

Development of a novel vegetable fish bar and evaluation of its proximate contents and sensory properties

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Abstract

The global food trade and lifestyle changes are causing a notable shift in people's dietary preferences. In this regard, ready-to-eat foods are gaining popularity nowadays owing to their convenience, adequate portion sizes, and ability to provide nutrition along with satiety. The objective of this study was to develop a novel fish bar containing vegetables for enhanced nutritional benefit. Proximate compositions such as moisture, ash, protein, fat, crude fiber, total carbohydrate, total sugar, reducing sugar and energy value were analyzed. The sensory quality of the fish bars in terms of their appearance, color, flavor, hardness, taste and overall acceptability was also evaluated. Results indicated that the vegetable fish bars contained moisture, ash, protein, fat, crude fiber, and total carbohydrates in the range of 11.97-12.83%, 8.47-9.89%, 15.59-17.17%, 14.91-16.20%, 5.49-6.60% and 38.59-42.42%, respectively. The energy value was in the range of 357.24-376.13 kcal/100 g. All vegetable fish bars received acceptable sensory scores (more than 5 out of 9) in appearance, color, flavor, hardness, taste and overall acceptability with sample 2 getting the highest score. These novel vegetable fish bars can be promising alternatives to their traditional commercial counterparts.

1. Introduction

Consumers are now more interested in foods that are nutritionally dense but low in digestible starch, as they are concerned about the health risks associated with consuming high amounts of digestible starch (Desai *et al.*, 2018). Consuming large quantities of easily digested starch can cause blood sugar levels to rise and may be linked to metabolic disruption (Guariguata *et al.*, 2013).

Diabetes mellitus (DM) is a chronic metabolic disease primarily characterized by high glucose levels in the bloodstream (Sun *et al.*, 2020). This metabolic disorder is also related to cardiovascular disease (De Rosa *et al.*, 2018), Alzheimer's disease (Barbagallo, 2014), and chronic kidney disease (Thomas *et al.*, 2016). Management of diabetes is challenging and it requires proper dietary management (Tao *et al.*, 2015), pharmacological therapy, and routine blood glucose monitoring (Chaudhury *et al.*, 2017).

A link between the development of type 2 diabetes and excessive consumption of carbohydrates, fat, and calories has been postulated in the previous study by Wang *et al.* (2015). Thus, it is recommended to incorporate low glycemic index (GI) foods in the diet of diabetes patients, as they have been shown to have a positive impact (Monro and Shaw, 2008). The GI is a relative measure that assesses the glucose response of different carbohydrates (Eleazu, 2016). Consuming a low -GI diet has been associated with reductions in glycated hemoglobin (HbA1c), fasting glucose, body mass index (BMI), total cholesterol, and low-density lipoprotein (LDL) (Banka *et al.*, 2015). Examples of low GI foods include whole grains, legumes, vegetables, whole fruits, nuts, seeds (Guariguata *et al.*, 2013) and different types of fish (Patel *et al.*, 2009).

Fishes, rich in omega-3 fatty acids (Rubio-Rodríguez *et al.*, 2010), minerals, and vitamin D (Balami *et al.*,

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2019), are the primary source of animal protein (Barik, 2017). Fish and fishery products are the most traded food commodities globally (Bellmann *et al.*, 2016). Fish is prevalent in the regular diet of Bangladesh. The most commonly consumed fish species in Bangladesh are Rui (*Labeo rohita*), Pangas (*Pangasius*), Hilsha (*Tenualosa ilsha*) and Tilapia (*Oreochromis mossambicus*) (Rahman and Islam, 2020). Due to its low price and availability, Ruhi fish is preferred by people of all economic backgrounds in Bangladesh (Rahman and Islam, 2020).

