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Design determination formula and shelf-life of new additive-free Mediterranean product

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Abstract

This study performed physical, chemical, and microbiological analyses to determine the best formulation and shelf life of a new additive-free Mediterranean diet product. The spreadable creamed product was formulated with roasted peanut (32%) and roasted hazelnut (32%) mixed, and the new product was sweetened with dried grape (15%) and sun-dried apricot (15%). Different storage temperatures as 25 °C, 35 °C, and 45 °C were used for the prediction of accelerated shelf-life. Microbiological analysis, color analysis, water activity, textural analysis, free fatty acidity, peroxide number, and sensory analyses were also performed two weeks periods during the shelf life. At the period, the water activity was measured as below 0.6, and the microbial risk was not observed. The shelf-life at 25 °C was estimated as 11 months by making regression analysis with the Arrhenius equation according to the values determined at a storage temperature of 45 °C.

Keywords: Accelerated shelf-life; Dried fruit; Mediterranean diet product; Peanut/hazelnut product; Spreadable product.

Highlights

- Design of a nuts/dried fruits mix cream with low water activity and long shelf-life
- Preservative-free nut-based spreadable food for children and sportsmen

1 Introduction

The Mediterranean diet term was put forward in the 1950s in some Mediterranean countries (including Portugal) to associate with low mortality and high life expectancy (Lorgeril & Salen, 2006). Generally, the diet contains different food sources such as fruit, legumes, cereals, olive oil, fish, vegetables, nuts, and the mentioned food types have various important food components such as fiber, monounsaturated oils, and antioxidants (Magalhães et al., 2016).

Nuts, one of the important food groups as a cornerstone of the Mediterranean diet (MedDiet) (Sofi, 2009), are recommended as a part of the human diet from ancient times. Nut cream products were developed with different combinations for different purposes as follows: consumption type, formulas, consumer group as athletes, etc. In this way, developing new nut-based spreadable food products will increase nuts and introduce new breakfast foods to consumers (Shakerardekani et al., 2013). Sweeting of the new nut-based spreads products can vary, containing sugary, without sugar, less sugar, with jelly and jams for its demand purposes (Felland & Koehler, 1997). The listed DF (dried fruit) has a concentrated form of carbohydrates such as fiber and monocarbohydrates and antioxidants such as flavonoids, phenolic acids, carotenoids, and vitamins (Bennett et al., 2011). The synergic situation of the nuts-DFs complex has an excellent compound combination; since it has beneficial effects on glucose and insulin metabolism. In addition to that, the results help prevent type 2 diabetes (T2D) (Hernández-Alonso et al., 2017). The food market needs this healthy and nutritious food product development. It is important to produce additive-free new products based on the nuts-DFs complex for the Mediterranean diet at the sports and child consumption markets

The aims of the study were; (1) to investigate the best dried fruits-nuts combination (apricot-raisins/hazelnut-peanut) suitable for the Mediterranean diet, (2) to formulate without any preservative and sweetener with a low water activity (aw), (3) to obtain an acceptable product in terms of sensory and economically, (4) to determine the accelerated shelf-life of the mentioned product.

2 Materials and methods

The nuts and dried fruits were provided by a nut processing company (Özbeyoğlu Kuruyemiş, Türkiye). Other components such as milk powder (Nestle, Thailand), and sunflower plant oil (Orkide Ayçiçek Yağı, Türkiye) were purchased from local markets, and chemicals were provided by Sigma (St. Louis, MO, USA) and Merck (Darmstadt, Germany) brands. Samples were produced duplicated, and the analysis was performed as triplicated.

2.1 Sample preparation method

The nuts were grounded in the Waring blender (Waring Products Division, Dynamics Corporation of America, New Hartford, CT) for 2 minutes. After all, components are weighed, the mixing direction is adjusted for 1 min with a fine-tip mixer, set to be clockwise. After that homogeneous mixture was created with ultraturrax (Ultra-Turrax, IKA T25 digital, Germany) for 2 min.

2.2 Samples for the shelf-life period

At the end of the trials, the best combination of nuts and dried fruits was decided as hazelnut 32%, peanut 32%, sun-dried apricot 15%, raisin 15%, sunflower oil 5%, and milk Powder 1%. The prepared containers are numbered duplicated samples for 11-week storage in 25, 35, and 45 ºC ovens.

