Agriculture and Food

AIMS Agriculture and Food, 3(3): 266–279.
DOI: 10.3934/agrfood.2018.3.266
Received date: 15 May 2018
Accepted date: 06 August 2018
Published date: 15 August 2018

http://www.aimspress.com/journal/agriculture

Research article

Effect of different flavoring agents on sensory aspects of hazelnut butter: Identification and prioritization using riddling and TOPSIS approaches

Amir Pourfarzad[1,]*, Mohammad Kavoosi-Kalashami[2] and Siamak Gheibi[1]

[1] Department of Food Science and Technology, Faculty of Agricultural Sciences, University of Guilan, Rasht, Iran
[2] Department of Agricultural Economics, Faculty of Agricultural Sciences, University of Guilan, Rasht, Iran

* **Correspondence:** Email: amir.pourfarzad@ gmail.com; Tel: +981333690274; Fax: +981333690281.

Abstract: Hazelnuts are nutrient nuts with complex matrices rich in unsaturated fatty and other bioactive compounds such as high-quality vegetable protein, fiber, minerals, tocopherols, phytosterols and phenolic compounds. One of the hazelnut processing methods is its conversion into various products such as hazelnut butter. In this research, the use of different flavorings (cardamom, vanilla, and cocoa) in the production of hazelnut butter was investigated. Indicators for comparison and prioritization of flavorings include color, aroma, appearance, consistency, texture, spreadability and overall acceptance. Prioritization of flavorings was done by two techniques of riddling and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). These procedures were used under two approaches: The central index of median scores for 7 indicators and the inverse dispersion index of the coefficient of variation for 7 indicators. The results of both approaches showed that cacao was the first priority based on all seven indicators.

Keywords: flavoring; formulation; hazelnut butter; prioritization

1. Introduction

Hazelnut fruit is known as *Corylus avellana* L. and is from the family Corylacae. Hazelnut is a shrub with about 2 meters height, which can reach up to 6 meters in suitable areas and easily form a massive forest [1]. Hazelnut is an edible-industrial fruit, which the northern regions of Iran are favorable area to grow so that in some areas people subsist on the production of hazelnuts. Turkey with 71% of the area under cultivation of hazelnut and annual production of 660,000 tons of hazelnuts is the largest producer of the hazelnut in the world, followed by Italy, the United States, Azerbaijan, Georgia, China, Iran, and Spain. Iran, with 21,000 hectares area under cultivation of hazelnut, is the seventh producer of hazelnut [2]. However, due to the benefits of hazelnut and its relatively high production in Iran, there are no suitable processing industries. Therefore, due to the development of the processing of this product, has an important role in providing the foreign-exchange gains. If the way to export hazelnuts is found and the production waste is also used, then the fear of losing the current trend in the hazelnut market is less, despite rivals that are technologically superior. In addition, such studies will open new ways to activate factories and food industry professionals. Hazelnut has high nutritional value since it is rich in bioactive compounds. Its oil is one of the healthiest and most useful vegetable oil. The amino acids found in hazelnut proteins are mainly composed of essential amino acids. In addition, due to its high phosphorus, boosts the brain functions and is rich in vitamins B and E, which are essential for maintaining brain health and hematopoiesis [1]. Although hazelnuts are used in different parts of the world, its per capita consumption is low. The average per capita consumption of hazelnuts in the world is 100 grams per year [3]. One of the ways to increase per capita consumption is the processing of hazelnuts in a various way, including the production of hazelnut butter. Hazelnut butter is one of the products of the hazelnut processing industry. Hazelnut butter is a product similar to peanut butter, which constitutes a large part of the food items consumed for breakfast in the Americas.