Furthermore, the addition of vegetables to fishery products may enhance the nutritional value of the products as vegetables contain high amounts of dietary fiber and minerals. Vegetables offer various health advantages like improved digestion, decreased risk of certain illnesses and increased satiety (Ogimoto *et al.*, 2000). Fiber-rich diet is also recommended for diabetic individuals because it helps to maintain their blood glucose level (Reynolds *et al.*, 2020). Food manufacturers and technologists are being compelled by dietary trends to develop novel, nutritionally dense, and minimally processed ready-to-eat foods due to the significant surge in nutrition and food technology research in recent decades (Butnariu and Sarac, 2019). The demand for ready-to-eat convenient foods/frozen food products is also increasing due to changing eating habits, small family sizes, disposable income, and willingness to try new foods. Thus, ready-to-eat food products produced from different vegetables and fishes may be a good choice for consumers, especially type 2 diabetes patients as a source of low GI foods. Various types of fish products such as fish burgers, fish sticks, fish balls, and fish cakes are currently available in the market (Shikha, 2021). But, to our knowledge, no research has been carried out on vegetable fish bar. Thus, this study aimed to develop a novel vegetable fish bar. The proximate content and sensory analysis of the vegetable fish bar were also investigated.

2. Materials and methods

2.1 Materials

Ruhi fish (*Labeo rohita*), potato (*Solanum tuberosum*), raw banana, papaya (*Carica papaya*), chick pea (*Cicer arietinum*), onion (*Allium cepa*), cumin powder (*Cuminum cyminum*), red chili powder (*Capsicum frutescens*), lemon (*Citrus limon*), turmeric (*Curcuma longa*), garlic (*Allium sativum*), egg, salt, rice paper (*Oryza sativa*) were purchased from local market of Mohammadpur Dhaka, Bangladesh. Other chemicals were obtained from Merck, Germany.

2.2 Study period and location

The study was carried out from October 2021 to May 2022 in the Quality Control Research Laboratory of Food Technology and Nutritional Science (FTNS) Department, Mawlana Bhashani Science and Technology University (MBSTU), Tangail and in the Integrated Nutrition and Health Research Center (INHRC), Dhaka.

2.3 Preparation of vegetable fish bar

Firstly, Ruhi fish was properly cleaned with fresh water and cut into small pieces. Secondly, salt, turmeric powder and vinegar were added to the fish pieces and the mixture for 1 hr after boiling it. After that, the bones of the fish were removed carefully. Thirdly, potatoes, raw bananas and papayas were washed, cut into small pieces and boiled. Finally, the above ingredients were blended to make a vegetable fish bar mixture. Afterwards, onions were washed, and sliced followed by deep frying. After cooling down the same pan, the spices such as ginger, garlic, turmeric and lemon were added to the vegetable fish bar mixture and the mixture was distributed evenly in the mold and let cool down. Subsequently, the mixture is put into mold to shape it as a bar (Figure 1 (A)).

Finally, rice paper was used to wrap each vegetable fish bar to make it firmer (Figure 1 (B)). The prepared vegetable fish bar was kept in a refrigerator at 4°C for further use. Three different samples of vegetable fish bar were prepared (Figure 1). Among these, additionally, chickpea was added to Sample 2 and Sample 3 where chickpeas were also processed as described earlier. The composition and ingredients of three vegetable fish bars with different formulations was provided in Table 1.

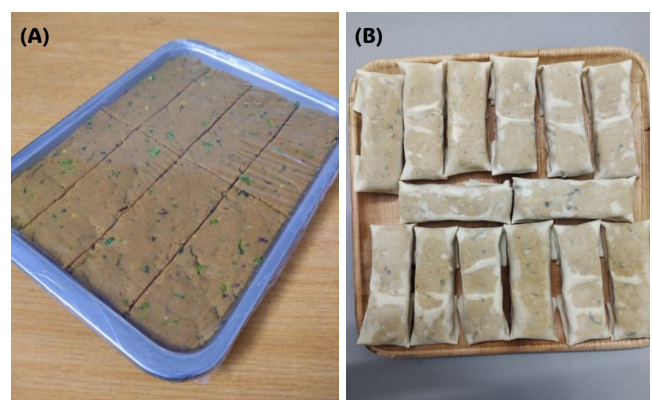


Figure 1. Molded vegetable fish bar (A) and vegetable fish bar wrapped with rice paper (B).

