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The effect of different spices on the moisture content, texture characterizations and consumer preferences of roasted sunflower seeds

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ABSTRACT

Roasting is an important process in the industry of nuts and seeds production. The aim of this study was the effect of different spices (red pepper, paprika, hibiscus tea, curry powder, sistani wrench, black plum peel puree, caraway, fennel, vegetables) on the moisture content, texture characterizations and sensory properties of roasted sunflower seed. The roasting process was performed under similar industrial conditions. Sholi (coating agents with spices (4 and 6%)) was prepared and added to the samples during the roasting process. The results showed the sample containing 4% vegetables had the highest hardness and penetration work, while, the sample with 6% hibiscus tea had the highest moisture content and the lowest elasticity. Furthermore, the sample contained 6% and 4% paprika had the highest elasticity and the lowest moisture content, respectively. Sensory properties of roasted sunflower seeds indicated that samples had moderate consumers' total acceptance, maybe, due to the new color and flavor of samples. The fracture force, hardness, penetration work and apparent modulus of elasticity of roasted sunflower seeds were in the range of 11.94–37.71 N, 28.31–55.83 N, 55.45–98.37 N.s and 12.53–24.06 N/s, respectively. PLS analysis showed the results of total acceptance, sensory hardness and instrumental properties were in agreement with each other. The use of new flavors and colors in this research can increase factory sales and respond to different consumer preferences.

Introduction

The sunflower, *Helianthus annuus*, is from the Asteraceae family and is the largest family of flowering plant. Sunflower is an important oilseed and food crop, and it produce 10% of oil in the world. Sunflower seed contains 15 g protein, 58 g lipid, 3 g ash, and 24 g carbohydrate with 675 kcal total energy per 100 g (de Oliveira Filho & Egea, 2021). The sunflower kernel contains a lot of oil, protein and phytochemicals and low crude fiber and it is a rich source of calcium, phosphorus, selenium, copper, zinc, vitamins E and B complex and antioxidant activity. The hull of sunflower seed has a large amount of lignin, pentosans, and cellulose (Adeleke & Babalola, 2020; Franco, Iseppi, & Taverna, 2018; Nandha, Singh, Garg, & Rani, 2014). Sunflower oil is low in the saturated fatty acids and high in oleic and linoleic acids that makes it suitable as edible oil (Adeleke & Babalola, 2020). Sunflower seed is mainly cultivated in Ukraine, Russia and Argentina. Iran is the 35th producer of sunflower seed in the world with about 40,000 tons in 2018 (FAO, 2020).

Sunflower seeds can be used in raw or roasted form (Goszkiewicz, Kołodziejczyk, & Ratajczyk, 2020). Roasting is one of the most important processes in the nut industry that improves the appearance, flavour, color, texture and total acceptance of the products (Özdemir & Devres, 2000; Pittia, Dalla Rosa, & Lerici, 2001; Saklar, Katnas, & Ungan, 2001). Hot air roasting contains the heating using air convection or radiant microwave heat. In the other roasting method, nuts and seeds were immersed in boiling oil, and then drawl to remove addition oil (Somogyi, 1996). During the roasting process, the moisture content of nuts decreased (Boge, Boylston, & Wilson, 2009) and the texture become more brittle and frangible (Vincent, 2004). Roasted sunflower kernels can be used in confectionery and bakery products like cakes, cookies, and pies. Physical and organoleptic properties of sunflower seed is acceptable and it can be used as nut substitutes (Talley, Brummett, & Burns, 1970).

The usage of spices is common in the world. Todays, there are a lot of herbs that used in the food. These spices have flavoring and preserving effects, antioxidant activity and phenolic compounds.

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Some of spices are used all over the world and in different cultures and some of them are special in geographical places (Nikousaleh & Prakash, 2008).

Many scientists studied on the roasting and mechanical properties of seeds and nuts (Bagheri, Kashaninejad, Aalami, & Ziaiifar, 2019; Bagheri, Kashaninejad, Ziaiifar, & Aalami, 2019; Demir & Cronin, 2005; Gholami & Ansari, 2020; Goszkiewicz et al., 2020; Idrus & Yang, 2012; Kahyaoglu & Kaya, 2006; Madrigal et al., 2019; Mohammadi-Moghaddam, Razavi, Sazgarnia, & Taghizadeh, 2018; Mosayebi, Kashaninejad, & Najafian, 2018; Olatidoye, Shittu, Awonorin, Ajisegiri, & Akin, 2019; Saklar, Ungan, & Katnas, 2003; Soleimanieh, Eshaghi, & Vanak, 2015; Yang, Kan, Wu, Liu, & Ouyang, 2019; Zzaman & Yang, 2014).