In several studies the sensorial methodologies were used to determine the influence of flavoring agents on sensory aspects of final products. Nattress et al. [4] examined the effect of the hazelnut paste on the sensory properties and the durability of bitter chocolate. Adding hazelnuts to bitter chocolate formulations changed the sensory characteristics. Chocolate flavors including burnt, rotten, hazelnut, green, and metallic, as well as texture characteristics including hardness, grain, consistency and viscosity, were determined by descriptive analysis and showed that the addition of hazelnut paste up to 10% caused a significant change in these characteristics. Haghani Haghighi et al. [5] prepared various formulations of pistachio butter with various additives including lecithin, antioxidant, sugar (or salt) and flavoring agents (cardamom and vanilla), and optimized the formulation of production through sensory evaluation of the product. Villegas et al. showed that the acceptability of milk and soymilk vanilla beverages is influenced by demographic characteristics, consumer habits and individual preferences [6].

Hazelnut butter formulation is the first step in the commercial production of this product. A literature survey indicated that no work has been carried out on the effect of different flavoring agents on the sensory characteristics of hazelnut butter. This product is flavorless and undesirable without any flavoring agent. Thus, it is expected that a formulation containing these ingredients will be more popular. Thus, the present study was designed: (a) To investigate the effect of different flavoring agents on the sensory characteristics of hazelnut butter; (b) to check the validity of riddling and TOPSIS approaches to identify and prioritize the effects of flavoring agents on the sensory properties.

2. Materials and methods

2.1. Materials

The hazelnut variety was Rasmi from Rudsar (Guilan, Iran) and was stored in a cool and dry place. Other materials used in this study were purchased from reputable companies.

2.2. Methods

2.2.1. Production of hazelnut butter

For this purpose, first the dry hazelnut was roasted at a temperature of 120 °C and the shell was separated. Then using the roller mill, the hazelnuts were converted into a continuous paste. The other formulation components including margarine (1%), sugar (10%), lecithin (0.5%), and flavorings including cardamom (0.75%) or vanilla (0.25%) or cocoa (1.25%) were added to the mixture and mixed until a completely smooth texture was obtained. The examined levels of flavorings are optimized and determined by initial tests. After completing the production steps were filled in 200 g containers and the samples were kept in the refrigerator until the tests were carried out.

2.2.2. Sensory evaluation

The ten trained panelists of both genders and of ages from 25 to 60 evaluated hazelnut butter samples. All assessors of the internal sensory panel have overtaken the basic flavor test, the odor test and the colour vision test. They have been trained in sensory methods at several sessions and their evaluation aptitude is routinely checked. The panel was particularly familiarized with the sensory descriptors and the attribute intensities by using verbal meanings describing the ends of the intensity scales of the features. Each sample contained 30 grams of hazelnut butter which were given to panellists in plastic containers and at room temperature. Color, aroma, appearance, consistency, texture, rubbing, and overall acceptance of samples was analyzed by a five-point scale. Scores 1 and 5 were respectively for samples with the minimum and maximum utility. Then the mean of the scores was calculated for each sensory feature [5].

2.2.3. Analysis of data

Data analysis and the effects of different flavorings on the sensory properties of hazelnut butter samples were conducted as factorial in a completely randomized design. After analysis of variance, Duncan’s multiple range test was used at 95% confidence level in order to analyze the significance of the difference between the mean of the numbers (three replications for each experiment). Also, in order to prioritize the flavoring, based on all seven indicators, two riddling (H-index) and TOPSIS methods were used.

In order to prioritize the flavoring in the riddling approach, a simple average of standardized seven indices was used under two approaches of the central index of median scores for 7 indicators and the inverse dispersion index of the coefficient of variation for 7 indicators:

$$H_j = \sum_{k=1}^{7} \left[\frac{m_{kj} - \overline{m}_k}{\delta_k} \right] / n \quad (1)$$

In the above relation, m_{kj} is the value of the k^{th} indicator for flavoring j, m_k is the mean of k^{th} indicator, δ_k is the standard deviation of k^{th} indicator and n is the number of indices.