2.4 Proximate analysis of the vegetable fish bar

2.4.1 Moisture content and sugar analysis

Moisture was determined following the method of Hasan *et al.* (2019). A specific amount of sample was heated at 100-105°C for 3-4 hrs in an oven, then cooled in a desiccator. The process was repeated several times

Table 1. Composition of vegetable fish bar per 100 g.

Ingredients	Sample 1	Sample 2	Sample 3
Ruhi fish paste-bone free (g)	16.0	16.0	16.0
Green papaya (g)	4.0	4.0	4.0
Potato (g)*	12.0	16.0	8.0
Green banana (g) *	0.0	8.0	4.0
Chickpea (g) *	0.0	2.5	5.0
Onion (g)	15.0	15.0	15.0
Garlic-ginger paste (g)	2.5	2.5	2.5
Turmeric powder (g)	2.5	2.5	2.5
Red chili powder (g) *	1.0	2.0	2.0
Green chili (g)	0.5	0.5	0.5
Cumin powder (g) *	1.5	2.0	2.0
Coriander leaves (g)	1.5	1.5	1.5
Lemon juice (mL) *	0.0	2.5	2.5
Yogurt (mL) *	5.0	2.5	0.0
Egg (g)	10.0	10.0	10.0
Oil (mL)	1.5	1.5	1.5
Salt (g)	3.0	3.0	3.0
Rice paper per piece (g)	16.0	16.0	16.0
Total	100.0	100.0	100.0

*Ingredients were varied for optimum taste.

until a constant weight and the moisture content was determined by the following equation (1):

$$\text{Moisture (\%)} = \frac{\text{Initial weight} - \text{final weight}}{\text{Sample weight}} \times 100 \quad (1)$$

Reducing sugar, total sugar, sucrose and inverted sugar was determined by the following equations (2) to 4):

$$\% \text{ of reducing sugar} = \frac{\text{Inverted sugar (mg)} \times \text{dilution}}{\text{Titration} \times \text{wt. (mg) of sample}} \times 100 \quad (2)$$

$$\% \text{ of total sugar} = \% \text{ of reducing sugar} + \% \text{ of sucrose} \quad (3)$$

$$\% \text{ of sucrose} = \% \text{ of total sugar} - \% \text{ of reducing sugar} \quad (4)$$

% of total sugar as inverted sugar is also calculated from the equation (2), making use of titre value obtained in the determination of total sugars (Wani et al., 2019).

2.4.2 Ash content

The ash content was determined following the method by Naguib *et al.* (2021). About 5-10 g of sample were weighed accurately into a porcelain crucible which had been heated previously to 600°C and cooled. The crucible was placed on a clay pipe triangle and heated over a long flame until all the materials were completely charred followed by heating in a muffle furnace for about 3-4 hrs at 600°C. Finally, the ash content was calculated with the following equation (5).

$$\text{Percentage of ash} = \frac{\text{The amount of ash in the supplied Sample}}{\text{Sample weight}} \times 100 \quad (5)$$

2.4.3 Fat content

The fat content of the vegetable fish bar was determined by the Soxhlet method. To assess fat content, approximately 2-5 g of the vegetable fish bar sample was oven-dried to remove moisture. Then, the dried sample was taken in a thimble and fat was extracted using petroleum ether in a Soxhlet apparatus. Finally, the solvent was evaporated using a rotary evaporator and the residue was weighed to calculate the total fat content using the following equation (6):

$$\text{Fat (\%)} = \left(\frac{\text{Weight of Extracted Fat}}{\text{Weight of Sample}} \right) \times 100 \quad (6)$$