Due to the high consumption of sunflower seeds and also its reasonable price in comparison with other nuts and the variety of spices, as well as the medicinal properties of these spices, the purpose of this study was to produce roasted sunflower seeds with various flavors and colors that people with different sense of taste can consume it. So, the aim of this study was the effect of different kind (paprika, red pepper, hibiscus tea, caraway, curry powder, fennel, sistani wrench, black plum peel and mix of vegetable) and percentage of spices (4 and 6%) on the moisture content, sensory properties (color, flavor, firmness and total acceptance) and texture parameters (fracture force, hardness, penetration work and apparent modulus of elasticity) of sunflower seeds have been investigated. For this purpose, roasting process was performed under similar industrial conditions. Sholi (coating agents with spices) was prepared and added to the samples during the roasting process. After cooling, samples were used for tests.

Materials and methods

Sample preparation

Raw materials include flower seed (Songhori variety, Neyshabur, Iran) salt (Sepid-Kani-Shargh co., 99.2% purity, Neyshabur), citric acid (Jovein co., Sabzevar, Iran), drinking water, starch, black plum peel puree (The defrosted peels were mixed with water in equal proportion and homogenized using a high-speed blender (Sunwood food processor, Italy). Then, the mixture was filtered in order to obtain the puree of black plum peel), paprika, red pepper, hibiscus tea, caraway, fennel, curry powder (Neyshabur, Iran), sistani wrench (It is one of the traditional and old spices of Sistan region, Iran and its made of wheat, onion, coriander seeds, dill seeds, black and green cumin, turmeric, salt and pepper), vegetables (mix of savory, rosemary, thyme, oregano, dried basil, marjoram, fennel, Sabzan co., Mallard, Iran).

Sunflower seeds were cleaned to remove impurities. The components of the sholi (coating agents) for 100 gr sunflower seeds included salt 14%, citric acid 3%, starch 3%, water 20% and different spices (4 and 6%). For hibiscus tea, since, its powder was not be usable, so, its solution was prepared and used. For this purpose, 4 and 6 gr of hibiscus tea were mixed with 50 gr hot water for 15 min and was added to other ingredients. The sunflower seeds were roasted at 200 °C for 8 min in the oven (Memmert, German). Then, sholi was added. After that, roasting process continued for 10 min. The samples were cooled at room temperature (25 ± 0.5 °C).

Moisture content determination

Moisture content of sunflower seeds was measured using oven method (105 ± 2 °C, FanAzma Shargh, Tehran, Iran) until a constant weight (Mohammadi-Moghaddam et al., 2018). Moisture content was measured in three replications.

Texture measurement

Texture parameters of roasted sunflower seeds were get from a penetration test using a TA.XT Plus Texture analyzer (Stable Micro Systems, England, UK). Penetration test was done for horizontal dimension for complete seeds with shell; by a 2 mm diameter steel needle, was used for sunflower seeds. Samples were penetrated at depth of 3 mm and speed of 60 mm/min. The textural parameters of kernels were expressed as fracture force (highest peak followed by a sudden drop [N]), hardness (peak penetration force [N] at target deformation), apparent modulus of elasticity or initial tangent modulus (sample rigidity that is the linear part of the force-deformation (time) curve [N/s]) and penetration energy (area under the curve for the penetration that is the work [N.s] required to attain deformation, indicative of internal strength of bonds within product). Texture measurements were performed in at least six replications.

Table 1
The effect of different spices on the moisture content of roasted sunflower seeds.

Kind/Percent	4%	6%
Red pepper	3.95 ± 0.12^{b}	2.75 ± 0.10^{h}
Paprika	$\mathbf{1.9 \pm 0.01}^{i}$	2.72 ± 0.10^{h}
Hibiscus tea	2.94 ± 0.10^{fgh}	$\mathbf{4.99 \pm 0.14}^{a}$
Curry powder	3.65 ± 0.11^{c}	3.05 ± 0.13^{efg}
Sistani wrench	3.33 ± 0.14^{de}	2.85 ± 0.10^{gh}
Black plum peel	3.39 ± 0.10^{cd}	2.98 ± 0.11^{fgh}
Caraway	3.64 ± 0.13^{c}	2.94 ± 0.08^{fgh}
Fennel	4.22 ± 0.15^{b}	3.06 ± 0.12^{efg}
Vegetables	3.05 ± 0.11^{efg}	3.22 ± 0.10^{def}

