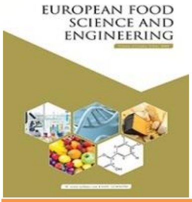


**European Food Science and Engineering**

Eur Food Sci Eng 2022, 3 (2), 52-57
doi: 10.55147/efse.1166320
https://dergipark.org.tr/tr/pub/efse

# Vegan and gluten-free granola bar production with pumpkin

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## ARTICLE INFO

***Research Article***
***Article History:***
Received: 25 August 2022
Accepted: 18 December 2022
Available Online: 30 December 2022
***Keywords:***
Gluten-free
Functional food
Granola bar
Celiac
Vegan

## ABSTRACT

The main objective of this study is to produce alternative snacks that will satisfy the needs of vegans and those with celiac disease. For this purpose, bars containing various fruits, dried fruits, nuts and spices were produced. To accomplish this, 7 different formulations were prepared using the design expert. While the ratio of pumpkin and banana was changed in the mixture, the ratios of other ingredients (oats, raisins, cranberries, pumpkin seeds, coconut oil, spice mix, flaxseed) were kept constant. The protein content of the bar samples ranged between 6.28% and 13.39%, and this value increased as the amount of pumpkin increased. The hardness values of the bar samples were determined between 2751.56 and 4469.53 G. Bars with more than 165 g of pumpkin and more than 112.35 g of bananas had a lower hardness value. In the sensory analysis, the gluten-free bars produced were appreciated by the panelists. There was no statistical difference in the ash content and $L^*$, $a^*$, $b^*$, $C^*$ color values of the gluten-free bars. The samples were optimized considering their protein content and sensory properties. The formulation with the highest acceptability value (0.884) was determined as the sample containing 75.79 g of banana and 184.21 g of pumpkin.

## 1. Introduction

In recent years, dietary habits have changed dramatically around the world. In food products; it is seen that there is a conscious consumer group that prefers snacks with ingredients such as "no added sugar", "source of fiber", "rich in protein", "reduced calories", and “gluten-free”, “low sodium". This situation causes the demand for functional foods to increase day by day. Functional foods can be defined as foods that increase the quality of life with their physiological active ingredients as well as being nutritious with the nutrients they naturally contain. Today, new snacks with balanced sugar, salt, saturated fat and calorie contents are designed depending on the healthy nutrition demands of consumers. Considering the aforementioned demands, depending on the increase in the consciousness level of the consumer, a wide variety of diets emerge, preferably or due to health problems. One of these diets is gluten-free food products suitable for the consumption preferences of celiac patients and the other is a vegan diet.

Some grains and grain products taken into the body with the daily diet cause some allergic reactions in the body of individuals with a weak immune system. Celiac disease is the most common allergy disease caused by food consumption in the world. It is an auto-immune (allergic) and chronic small intestine disorder that occurs in individuals with a high genetic predisposition and weak immune and digestive systems. It occurs when the body cannot tolerate the gluten protein found

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in wheat, barley, rye, oats and bakery products taken in the daily diet. The disease is accelerated in susceptible individuals by ingestion of cereal proteins, particularly the gliadins of wheat gluten and similar prolamins in rye and barley. Celiac disease can be defined as an immune-mediated systemic disease triggered by ingestion of the gliadin fraction of wheat gluten in genetically predisposed individuals. The gliadin peptides, which are a fraction of gluten, can activate cells involved in innate immunity such as macrophages, dendritic cells and cytotoxic intraepithelial lymphocytes, or have a direct toxic effect on enterocytes (Prandi et al., 2017). Strict adherence to a gluten-free diet is essential for mucosal healing and prevention of associated complications such as intestinal lymphoma. The main causative agent in celiac patients is the gliadin fraction of gluten. All types of structural gliadins (α, β, γ, and ω) are active and are involved in a rapid cytotoxic effect in the intestinal epithelium and an immune response involving T cells that recognize specific prolaminepitopes (Molberg et al., 2005).

