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# Development of High-Protein Bar Incorporated with Moringa Oleifera Flower

**Sanggary M Subramaniam[1], Hatijah Basri[1]***

[1] *Faculty of Applied Sciences and Technology, UTHM Kampus Cawangan Pagoh, Hab Pendidikan Tinggi Pagoh, KM 1, Jalan Panchor, 84600 Pagoh, Muar, Johor, MALAYSIA*

*Corresponding Author: hatijah@uthm.edu.my
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### Abstract

New approaches need to be considered to fulfil the demand for high-quality protein and alleviate environmental concerns. Currently, most sources of protein are highly processed leading to unhealthy diet. The purpose of this study was to develop high-protein organic bars by using organic ingredients in different proportions. Formed bars were stored at a temperature of 4°C for 10 hours and then proceeded with further analysis. Three formulations of high-protein organic bars were developed with base ingredients of dates (64g), apricots (16g), whey protein concentrate (12g) and cheddar cheese (8g) of the same proportions. Control bar (F1) consisted of only rice flour (15g) without the addition of chickpea flour and moringa flower powder as protein sources. F2 consisted of chickpea, rice flour and moringa flower powder in 5g each while F3 consisted of chickpea (2.5g), rice flour (2.5g) and moringa flower powder (10g). The control and formulated protein bars were analysed in terms of physical, physicochemical and sensory properties. From the current study, the protein content ranged from 3.88 to 11.47% among the formulated and commercial bars, in which F3 had the highest protein content among the formulated bars. Protein content for all the protein bars is shown to be non-significant with an F-value of 0.01 and a P-value of 0.99 (>0.05). Moisture content for all the protein bars is shown to be significant with F-value of 11.491 and a P-value of 0.009 (<0.050) in which F2 had the highest moisture content. In terms of texture, hardness and springiness is shown to be non-significant. It was observed that the water activity for the control and formulated the protein bars is shown to be significant with an F-value of 28 and a P-value of 0.001 (<0.05). Subsequently, pH for the control and formulated the protein bars is shown to be significant with an F-value of 22.75 and a P-value of 0.001 (<0.05). Results show that the sensory attributes for taste, aroma, texture, colour and overall acceptability were non-significantly higher (p>0.05) in F3 (code 054). These bars will raise consumer awareness of healthier protein bar options with high protein content and health related issues caused by high sugar intake.

## 1. Introduction

Global modernization has had a variety of effects on how people eat in society. Fast food consumption, the encouragement of healthy eating habits, and food accommodations have all had an impact on the growth of meal replacement products sold worldwide. "Meal replacement" foods—which include nutritious dish substitutes shaped as bars, powder, snacks, or soup or drink—are often used to replace entire meals (Szydłowska *et al.*, 2020) [17]. Because of their high protein, carbohydrate, fat, and mineral contents, food bars are well known for being excellent sensory and nutritional snacks (Nadeem et al., 2012) [12]. One of the item categories that is growing rapidly is high-protein bars. These nourishments are higher in proteins (>20g of protein per serving) and fibre, comprise less amount of sodium with carbohydrate substances and wealthy in vitamins, minerals, and cancer prevention agents. These high-protein bars are essentially committed to the target population who are physically dynamic and health-conscious (Szydłowska *et al.*, 2020) [17].

Snacks that are readily available on the market, like chocolate bars, extruded products, and potato chips, cannot satisfy the needs of a balanced diet. Convenience and nutrition are combined in food bars, a response to growing customer demand for nutrient-dense snacks (Nadeem *et al.*, 2012) [12]. These nutritionally dense bars can fulfil a multitude of needs and purposes when they are produced ethically and skilfully, thanks to variances in mineral and vitamin levels tailored to support certain goals. On the other hand, a protein bar can be thought of as a supplement bar that provides a fantastic way to increase protein intake (Mukherjee, 2021) [10]. These bars help you maintain a healthy weight, substitute meals, and get energy quickly. A vast array of food ingredients contributes to improved muscular function, increased physical output, increased endurance, and numerous other brain functions. [Jabeen and others, 2022) [5].