2.3 Dry matter analysis

Determination of Dry Matter following the Association of Official Analytical Chemists (AOAC) method (925.45) (Association of Official Analytical Chemists, 1990). The samples were weighed in 0.0001 precision (3 g) in aluminum containers and dried, and humidity was calculated gravimetrically.

2.4 Protein analysis

The total protein amounts of the samples were analyzed with AOAC 950.48 method (Kiejdahl Method) (Association of Official Analytical Chemists, 1990).

2.5 Lipid content determination

The 60 grams of samples were taken into the 250 grams beaker, and 100 mL of hexane was added and mixed in the shaker. Afterward, it was filtered through the folded coarse filter paper and placed under a vacuum pressure of 335 mbar at 40 on a rotary evaporator (Buchi Rotavapor R-3, Switzerland).

2.6 Water activity measurements

Samples were filled in the special containers at 2/3 and measured at 25 °C (Aqualab Dewpoint Water Activity Meter 4TE, USA).

2.7 Free fatty acid analysis

The samples' free fatty acids (based on oleic acid) were analyzed with the AOAC 940.28 method based on titration, where oils dissolved in hot neutralized ethanol/diethyl ether using phenolphthalein as an endpoint indicator (Association of Official Analytical Chemists, 1990).

2.8 Peroxide number analysis

The peroxide numbers of the samples were measured during shelf-life. The Analysis has occurred with AOAC 965.33 method (Association of Official Analytical Chemists, 1990).

2.9 Microbiological analysis

For Total Mesophilic Aerophilic Microorganisms and Yeast and Moulds Counts, the samples were weighed as 10 grams into sterile stomacher bags and 90 mL peptone water (0.1%) was put in it. After that, a 1 mL sample was taken from the stomacher bag, and 9 mL peptone water (0.1%) was added and formed dilutions according to the microbial load of the samples. The samples were inoculated in a sterile one-use Petri dish and incubated at a suitable time and temperature (Faid et al., 1995).

2.10 Textural analysis

Texture Profile Analysis (TPA) and Spreadable Analysis (SA) were measured by using Texture Analyser TA.XT.plus (Stable Micro System, England). At TPA, a 35 mm diameter A/BE probe was used and adjusted its penetration distance 4 mm and speeds as 2 mm/s (before the test), 0.08 m/s (during the test), and 5 mm/s (after trial).

2.11 Color measurements

Product color values L*, a* and b* (L = 0 (black), L = 100 (white), -a (green), +a (redness), -b (blueness) and +b (yellowness) were measured (at the 1st, 3rd, 5th, 7th and 9th weeks) using color measurement devices (Konica-Minolta CR-400) at different places on products.

2.12 Sensory analysis:

The panelists (10 master and doctorate students of Ondokuz Mayıs University Food Engineering) evaluated the samples in color, taste-aroma, spreadability, and texture/mouth feel factors with a 1 to 9 numerical scale.

2.13 Statistical analysis

Statistical Analysis of the test results was analyzed with SPSS (one-way ANOVA) V23, IBM Corporation, North Castle, NY, USA; 2015. Comparisons with respect to temperature and time were examined with generalized linear models. Analysis results are presented as mean and standard deviation. The significance level was taken as $p < 0.05$.

3 Results and discussion

3.1 Formulation design

The proper combination of the ingredients is essential to ensure stability during the shelf-life of the nut spread product (Shakerardekani et al., 2013). At the end of the trials, the main formula of the new product was decided 64% total percentage of nuts, 32% of roasted hazelnut, and 32% of roasted peanuts, with 30% of dried fruits, 15% of raisins and 15% of dried apricot.

3.2 Proximate analysis

Water contents of components of some products during the life period have been determined as sliced hazelnut (1.47-3.52%), hazelnut flour (1.03-2.28%), roasted hazelnut (1% to 3%) (Bernat et al., 2015), dried apricots (24-25%) (García-Martínez et al., 2013) and the dry matter of the new product was found at 98.4 ± 0.17% at this study.