In TOPSIS approach, the matrix of option m and criterion n are evaluated. In this algorithm, it is assumed that every indicator and criterion in the decision matrix has a uniform additive utility. In other words, the higher values of the criteria indicate higher utility. One of the important advantages of this method is simultaneous use of indicators and objective and subjective criteria. This approach is based on the notion that the optimal choice of decision making should have the minimum distance with the positive ideal solution (Ai^+) or the solution that is most among the positive criteria, and least among the negative criteria also have the maximum distance with the negative ideal solution (Ai^-) or the solution that is most among the negative criteria and least among the positive criteria. In order to prioritize the flavorings, using the TOPSIS approach, in the first step, the decision-making matrix D with dimensions of O × I, is created using flavoring O and decision-making indicator I.

Matrix D element represented by r_{ij} which is known as j decision making index related to i flavoring. In second stage, mentioned matrix elements descaled using Euclid norm and desclaed matrix of N has been formed. The relation used to normalize the D-matrix entries is as follows [7]:

$$n_{ij} = \frac{r_{ij}}{\left(\sum_{i=1}^{m} r_{ij}^2\right)^{\frac{1}{2}}} \quad , \quad (i = 1,...,O), (j = 1,..., I) \quad (2)$$

In the third step, descaled weighted matrix is created using the following equation:

$$V = N \times W_{I \times I} \quad (3)$$

In the above equation, V is a descaled weighted matrix and W is a diagonal matrix of the obtained weights for decision-making indicators and N is an unscaled matrix. It should be noted that the weight of each decision-making indicators is calculated using Shanon entropy and multiplied in each of the options (flavorings), to obtain the values of the unscaled matrix entries in definite numbers. In the fourth step, the positive ideal (Ai^+) and negative (Ai^-) is determined. In the following relation, J1 = 1, 2, ..., n for indicator j is positive and J2 = 1, 2, ..., n for indicator j is negative [8].

$$\begin{aligned} A_i^+ &= \left\{ (\max V_{ij} \mid j \in J_1), (\min V_{ij} \mid j \in J_2) \middle| i = 1, 2, ..., O \right\} \\ A_i^- &= \left\{ (\min V_{ij} \mid j \in J_1), (\max V_{ij} \mid j \in J_2) \middle| i = 1, 2, ..., O \right\} \\ A_i^+ &= \{V_1^+, V_2^+, \ldots, V_n^+\} \\ A_i^- &= \{V_1^-, V_2^-, \ldots, V_n^-\} \end{aligned} \quad (4)$$

In the fifth step, the values of the distance of Oth flavoring with the ideal values are calculated using the Euclidean approach:

$$d_i^+ = \left\{ \sum_{j=1}^{n} \left(V_{ij} - V_j^+\right)^2 \right\}^{\frac{1}{2}}$$
$$d_i^- = \left\{ \sum_{j=1}^{n} \left(V_{ij} - V_j^-\right)^2 \right\}$$
$$(i = 1, 2, \ldots, O) \tag{5}$$

Based on the computational values of di$^-$ and di$^+$ for each flavoring, in the last step the relative closeness index Ci is calculated:

$$C_i = \frac{d_i^-}{(d_i^- + d_i^+)} \quad , \quad \left(i = 1, 2, \ldots, O\right) \tag{6}$$

Finally, the studied flavorings can be ranked based on the above index value. At all steps, modelling and statistical analysis of the data were done using Minitab software (Minitab 15, Minitab Inc., State College, PA, USA), SPSS23 (IBM SPSS Statistics 23) and TOPSIS Solver 2014.

3. Results

In order to evaluate the scores provided by 10 experts, descriptive statistics, the statistical difference in mean and multiple comparisons of the three flavorings score are presented separately for each indicator.

3.1. Color index

The results of the descriptive statistics of the color index showed that the flavorings of cocoa and cardamom were allocated the highest and lowest scores, respectively (Table 1). The distribution of the score for the color index in cacao was more than two other flavorings.

The results of the variance analysis table showed that there was a significant statistical difference between the mean scores of three flavorings in the color index at 1% level (Table 2). In order to investigate the differences in paired mean values, multiple comparisons were performed using Tukey HSD test (Table 3). The results showed that there was a statistically significant difference between the mean scores of cacao-cardamom, cacao-vanilla, and cardamom-vanilla in the color index at 1% level.