Deals involving meal replacement items were projected to be valued USD 15.1 billion globally in 2016 and to grow to USD 20.6 billion by 2021. Dinner replacements should provide 300 calories per serving, 8 to 10 grams of protein (or 2550% of an item's total energy), and 100% of the daily recommended intake of at least 12 essential vitamins and minerals. Regulation (EC) No 1924/2006 based on the nutrition and health claims made on foods states that a food can only be labelled as high in protein if protein makes up at least 20% of its calorie value (Szydłowska *et al.,* 2020) [17]. Not only are consumers making purposeful efforts to increase the amount of protein in their meals, but protein consumption has become one of the top 10 health concerns in the US. It has been shown that this important macronutrient enhances sensations of fullness, supports weight control, maintains lean muscle mass, and enhances athletic performance. The majority of customers are aware of this health benefit, which has contributed to the growth of the food, beverage, and supplement industries. Actually, 87% of consumers know that protein can help with muscular growth, and 72% think it helps increase feelings of fullness. Increasing the amount of protein in daily meal choices is highly prioritized, especially among millennials (Rock *et al.*, 2017) [14].

Active individuals should consume up to 2.0 g of protein per kg of body weight, which is 1.2 g more than the typical adult's recommended daily consumption, depending on the type of activity they engage in (Rock *et al.*, 2017) [14]. High-quality raw materials that contain biologically active compounds, or non-nutritive compounds combined with basic nutrients that exist in the product or raw material in its natural state after technological processing and influence the body's physiological and metabolic processes, are heavily used in the production of high-protein bars. Foods labelled as organic are believed to provide more nutrients than conventional foods. Organic plant raw materials are greater in dry matter, phenolic and polyphenolic compounds, vitamin C, particular mineral components, essential amino acids, and total sugars than conventional plant materials. However, they are lower in β-carotene amino acid. Furthermore, organic farming is always certified in compliance with stringent requirements, guaranteeing a transparent food chain (Szydłowska, 2020) [17].

Demand for proteins is rising along with global per capita income, especially dairy proteins, which are more popular than most plant-based proteins. Dairy proteins frequently have greater nutritional values. Dairy products, baked foods, infant formula, and canned milk are a few common uses for dairy protein. Dairy proteins are also sought after for their functional properties, and components are now commonly used as clean-label solutions. Dairy proteins separated from filtration methods is one of the greatest clean-label solutions (Carter *et al.*, 2021) [4]. Dairy products like WPI and cheddar cheese are excellent sources of proteins and bioactive peptides. Among the ingredients of the protein and vitality implanted bars, dates, dried apricots, cheddar cheese, whey protein isolate, chickpeas, and rice flour provide the physical and chemical intelligence. Natural products are often used to provide an essential amount of useful components and supplements. Its ability to hold onto water is increased by the expansion of high-fibre ingredients, such as chickpea flour, which delays the hydration process. Flour (rice and chickpea) is added to these bars to give them texture and shelf life (Jabeen *et al.*, 2022) [5].

In contrary with the health significance of the organic ingredients, this study is designed to develop high-protein bars prepared using moringa oleifera flower powder, whey protein concentrate (WPC), dates, cheddar cheese (CC), dried apricots, roasted chickpea flour and rice flour at different proportions. The high-protein bars analysis will be done based on compositional, moisture, texture profile, water activity, pH, sensory testing and statistical analysis. The consumer's acceptance towards the high protein bars formulation will be evaluated using the hedonic method of sensory evaluation.

## 2. Materials and methods

### 2.1 Materials, chemicals, instruments and equipments

Moringa oleifera flower, dates, dried apricots, cheddar cheese, roasted chickpea flour and rice flour, sieve, scissors, spoon, wooden ladles, bowls, cooking pan, stove, zip lock bags, electronic balance, food processor, basin, texture analyser using a 36 mm centrifuge, MX-50 moisture analyser, chromameter, pH 700 pH meter, Khind 26L electric oven, knife, chopping board, shredder, mortar and pestle.