The protein amount was found at 14.3% to 16.84%. When it was compared the literature about the protein values of 13% for hazelnut (Bernat et al., 2015), 35.7% to 52.6% for spreadable nut products (Lima et al., 2012), the value of the Mediterranean product (15.57 ± 1.8%) was similar depend on its component formula.

The oil content of the new product was detected as 29.36% ± 2.11%, and this value is lower than the same amount of nuts (for hazelnut 62% -Bernat et al., 2015).

3.3 Analytical determinations of the sample during accelerated shelf life

In this study, the temperatures were selected for three types 25 °C, 35 °C, and 45 °C because of the simulated temperature of the environment from room temperature to high environmental temperature.

3.3.1 Water activity results

In our study, the interval of values was found at 25 °C, 35 °C, and 45 °C storage sets as 0.503-0.516, 0.499-0.542, and 0.502-0.527, respectively. The mean values can be listed as 0.509 ± 0.012, 0.514 ± 0.022 and 0.514 ± 0.014 for the temperature groups. Water activity can affect microbial growth, chemical and enzymatic reactions (Cam & Kilic, 2009) for foods; in addition to that water activity is an essential factor for preservative-free foodstuff. All the formulation ranges as 0.42-0.56 aw at the preliminary trials period, and at the beginning of the storage, the product aw value was found as 0.501 ± 0.076 aw. In addition, there was no significant importance between the storage groups. There were fluctuations in the storage temperature groups, and it was similar to the finding of Yilmaz et al. (2019). In the third week of the storage, it was statistically significant ($p < 0.05$) from the other weeks for 35 and 45 °C temperature groups. But there was no statistically significant ($p > 0.05$) between the first week and last week of the storage period and between each temperature group. The mean values of the groups were found as 0.509 ± 0.012, 0.514 ± 0.022 and 0.514 ± 0.014 and there were no significant differences between each group ($p < 0.05$).

3.3.2 Free Fatty Acid (FFA)

In oil or fat, significant amounts of free fatty acids indicate hydrolytic rancidity; on the other hand, other oxidation reactions can also cause FFA production. (Shakerardekani et al., 2013). The factors such as light, enzymes, seasonal variations in temperature, and relative humidity affect the increase in Peroxide Values (PV) and FFA under ambient storage conditions. At hazelnut meal, the maximum FFA (% oleic acid) is found as 1% (Cam & Kilic., 2009).

In the study, the free fatty acidity of the samples was analyzed during accelerated shelf-life, and it is clear that temperature was the main effecting factor on free fatty acidity was statistically significant ($p < 0.05$). The average values of the samples stored at 25 ºC, were calculated as 0.722 ± 0.069, 0.760 ± 0.105 and 0.883 ± 0.153 at 25 ºC, 35 ºC, and 45 ºC, respectively. There were statistical differences ($p < 0.05$) between all temperature storage mean values. Besides, the values increased with the storage duration, and the interaction between time and temperature was also statistically significant ($p < 0.05$). The highest value was measured in the last weeks of the 45 ºC storage, and the lowest values were calculated in the first weeks of all the temperature storage. At the end of the accelerated shelf-life at 45 ºC, the odor taste has become noticeable; the free fatty acid has become a factor in shelf-life because of the increasing free fatty acid effect on sensory parameters. Free fatty acidity values in terms of % oleic acid by the time given in Table 1. Yumlu (2006) measured the free fatty acid values during the shelf-life of the new product formed with hazelnut puree and cacao. Moreover, similar to our study, the values were found at the beginning of the storage period as 0.723 g oleic acid/100 g and measured at 20 °C and 35 °C on the 45th day of the period 1.005 and 1.154 oleic acid/100 g, respectively.