Table 1. Evaluation of descriptive statistics of color index score in replications of tastes.

Tastes	N	Mean	Std. Deviation	Minimum	Maximum
Cocoa	9	4.86	0.07	4.81	4.95
Cardamom	9	2.32	0.05	2.25	2.36
Vanilla	9	4.04	0.03	3.99	4.07
Total	27	3.74	1.08	2.25	4.95

Table 2. Statistical difference in the mean of the replications of tastes for color index.

Variation resource	Sum of squares	d.f.	Mean square	F	Sig.
Between groups	30.29	2	15.15	5317.82	0.00
Within groups	0.07	24	0.003		
Total	30.36	26			

Table 3. Multiple comparisons (Tukey HSD test) of the replications of tastes for color in.

(I) Taste	(J) Taste	Mean difference (I–J)	Std. Error	Sig.
Cocoa	Cardamom	2.54	0.02	0.00
	Vanilla	0.81	0.02	0.00
Cardamom	Cocoa	−2.54	0.02	0.00
	Vanilla	−1.73	0.02	0.00
Vanilla	Cocoa	−0.81	0.02	0.00
	Cardamom	1.73	0.02	0.00

3.2. Aroma index

The results of the descriptive statistics of the aroma index showed that the flavorings of cocoa and vanilla were allocated the highest and lowest scores, respectively (Table 4). The distribution of the score for the aroma indicator in cocoa was less than two other flavorings.

The results of the variance analysis table showed that there was a significant statistical difference between the mean scores of three flavorings in the aroma index at 1% level (Table 5). In order to investigate the differences in paired mean values, multiple comparisons were performed using Tukey HSD test (Table 6). The results showed that there was a statistically significant difference between the mean scores of cacao-cardamom and cacao-vanilla in the aroma index at 1% level. There was no significant difference between the mean scores of cardamom-vanilla in the aroma index.

Table 4. Evaluation of descriptive statistics of aroma index score in replications of tastes.

Tastes	N	Mean	Std. Deviation	Minimum	Maximum
Cocoa	9	3.99	0.03	3.95	4.02
Cardamom	9	3.51	0.23	3.22	3.75
Vanilla	9	3.49	0.23	3.19	3.69
Total	27	3.66	0.29	3.19	4.02

Table 5. Statistical difference in the mean of the replications of tastes for aroma index.

Variation resource	Sum of squares	d.f.	Mean square	F	Sig.
Between groups	1.42	2	0.71	19.96	0.00
Within groups	0.86	24	0.04		
Total	2.28	26			

Table 6. Multiple comparisons (Tukey HSD test) of the replications of tastes for aroma index.

(I) Taste	(J) Taste	Mean difference (I–J)	Std. Error	Sig.
Cocoa	Cardamom	0.48	0.09	0.000
	Vanilla	0.49	0.09	0.000
Cardamom	Cocoa	−0.48	0.09	0.000
	Vanilla	0.01	0.09	0.988
Vanilla	Cocoa	−0.49	0.09	0.000
	Cardamom	−0.01	0.09	0.988

3.3. Appearance index

The results of the descriptive statistics of the appearance index showed that the flavorings of cocoa and cardamom were allocated the highest and lowest scores, respectively (Table 7). The distribution of the score for the appearance indicator in cocoa was less than two other flavorings.

The results of the variance analysis table showed that there was a significant statistical difference between the mean scores of three flavorings in the appearance index at 1% level (Table 8). In order to investigate the differences in paired mean values, multiple comparisons were performed using Tukey HSD test (Table 9). The results showed that there was a statistically significant difference between the mean scores of cacao-cardamom, cacao-vanilla and, cardamom-vanilla in the appearance index at 1% level.

Table 7. Evaluation of descriptive statistics of appearance index score in replications of tastes.

Tastes	N	Mean	Std. Deviation	Minimum	Maximum
Cocoa	9	3.96	0.02	3.95	3.99
Cardamom	9	2.99	0.03	2.96	3.03
Vanilla	9	3.19	0.07	3.11	3.25
Total	27	3.39	0.43	2.96	3.99

Table 8. Statistical difference in the mean of the replications of tastes for appearance index.