Sensory evaluation

Sensory properties were assessed to investigate consumers' preferences in the context of using different spices in roasted sunflower seeds. Sensory properties of roasted sunflower seed were evaluated by 15 trained panelists (7 men and 8 women, 20–40 years old) from students and personnel of Neyshabur University of Medical Sciences, Iran). Evaluations were done at room temperature (25 ± 0.5 °C). The five-point hedonic score (Standardization, 2003) (1 = Dislike extremely, 5 = like extremely) was used to specify the sensory properties of roasted sunflower seeds. Triangle test was used to identify sensory differences between the samples. Throughout panel sessions, panelists were instructed to rinse their mouths with warm water before testing each sample. For consumers' sensory evaluation, five parameters containing color, odor, flavor, hardness and total acceptance were measurement.

Statistical analysis

Data were analyzed with Minitab statistical software (Version 16, USA, 2010). Means were separated by Tukey analysis at a least significant difference of $P \leq 0.05$ value. Partial Least Square (PLS) method was used to show the relationships between sensory hardness, total acceptance, and texture properties of roasted sunflower seeds. GraphPad Prism (Version 8.0.1, USA) also used to plot the curves.

Results and discussion

Moisture content

Table 1 illustrates the effect of different spices on the moisture content of roasted sunflower seeds. It can be seen that the usage of different spices had significant effect on the moisture content of roasted sunflower seeds ($P < 0.05$). The sample containing 4% paprika had the lowest moisture content and the sample containing 6% hibiscus tea had the highest moisture content. Hibiscus tea that was applied as spices had no solids and it was a red water solution, so the seeds containing the hibiscus tea solution had the highest moisture content. Analysis of variance (ANOVA) indicated that the effect of spices concentrations on the moisture content was not significant ($P > 0.05$). The moisture

Table 2
The effect of different spices on texture parameters of roasted sunflower seeds.

Texture parameter	Fracture force (N)		Hardness (N)		Penetration work (N.s)		Apparent modulus of elasticity (N/s)	
Kind/Percent	4%	6%	4%	6%	4%	6%	4%	6%
Red pepper	32.29 ± 2.51	14.24 ± 2.76	^{ab}48.59 ± 5.23	^{bcd}35.35 ± 5.02	^{ab}90.83 ± 4.23	^{abc}74.17 ± 7.56	^{ab}15.36 ± 4.56	^{ab}16.98 ± 1.45
Paprika	23.49 ± 3.11	30.15 ± 3.45	^{abcd}39.73 ± 2.56	^{abcd}44.91 ± 4.25	^{abc}72.49 ± 2.53	^{abc}81.74 ± 8.23	^{ab}16.02 ± 1.05	^{ab}**24.06** ± 2.75
Hibiscus tea	16.00 ± 1.23	20.51 ± 3.14	^{bcd}36.39 ± 4.25	^{cd}29.92 ± 1.78	^{abc}68.51 ± 6.57	^{c}**55.45** ± 4.56	^{ab}16.31 ± 3.56	^{b}**12.53** ± 1.33
Curry powder	**11.94** ± 2.03	33.90 ± 4.23	^{cd}30.51 ± 3.14	^{abc}45.07 ± 4.42	^{bc}59.94 ± 4.23	^{ab}89.04 ± 7.86	^{b}12.90 ± 1.25	^{ab}23.83 ± 2.46
Sistani wrench	22.95 ± 4.02	19.65 ± 2.12	^{bcd}35.87 ± 2.89	^{d}**28.31** ± 2.35	^{bc}66.79 ± 5.65	^{c}58.31 ± 5.23	^{ab}17.62 ± 2.05	^{b}14.13 ± 1.09
Black plum peel	21.06 ± 3.22	16.33 ± 3.56	^{cd}31.65 ± 5.05	^{bcd}34.01 ± 3.56	^{c}59.68 ± 6.23	^{bc}62.61 ± 4.56	^{ab}19.24 ± 2.45	^{ab}16.49 ± 3.23
Caraway	28.64 ± 3.13	37.49 ± 3.14	^{abc}45.41 ± 4.35	^{abcd}43.95 ± 4.08	^{abc}82.78 ± 4.56	^{abc}83.48 ± 9.65	^{ab}20.46 ± 3.12	^{ab}22.02 ± 3.45
Fennel	15.05 ± 4.12	24.38 ± 4.01	^{cd}29.87 ± 4.35	^{bcd}35.74 ± 2.78	^{c}57.54 ± 4.78	^{abc}70.30 ± 7.53	^{ab} 14.18 ± 0.89	^{ab}16.40 ± 1.37
Vegetables	**37.71** ± 4.56	17.50 ± 3.42	^{a}**55.83** ± 3.45	^{cd}30.82 ± 4.23	^{a}**98.37** ± 6.53	^{c}58.98 ± 6.32	^{a}25.57 ± 1.23	^{ab}14.83 ± 1.86