3.3.3 Peroxide Values (PV)

The PV results are influenced by the structure and reactivity of the peroxides, especially the reaction temperature. In our study, the PV values have been increased with temperature and time; in addition to that, the maximum PV value was determined at the end of the storage time at 45 °C. Cam and Kılıc (2009) observed that the peroxide value reached the limit value during storage in roasted hazelnuts and showed a continuous fluctuation, but found that the peroxide value did not show a significant change during 16 weeks of storage in unprocessed kernels with an inner membrane. The mentioned study has also shown similar fluctuations in the value, but an equation suitable for the regression calculation required for shelf-life determination could not be developed. In the study made by Rozalli et al. (2016), the peanut butter peroxide value measured as 0.40 ± 0.04 meq peroxide/kg in the first measurement increased significantly with PV, samples stored at 10 °C and during storage. In determining the shelf-life of the new product developed by Yumlu (2006) using organic molasses hazelnut paste and cocoa mixture, peroxide counts were measured at four different temperatures in the hazelnut puree, and the product was developed. It was initially measured as 0.906 meq/kg; on the 45th day, it was measured as 1.604 at 20 °C and 2.085 meq/kg at 35 °C. Although the peroxide number fluctuates in our study, it was similar due to the increase in the initial and final values (Table 1). We found the values as 0.921 ± 0.181, 0.957 ± 0.135 and 1.105 ± 0.243 (Meq/O_2) statistical differences between storage temperatures as 25, 35 and 45 °C, respectively. In another research, all traditional peanuts stored at 30 °C reached 20 meq O_2 / kg peroxide in 6-7 weeks (Wilkin et al., 2014). Yeh et al. (2002) declared that it is normal for peroxide values to increase with the increase in storage temperature during the shelf-life of spreadable nut-based products.

Table 1. Changes in Peroxide Values (PV) and Free Fatty Acid (FFA) values during different temperatures and weeks during accelerating shelf-life.

Temp. (°C)	Week	FFA (Oleic Acid)	Mean Value	Peroxide Number (Meq/O_2)	Mean Value
	0	0.665 ± 0.005^{de}		0.757 ± 0.09^{ef}	
25 °C	1st	0.668 ± 0.002^{cdef}	0.722 ± 0.069^{C}	0.757 ± 0.09^{ef}	0.921 ± 0.181^{C}
	3 rd	0.616 ± 0.002^{f}		0.829 ± 0.01^{g}	
	5 th	0.726 ± 0.001^{ef}		0.892 ± 0.02^{ef}	
	7 th	0.728 ± 0.002^{cdef}		0.995 ± 0.02^{d}	
	9 th	0.782 ± 0.09^{cdef}		0.815 ± 0.02^{gh}	
	11th	0.807 ± 0.08^{cdef}		0.916 ± 0.03^{e}	
35 °C	1st	0.666 ± 0.002^{cdef}	0.760 ± 0.105^{B}	1.19 ± 0.01^{c}	0.957 ± 0.135^{B}
	3 rd	0.671 ± 0.003^{ef}		0.797 ± 0.02^{gh}	
	5 th	0.668 ± 0.005^{ef}		0.815 ± 0.01^{h}	
	7 th	0.781 ± 0.001^{cdef}		0.786 ± 0.03^{gh}	
	9 th	0.892 ± 0.054^{bcde}		0.906 ± 0.02^{e}	
	11th	0.924 ± 0.021^{abcd}		0.999 ± 0.01^{d}	
45 °C	1st	0.673 ± 0.005^{cdef}	0.883 ± 0.153^{A}	1.279 ± 0.02^{b}	1.105 ± 0.243^{A}
	3 rd	0.722 ± 0.06^{cdef}		0.847 ± 0.02^{g}	
	5 th	0.894 ± 0.056^{bcdef}		0.906 ± 0.02^{e}	
	7 th	0.944 ± 0.002^{abc}		0.999 ± 0.01^{df}	
	9 th	1.006 ± 0.002^{ab}		1.19 ± 0.01^{c}	
	11th	1.098 ± 0.018^{a}		1.253 ± 0.03^{b}	

a-c: There is no difference between interactions with the same letter, A-E: There is no difference between temperatures/times with the same letter.