Vegans, on the other hand, have adopted a diet and lifestyle in which they do not consume or use any animal food (red meat, chicken, fish, etc.) and secondary animal products (milk and dairy products, eggs, etc.) of animal origin (wool, leather, etc.). There are many in vivo, in vitro and clinical trial data showing that a plant-based diet can reduce the risk of chronic disease, especially cancer. Since their diet includes vegetables, fruits, legumes, grains and oil seeds (nuts such as almonds, hazelnuts, peanuts) and they do not consume foods of animal origin, they especially suffer from deficiencies of saturated fatty acids, vitamins D and B12, iron and zinc minerals (Craig, 2009).

Pumpkin (*Cucurbitamoschata*) is a fibrous and orange-colored fruit from the *Cucurbitaceae* family that grows in temperate climates. Pumpkin can be consumed directly, or it can be used as a raw material in the production of bread, soup, cookies, puree, jam and syrup by going through various processes. Pumpkin is a nutritious food in terms of protein and carbohydrate content, but also has a high content of vitamins and minerals. It is especially rich in calcium, potassium, magnesium and phosphorus and contains significant levels of vitamins A, C and B2 and carotenoid substances. Pumpkin is an important fruit with a high potential for use in the food industry, as it has positive effects on health such as being rich in fiber and carotenoids (Kaur et al., 2020). As a result of studies, it has been determined that a diet with high pumpkin consumption reduces the risk of lung, stomach, colon and breast cancer, as well as pumpkin oil reduces the risk of high cholesterol and hypertension (Białek et al., 2015). Alkaloids (180 mg/100 g) contained in pumpkin prevent microorganisms (bacteria, fungi, protozoans, etc.) and thus the onset of different diseases. Tannins have astringent properties such as wound healing and inflamed mucous membranes (Rajasree et al., 2016). In addition to the high nutritional properties of pumpkin as a good raw material, it provides great advantages in the production of products such as bread, pasta and cakes due to its fibrous structure.

Banana is a very popular fruit in the world market due to its importance as a food crop. It is cultivated in more than 130 countries; It is mostly in tropical and subtropical regions and has a Southeast Asian origin. Economically, it is the fifth agricultural food product after coffee, grain, sugar and cocoa in terms of world trade. Banana fruit is a rich source of important phytonutrients, including vitamins and phenolic compounds (Lim et al., 2007; Wall, 2006). It is also rich in minerals such as phosphorus, sodium, potassium, calcium, magnesium, iron, copper, zinc and manganese (Forster et al., 2003). Including bananas in recipes for many food products improves total dietary fiber, resistant starch, total starch, and some essential minerals (phosphorus, magnesium, potassium, and calcium). The use of banana as an ingredient in different food products has a beneficial effect on human health. Banana has a high content of potassium, iron and is effective in controlling blood pressure as it has low salt and high potassium content. The serotonin hormone found in bananas helps in changing mood and overcoming depression. Banana fruit contains resistant starch, which is less digestible, unlike cereal starches with a high glycemic index. Resistant starch in bananas is suitable for the diet of heart patients and diabetics due to its positive effects on the human intestine (Alarcon-Aguilara et al., 1998).

Oats come to the fore in human nutrition with their protein quality, high unsaturated fat and fiber content and antioxidant richness. Thanks to the nutrients it contains, oat grains have positive effects on chronic diseases such as cholesterol, diabetes, anemia, cardiovascular diseases and colon cancer. Oat consumption in the human diet has increased due to the health benefits associated with dietary fibers such as β-glucan, functional protein, lipid and starch components, and phytochemicals found in the oat grain. Considering the nutritional benefits of oats, its use in the food industry has become widespread in the production of baby foods, bread, oat milk, breakfast cereals and biscuits (Ballabio et al., 2011; Rasane et al., 2013).

Snacks are preferred due to various health benefits such as increased expectations of healthy eating, people with vegan diets having problems with assortment, appetite control in people with diabetes, body weight regulation and improved blood sugar control (Cowan et al., 2020). It is noteworthy, however, that people are often motivated to consume snacks as an alternative to excess food portion sizes and energy density. In order to contribute to what can be done about alternative food products that can be reached by people with different nutritional diets, enrichment of snacks consumed between meals in terms of protein, fatty acids and dietary fiber is applied as important approaches (Morris et al., 2019). Academic and industrial studies on this subject are increasing day by day.