Variation resource	Sum of squares	d.f.	Mean square	F	Sig.
Between groups	4.67	2	2.33	1244.74	0.00
Within groups	0.04	24	0.002		
Total	4.71	26			

Table 9. Multiple comparisons (Tukey HSD test) of the replications of tastes for appearance index.

(I) Taste	(J) Taste	Mean difference (I–J)	Std. Error	Sig.
Cocoa	Cardamom	0.96	0.02	0.00
	Vanilla	0.76	0.02	0.00
Cardamom	Cocoa	−0.96	0.02	0.00
	Vanilla	−0.2	0.02	0.00
Vanilla	Cocoa	−0.76	0.02	0.00
	Cardamom	0.2	0.02	0.00

3.4. Consistency index

The results of the descriptive statistics of the consistency index showed that the flavorings of cocoa and cardamom were allocated the highest and lowest scores, respectively (Table 10). The distribution of the score for the consistency indicator in cardamom was less than two other flavorings.

The results of the variance analysis table showed that there was a significant statistical difference between the mean scores of three flavorings in the consistency index at 1% level (Table 11). In order to investigate the differences in paired mean values, multiple comparisons were performed using Tukey HSD test (Table 12). The results showed that there was a statistically significant difference between the mean scores of cacao-cardamom and, cardamom-vanilla in the consistency index at 5% level.

Table 10. Evaluation of descriptive statistics of consistency index score in replications of tastes.

Tastes	N	Mean	Std. Deviation	Minimum	Maximum
Cocoa	9	2.97	0.2	2.78	3.23
Cardamom	9	2.45	0.003	2.44	2.45
Vanilla	9	2.8	0.05	2.75	2.88
Total	27	2.74	0.25	2.44	3.23

Table 11. Statistical difference in the mean of the replications of tastes for consistency index.

Variation resource	Sum of squares	df	Mean square	F	Sig.
Between groups	1.26	2	0.63	42.47	0.00
Within groups	0.36	24	0.01		
Total	1.61	26			

Table 12. Multiple comparisons (Tukey HSD test) of the replications of tastes for consistency index.

(I) Taste	(J) Taste	Mean difference (I–J)	Std. Error	Sig.
Cocoa	Cardamom	0.52	0.06	0.00
	Vanilla	0.17	0.06	0.02
Cardamom	Cocoa	−0.52	0.06	0.00
	Vanilla	−0.35	0.06	0.00
Vanilla	Cocoa	−0.17	0.06	0.02
	Cardamom	0.36	0.06	0.00

3.5. Texture index

The results of the descriptive statistics of the texture index showed that the flavorings of cocoa and vanilla were allocated the highest and lowest scores, respectively (Table 13). The distribution of the score for the texture indicator in cardamom was less than two other flavorings.

The results of the variance analysis table showed that there was a significant statistical difference between the mean scores of three flavorings in the texture index at 1% level (Table 14). In order to investigate the differences in paired mean values, multiple comparisons were performed using Tukey HSD test (Table 15). The results showed that there was a significant difference between the mean scores of cacao-vanilla in the texture index at 5% level. There was no significant difference between the mean scores of cacao-cardamom in the texture index.

Table 13. Evaluation of descriptive statistics of texture index score in replications of tastes.

Tastes	N	Mean	Std. Deviation	Minimum	Maximum
Cocoa	9	2.57	0.09	2.45	2.65
Cardamom	9	2.47	0.08	2.37	2.56
Vanilla	9	1.53	1.09	0.07	2.30
Total	27	2.19	0.78	0.07	2.65

Table 14. Statistical difference in the mean of the replications of tastes for texture index.

Variation resource	Sum of squares	d.f.	Mean square	F	Sig.
Between groups	5.92	2	2.96	7.32	0.003
Within groups	9.7	24	0.404		
Total	15.63	26			

Table 15. Multiple comparisons (Tukey HSD test) of the replications of tastes for texture index.