content of samples varied from 1.9% to 4.99%. Gupta and Das (2000) reported the moisture content of sunflower seeds and kernels 5.62 and 4.14%, respectively. Different amounts of moisturecontent have been reported by other researchers (Delic et al., 1971; Earle, Vanetten, Clark, & Wolff, 1968; Mosayebi, Kashaninejad, & Najafian, 2018; Pierce, 1970; Wamble, 1969). The values obtained in this study were lower than the values reported by other researchers. The results obtained in this study are near to the values obtained by Soleimanieh et al. (2015) (Soleimanieh et al., 2015) for roasted sunflower seeds.

Texture measurement

Texture evaluation is often an important step in developing a new food product or optimizing processing variables and it defines as an imitation of the mastication operation and may be used to predict the behavior of a solid food in mouth (Bourne, 2002).

Table 2 shows the effect of different spices on texture parameters of roasted sunflower seed. The use of different spices did not show a significant effect on the fracture force of roasted sunflower seeds ($P > 0.05$). The fracture force of roasted sunflower seeds was in the range of 11.94 to 37.71 N.

Hardness defined as the force required to break the sample into several segments during the first bite by the molars. For evaluation the hardness of solid foods, the sample is placed between the molar teeth and the panelist bites down evenly, evaluating the force to compress the food (Bourne, 2002). The results showed that hardness changed dramatically with different spices ($P < 0.05$). The sample containing 4% vegetables had the highest hardness and the sample containing 6% sistani wrench had the lowest hardness. The hardness of roasted sunflower seeds was in the range of 28.31 to 55.83 N.

Results of ANOVA showed that the usage of different spices modified the penetration work markedly ($P < 0.05$). The sample containing 4% vegetables had the highest penetration work and the sample containing 6% hibiscus tea had the lowest penetration work. To roast sunflower seeds containing hibiscus tea, an aqueous solution was used, which had low total solids. Having low solids increased the moisture content and ultimately reduced the hardness of roasted sunflower seeds. The penetration work of samples ranged within 55.45–98.37 N.s.

Apparent modulus of elasticity, determined from the initial slopes of the force–distance curves. There is a wide range of apparent modulus of elasticity for different foods (Bourne, 2002). Significant change ($P < 0.05$) in the apparent modulus of elasticity was observed with various spices. The sample containing 6% paprika had the highest apparent modulus of elasticity and the sample containing 6% hibiscus tea had the lowest apparent modulus of elasticity which can be due to the high moisture content and low hardness of sample. The apparent modulus of elasticity of samples ranged from 12.53 to 24.06 N/s.

Statistical analysis indicated that the concentration of spices did not have a significant effect on all textural parameters of roasted sunflower seeds ($P > 0.05$).

Gupta and Das (2000) (Gupta & Das, 2000) studied the textural properties of sunflower seeds at horizontal and vertical orientations and different moisture content. According to their results, rupture force, energy absorbed and rupture energy for horizontal orientation were 65.5–35.5 N, 95.2–184.2 and 38.9–65.8 J/m^3, respectively.

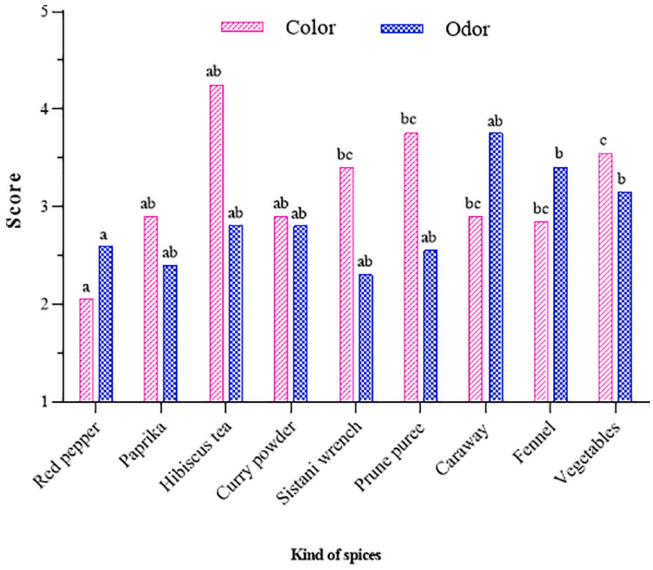

Fig. 1. The effect of different spices on sensory properties of roasted sunflower seeds.