3.3.4 Microbiological results

According to the Turkish Food Codex (2009), yeast-mold limits are specified as 10^3 cfu/g for hazelnut and peanut butter. The microbiological situation of our product during its shelf-life was suitable for the mentioned limit values. In research, the microbial count was measured below as 7900 cfu/g at natural peanut paste at 35 °C storage (Rozalli et al., 2016), and this funding was similar to our one in terms of microbiological count stored at 4, 20, 30, and 35 °C temperatures for the determination of the shelf-life of the new product developed with organic molasses hazelnut puree and cacao mixture, and carried out the microbiology analysis of the product on the 0, 45 and 100 days. As a result of the analysis, the total number of aerophilic mesophilic bacteria Plate Count Agar (PCA, Merck) was determined as 10^3 at all temperature and time parameters. As a result of the microbiological analysis, no mold-yeast Potato Dextrose Agar (PDA, Merck) was found in any samples. In this study, the total number of aerophilic mesophilic bacteria is $<10^3$, similar to Yumlu's (2006) work. In this study, it is thought that the use of fruits with microorganisms in their natural environment is effective in the formation of yeast-mold counts. Lima et al. (2012) found the mold-yeast count below $<10^3$ at the cashew-based spreadable product and stated that it was not a risk to human health.

3.3.5 Textural results

Nut-based spreadable products such as peanut butter have important quality parameters like texture, color, flavor, and nutritional value McNeill et al. (2000). Texture and taste are among the most important factors affecting consumer preferences in spreadable hazelnut paste (Ozcelik & Karaali, 2002). For this reason, spreadability and TPA analyses were performed on products during storage, and the changes in the values of the texture parameters were given in Table 2. The hardness parameter of the samples was statistically significant between 45 °C and the other temperature storage. In a study related to determining shelf-life for honey-hazelnut based spreadable products, there was no significant change in any textural properties of the product during the storage period at 22 °C, the textural properties of the product began to change from the 3rd week at 35 °C, and the hardness value of the products increased during storage. In addition to that spreadability, values were decreased over time, and there were no differences between elasticity and gumminess values.

3.3.6 Color results

According to McNeill et al. (2000), important qualities of peanut butter include texture, color, flavor, and nutritional value. In our study, a significant change is observed in L*, a*, and b* values during the storage period and temperature. The L* value decreased at all temperature storages, but a fluctuation at a* and b* values was observed.

The temperature factor had a significant effect on L* average values ($p < 0.05$). The average values at different temperatures as 51.783 at 25 °C, 49.890 at 35 °C, and 39.633 at 45 °C. A statistically significant difference was verified between all temperatures and the highest L value. The time factor also had an important effect on L mean values ($p < 0.05$). While the average value was the highest in the 1st week, the average value was lowest in the last week of storage (Table 3).

Table 2. Changes of textural properties during different temperatures and weeks during accelerating shelf-life.