(I) Taste	(J) Taste	Mean difference (I–J)	Std. Error	Sig.
Cocoa	Cardamom	0.097	0.29	0.94
	Vanilla	1.04	0.29	0.006
Cardamom	Cocoa	−0.097	0.29	0.94
	Vanilla	0.94	0.29	0.012
Vanilla	Cocoa	−1.04	0.29	0.006
	Cardamom	−0.94	0.29	0.012

3.6. Spreadability index

The results of the descriptive statistics of the Spreadability index showed that the flavorings of cardamom and vanilla were allocated the highest and lowest scores, respectively (Table 16). The distribution of the score for the Spreadability indicator in cocoa was less than two other flavorings.

The results of the variance analysis table showed that there was no significant difference between the mean scores of three flavorings in the Spreadability index (Table 17).

Table 16. Evaluation of descriptive statistics of rubbibility index score in replications of tastes.

Tastes	N	Mean	Std. Deviation	Minimum	Maximum
Cocoa	9	3.18	0.09	3.10	3.30
Cardamom	9	3.22	0.32	3.00	3.65
Vanilla	9	2.79	0.71	2.32	3.74
Total	27	3.07	0.48	2.32	3.74

Table 17. Statistical difference in the mean of the replications of tastes for rubbibility index.

Variation resource	Sum of squares	d.f.	Mean square	F	Sig.
Between groups	0.98	2	0.49	2.41	0.11
Within groups	4.89	24	0.2		
Total	5.87	26			

3.7. Overall acceptance index

The results of the descriptive statistics of the overall acceptance index showed that the flavorings of cocoa and cardamom were allocated the highest and lowest sensory scores, respectively (Table 18). The distribution of the score for the overall acceptance indicator in cocoa was less than two other flavorings.

The results of the variance analysis table showed that there was a significant statistical difference between the mean scores of three flavorings in the overall acceptance index at 1% level (Table 19). In order to investigate the differences in paired mean values, multiple comparisons were performed using Tukey HSD test (Table 20). The results showed that there was a significant difference between the mean scores of cacao-vanilla and cocoa-cardamom in the overall acceptance index at 1% level. There was a significant difference between the mean score of cardamom-vanilla in the overall acceptance index at 5% level.

Table 18. Evaluation of descriptive statistics of overall acceptance index score in replications of tastes.

Tastes	N	Mean	Std. Deviation	Minimum	Maximum
Cocoa	9	4.25	0.098	4.13	4.36
Cardamom	9	3.32	0.28	3.00	3.66
Vanilla	9	3.67	0.29	3.39	4.05
Total	27	3.75	0.45	3.00	4.36

Table 19. Statistical difference in the mean of the replications of tastes for overall acceptance index.

Variation resource	Sum of squares	d.f.	Mean square	F	Sig.
Between groups	3.950	2	1.975	33.855	0.000
Within groups	1.400	24	0.058		
Total	5.350	26			

Table 20. Multiple comparisons (Tukey HSD test) of the replications of tastes for overall acceptance index.

(I) Taste	(J) Taste	Mean difference (I–J)	Std. Error	Sig.
Cocoa	Cardamom	0.93	0.11	0.00
	Vanilla	0.58	0.11	0.00
Cardamom	Cocoa	−0.93	0.11	0.00
	Vanilla	−0.35	0.11	0.015
Vanilla	Cocoa	−0.58	0.11	0.00
	Cardamom	0.35	0.11	0.015

3.8. Prioritization of flavorings based on seven indicators using a riddling approach (H index)

Each of the experts in the panel has stated scores for seven indicators, separately. In order to consider a single score for each indicator and enter it in the prioritization (ranking) model in such circumstances, two approaches can be used: 1) Statistical central tendency indices; 2) the inverse of the statistical dispersion index. In this research, both approaches were used. Considering the favorable characteristics of the median index compared to the mean, this statistic was used. Also, due to the fact that the coefficient of variation (CV) index among the indexes of dispersion was without dimension (measure), this statistic was used. The simultaneous use of these two types of statistics enables the comparison of results and prioritization under these two approaches. The ranking results obtained from riddling approach are presented in Table 21. The values in the table express the preference ranking of hazelnut butter depending on the determined method. Based on the results, cacao has the highest priority. According to central index of median, cardamom has the lowest priority. While, the third ranking is relate to vanilla by calculation of inverse dispersion index of the coefficient of variation.

