipyretic, antioxidant, and anti-inflammatory activities (Mukherjee *et al*., 2009). The lotus stem is a nutritious vegetable with a moderate calorie content, high dietary fiber, and some saturated fat, making it beneficial for those aiming to lose weight. Its high fiber content and complex carbohydrates aid in lowering blood sugar levels and alleviating constipation (Zhang *et al*. 2015; Bangar *et al*. 2022). Furthermore, the lotus stem is rich in calcium and iron (Begum and Punia, 2021). Carrots, or Daucus carota, are root vegetables that are an excellent source of calcium pectate, a unique pectin fiber known for its cholesterol-lowering properties. Consuming carrots can help reduce the risk of high blood pressure, stroke, heart disease, and certain types of cancer (Varshney and Mishra 2022; Deding *et al.* 2023). Carrots are often eaten raw, juiced, used in salads, cooked as vegetable dishes, or incorporated into sweet recipes. The popularity of fruit and vegetable juices has risen in recent years as people seek natural alternatives to traditional caffeine-containing drinks like coffee, tea, or carbonated soft drinks (Kaur *et al*., 2009). Carrot pomace, the by-product of carrot juice extraction, retains a significant amount of vitamins, minerals, and dietary fiber. Despite its nutritional value, carrot pomace has not been fully utilized and poses environmental challenges due to its perishability, with a moisture content of approximately 88 ± 2%. Drying or dehydrating the pomace can extend its shelf life for future use. Dried carrot pomace contains β-carotene and ascorbic acid ranging from 9.87 to 11.57 mg and 13.53 to 22.95 mg per 100 g, respectively (Upadhyay *et al*. 2008). It is rich in insoluble fiber, which helps lower cholesterol levels. Carrot pomace can be incorporated into foods such as bakery items, dressings, and beverages (Singh *et al*. 2006). It is a valuable source of minerals, dietary fiber, and vitamins (Sindhu *et al*. 2016). The carotene and ascorbic acid content in dried carrot pomace powder ranges from 0.87 to 11.57 mg/100 g and 13.53 to 22.95 mg/100 g, respectively (Upadhyay *et al*. 2008). By dry weight, carrot pomace consists of 28% cellulose, 2.1% pectin, 6.7% hemicellulose, and 17.5% lignin (Nawiska and Kwasniewska, 2005).

Therefore, this study aimed to enhance the sensory and functional qualities of an energy bar by incorporating lotus stem powder and carrot pomace powder as functional components. The research also explored how these additions affected the proximate composition, physicochemical characteristics, and texture of the experimental energy bar. Furthermore, an investigation was carried out to identify the optimal blanching treatment by evaluating factors such as color, the activity of the enzyme polyphenol oxidase (PPO), total phenolic content, total carotenoid content, and the percentage of antioxidant activity.

**2 - Material and Methods**

***2.1 - Materials***

The main vegetables such as carrots and lotus for the preparation of powders were obtained from local fruit and vegetable vendor shop in Vadodara. The honey served as the source of sweetener of “Dabur” brand was procured from Medical shop, Waghodia. 'Amul' brand sugar free dark chocolate was purchased from the local market in Vadodara, Gujarat. The remaining ingredients such as oats, dates pumpkin seeds, almonds and cashews were obtained from D-mart, Vadodara.

*Equipment’s*

The equipment utilized in the present investigation were a) Weighing balance of M/s. Precisa Instruments Ltd., Switzerland b) Electrical grinder of Havells, Model MX-1155 and c) Cabinet dryer of M/s. Pal Engineers, Ahmedabad, Gujarat.

**2.2 – Methods**

*Preparation of Lotus stem powder*

The lotus stems were separated, trimmed, and cleaned well with running water. They were then either shredded or chopped into slices or pieces, and blanched. The blanching is done to inactivate the enzymes such as catalase and PPO. The lotus stems were treated before the main treatment. We submerged the sliced portions in water and microwaved them for varying durations: 2, 4, 5, 6, and 7 minutes. The lotus stems were blanched and then dried in a mechanical cabinet air dehydrator at a temperature of 60±3°C for a period of 4 to 5 hrs (Li *et al*. 2024). Dried lotus stems were pulverized using an electric grinder. The prepared lotus stem powder was filtered through 30 mesh sieves. Such powder is used as a functional ingredient in energy bar. The photograph of lotus stem powder is shown in the Figure 1.