The main purpose of this study is to design alternative snacks that will meet the expectations of celiac patients and vegans. For this purpose, gluten-free vegan granola bar formulations have been created, with improved functional properties with the addition of various fruits, spices and dried fruits. The formulation parameters were evaluated and optimized using the D-Optimal Mixture design. By using experimental design, the number of experiments needed is significantly decreased, the interactions and effects of the process variables are assessed, and the knowledge required to produce the best product is provided.

## 2. Materials and methods

### 2.1. Materials

In this study, all the ingredients used in granola bar formulations (pumpkin, banana, oats, raisins, cranberry, inner pumpkin seeds, coconut oil, flaxseed, turmeric, cinnamon, allspice and nutmeg), dough mixer and granola bar molds obtained from the local market. All chemicals used were of an analytical grade and obtained from Merck (Germany).

### 2.2. Experimental design

D-Optimal Mixture design was selected to evaluate and optimize the formulation parameters. The experimental design matrix and all data analyses were performed using Design-

Expert® (version 7.0, Stat-Ease Inc., Minneapolis, MN, USA).For mixture preparation processes, 9 mixture components (pumpkin, banana, oat, raisin, cranberry, pumpkin seed kernel, coconut oil, spice mixture, flaxseed) were determined. Considering the large number of these mixture components and the complexity of the analysis of the data to be obtained, only the proportions of pumpkin and banana were included in the mixture experiment design, and the ratios of other components were kept constant. Spice mixtures consist of ginger, cinnamon, nutmeg and allspice in the same proportions. The lower/upper levels of each determined categorical factor were determined by preliminary trials. The D-optimal Mixture experimental design trial plan and levels, which were created to determine the mixing ratios in the production of gluten-free and vegan granola bars from pumpkin, can be seen in Table 1.

**Table 1.** D-optimal Mixture Design levels in the mix preparation process

| Symbols | Mix Components | Lower/Higher Ratios | |
|---|---|---|---|
| $X_1$ | Banana (g) | 130 | 200 |
| $X_2$ | Pumpkin(g) | 60 | 130 |

Fixed mix components: Oat 120 g, raisin 30 g, cranberry 30 g, pumpkin seed kernel 20 g, coconut oil 10 g, spices 2 g each (total 8 g), flaxseed 2 g (overall 480 g).

### 2.3. Gluten-free and vegan granola bar production of pumpkin

Samples of pumpkin gluten-free and vegan granola bars were carried out using gluten-free oats. It was tried to reach the most efficient final product formulation by making changes in the ratios of pumpkin and banana from the liquid components in the product. First of all, the skins of the pumpkins and bananas were separated, and each sample was weighed (Shimadzu ATX-224, Japan) and bagged separately in order not to spoil, and stored at +4 °C in the refrigerator (Profilo BD2155WFNN, Turkey). Then it was taken out of the freezer and the liquid ingredients were mixed in the dough mixer (Cookplus Promix Ef802, Turkey) for about 8-10 min homogenized. Dry ingredients and spices were added to the mixer and mixed until the desired dough consistency was obtained. 480 g dough was distributed evenly in 8 granola molds, and the baking process was applied for 25 minutes in an oven (FIMAK, Turkey) at 175 degrees. The cooked granola bars were cooled and removed from the mold, and finally, they were wrapped in aluminum foil to be prepared for analysis and stored in the refrigerator at +4 °C. Production stages of granola bars can be seen in Figure 1.

### 2.4. Quality analysis of gluten-free bar

#### 2.4.1. Protein concentration value of gluten-free bar

Protein analysis was performed with protective gloves, solution preparation glass and materials, sulfuric acid, catalyst, NaOH solution, Boric acid, methyl blue-bromcresol green indicators and Kjeldahl analyzer. For protein analysis, 0.5 g of the sample was placed in Kjeldahl tubes, and then 20 ml of $H_2SO_4$ and 2 Kjeldahl tablets were added to it, allowing it to be burned in the incinerator at 400°C for 30 minutes. After cooling, 90 ml of distilled water was added and the samples were placed in the distillation device. For distillation, 3 drops of methyl blue and bromcresol green indicator were added to 2% boric acid solution and titrated with 0.1 N HCl solutions, and the amount spent was determined and calculations were made (Jiang et al., 2014).