Table 21. Prioritization results based on Riddling approach under two approaches.

Dispersion index of the coefficient of variation inverse			Central index of median		
Priority	H index	Taste	Priority	H index	Taste
1	0.59	Cocoa	1	0.95	Cocoa
2	−0.12	Cardamom	3	−0.56	Cardamom
3	−0.47	Vanilla	2	−0.39	Vanilla

3.9. Prioritization of flavorings based on seven indicators using TOPSIS approach

TOPSIS is one of the multi-criteria decision-making techniques. TOPSIS uses the attitude that the chosen alternative must have the shortest distance from the ideal solution and furthest from the ideal solution from a geometric viewpoint by using the Euclidean distance to resolve the relative proximity of an alternative with the best possible solution [9]. TOPSIS has been extensively applied in the literature because of its capability to deal with different assessment problems addressed to the ranking of alternatives even in uncertain environments and/or in the presence of multiple decision makers [10]. The next prioritization of flavoring agents reported in Table 22 is performed using the proposed TOPSIS method. Two approaches were used in order to prioritize the flavorings in this approach: The central index of median scores and the inverse dispersion index of the coefficient of variation. Based on the results of the two approaches, cacao and vanilla have the highest and lowest priorities.

Table 22. Prioritization results based on TOPSIS approach under two approaches.

Dispersion index of the coefficient of variation inverse			Central index of median		
Priority	Coefficient of proximity	Taste	Priority	Coefficient of proximity	Taste
1	0.64	Cocoa	1	0.99	Cocoa
2	0.36	Cardamom	2	0.69	Cardamom
3	0.06	Vanilla	3	0.01	Vanilla

4. Discussion

Nut butters quality is comprised of several attributes such as color, aroma, appearance, consistency, texture, rubbing, and overall acceptance. These attributes have been defined, and may be evaluated as either sensory or instrumental measurements, or both of them. Sensory measurement are generally more helpful in the development of novel products and determining product standards while instrumental methods are higher in measuring quality on a routine basis [11]. A consumer direction views the product through the sensory viewpoint of the customer at the points of buy and consumption [12]. Consumers frequently purchase the first time based on appearance, but repeat purchases are driven by supposed quality factors verified by flavor compounds and texture [13]. The effect of various flavoring agents on the sensory characteristics of hazelnut butter was reviewed. It was noted that there has been more attention paid in the literature to the effects of sensory analysis on new product development. Since these flavoring agents are most likely to adversely affect sensory characteristics, this focus and prioritization seems appropriate.

Samples containing cocoa and cardamom had the highest and lowest scores of color, appearance, consistency and overall acceptance indices, respectively. Although the best aroma and texture indices were related to cocoa samples but the least scores of these characteristics were observed in vanilla samples. Also, evaluation of spreadability index showed that the flavorings of cardamom and vanilla were allocated the highest and lowest scores, respectively. Explanation of the sensory results is very difficult especially to determine which sample is best since there are several results, and each of them is independent of the other. As stated above, the addition of cocoa improved the most sensory aspects of samples except for spreadability index. But the choice between vanilla and cardamom is relatively difficult. Since vanilla-flavored hazelnut butters were mostly appreciated considering the color, appearance, consistency and overall acceptance indices, and the hazelnut butters including cardamom were preferred according to scores of spreadability, aroma and texture indices. In order to facilitate prioritization, using of multi-decision criteria techniques may be considered to obtain one result which was obtained from seven different sensory scores. Prioritization schemes using riddling and TOPSIS approaches tended to be relatively stable so that new value prioritizations were not made for each food choice. The results of prioritization based on riddling methodology (H index) showed that although the index level for different tastes varies in two approaches, the taste priorities do not differ. Consequently, the convergence and stability of the results were confirmed under two approaches in the riddling (H index) prioritization or ranking model. The same pattern of results can be seen in the TOPSIS. Investigators have determined that cacao and vanilla have the highest and lowest priorities, respectively.