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***Figure 1: Lotus stem powder***

*Preparation of Carrot pomace powder*

The carrot pomace powder was prepared using method suggested by Ahmad *et al*. (2016) with slight modifications. The carrots were sorted, trimmed, and thoroughly washed with running water. They were then shredded or chopped into slices with slicer. After that, use an electric grinder to grind it. The procedure included squeezing off the juice and separating the pomace by passing it through a sieve. Next, we dried the carrot pomace in the mechanical cabinet air dehydrator for 4-5 hrs. at a temperature of 60±3°C (Ahmad *et al.* 2016). We dried the pomace in the electrical grinder, and then we passed the obtained powder through 30 mesh sieves. We used established procedures to assess the powder's numerous physicochemical properties. The photograph of carrot pomace powder is shown in the Figure 2.

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***Figure 2: Carrot pomace powder***

*Formulation for Energy bar*

The various ingredients used in energy bar as below:

**Table 1:** Ingredients and quantity used in the production of Fiber rich bar

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ingredients (g)** | **T0** | **T1** | **T2** | **T3** |
| Lotus stem powder | - | 10 | 15 | 20 |
| Carrot pomace powder | - | 10 | 15 | 20 |
| Date paste | 40 | 50 | 45 | 40 |
| Honey | 20 | 30 | 25 | 20 |
| Sesame seed | - | 10 | 10 | 10 |
| Pumpkin seed | - | 10 | 10 | 10 |
| Oats | 50 | 50 | 50 | 50 |
| Almonds | 10 | 10 | 10 | 10 |
| Cashews | 10 | 10 | 10 | 10 |
| Sugar free dark chocolate | - | 100 | 100 | 100 |

*Preparation of Energy bar*

The preparation of the fiber-rich bar begins with the selection of basic materials, including carrot and lotus stem, which are processed into carrot pomace powder and lotus stem powder, respectively. Subsequently, all constituents are measured with precision. The dried ingredients, comprising sesame seeds, almonds, cashews, and pumpkin seeds, are subjected to roasting in order to augment their flavor and texture. Thereafter, both the moist and dry ingredients are combined meticulously. The mixture is subsequently placed into molds and refrigerated for a duration of one hour to facilitate adequate binding. Subsequent to refrigeration, the bars are enrobed in chocolate and permitted to solidify for a duration of 15 minutes. Ultimately, the meticulously prepared fiber-rich products are encased in aluminum foil for the purposes of storage and distribution.

ANALYSIS

*Proximate composition*

The lotus stem and carrot pomace powder were assessed for the Moisture, Fat, Ash, Fiber, and protein content (AOAC, 1995). The control and experimental samples of energy bar also evaluated for its Moisture, Ash, Protein, Fat, Energy value, and Fiber as per the process given in AOAC (1990). The total carbohydrates are estimated by difference method.

*Physico-chemical parameters:*

The external color of the bars was measured using a handheld tristimulus reflectance colorimeter (Minolta Chromameter; model CR-400, Konica Minolta, Japan). Results were recorded in lightness with L\* = (100 for lightness, and zero for darkness), a\* [chromaticity on a green (-) to red (+)], and b\* [chromaticity on a blue (-) to yellow (+)]. The values reported are the means of triplicate measurements (Omran, 2018). The hardness of bar samples was measured by Universal Testing Machine (Cometech, B type, Taiwan) provided with software as described by Bourne (2003). Three replicates of each oat bar formula were cut using a flat-ended probe (2.50 mm thickness) with a cross-head speed of 1 mm/s at a 20% level of compression. Hardness was recorded using Newtons (N). The water activity (aw) of the bars was measured using Rotronic Hygrolab3 CH-8303, Switzerland, as described by Cadden (1998).

*Sensory evaluation*

Bar made from lotus stem powder, carrot pomace, oats, and other ingredient were subjected to sensory evaluation using 9.0 hedonic scale (Wichchukit and O'Mahony, 2015).

# RESULTS AND DISCUSSION

*Proximate composition of lotus stem powder, carrot pomace powder, and oats*

The proximate composition of lotus stem powder, carrot pomace powder, and oats used for bar preparation are shown in Table 2. The lotus stem powder and carrot pomace powder contains high protein, fiber, and ash content than oats; while moisture content is less.

**Table 2:** Proximate composition of ingredients used for fiber rich bar

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters (%)** | **Lotus stem powder (DB)** | **Carrot pomace powder** | **Oats** |
| **Moisture** | 4.70 | 4.87 | 8.45 |
| **Protein** | 8.48 | 7.90 | 13.62 |
| **Fat** | 1.10 | 0.80 | 5.26 |
| **Crude Fiber** | 17.00 | 20.09 | 8.01 |
| **Ash Content** | 3.56 | 5.52 | 1.80 |

*Effect of lotus stem and carrot pomace powder on proximate composition of FRB*

Along with the control sample, four distinct composite bar samples were examined for moisture content, protein, fat, ash, dietary fiber, carbohydrates, and energy. Table 3 shows that proximate composition of FRB varying LSP, CPP and oats. The control and experimental samples of composite bars were considered.