#### 2.4.2. Oil contents of gluten-free bar

Total oil contents of granola bar samples were determined by Soxhlet oil extraction device according to the AOAC (2000) method. 5 g of the weighed sample and n-hexane were added to the Soxhlet cartridges and the extraction process was applied for 3 hours. At the end of the period, the solvent was separated with the help of the Rotary Evaporator and the glass balloons were kept in the oven at 105°C for 1 hour and the remaining solvent was removed. The oil content in the sample was determined as a percentage (Jiang et al., 2014).

#### 2.4.3. Color measurement

Granola bar color parameters were defined by calorimeter device and CIELAB system. Reading values were displayed according to the CIELAB system of color measurement. The $L^*$ (brightness), $a^*$ (± red-green) and $b^*$ (± yellow-blue) values of the samples were measured and using these values the chroma (C*) values were determined by the Eq. (1) (Jiang et al., 2014).

$$C^* = \sqrt{(a^*)^2 + (b^*)^2} \quad (1)$$

**Figure 1.** Production phase of vegan and gluten-free granola bar with pumpkin

#### 2.4.4. Ash content (%)

Ash content analysis was made according to AOAC (1997). The crucible to be used in the analysis was dried in an ash furnace at 650°C and cooled in a desiccator. 2-5 g samples were placed in the cup and weighed, and the samples were burned at 650°C for 3 hours. After the crucible cooled in the desiccator, the % ash to be weighed was determined (Jiang et al., 2014).

An oven was used to determine the moisture content. With the constant weight weighing method, it was kept in an oven at 130 °C with two repetitions and the measurement was made when it came to constant weighing (Jiang et al., 2014).

#### 2.4.5. Texture analyses

The textural properties of the granola bar samples were carried out using a texture analyzer (TA.HD Plus, Stable Micro System, Godalming, UK). A 5 kg load cell was used in the analysis. The force required to break the granola bar samples was determined using the 3-point bending apparatus. It was calculated using the device software from the force graph corresponding to the time obtained during the measurement (Jiang et al., 2014).

#### 2.4.6. Sensory properties

Sensory analysis; 7 samples obtained with experimental designs were evaluated by 10 semi-trained panelists. A panelist team consisting of 5 men and 5 women aged between 24 and 40 who were not allergic to the components in the samples was formed. 15 g of each sample were weighed into transparent plastic cups and 3-digit random codes were given. The scoring process was evaluated as 1 worst and 5 best. While going from one sample to the next, the panelists will be asked to eat unsalted crackers and start testing the other sample after drinking water (Savaş, 2014).

### 2.5. Statistical analysis

Statistical Analysis; All analyzes were performed with at least 2 replications, and the data obtained considering the standard deviation values were evaluated by analysis of variance (ANOVA) in the SPSS program (SPSS 16.0). Duncan test was used to determine statistical difference. The D-Optimal Mixture experimental design matrix and all data analyses were performed using Design- Expert® (version 7.0, Stat-Ease Inc., Minneapolis, MN, USA).