### 2.2 Methods

#### 2.2.1 Preparation of Organic Ingredients

Three different formulations of high-protein bars will be prepared and designated as F1, F2 and F3 (Table 3.1). First, the dates were cut in half with a knife to remove the seeds. After cleaning and soaking with hot water, the dates and dried apricots will be ground into a paste using a food processor (Jabeen *et al.*, 2022) [5]. The dried dates will be soaked in hot water for 30 minutes along with the dried apricots before use and then will be shredded into a smooth mass (Szydłowska *et al.*, 2020) [17]. The cheddar cheese will be shredded with a shredder while chickpea and rice flours will be roasted (80°C/3 min) on a cooking pan placed on stove at medium heat (Jabeen *et al.*, 2022) [5]. Fresh mature moringa flowers (M. oleifera) were harvested from the tree using a scissors. Flowers were cleaned thoroughly in a basin with water to remove extraneous dirt, dried completely in a hot air oven at 45 ± 2 ∘C, ground in a grinder and sieved (#60 mesh sieves). The powder obtained was stored in an air-tight container at room temperature until further use (Madane *et al.*, 2019) [7].

**Table 3.1** *The formulations of high-protein organic bars (Jabeen et al., 2022)*

| Formulation | Dates (g) | Apricots (g) | Whey protein concentrate (g) | Cheddar cheese (g) | Chickpea flour (g) | Rice flour (g) | Moringa flower powder (g) | Total (g) |
|---|---|---|---|---|---|---|---|---|
| F1 | 64 | 16 | 12 | 8 | - | 15 | - | 115 |
| F2 | 64 | 16 | 12 | 8 | 5 | 5 | 5 | 115 |
| F3 | 64 | 16 | 12 | 8 | 2.5 | 2.5 | 10 | 115 |

#### 2.2.2 Formulation of Organic Ingredients

Based on Table 3.1, bar F1 contain 64 g dates, 16 g dried apricots, 12 g whey protein concentrate, and 8 g cheddar cheese. Bar F2 contained the same proportion of these ingredients with an addition of 5 g roasted chickpea flour and 5 g moringa oleifera flower powder, while bar F3 contained 2.5 g roasted rice flour, 2.5 g roasted chickpea flour and 5g moringa oleifera flower powder. Control bar F1 has no addition of chickpea and moringa oleifera flower powder (Jabeen *et al.*, 2022) [5]. An electronic balance was used to weigh the ingredients accurately.

#### 2.2.3 Production of High-Protein Organic Bars

All the grounded, shredded, and roasted ingredients and whey protein concentrate will be homogenously mixed with a ladle to form the dough, followed by sheeting and cutting into bars with a length of 6 cm, width of 2 cm, and depth of 1 cm (Jabeen *et al.*, 2022) [5]. Formed bars will be stored at a temperature of 4°C for 10 hours and then will be proceeded with baking at 130 °C for 15 minutes. Baked bars were set aside to cool and carried out with further analysis (Szydłowska *et al.,* 2020) [17].

**Equations**

Percentage of protein = (A-B) x N x 1.4007 x 6.25 / W (3.4)

A = amount of 0.2N HCl used in sample titration 52

B = amount of 0.2N HCl used in blank titration

N = normality of HCl

W = weight of sample (g)

1.4007 = atomic weight of nitrogen

6.25 = protein-nitrogen conversion factor

## 3. Results and discussion

### 3.1 Compositional Analysis

From the current study, protein content ranged from 3.88 to 11.47% among the formulated and commercial bars, in which the protein content is considered to be low when compared to previous studies. According to previous research, the average protein content in three protein bars #1, 2 and 3 were 22.3% ± 0.2%, 23.6% ± 1% and 23.2% ± 0%, respectively in 100/112g serving size, whereby the bars are known to be high in protein with percentages of more than 20 percent complying with the protein percentage of the FDA (Jabeen *et al.*, 2022) [2]. There was a non-significant difference observed between the control and formulated bars. It was observed that the F value of 0.01 is lower than the F-critical value of 5.14. Thus, protein content for all the protein bars is shown to be non-significant with an F-value of 0.01 and a P-value of 0.99 (>0.05).