2.4.4 Protein content

To determine the protein content, approximately 1 g of the homogenized vegetable fish bar sample was weighed and digested with concentrated sulfuric acid to convert organic nitrogen into ammonium sulfate. Sodium hydroxide was added to the digested sample and distilled it to release ammonia with subsequent trapping the ammonia in a boric acid solution. Then, the trapped ammonia was titrated with hydrochloric acid to calculate the total nitrogen content. Finally, nitrogen content was converted to protein using a protein factor of 6.25 using the following equation (7):

$$\text{Protein (\%)} = \text{Nitrogen (\%)} \times 6.25 \quad (7)$$

2.4.5 Fiber content of the vegetable fish bar

The total dietary fiber (TDF) was determined as the sum of insoluble dietary fiber (IDF) and soluble dietary fiber (SDF) using an enzymatic-gravimetric procedure as specified by AOAC Official Method 2011.25 (Association of the Official Analytical Collaboration (AOAC) International, 2011). First, the sample was suspended in a phosphate buffer, treated with alpha-amylase at 100°C to hydrolyze starch, followed by protease at 60°C to digest proteins. Residual starch was further hydrolyzed at pH 4.2 with amyloglucosidase at 60°C. For IDF determination, the enzymatically treated mixture was filtered through pre-weighed filter paper containing Celite. The residue was washed sequentially with 78% ethanol, 95% ethanol, and acetone, dried at 105°C, and weighed to obtain IDF.

The filtrate from the IDF step was used to isolate SDF. Ethanol (95%) was added to precipitate the SDF, which was then filtered through pre-weighed Celite-containing filter paper. The residue was washed with 78% ethanol, 95% ethanol, and acetone, dried at 105°C, and weighed. Both IDF and SDF residues were corrected

for ash content by ashing at 550°C. The total dietary fiber (TDF) was calculated as the sum of IDF and SDF, expressed as a percentage of the sample's dry weight.

2.4.6 Carbohydrate and energy content of the vegetable fish bar

Total carbohydrate content was calculated by difference method following Ullah *et al.* (2020). The energy content of vegetable fish bars was determined using factors 4, 4, and 9 for carbohydrates, protein, and fat, respectively (Mcgill *et al.*, 2004).

2.5 Sensory evaluation

The prepared vegetable fish bar was deep-fried in oil for consumption. Appearance, taste, flavor, texture, and overall acceptability of the fried samples were assessed through sensory evaluation using a nine-point Hedonic scale following the method of Bergara-Almeida *et al.* (2002). A panel of 15 semi-trained diabetic patients conducted the assessment. They were instructed to rate the sensory characteristics (appearance, color, flavor, hardness, taste, and overall acceptability) of the vegetable fish bars coded with three-digit random numbers. The scale included descriptive terms that ranged from 'like extremely' (assigned a score of 9) to 'dislike extremely' (assigned a score of 1). The panelists were also asked about their preference for vegetable fish bar.

2.6 Statistical analysis

All the experiments were conducted in three replicates. Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) (version 26.0) for Windows (IBM Co., USA). The results were reported as the mean values accompanied by the corresponding standard deviations (SD). Additionally, a one-way analysis of variance (ANOVA) test was employed to compare various samples of vegetable fish bar. A significance level of less than 0.05 ($P < 0.05$) was

considered statistically significant for all tests.

3. Results and discussion

3.1 Proximate analysis of vegetable fish bar

Fish, vegetables and legumes are high in protein, fiber and micronutrients. Thus, legumes and fish consumption show better function of high-density lipoprotein (Hernández *et al.*, 2019). In addition, when combined, they complement each other's amino acid profiles and improve protein efficiency (Pellett and Young, 1988).

The proximate content of the vegetable fish bars was delineated in Table 2. The moisture content of the vegetable fish bar ranged from $11.9 \pm 0.17\%$ to $12.83 \pm 0.17\%$ (Table 2). However, the sample 1 exhibited significantly lower ($P < 0.05$) moisture content than others, indicating that it was drier compared to the other two samples (Table 2). These differences in moisture content could be attributed to the addition of water during the preparation of the vegetable fish bars and the moisture content of fish flesh and vegetables. The moisture content of the vegetable fish bars in the present study was significantly higher than the previous study by Aziz *et al.* (2012) where the moisture content of the cereal-based bar and meat-based bar has been reported about 7.89% and 28.01%, respectively. This discrepancy could be attributed to the fact that the above previous study analyzed the moisture content of the cereal or meat-based bar where as the present study analyzed the vegetables and fish-based bar.