## 3. Results and Discussion

In this study, according to the D-optimal Mixture experimental design, seven experimental studies were carried out in 2 parallels and the results obtained in each experimental points (protein content, textural hardness value and sensory analysis) are tabulated in Table 2. The number of experimental points was kept as low as possible in order to make a healthier evaluation in the sensory analysis process. The protein content of the produced granola bar was determined in the mixture containing 77.64 g of banana and 182.36 g of pumpkin. According to the created experimental equation, the protein content of the granola bar produced increased with the increase in the pumpkin. This increase is statistically significant ($p<0.05$). Another significant factor that affects a food product's overall quality and consumer acceptability is its texture. Combining fruit (banana and pumpkin) in different proportions may have resulted in products with varying levels of hardness. In the textural hardness analysis, it was observed that increasing the amount of pumpkin to 165 g increased the hardness, while the addition of more than 165 g pumpkin decreased the hardness. Likewise, Róyo et al. (2014) reported that adding pumpkin puree to bread affects the hardness of the bread. Similarly, increasing the amount of banana to 112.35 g increased the hardness, while the addition of more than 112.35 g of banana decreased the hardness. High hardness values are an undesired feature of cereal bars (Samakradhamrongthai et al., 2021). The product must therefore be added the proper quantity of banana and pumpkin to provide it the correct balance of hardness. The granola bars showed sensory rating scores in the range from worst to best: taste (3.13–3.58), smell (3.46–4.25), chewiness (3.46–4.13), tooth adhesion (3.95–4.34), color (4.06–4.35), and general acceptability (3.53–3.98) as shown in Table 2. In sensory analysis, there was no statistically significant difference between experimental points for taste, tooth adhesion, appearance, color, and general acceptability parameters. The smell and chewiness parameters tended to increase as the ratio of both pumpkin and banana increased. This was to be expected as the addition of fibrous ingredients generally affects the texture of foods, increasing chewiness, and many consumers prefer chewiness as a desirable quality in cereal bars (Bower & Whitten, 2000, Carvalho & Conti-Silva, 2018).

Comparisons were made with an equivalent product of a well-known brand in the market for optimization processes in the creation of gluten-free vegan granola bar formulations with improved functional properties by adding various fruits, spices and dried fruits. The protein, fat and hardness values of the equivalent product obtained from the market were found as 12.94, 4.2, and 5745 G, respectively. The equivalent product contains oat, apricot, date, hazelnut, cinnamon, apple concentrate. Optimization process; it was determined by considering the conditions where protein content, flavor, appearance properties, color and general acceptability were the highest, and the textural hardness, tooth adhesion, and smell properties were similar to the equivalent product. As a result of the optimization process, it was found that the product formulation of 75.79 g of banana and 184.21 g of pumpkin had the highest desirability value. The acceptability (desirability) value was determined as 0.884 with these formulation ratios. Since this value is very close to 1, validation of the optimization process gives good results. The optimum formulation data obtained according to the D-Optimal mixture experimental design study are in Table 3. In this experimental design, the fit of the data to the second/third order models was analyzed by ANOVA. A high (close to 1) $R^2$ coefficient is considered as evidence of the applicability of the regression model over the range of variables included. $R^2$ values for protein, textural hardness, taste, smell, chewiness, tooth adhesion, appearance, color, general acceptability parameters are 0.8816, 0.9226, 0.7381, 0.7519, 0.5798, 0.5660, 0.7143, 0.7454, 0.7281, respectively (Table 4). Relative scoring in the sensory analysis section caused some parameters to have low $R^2$ values. The other quality analysis results of the granola bar we have produced can be seen in Table 5. When the quality analyzes of the experimental points were examined, it was seen that the amount of ash did not create a statistically significant difference, there was no correlation in moisture and fat content. The moisture content which plays significant role in determining the shelf life was ranged from 37.31 to 44.10%. Kaur et al. (2018) found the mean moisture content of the cereal bar containing quinoa, brown rice, flaxseed and dried fruits to be 8.53%.

**Table 2.** D-optimal Mixture Design experimental parameters and the observed response values for gluten-free and vegan granola bar