**Table 4.1** *Protein content of high-protein organic bars*

| Formulation | Moisture |
|---|---|
| F1 | 3.88 |
| F2 | 4.07 |
| F3 | 4.69 |
| Commercial | 11.47 |

Table 4.1 shows that F1 had the lowest protein content of 3.88g among all the formulated bars. It can be inferred that the absence of chickpea flour and moringa flower powder affected the content of protein. F3 presented the highest protein content of 4.69g among the formulated bars in which F3 had twice the amount of moringa flower powder than in F2. On the other hand, the commercial bar showed protein value of 11.47g. According to the U. S. Food and Drug Administration (FDA), 5 % or less of the Daily Value (%DV) of protein is considered low while 20 % or more of protein is considered high (Stoody *et al.*, 2020) [16]. According to Szydłowska *et al.* (2020) [17], high-protein bars should contain other nutritionally advantageous ingredients in addition to a high protein content of 15–35 % w/w. In different research, the protein content ranged from 17.13 to 21.35 % which indicated that the variations in moringa flower treatments could be caused by various environmental factors, growth conditions and botanical origins. Shade-drying treatment proved to have an output of higher protein content (21.35) (Javed *et al.*, 2021) [6].

Another study indicated that the protein content of Moringa flowers ranged around 17.87 ± 0.28 % whereby the chemical composition depends on the edible part of a plant being analysed. Factors such as soil types, cultivars, stage of maturity of flowers and influence of the climatic or weather conditions in the region could attribute to different levels of protein content in the flowers (Madane *et al.*, 2019) [7]. Subsequently, the incorporation of additional high-protein components and production techniques like grinding or soaking in hot water may be the cause of the variations in the amount of protein added compared to the amount of protein acquired in the finished products. The production techniques which resulted in a reduction in the weight of the final products may have affected the protein content of the bars (Szydłowska *et al.*, 2020) [17]. It is concluded that the amount of chickpea flour and moringa flower powder should be increased along with improved production methods in the upcoming study to obtain high protein content of the bars.

The isolation of protein from Moringa flowers ranged from 85-90 % and 60 % for isolate and concentrate respectively (Javed *et al.*, 2021) [6]. According to Nadeem *et al.* (2012) [12], date bars' physical and chemical characteristics as well as their nutritional status have improved with the inclusion of whey protein concentrate and vetch protein isolate in the right amounts. In date bars, the protein content rose to 7.55 %. Other researchers found similar outcomes, observing that the addition of other protein-based additives increased the protein content of date bars from 10.7 to 12.1 %. Additionally, by fortifying specific types of flours, the protein content of bars can be raised. This process also enhances minerals like calcium, magnesium, sodium, potassium, zinc, and important amino acids without compromising the bars' sensory appeal.

## 3.2 Moisture

Moisture content is a crucial element that affects how long food will last on the shelf, which is also known as shelf stability of food. It is closely related to both the texture of food products and the proliferation of microbes (Jabeen *et al.,* 2022) [5]. The moisture content of the high-protein bars was determined by the MX-50 Moisture Analyzer after meshing all the samples in a pestle and mortar. The unit of moisture content was expressed in units of percentages. Table 4.2 shows the moisture content of all samples tested. The highest moisture content value was obtained on the protein bar F2. The dates and apricots contribute to high moisture content since they are fruits with high levels of humidity (Jabeen *et al.*, 2022) [5].

Another inference is made whereby the high moisture content is due to an equal amount of chickpea flour, rice flour and moringa powder added as 5 grams each compared to the other two formulations. Dry roasting of ingredients led to a reduction in water activity and moisture loss in the bars (Jabeen *et al.*, 2022) [5]. Sofi *et al.* (2020) [15] reported that the product's water absorption increased when chickpea flour was added. In the present study, roasted rice flour in F1 was added in 15 grams causing the moisture content to be lower in which roasting of rice flour causes moisture loss in the bars. In the contrary, the lowest moisture content was found in F3. Table 4.2 shows that the F value of 11.491 is greater than F-critical value of 5.143. Also, moisture content for all the protein bars is shown to be significant with an F-value of 11.491 and a P-value of 0.009 (<0.050).