As per the Table 3, it is concluded that the substitution of lotus stems powder and carrot pomace powder significantly increased the protein, ash, and fat contents of the samples. Data showed that T1 had the highest protein (23.76 %) and fat (17.05) content followed by T1 treatment (9.7 % and 13.65%, respectively). On the other hand, T4 had the lowest total carbohydrate content (47.23%). Whereas, crude fiber content is non-significantly affected by the replacement of oat with LSP and CPP. The present findings are in accordance with the study conducted by Silva *et al.* (2014).

**Table 3:** Proximate composition of Control and Experimental Bars

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameters (%)** | **T0** | **T1** | **T2** | **T3** |
| Moisture | 6.92±0.23 | 9.88±0.10 | 8.52±0.13 | 7.56±1.58 |
| Ash Content | 1.87±0.01 | 2.08±0.05 | 2.01±0.01 | 2.06±0.02 |
| Protein | 9.7±0.23 | 23.76±0.02 | 22.23±0.26 | 22.36±0.34 |
| Fat | 13.656±0.2 | 17.05±0.05 | 16.38±0.30 | 16.56±0.34 |
| Carbohydrates | 67.85±2.67 | 47.23±1.85 | 50.86±1.39 | 51.46±0.17 |
| Dietary Fiber | 3.5±0.08 | 9.48±0.03 | 8.11±0.25 | 8.21±0.32 |

*T0 – Control sample devoid of LSP and CPP; T1, T2 and T3 – Experimental samples containing LSP and CPP 1.0, 1.5 and 2.0 % respectively; Values indicated row wise having different superscripted alphabets differs significantly (p<0.05) from each other; n=4*

There was a gradual increase in moisture content with an increase in the concentration of date paste the in the control and experimental samples bar and this was clearly indicated from the results. The fiber content also increased gradually as the concentration of fiber-rich powder in the bar increased and decrease with decreasing concentrations of fiber-rich powder.

Fiber-bar of T1 formulation made by (10 gm) carrot pomace powder, (10gm) lotus stem powder, (10gm)sesame seed,(10gm) pumpkin seed, (10gm) almonds, (10gm) cashew, (30gm) honey, 50g date paste, (50gm) oats, was highly accepted by the taste panel member. The mean moisture content of the bar was (9.88±0.10). The lower moisture content ensures the prevention of microbial growth and elongates the shelf stability of the product hence it is an important factor in food preservation. The Ash content of the bar was found to be (2.08±0.05) and the protein content was found to be (23.76±0.02). The fat and carbohydrate content in the bar was (17.05±0.05) & (47.23±1.85) respectively. The total energy provided by the bar was (437.17) Kcal.

*Effect of lotus stem and carrot pomace powder on physico-chemical properties of FRB*

*Water Activity (aw)*

Food safety and quality are observed through water-related activities. It describes the various states in which water can be found, including the amount of water that is "bound" in the food, the amount of water that is available to take part in chemical or biological reactions, and the amount of water that is available to help the growth of microbes (FDA, 2014). A useful indicator for determining the growth of bacteria, yeasts, and molds is the water activity of food. The shelf life of food products is increased when water activity is decreased. All the given values of aw were measured at 22±1°C and the data demonstrated that using fiber powder, dry fruit, and date paste seeds had insignificantly affected aw values of the bars at zero time. T1 recorded the lowest value. The aw significantly decreased during storage for three months.

**Figure 3: Water activity of Control and experimental samples**

*Hardness*

Figure 4 represents the hardness of the bars during a storage period of three months. Data show that the substitution of oat with fiber-rich powder and ingredients (T2, T0, and T3) had significantly decreased hardness respectively compared to T1 at zero time. From the figure 4, mentioned data, it could be stated that T0 had the highest hardness and T1 had the lowest one. After storage for three months, hardness values significantly increased gradually in all formulas compared to zero time. The cereal bars' acceptance is influenced by their hardness ratings (Estevez *et al*., 1995). The use of pumpkin boosted the cereal bar's density, increasing its hardness and cutting strength. It is possible to observe a decrease in the power to cut and hardness when pumpkin is completely substituted for oats in the making of cereal bars (Silva *et al*., 2014).

**Figure 4: Hardness (N) value of Control and experimental samples**

*Effect of lotus stem and carrot pomace powder on sensory attributes of FRB.*

The sensory evaluation of the developed samples under different treatments (T0 to T3) was conducted for attributes such as **color and appearance, texture, flavor,** and **overall acceptability**. The data are summarized in Table 4 and graphical representations are shown in Figure 5.