| Experimental Points | Banana (g) | Pumpkin (g) | Protein (%) | Textural Hardness (G) | Sensory Analysis | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Taste | Smell | Chewiness | Tooth Adhesion | Appearance | Color | General Acceptability |
| **1** | 130 | 130 | 6.28±0.03$^{a}$ | 3593.42±233$^{b}$ | 3.58±0.12$^{a}$ | 4.15±0.12$^{bc}$ | 4.13±0.13$^{b}$ | 4.17±0.74$^{a}$ | 3.95±0.59$^{a}$ | 4.35±0.12$^{a}$ | 3.74±0.72$^{a}$ |
| **2** | 112.35 | 147.65 | 8.03±0.94$^{b}$ | 4469.53±80$^{c}$ | 3.13±0.13$^{a}$ | 3.46±0.13$^{a}$ | 3.46±0.18$^{a}$ | 3.95±0.59$^{a}$ | 3.80±0.77$^{a}$ | 4.06±0.49$^{a}$ | 3.53±0.79$^{a}$ |
| **3** | 130 | 130 | 7.52±0.11$^{b}$ | 3447.04±301$^{b}$ | 3.34±0.25$^{a}$ | 3.97±0.18$^{bc}$ | 3.87±0.21$^{ab}$ | 4.09±0.61$^{a}$ | 3.77±0.46$^{a}$ | 4.31±0.18$^{a}$ | 3.98±0.42$^{a}$ |
| **4** | 60 | 200 | 11.39±0.83$^{c}$ | 2751.56±286$^{a}$ | 3.40±0.97$^{a}$ | 4.25±0.19$^{c}$ | 4.06±0.16$^{b}$ | 4.34±0.48$^{a}$ | 3.92±0.06$^{a}$ | 4.14±0.70$^{a}$ | 3.73±0.81$^{a}$ |
| **5** | 95 | 165 | 10.62±0.63$^{c}$ | 4416.99±75$^{c}$ | 3.26±0.79$^{a}$ | 3.73±0.11$^{ab}$ | 3.80±0.05$^{ab}$ | 4.33±0.32$^{a}$ | 4.26±0.58$^{a}$ | 4.33±0.57$^{a}$ | 3.80±0.72$^{a}$ |
| **6** | 60 | 200 | 13.06±0.62$^{d}$ | 3045.14±471$^{ab}$ | 3.26±0.75$^{a}$ | 4.01±0.25$^{bc}$ | 3.94±0.05$^{ab}$ | 4.18±0.64$^{a}$ | 3.80±0.18$^{a}$ | 4.12±0.41$^{a}$ | 3.71±0.64$^{a}$ |
| **7** | 77.64 | 182.36 | 13.39±0.31$^{d}$ | 3616.62±167$^{b}$ | 3.53±0.45$^{a}$ | 3.66±0.44$^{ab}$ | 3.46±0.40$^{ab}$ | 4.26±0.56$^{a}$ | 4.13±0.51$^{a}$ | 4.26±0.37$^{a}$ | 3.80±0.16$^{a}$ |

Data were expressed by means ± standard deviation. Values followed by different letter in the same column are significantly different ($p < 0.05$).

**Table 3.** Optimal formulation data obtained according to D-Optimal mixture experimental design study

| Banana (g) | Pumpkin (g) | Protein (%) | Textural Hardness (G) | Taste | Smell | Chewiness | Tooth Adhesion | Appearance | Color | General Acceptability | Desirability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 75.79 | 184.21 | 11.66 | 3810 | 3.52 | 3.73 | 3.66 | 4.23 | 4.20 | 4.32 | 3.85 | 0.884 |

**Table 4.** Summary of ANOVA analysis (p value) according to each response generated as a result of D-Optimal mixture design

| Source | Protein (%) | Textural Hardness (G) | Taste | Smell | Chewiness | Tooth Adhesion | Appearance | Color | General acceptability |
|---|---|---|---|---|---|---|---|---|---|
| **Model** | 0.0140$^{a}$ | 0.0060$^{a}$ | 0.2087$^{b}$ | 0.0615$^{a}$ | 0.1766$^{a}$ | 0.4162$^{b}$ | 0.2358$^{b}$ | 0.2005$^{b}$ | 0.2200$^{b}$ |
| **Linear Mixture** | 0.0060 | 0.0228 | 0.8171 | 0.5493 | 1.0000 | 0.2275 | 0.6205 | 0.1846 | 0.7375 |
| **AB** | 0.2934 | 0.0041 | 0.3606 | 0.0268 | 0.0786 | 0.9214 | 0.1178 | 0.9301 | 0.8039 |
| **Lack of Fit** | 0.3885 | 0.2813 | 0.8229 | 0.3768 | 0.2268 | 0.2937 | 0.2229 | 0.0946 | 0.0680 |
| **R-Squared** | 0.8816 | 0.9226 | 0.7381 | 0.7519 | 0.5798 | 0.5660 | 0.7143 | 0.7454 | 0.7281 |

$p < 0.05$ indicate statistical significance. In the signs in the model part, the letter ($^{a}$) means for quadratic model and the letter ($^{b}$) means for cubic model.