Previous study shows that there was a non-significant difference (p > .05) in the moisture content of the protein bars which is 22.5 % ± 0.1 %. A nonsignificant effect is caused by the addition of ingredients such as dates, dried apricots and cheddar cheese which contributes to the prepared bars moisture content (Jabeen *et al.*, 2022) [5]. According to research on the creation of apricot date bars, adding dried apricot paste, which ranged in moisture content from 17.14 % to 19.21 %, considerably changed the moisture content of the bars (Nadeem *et al.*, 2012) [12]. The moisture contents of moringa flowers were in the range of 63.68 to 71.11 % which were in corroboration with the previous results of Aremu and Akintola, who observed the moisture contents of moringa flowers were 74.18 %. Varietal and environmental variations may have contributed to the small differences in observed values (Javed *et al.*, 2021) [6].

**Table 4.2** *Moisture of high-protein organic bars*

| Formulation | Moisture |
|---|---|
| F1 | 20.853±0.473 |
| F2 | 22.296±0.356 |
| F3 | 19.23±1.221 |

## 3.3 Texture Profile Analysis

Texture profile analysis is an instrumental texture approach in which two successive sample compressions are used to roughly simulate two bites by a consumer with output that has been used to describe the texture of many different foods (Banach *et al.*, 2016) [2]. Texture profile analysis of the high-protein organic bars was measured based on parameters such as firmness (g) and springiness (%).

### 3.3.1 Hardness

The effort required to crush a high-protein bar with the molars is known as sensory hardness (Jabeen *et al.*, 2022) [5]. According to Table 4.3, F3 had the lowest hardness value compared to the other formulations. This inference could be due to the amount of chickpea flour and rice flour used is less than the other bars. Thus, usage of less flour provides a less hard texture and structure of the bar. The added proteins are to keep the ingredients of snack bars intact, set the structure, increase the strength, and helps with water holding capacity. Subsequently, protein bars consisting of added proteins are indicated to have high fracturability force as the force continues with passage of time and an increase in the hardness of bars has been detected (Nadeem *et al.*, 2012) [12].

In the contrary, F2 had the highest hardness compared to the control bar, whereby equal amounts of chickpea flour, rice flour and moringa flower powder was added, each in quantity of 5 grams to make the bar. F1 had a slightly less hardness than F2 as there was absence of chickpea flour and moringa flower powder during the making of the bar. The F value of 0.172 is lesser than F-critical value of 5.143. Thus, hardness for the control and formulated the protein bars is shown to be non-significant with an F-value of 0.172 and a P-value of 0.846 (>0.050).

**Table 4.3** *Hardness of high-protein organic bars*

| Formulation | Hardness |
|---|---|
| F1 | 16266.17±1188.758 |
| F2 | 17490.98±1571.701 |
| F3 | 15828.34±668.1708 |

### 3.3.2 Springiness

Springiness is the ability to return to its original shape after removing the applied force. Based on Table 4.4, F2 has the highest springiness value compared to F1 which is the control bar and F3. It can be observed that F3 has the lowest springiness value compared to the other 2 bars. The F value of 1.586 is lesser than F-critical value of 5.143. Thus, springiness for all the protein bars is shown to be non-significant with an F-value of 1.586 and a P-value of 0.279 (>0.050).

**Table 4.4** *Springiness of high-protein organic bars*

| Formulation | Springiness |
|---|---|
| F1 | 32.117±0.836 |
| F2 | 98.317±3.913 |
| F3 | 88.617±0.794 |

Based on Table 4.4, F2 is noted to have the highest springiness value due to equal amounts of chickpea flour, rice flour and moringa flower powder added, each in quantity of 5 grams. Meanwhile in the control bar, F1, only rice flour was added and in 15 grams which contributed to slight hardening and less springiness compared to, F2. Consequently, F3 had the lowest springiness among all the other bars. Incorporating lesser amount rice flour compared to the other bars, caused a softer structure of the bar, thus leading to a lower springiness value. According to McMahon *et al.,* (2009) [9], moisture migration between carbohydrates (such as sugars and starches) and proteins may be the cause of the increasing stiffness in protein bars.