#### ****Color and Appearance****

The color and appearance scores ranged from **7.67 (T0)** to **8.25 (T3)**. The treatment T3 scored the highest, indicating better visual appeal compared to the control (T0). The **critical difference (CD) value was 0.71,** suggesting that the differences between treatments were statistically significant. This implies that the addition of ingredients in T3 might have enhanced the visual characteristics of the product.

#### ****Texture****

The texture scores varied from 7.83 (T2) to 8.25 (T1). The treatment T1 received the highest score for texture, possibly due to improved structural integrity or mouth feel. However, the **CD was non-significant (NS),** indicating that the observed differences among treatments were not statistically significant. This suggests that the treatments had no substantial impact on the textural characteristics as perceived by the panelists.

#### ****Flavor****

Flavor is a crucial determinant of consumer preference. The scores ranged from **7.50 (T3)** to **8.50 (T1).** Treatment T1 had the highest flavor score, which was significantly different from the other treatments **(CD = 0.71),** indicating a notable improvement in flavor due to the specific ingredient or process used in this treatment.

#### ****Overall Acceptability****

Overall acceptability reflects the cumulative impact of all sensory attributes. The highest score was recorded for **T1 (8.25)**, followed closely by **T2 (8.19)**, whereas **T3** showed the lowest acceptability score (**7.50**). The difference was statistically significant (**CD = 0.56**), confirming that treatment T1 was most preferred by the sensory panel. The **coefficient of variation (CV)** for all sensory parameters ranged from **6.86% to 8.75%**, which reflects acceptable variability and good panel consistency. The **standard error of mean (SeM)** values was also relatively low, indicating precise measurements.

Table 4: Effect of lotus stem and carrot pomace powder on sensory attributes of FRB.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Color & Appearance** | **Texture** | **Flavor** | **Overall Acceptability** |
| T0 | 7.67 ± 0.89 | 7.92 ± 0.74 | 7.75 ± 0.69 | 7.88 ± 0.52 |
| T1 | 8.00 ± 0.98 | 8.25 ± 0.82 | 8.50± 0.92 | 8.25 ± 0.83 |
| T2 | 8.17 ± 0.78 | 7.83 ± 0.86 | 8.00± 0.88 | 8.19 ± 0.79 |
| T3 | 8.25 ± 0.55 | 8.00 ± 0.68 | 7.50± 0.78 | 7.50 ± 0.54 |
|  | | | | |
| SeM | 0.24 | 0.25 | 0.25 | 0.19 |
| CD | 0.71 | NS | 0.71 | 0.56 |
| CV | 7.64 | 7.61 | 8.75 | 6.86 |

**Figure 5: Effect of lotus stem and carrot pomace powder on sensory attributes of FRB.**

Overall, **T1 emerged as the best formulation** with the highest scores for texture, flavor, and overall acceptability. The improvement in sensory parameters could be attributed to the optimized formulation, which enhanced the product’s palatability. The findings suggest that the modifications introduced in T1 positively influenced consumer perception, especially in terms of flavor and overall appeal. The cereal bar’s acceptance rate converts to a large number of potential buyers for such a product (de Conto *et al*., 2015).

# CONCLUSION

### The findings indicate that T1 emerged as the most effective formulation among those containing different amounts of lotus stem powder, carrot pomace powder, pumpkin seed, sesame seed, almond, cashew, honey, date paste, and sugar-free dark chocolate. T1 comprises 9.88% moisture, 2.08% ash, 23.76% protein, 17.05% fat, 47.23% carbohydrates, 9.48% dietary fiber, and provides 437.17 kcal of energy. This formulation is recognized for its rich nutrient content. The primary aim of developing this product is to create a nutritionally dense item. In the product development process, a fiber-rich powder was crafted using lotus stem and carrot pomace. The study concludes that this fiber-rich powder can be incorporated into bars up to 10 g, enhancing the fiber content of cookies to about 9.48g/100 g. It serves as a healthy alternative to less nutritious foods. Additionally, the fiber bar is an excellent choice for individuals who cannot eat their meals on time, as it delivers ample energy and protein. The ingredients for the fiber-rich bar were carefully selected to ensure adequate energy and protein, benefiting diabetic and celiac patients. This fiber bar is anticipated to be a nutritious food product, offering protein, energy, and other essential nutrients. It can also be considered a meal replacement bar, as it supplies the body with sufficient energy and nutrients.

**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 the writing or editing of this manuscript.

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