**Table 5.** Quality analysis results of pumpkin and banana granola bar

| Experimental Points | Banana (g) | Pumpkin (g) | Ash Values (%) | Moisture Values (%) | Fat (%) | Color | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | ***L**** | ***a**** | ***b**** | ***C**** |
| 1 | 130 | 130 | 1.38±0.26$^{a}$ | 41.36±0.99$^{c}$ | 3.36±0.40$^{cd}$ | 44.91±1.46$^{a}$ | 4.43±0.81$^{a}$ | 15.90±0.91$^{a}$ | 16.50±1.21$^{a}$ |
| 2 | 112.35 | 147.65 | 1.78±0.11$^{a}$ | 37.79±0.24$^{a}$ | 2.01±0.78$^{a}$ | 43.48±0.92$^{a}$ | 4.07±0.62$^{a}$ | 15.09±0.64$^{a}$ | 15.62±0.89$^{a}$ |
| 3 | 130 | 130 | 1.62±0.29$^{a}$ | 41.33±0.45$^{c}$ | 4.16±0.06$^{d}$ | 45.49±1.18$^{a}$ | 4.20±0.38$^{a}$ | 16.06±1.00$^{a}$ | 16.60±1.07$^{a}$ |
| 4 | 60 | 200 | 1.36±0.08$^{a}$ | 44.10±0.24$^{d}$ | 2.57±0.40$^{ab}$ | 45.52±1.11$^{a}$ | 4.35±0.38$^{a}$ | 15.78±1.47$^{a}$ | 16.39±1.51$^{a}$ |
| 5 | 95 | 165 | 1.57±0.28$^{a}$ | 39.56±0.06$^{b}$ | 3.72±0.25$^{cd}$ | 44.78±1.43$^{a}$ | 4.03±0.69$^{a}$ | 17.82±1.17$^{a}$ | 18.26±1.35$^{a}$ |
| 6 | 60 | 200 | 1.17±0.21$^{a}$ | 45.32±0.42$^{e}$ | 2.60±0.19$^{ab}$ | 46.38±0.72$^{a}$ | 4.08±0.21$^{a}$ | 16.64±1.20$^{a}$ | 17.39±1.39$^{a}$ |
| 7 | 77.64 | 182.36 | 1.41±0.14$^{a}$ | 37.31±0.25$^{a}$ | 3.20±0.30$^{bc}$ | 43.29±1.02$^{a}$ | 3.89±0.29$^{a}$ | 17.14±1.66$^{a}$ | 18.55±1.08$^{a}$ |

Data were expressed by means ± standard deviation. Values followed by different letter in the same column are significantly different ($p < 0.05$).

The addition of fresh pumpkin and banana may have increased the moisture value of the bars. The proximate of the pumpkin pulp ranged between 75.8 and 91.33% moisture and the fresh banana had a moisture of 70.05% (Păucean, 2014; Macedo, 2020). There was no statistical difference in *L**, *a**, *b**, *C** color values. When the color values were examined, it was seen that there was no statistically significant difference in color and appearance parameters, as in the sensory analysis.

## 4. Conclusion

As a result of this study, an alternative snack was designed using pumpkin, which is an important nutritional source that has positive effects on health. Gluten-free vegan granola bar formulations with improved functional properties were created by adding various fruits, spices and dried fruits in order to ensure that pumpkin is consumed outside the production season, to develop alternatives to food products produced from fresh pumpkin, and to expand the snack preferences and gluten-free product range of vegan consumers. Experiments were made with different ratios of banana and pumpkin formulations in granola bar samples and quality analyzes of these granola bars were carried out. This designed granola bar will contribute to the food market as an alternative functional product for celiac patients, vegans. In future studies, new granola bar formulations can be produced by using different fruit and nut mixtures. For those on a gluten-free diet, this formulation can be used in different products and alternative snacks can be produced.

**Acknowledgement**

This work was funded by the Scientific and Technological Research Council of Turkey (TUBITAK), 2209-B Undergraduate Research Projects Support Program for Industry. Project No: 1134B412000204

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