## 3.4 Water Activity

It was taken into account that F1 had the highest $A_w$ of 0.71 while the lowest $A_w$ of 0.69 was observed in F2. In a former research bar #1 has a considerably higher Aw since dates and apricots have a higher moisture content than other fruits (Jabeen *et al.*, 2022) [5], complying with the data of the current study. From the one-way ANOVA analysis, it was observed that the water activity for the control and formulated the protein bars is shown to be significant with an F-value of 28 and a P-value of 0.001 (<0.05). Thus, this research proves that the water activity of all the formulated bars is suited within the range of 0.6 and 0.9 with significant differences ($p<0.05$). However, when dry-roasted components were used in bars #2 and #3, the addition of rice and chickpea flours might have helped to lower the amount of $A_w$ (Jabeen *et al.*, 2022) [5]. Subsequently, Sofi *et al.*, (2020) [15] mentioned that the addition of chickpea flour increased the water absorption in protein bars. The protein bars' decreased moisture content and $A_w$ were probably caused by the addition of roasted rice and gram flour.

According to Szydłowska *et al.* (2020) [17], for both the P2 (pumpkin bar) sample and all coconut bars, the highest values of water activity were found ($p < 0.05$) while values for commercial protein bars ranged from 0.60 to 0.65. Foods classified as intermediate-moisture have water activity between 0.6 and 0.9, and high-protein bars are in this range Szydłowska *et al.* (2020) [17]. Previous study shows that the date nutrition bars' water activity varied from 0.62 to 0.73. The result from this study concurs with those of a recently published paper (Munir *et al.*, 2018) [11], which found that date bars had a consistent shelf life and a low water activity of between 0.5 and 0.6. Overall, the information gathered points to the date nutrition bars' stability and safety, which allows them to be labelled as ready-to-eat snacks. Another study conducted on the development of apricot date bars indicated that $A_w$ ranged from 0.534 to 0.546, and $A_w$ of bars was affected significantly with the addition of dried paste of apricots (Nadeem *et al.*, 2012) [12].

**Table 4.5** *Water activity of high-protein organic bars*

| Formulation | Water activity |
|---|---|
| F1 | 0.71±0 |
| F2 | 0.69±0 |
| F3 | 0.70±0.01 |

The results regarding the variation in $A_w$ are consistent with the research conducted by Estevez *et al.* (2000), which found that during storage, the $A_w$ level in cereal and nut bars dropped from 0.71 to 0.52 at 0 and 60 days, respectively. The two percentages of peanut or walnut (15 % and 18 %) added to the prepared cereal bars were the cause. This claim demonstrates how the decrease in the $A_w$ level of protein bars results from adding additional dry components during bar production. Moreover, food products with an $A_w$ of less than 0.7 have an excellent shelf life and are stable for around six months, according to Barbosa-Canovas *et al.* (2020). Subsequently, Sofi *et al.* (2020) mentioned that the addition of chickpea flour increased the water absorption in protein bars. It is probable that the protein bars' decreased moisture content and $A_w$ were caused by the addition of roasted rice and gram flour.

High water activity value of bars made of high proteins may be related to the high capacity of the type of protein-based ingredient used to significantly absorb water as evidenced by the research of Ren *et al.* (2012). According to the obtained results, it can be suspected that the addition of other types of proteins to food products may have a positive effect on reducing the water activity and modifying the textural parameters of the final product (Małecki *et al.*, 2020). In this study it is once again proven that the roasted gram flour and rice flour contributed to the protein bars' lower moisture content and $A_w$. According to the findings, the water activity of the moringa flower bars did not significantly change while they were being stored. The highest water activity was measured at 0.41 & 0.41 on days 14 & 28 of storage, and the lowest level (0.33) was recorded on day 21 of storage. Almost the entire storage period saw no change in the water activity. The differences between the study's results and Barrett *et al.* (2010)'s earlier findings could be caused by variations in the sugar level and treatments.