Weeks	Storage Temperatures		
	25 °C	35 °C	45 °C
		Firmness(g)	
1st	53.15 ± 10.08^{f}	76.45 ± 17.32^{ef}	157.83 ± 69.61^{abc}
3 rd	58.32 ± 10.97^{ef}	66.37 ± 29.25^{f}	152.79 ± 106.66^{abc}
5 th	99.24 ± 23.70^{def}	111.53 ± 31.41^{bcde}	195.33 ± 56.66^{abcd}
7 th	169.32 ± 47.26^{abcd}	76.64 ± 36.42^{bcd}	192.42 ± 74.47^{abc}
9 th	199.24 ± 40.92^{abc}	132.39 ± 26.82^{cde}	188.83 ± 47.94^{ab}
11th	195.62 ± 6.76^{abc}	158.38 ± 9.11^{abcd}	229.15 ± 18.17^{a}
Mean	129.15 ± 67.27^{A}	112.51 ± 46.97^{A}	186.06 ± 27.91^{A}
		Work of shear (g s)	
1st	152.44 ± 11.78 ^{ab}	103.64 ± 52.23 ^{b}	247.40 ± 33.89 ^{a}
3 rd	153.82 ± 44.65 ^{ab}	148.31 ± 38.55 ^{ab}	224.49 ± 67.72 ^{ab}
5 th	166.76 ± 58.08 ^{ab}	170.18 ± 11.33 ^{ab}	203.94 ± 84.84 ^{ab}
7 th	210.31 ± 11.93 ^{ab}	160.29 ± 13.71 ^{ab}	200.17 ± 67.39 ^{ab}
9 th	255.35 ± 14.07^{a}	237.90 ± 65.34 ^{ab}	258.713 ± 49.77 ^{a}
11th	251.75 ± 21.93 ^{a}	255.84 ± 13.57^{a}	223.56 ± 22.69 ^{ab}
Mean	198.41 ± 52.38^{A}	179.36 ± 93.43^{A}	228.05 ± 61,81^{A}
		Hardness (g)	
1st	545.39 ± 7.30^{de}	412.85 ± 28.07^{hi}	751.46 ± 36.46^{a}
3 rd	295.15 ± 19.87^{jk}	279.01 ± 46.^{79k}	545.38 ± 52.22^{de}
5 th	515.99 ± 58.75^{ef}	355.16 ± 23.64ij	490.98 ± 61.52^{efg}
7 th	456.76 ± 34.82^{fgh}	697.61 ± 55.65ab	699.79 ± 45.85^{ab}
9 th	444.48 ± 29.98^{gh}	750.40 ± 29.17^{a}	597.06 ± 8.51^{cd}
11th	424.46 ± 25.37 ^{gh}	750.27 ± 23.99^{a}	652.83 ± 18.88^{bc}
Mean	447.04 ± 87.31^{B}	540.88 ± 13.38^{B}	622.92 ± 20.26^{A}
		Gumminess (g)	
1st	167.60 ± 15.31^{abcde}	159.71 ± 49.45^{bcde}	228.06 ± 8.56^{abc}
3 rd	106.17 ± 9.32^{e}	117.69 ± 47.76^{de}	158.22 ± 33.49^{cde}
5 th	162.97 ± 28.80^{bcde}	97.80 ± 28.19^{e}	228.24 ± 33.74^{abc}
7 th	181.62 ± 9.75^{abcd}	196.45 ± 71.52^{abc}	242.40 ± 78.59a
9 th	211.54 ± 24.31^{abc}	203.19 ± 23.22^{abc}	159.38 ± 74.36^{bcde}
11th	236.11 ± 12.76^{ab}	193.51 ± 11.52^{abc}	170.98 ± 14.42^{abcde}
Mean	177.67 ± 44.73^{A}	161.39 ± 55.62^{A}	197.88 ± 54.92^{A}

a-c: There is no difference between interactions with the same letter at the same texture parameter, A-E: There is no difference between temperatures/times with the same letter at the same line.

Moreover, the a* values were 5.536, 5.558, and 4.962 at 25, 35, and 45 °C temperatures. The mean a *value of the 35 °C storage was statistically different from the others. The findings for b* values were 24.330, 21.663, 18.151 at 25, 35, and 45 ºC temperatures, respectively.

Table 3. Changes of color properties during different temperature and weeks during accelerating shelf-life.

Temp.	Weeks	L*	a*	b*
25 °C	0	56.099 ± 0.981	6.914 ± 0.087	21.881 ± 0.916
	1st	55.283 ± 1.233^{a}	6.667 ± 0.242^{a}	23.189 ± 0.340^{de}
	3 rd	54.823 ± 2.458^{ab}	6.290 ± 0.240^{a}	28.615 ± 2.781^{bc}
	5 th	54.540 ± 0.410^{ab}	6.060 ± 0.110^{a}	33.515 ± 1.335^{a}
	7 th	51.910 ± 0.030^{bcd}	5.820 ± 1.686^{ab}	24.582 ± 1.678^{cd}
	9 th	47.987 ± 0.545^{ef}	3.860 ± 0.046^{bc}	18.826 ± 2.489^{ef}
	11th	46.156 ± 0.175^{ef}	4.521 ± 0.087^{bc}	17.255 ± 1.512^{ef}
	Mean	51.783 ± 3.539^{A}	5.536 ± 0.728^{A}	24.330 ± 5.544^{A}
35 °C	1st	53.900 ± 0.858^{ab}	6.787 ± 0.702^{ab}	22.493 ± 0.621^{de}
	3 rd	50.523 ± 0.805^{cde}	6.360 ± 0.690^{ab}	23.754 ± 2.539^{d}
	5 th	53.640 ± 1.516^{abc}	6.600 ± 0.570^{a}	30.110 ± 2.070^{ab}
	7 th	49.997 ± 1.885^{de}	6.597 ± 0.095^{a}	21.213 ± 0.308^{def}
	9 th	43.417 ± 0.055^{g}	4.020 ± 0.100^{bc}	16.580 ± 0.330^{fg}
	11th	42.890 ± 0.130^{g}	3.987 ± 0.124^{bc}	15.831 ± 0.451^{fg}
	Mean	49.061± 4.422^{A}	5.558 ± 1.193^{B}	21.663 ± 4.769^{B}
45 °C	1st	52.277 ± 1.014^{abcd}	6.787 ± 0.614^{a}	22.615 ± 0.321^{de}
	3 rd	45.780 ± 1.520^{fg}	6.820 ± 0.240^{a}	23.963 ± 2.297^{cd}
	5 th	44.167 ± 0.095^{g}	6.570 ± 0.010^{a}	23.058 ± 1.392^{de}
	7 th	34.383 ± 0.065^{h}	3.523 ± 0.025^{c}	14.048 ± 0.098^{g}
	9 th	31.113 ± 0.077^{i}	3.093 ± 0.025^{c}	12.948 ± 0.038^{g}
	11th	30.810 ± 0.081$_{1}$	2.981 ± 0.011^{cd}	12.274 ± 0.025^{g}
	Mean	39.633 ± 8.262^{C}	4.962 ± 1.772^{A}	18.151 ± 5.103^{C}