5. Conclusions

The demand of consumers for health-promoting foods has grown in current years due to their increased knowledge about the relation between diet and health. Nut butters are widely consumed by people all over the world. However, formulation without flavoring agents alone is not sufficient for the consumption of the product. The sensorial characteristics of the product are also critical factors affecting the acceptance of the product by the consumer. In this respect, the sensorial characteristics of butters with different flavorings were also determined. Multicriteria decision techniques (Riddling and TOPSIS) were carried out to compare the samples in accordance with sensorial scores. Based on descriptive statistics, the incorporated hazelnut butter samples with cocoa almost had the most sensorial scores. Riddling and TOPSIS approaches were effective for selecting the best flavoring agent in the formulation of hazelnut butter. Overall, multiple comparisons provided better resolution to investigate the effect of different flavoring on the sensory characteristics. Based on the results obtained using central index of median and inverse dispersion index of the coefficient of variation, the flavoring of cacao has the highest priority. In the end, we have validated riddling and TOPSIS approaches as rapid methods to formulation on the basis of identification and prioritization of sensory aspects. With this recognition, the proposed TOPSIS-based approach represents a structured way to set priorities among flavoring agents. Overall, these methods could enable a wide range of studies in the field of formulation of novel products by drastically decreasing analysis time compared to other statistical methods.

Acknowledgments

We would like to acknowledge the Hazelnut Research Core of University of Guilan for their valuable help.

Conflict of interest

All authors declare no conflicts of interest in this paper.

References

1. Maguire L, O'sullivan S, Galvin K, et al. (2004) Fatty acid profile, tocopherol, squalene and phytosterol content of walnuts, almonds, peanuts, hazelnuts and the macadamia nut. *Int J Food Sci Nutr* 55: 171–178.
2. FAO (2012) Food and Agriculture Organization of the United Nations. Rome, Italy.
3. Aranceta J, Rodrigo CP, Naska A, et al. (2006) Nut consumption in Spain and other countries. *Br J Nutr* 96: 3–11.
4. Nattress LA, Ziegler GR, Hollender R, et al. (2004) Influence of hazelnut paste on the sensory properties and shelf-life of dark chocolate. *J Sens Stud* 19: 133–148.
5. Haghani Haghighi H, Azar M, Mazloumi MT, et al. (2008) Survey of formulation, production and sensory evaluation of pistachio butter. *Iran J Food Sci Technol* 5: 19–26.
6. Villegas B, Carbonell I, Costell E (2009) Acceptability of milk and soymilk vanilla beverages: Demographics consumption frequency and sensory aspects. *Food Sci Technol Int* 15: 203–210.
7. Deng H, Yeh CH, Willis RJ (2000) Inter-company comparison using modified TOPSIS with objective weights. *Comput Oper Res* 27: 963–973.
8. Chen CT (2000) Extensions of the TOPSIS for group decision-making under fuzzy environment. *Fuzzy Sets Syst* 114: 1–9.
9. Łatuszyńska A (2014) Multiple-criteria decision analysis using TOPSIS method for interval data in research into the level of information society development. *Folia Oecon Stetinensia* 13: 63–76.
10. Carpitella S, Certa A, Izquierdo J, et al. (2018) k-out-of-n systems: An exact formula for the stationary availability and multi-objective configuration design based on mathematical programming and TOPSIS. *J Comput Appl Math* 330: 1007–1015.

11. Shewfelt RL (2014) Measuring quality and maturity. *Postharvest Handl* 2009: 387–410.
12. Prussia SE, Shewfelt RL (1993) Systems approach to postharvest handling. *Postharvest handling: A systems approach Academic Press, San Diego*, 43–71.
13. Waldron KW, Parker M, Smith AC (2010) Plant cell walls and food quality. *Compr Rev Food Sci Food Saf* 2: 128–146.