## 3.5 pH

The pH value was measured in triplicates of each sample using the pH meter. It is clear from Table 4.6 that the protein bar with the highest pH value of 5.073 is F2 whereas F3 claims the lowest pH of 5.04. The pH value range for newly created high-protein bars was 6.343 to 7.013 (Szydłowska *et al.*, 2020) [17]. Muesli-based bars containing high protein ingredients such as whey protein concentrate in different proportions had the greatest variation ($p < 0.05$), with respective values of 6.793, 7.013, and 6.334. The pH levels of the other two types of bars, pumpkin and coconut, were comparable at roughly 6.9 ($p > 0.05$) as these bars had high amount of whey protein concentrate added as well during development of the bars (Szydłowska *et al.*, 2020) [17]. It was observed that the F value of 22.75 is more than F-critical value of 5.143. Thus, pH for the control and formulated the protein bars is shown to be significant with an F-value of 22.75 and a P-value of 0.001 (<0.05). Thus, pH for all the protein bars is shown to significant ($p<0.05$).

**Table 4.6** *pH of high-protein organic bars*

| Formulation | pH |
|---|---|
| F1 | 5.07 |
| F2 | 5.073 |
| F3 | 5.04 |

The pH of the moringa flower incorporated bars was shown to be significantly impacted by the length of storage. The pH was highest (6.74) on the first day of storage and lowest (6.19) on the 28th. The reason for the pH's progressive drop during several storage days was an increase in acidity; nonetheless, the texture and flavour were mostly unaffected. The outcomes of this investigation supported the earlier conclusions made by Arise *et al.*, (2014) [1].

### 3.6 Sensory evaluation

In a former study, 9-point hedonic scale with a range of "1 dislike-extremely to 9 like-extremely" was used to rate the product's taste, scent, texture, colour and general acceptability for a sensory evaluation (Jabeen *et al.*, 2022) [5]. Therefore, in this study twenty-five untrained panellists consisting of UTHM students and staff took part to evaluate on high-protein organic bars made from moringa oleifera flower powder, dates, cheddar cheese (CC), dried apricots, roasted chickpea flour and rice flour which was conducted at the UTHM Sensory Analysis laboratory. The sensory evaluation was carried out in well-ventilated sitting compartments (cabins) with excellent illumination facility at an ambient temperature of 20-25 °C. Throughout the review, water was provided to each panellist so they may rinse their mouths before evaluating the following bars. The sensory attributes that were evaluated include taste, aroma, texture, colour and overall acceptability of the high-protein organic bars. Moreover, the nine-point hedonic scale ranging from 1 = dislike extremely and 9 = like extremely meant that the highest scale indicated the most preferred attribute while the lowest scale indicated the least preferred attribute.

**Table 4.7** *Sensory evaluation of high-protein organic bars*

| Formulation | Taste | Aroma | Texture | Colour | Overall |
|---|---|---|---|---|---|
| F1 | 7.2±1.35 | 6.88±1.40 | 6.8±1.19 | 6.4±1.35 | 7.08±1.15 |
| F2 | 6.36±1.68 | 6.68±1.38 | 6.16±1.57 | 6.24±1.5 | 6.72±1.31 |
| F3 | 6.2±1.83 | 6.72±1.31 | 6.8±1.22 | 6.56±1.16 | 6.64±1.47 |

The sensory attributes of high-protein organic bars in different formulations such as taste, aroma, texture, colour and overall acceptability are observed to be significantly different. Based on Fig. 4.6, F1 (code 932) had the highest score of 7.2 for the taste category and among all the formulated bars. Szydłowska *et al.* (2020) [17] stated that there was a positive impact on the overall sensory quality of high-protein bars caused by fruit flavour, which the current study utilized dates and apricots for the development of the high-protein organic bars.

In a different study, the authors evaluated recently created date bars and discovered that there was poor overall approval (3.7–3.8 on a 7-point hedonic scale). A high-protein diet bar containing chia seeds was assessed in related investigations. The majority of consumers intended to purchase this product since it met their expectations about organoleptic standards (Veggi *et al.*, 2018) [18]. Previous studies have indicated that bars incorporated with whey protein concentrate received the greatest rating marks. In the bars with the highest ratings, the evaluators found that the exterior look, colour and taste sensations were the most pleasing. The evaluators concluded that good consistency, taste, and colour are linked to high evaluations for these kinds of protein bars (Małecki *et al.*, 2020) [8].