a-c: There is no difference between interactions with the same letter in the same column, A-E: There is no difference between temperatures/times with the same letter at the same column.

3.3.7 Sensory results

According to evaluations, the total scores were calculated as 252 for 25 °C, 228 for 35 °C, 181 scores for 45 °C. On the nine-point hedonic scale, it fell below the score of 5: neither good nor bad' and reached the end of the shelf-life at 45 with the lowest score of 3.50. Sensory analysis results of the product during storage were given in Table 4. Overall decreasing observation for spreadability scores, especially at 45ºC temperature during storage time, the scores decreased from 6.72 ± 0.26 to 6.33 ± 1.15 at 25 °C, from 6.91 ± 0.41 to 4.75 ± 0.58 at 35 °C and from 6.25 ± 0.37 to 4.75 ± 2.08 at 45 °C.

Similar decreases were observed at other textural parameters like color, odor, aroma, texture/mouth feel, and general acceptability in Table 1. In addition, a significant decrease was observed below five scores at the available acceptability parameter, and it was calculated as 3.50 ± 3.51 at the last week of the storage time. The time parameter has no statistical effect on storage at 25 ºC; after 11 weeks duration at 35 ºC, the sensory score decreased by about five values. However, time was statistically significant at 45 ºC at long storage (11 weeks).

Table 4. Change of sensory properties at selected temperature and weeks during accelerated shelf-life.

Temp.	Week	Color	Spreadability	Odor	Taste	Mouth Feel	Acceptability
25 °C	1st	8.50 ± 0.58^{a}	6.72 ± 0.26^{abcd}	6.31 ± 0.65^{ab}	7.50 ± 0.58^{a}	7.00 ±0.82^{a}	6.94 ± 0.77^{a}
	3rd	7.17 ± 0.44^{ab}	6.96 ± 0.19^{abcd}	6.71 ± 0.07^{a}	7.54 ± 0.79^{a}	7.04 ±0.38^{ab}	7.33 ± 0.19^{a}
	5th	7.06 ± 0.31^{bc}	6.25 ± 0.74^{abcd}	7.63 ± 0.75^{a}	6.81 ± 0.38^{ab}	6.69 ±0.63^{abc}	6.94 ± 0.13^{a}
	7 th	6.00 ± 0.63^{bcde}	7.00 ± 0.79^{ab}	7.00 ± 0.38^{a}	8.00 ± 0.77a	6.00 ±0.58^{bcdef}	7.00 ± 0.63^{a}
	9 th	6.75 ± 1.50^{ab}	7.25 ± 0.96^{a}	7.25 ± 0.50^{a}	7.25 ± 1.71^{abc}	6.00 ±0.38^{bcdef}	7.00 ± 0.82^{a}
	11th	6.00 ± 1.00^{bcd}	6.33 ± 1.75^{ab}	7.67 ± 0.58^{a}	7.00 ± 1.73^{abcd}	6.67 ±1.15^{defg}	7.33 ± 0.13^{a}
35 °C	1st	6.28 ± 0.46^{bcd}	6.91 ± 0.41^{abcd}	6.53 ± 0.62^{a}	6.59 ± 0.51^{abcd}	6.38 ±0.49^{abcd}	6.75 ± 0.54^{a}
	3rd	7.08 ± 0.07^{bc}	7.33 ± 0.26^{ab}	7.04 ± 0.29^{a}	7.06 ± 0.35^{a}	7.08 ±0.19^{abc}	7.02 ± 0.51^{a}
	5th	6.00 ± 1.08^{bcd}	6.63 ± 0.97^{ab}	6.38 ± 0.32^{ab}	6.19 ± 0.24^{abcd}	6.00 ± 0.74^{abcdef}	6.25 ± 0.61^{abc}
	7 th	5.00 ± 0.63^{defg}	6.00 ± 0.79^{abcd}	7.00 ± 0.38^{a}	7.00 ± 0.58^{ab}	6.00 ± 1.03^{efghi}	7.00 ± 1.15^{abc}
	9 th	5.75 ± 0.96^{bcde}	7.25 ± 0.50^{abc}	6.75 ± 1.26^{a}	6.75 ± 1.26^{abcd}	6.00 ± 0.82^{defgh}	6.25 ± 0.96^{ab}
	11th	5.75± 0.58^{bcdef}	4.75 ± 0.58^{d}	5.00 ± 0.58^{c}	5.50 ± 1.53^{d}	5.50 ± 0.58f^{ghi}	5.25 ± 1.00^{de}