The ash content of the vegetable fish bars was shown in Table 2 and it was observed that sample 2 contained higher ash content compared to the others. Potato, raw bananas, and red chili powder possess ash contents (Romauli *et al.*, 2021). Incorporating these ingredients in larger quantities in sample 2 compared to sample 1 and sample 3 could potentially result in higher levels of ash content in sample 2. Shikha (2021) developed a fish ball

Table 2. Proximate composition and nutritive value of vegetable fish bar.

	Sample 1	Sample 2	Sample 3
Moisture (%)	11.97 ± 0.17^a	12.83 ± 0.17^b	12.81 ± 0.12^b
Ash (%)	8.47 ± 0.26^a	9.89 ± 0.15^b	9.47 ± 0.30^b
Protein (%)	15.62 ± 0.37^a	17.17 ± 0.17^b	15.59 ± 0.27^a
Fat (%)	16.20 ± 0.10^a	14.91 ± 0.21^b	15.30 ± 0.47^{ab}
Crude fiber (%)	5.49 ± 0.13^a	6.60 ± 0.25^b	5.85 ± 0.08^a
Total carbohydrates (%)	42.42 ± 0.51^a	38.59 ± 0.03^b	40.96 ± 0.89^a
Total sugar (%)	3.57 ± 0.28^a	3.27 ± 0.39^a	2.96 ± 0.10^a
Reducing sugar (%)	1.09 ± 0.07^a	0.86 ± 0.07^a	0.98 ± 0.21^a
Energy (Kcal)	376.13 ± 0.55	357.24 ± 2.45	363.93 ± 2.40

Values are presented as mean \pm SD. Values with different superscripts within the same row are statistically significantly different at $P < 0.05$.

from silver carp fish and observed its ash content of about 2.05%, which is lesser compared to the present study. In addition, another study conducted by Surasani (2017) developed a fish cutlet and found its ash content of about 2.9%, which is also less than the vegetable fish bar prepared in this study. The addition of various vegetables and processing conditions may influence the high ash content of the vegetable fish bar of this study.

The fat content of the vegetable fish bars was shown in Table 2 and it was observed that sample 2 has significantly lower ($P < 0.05$) fat content than others. Chickpeas have high-fat content (Jukanti *et al.*, 2012). A greater quantity of this ingredient was incorporated in sample 3 compared to sample 2, it is worth noting that sample 1 does not contain chickpeas. Conversely, sample 1 featured a higher yogurt concentration than sample 2, while sample 3 did not include any yogurt. The disparity in the amounts of chickpeas and yogurt likely contributed to lower levels of fat in sample 2. Bhakha *et al.* (2019) observed fat content of snack bars made of pulse was about 1.9-3.6%, which is less than the present study. Since the vegetable fish bar is composed of fish, whereas the previously mentioned snack bars are cereal-based, it is noteworthy that the vegetable fish bar exhibits a higher fat content. However, Surasani (2017) observed a higher fat content (14.9%) in the fish cutlets made from Ruhi fish than the vegetable fish bars prepared in this study. The disparity in fat content could be attributed to variations in ingredient selection, processing techniques and cooking methods.

Foods rich in dietary fiber not only reduce the glycaemic index but also help to delay gastric emptying (Banka *et al.*, 2015). The fibre content of sample 1, sample 2 and sample 3 were $5.49 \pm 0.13\%$, $6.60 \pm 0.25\%$ and $5.85 \pm 0.08\%$, respectively (Table 2). The fiber content of sample 2 was significantly higher ($P < 0.05$) than the others (Table 2). Potato and bananas contain higher dietary fiber and adding these two ingredients in higher amounts in sample 2 than in sample 1 and sample 3 may likely contribute to elevated dietary fiber levels in sample 2 (Onwuka *et al.*, 2015; Furrer *et al.*, 2018).