The low score of 6.4 for colour in was detected F1 was due to the absence of moringa flower powder which contributes a darker colour to the bar. It was also inferred that F1 (code 932) was the most preferred bar among all the other bars with an overall score of 7.08. In terms of aroma, F1 (code 932) anticipated the highest score of 6.88 compared to F2 (code 223) and F3 (code 054). F1 (code 932) and F3 (code 054) seemed to have the same score for texture (6.8) compared to F2 (code 223) which held a lower score of 6.16. The sensory assessment of these products may shift as a result of protein enrichment in bars. Apart from the aroma and flavour, one of the primary differentiators is the consistency. Bars with high protein content may become harder with time. The primary cause of the physicochemical alterations in the bars is water loss during storage. In contrary, whey protein concentrate was discovered to preserve a softer bar texture over time, however it may also have an unpleasant taste.

On the other hand, the attribute of colour presented a high score of 6.56 for F3 (code 054). This could be due to the moringa flower powder having a darker colour in comparison with the other ingredients used to develop the high-protein organic bars and the incorporation of higher amount of moringa flower powder (15 g) compared to the other formulations. Results show that the sensory attributes for taste, aroma, texture, colour and overall acceptability were non-significantly higher ($p>0.05$) in F3 (code 054) compared to all the other bars. It was taken note that incorporation of higher amount of moringa flower powder contributed to a much darker colour for protein bar of F3. Thus, while creating new products, attributes like taste, aroma, texture, colour and general quality are crucial.

## 4. Conclusion

In this study, the incorporation of organic ingredients such as moringa oleifera flower powder, whey protein concentrate (WPC), dates, dried apricots, cheddar cheese (CC), dried apricots, roasted chickpea flour and rice flour were intended to develop high-protein organic bars as protein-based snacks nowadays are highly processed with added sugars leading to a unhealthy diet. The aim was to deliver these high-protein bars for the health-conscious community. Subsequently, moringa leaves have been highly utilized to make snacks and meals. This research has purpose to implicate the use of moringa flowers to create high-protein bars instead of leaves as protein source. The use of organic ingredients produced protein bars of high acceptability by the panellists. The addition of moringa flower powder improved the sensory attributes of protein bars. Whilst development of protein bars made from organic ingredients was a success, the objective to formulate high-protein organic bars was not fully achieved due to the low protein level detected which did not meet the range of high protein level for high-protein bars as expected.

To conclude, the protein content of the prepared and commercial bars varied from 3.88 to 11.47%. A non-significant variation was noted between the formulation and control bars. Out of all the designed bars, F3 had the highest protein level (4.69g), and it contained twice as much moringa flower powder than F2. Regarding hardness and springiness values, there was no significant difference ($p>0.05$) seen in the texture profile analysis (TPA) between the formulation and control bars. It is evident that the developed bars had no bearing on the hardness product attribute. Also, moisture content for all the control and formulated protein bars is shown to be significant with a P-value of 0.008 ($<0.05$) while water activity for all the control and formulated protein bars is shown to have non-significant differences ($p>0.05$). On the other hand, pH for all the protein bars is shown to be non-significant ($p>0.05$) as well.

The sensory assessment of the protein bars revealed that the sensory characteristics of the formulation and control bars did not significantly differ from one another. Results show that the sensory attributes for taste, aroma, texture, colour and overall acceptability were non-significantly higher ($p>0.05$) in F3 compared to control. Formulation 3 resulted a greater approval in terms of its flavour, aroma, texture, colour and general acceptability when compared to formulation 1 and 2. This inference could be due to the addition of chickpea flour, rice flour and higher amount of moringa flower powder incorporated into the bar compared to the other formulations. The findings revealed that the moringa flower powder and chickpea flour as good protein sources are convenient to be added during the development of the bars without affecting the sensory attributes, textural attributes, moisture content, water activity and pH.

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## Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

*The author confirms sole responsibility for the following:* ***study conception and design***, ***data collection***, ***analysis and interpretation of results***, *and* ***manuscript preparation:*** *Sanggary M Subramaniam, Hatijah Basri. All authors reviewed the results and approved the final version of the manuscript.*

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