Table 4. Continued…

Temp.	Week	Color	Spreadability	Odor	Taste	Mouth Feel	Acceptability
45 °C	1st	6.59 ± 0.98^{bcde}	6.25 ± 0.37^{abcd}	5.66 ± 0.45^{c}	5.41 ± 0.61^{bcd}	4.88 ± 0.60^{fghi}	5.16 ± 0.73^{bcd}
	3rd	5.88 ± 0.45^{cdef}	6.00 ± 0.25^{abcd}	5.79 ± 0.36^{bc}	5.42 ± 0.63^{b}	5.38 ± 0.65^{ghi}	5.71 ± 0.69^{abcd}
	5th	5.31 ± 0.90^{efg}	5.31 ± 0.75^{bcd}	5.31 ± 0.13^{c}	5.00 ± 0.35^{cd}	4.63 ± 0.43^{i}	5.06 ± 0.43^{cd}
	7 th	3.88 ± 1.24^{fg}	4.25 ± 1.77^{cd}	5.63 ± 0.53^{c}	5.50 ± 0.71^{bcd}	4.88 ± 0.18^{hi}	5.00 ± 0.63^{cd}
	9 th	4.69 ± 1.89^{gh}	4.63 ± 2.43^{abcd}	4.56 ± 1.40^{d}	6.50 ± 1.00^{abcd}	5.19 ± 0.55^{hi}	5.00 ± 2.16^{ef}
	11th	3.50 ± 1.21^{h}	4.75 ± 2.08^{bcd}	3.75 ± 1.61^{d}	3.50 ± 1.21^{e}	3.50 ± 0.51^{j}	3.50 ± 0.51^{f}

a-c: There is no difference between interactions with the same letter at the same column, A-E: There is no difference between temperatures/times with the same letter at the same column.

4 Conclusion

The most common acceleration factor is temperature, associated with degradation rate and the rancidity of peanut and hazelnut products as a factor for general acceptability to the end of the shelf-life. At this point, the sensory evaluation score of the general acceptability was an indicator for ending the new product. The product's shelf-life was completed at 45 ºC, and the shelf-life time at 25 ºC was estimated by calculating k (reaction rate constant) values from the Arrhenius equation. According to the calculation, the additive-free Mediterranean diet product's shelf-life with nuts/dried fruit mix was 11 months at 25 ºC with the following regression equation $y = 0.0211x+0.571$ ($R^2= 0.918$). The results showed that a suitable dried fruits-nuts combination (has low water activity) for the Mediterranean diet was possible. It can ensure adequate shelf-life with good sensory properties. It was important for the food industry to have sufficient shelf-life without any preservatives and good sensory properties with a nutritional combination for the Mediterranean diet.

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