The protein content of sample 1, sample 2 and sample 3 were $5.49 \pm 0.13\%$, $6.60 \pm 0.25\%$ and $5.85 \pm 0.08\%$, respectively and protein content did not significantly vary among the samples (Table 2). Bhakha *et al.* (2019) observed lower protein content that was estimated to be around 0.05%, 3.38 - 4.04% and 9.8% in the cereal bars compared to this study. As the main ingredient of the vegetable fish bars is fish, it may increase the total protein content of the vegetable fish bars.

The vegetable fish bar contains potatoes, which may

contribute to its total carbohydrate content (Onwuka *et al.*, 2015). Since the amount of added potato and banana varies among samples (Table 1), the percentage of carbohydrates differs among the samples (Table 2). Sample 1, sample 2 and sample 3 exhibited carbohydrate contents of $42.42 \pm 0.51\%$, $38.59 \pm 0.03\%$, and $40.96 \pm 0.89\%$, respectively (Table 2). Thus, the carbohydrate content of sample 2 was significantly lower than the other samples (Table 2). This difference in carbohydrate content could be attributed to the reduced amount of potato, banana and chickpea in sample 2 compared to the other two samples.

Foods low in sugar content are generally considered to have a low glycaemic index (Livesey and Taylor, 2008). The evaluation of sugar content in food is crucial to managing blood glucose levels effectively, the risk of mitigating chronic conditions such as obesity, and chronic diseases, and supporting the establishment of a well-balanced and nutritious diet (Venn and Green, 2007). Sample 1 has a total sugar content of about $3.57 \pm 0.28\%$, while sample 2 and sample 3 have about $3.27 \pm 0.39\%$ and $2.96 \pm 0.10\%$, respectively, with no significant differences among them.

3.2 Sensory evaluation of the vegetable fish bar

The vegetable fish bars were standardized in the laboratory for their portion size and cooking procedure. Three samples were served to the sensory panels. Deep frying of the vegetable fish bars enhanced the taste, appearance, aroma and texture of the fish bars. Apart from the nutritional aspect, these findings suggest that careful selection of ingredients and preparation methods is essential for creating appealing vegetable fish bars that retain their beneficial nutrients. Sensory evaluation was done using a nine-point hedonic scale for all the sensory attributes. The score for sensory attributes such as appearance, color, flavor, taste, hardness and overall acceptability of the different vegetable fish bars are shown in Table 3.

Sample 2 has significantly higher mean scores for colour ($8.27 \pm 0.71\%$), taste ($7.93 \pm 0.59\%$), hardness ($7.40 \pm 0.51\%$) and overall acceptability ($7.7 \pm 0.56\%$) compared to other samples. The positive results can be attributed to the modifications in the ingredients and processing techniques, leading to different scores for each sample. Thus, among the samples of vegetable fish bar, sample 2 exhibited the highest acceptability score than sample 1 and sample 3. So, sample 2 was considered a final vegetable fish bar product in this study.

Table 3. Sensory evaluation scores of vegetable fish bars.

Sensory parameters	Sample 1	Sample 2	Sample 3
Appearance	7.07±0.59 ^a	7.47±0.52 ^a	6.53±0.64 ^b
Color	7.33±0.82 ^a	8.27±0.71 ^b	7.60±0.74 ^{ab}
Flavor	5.87±0.35 ^a	7.13±0.52 ^b	6.93±0.46 ^b
Hardness	6.07±0.59 ^a	7.40±0.51 ^b	6.60±0.63 ^c
Taste	6.73±0.46 ^a	7.93±0.59 ^b	6.93±0.59 ^a
Overall acceptability	6.53±0.52 ^a	7.80±0.56 ^b	6.73±0.46 ^a

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different at P<0.05.

4. Conclusion

In the present study, a healthy and convenient vegetable fish bar using locally sourced ingredients was developed. These products are devoid of any artificial flavors or preservatives while being protein and mineral-rich. Sensory evaluation reveals the overall acceptability of the fish bars, particularly sample 2. Hence, this novel vegetable fish bar promises to be consumed as a nutritious alternative to its traditional commercial counterparts.

Conflict of interest

The authors declare no conflict of interest.

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