Sensory evaluation

Sensory properties of foods is influenced by the type of food, the environs and users. For solid foods, consumer acceptability is very momentous and it is determined by sensory factors containing flavor, texture, appearance and kind of packaging. Acceptance of food affects by the sensory properties of the food, expectancy of consumer, culture, physiological situation like hunger, thirst, sickness and many other factors (Costell, Tárrega, & Bayarri, 2010; Joyner, 2019).

Fig. 1 shows the effect of different spices on sensory properties of sunflower seed. Color score saw a significant change with different spices ($P < 0.05$). The sample containing 4% hibiscus tea had the highest color score and the sample containing 4% red pepper had the lowest color score.

Dissolution of hibiscus tea in water created a pink color, and due to the fact that there were no solids in this solution; this color was showed on sunflower seeds very well, which was favorably accepted by panelists. The color score of samples ranged within 1.9–4.5.

Results of ANOVA showed that the usage of different spices changed the odor of roasted sunflower seeds significantly ($P < 0.05$). The sample containing 6% caraway had the highest odor score and the sample containing 6% paprika had the lowest color score. The color score of samples ranged within 2.10–3.8.

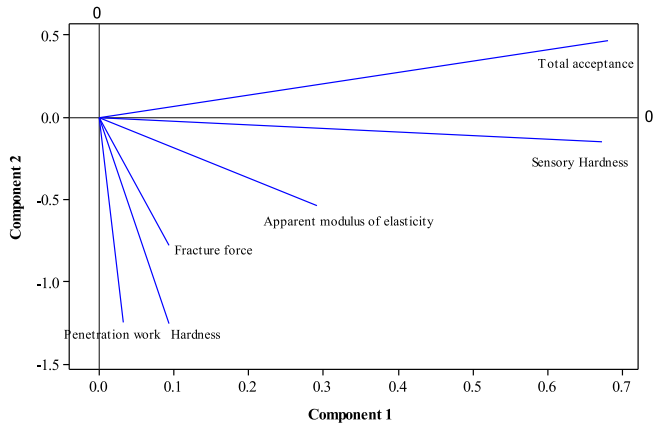

Fig. 2. Correlation between total acceptance, sensory hardness and instrumental properties of roasted sunflower seeds.

Statistical analysis showed that application of different spices did not have a significant efficacy on flavor, hardness and total acceptance of roasted sunflower seeds ($P > 0.05$). In addition, the use of different percentages of spices did not show a dramatic effect on all sensory parameters of roasted sunflower seeds ($P > 0.05$). Flavor, hardness and total acceptance of roasted sunflower seeds ranged from 2.60 to 4.00, 3.90–4.50 and 2.60–3.00, respectively.

Soleimanieh et al. (2015) (Soleimanieh et al., 2015) studied the microwave and electrical oven method for roasting the sunflower seeds. Their results showed that color, odor, hardness, flavor and total acceptance of roasted seeds were more acceptable than control samples. Mosayebi et al., (2018) (Mosayebi, Kashaninejad, & Najafian, 2018) used IR method for sunflower seeds roasting. According to the panelists, IR method didn't show undesirable changes on flavor, texture and appearance of kernels.

Correlation between consumer acceptance and instrumental variables

Correlation is commonly used to determine the relationship between the instrumental and sensory properties to predict consumer responses or to evaluate quality control tools or parameters (Szczesniak, 1987). In examination the relation between sensory and instrumental parameters, it's so important to get the close relationship to represent the actual perception of the food properties (Dijksterhuis & Piggott, 2000). Fig. 2 shows the results from PLS2 regression analysis, which describe the relationship between instrumental properties with sensory hardness and total acceptance. It can be seen that texture parameters were positively correlated together and sensory hardness and negatively correlated with total acceptance, so it can be said, the lower the textural values, the higher consumer acceptance scores and total acceptability.

Conclusion

Roasting is a common method in the industry of roasted products. Today, due to the diversity of consumer tastes, industries are looking to create new and consumer-friendly products. In this study, under industrial simulated conditions, roasted sunflower seeds with different flavors and colors were produced. According to the consumers' point of view, samples had moderate total acceptance. Perhaps, the reason is the new color and flavor of samples. According to the results of this research, it seems that usage of new flavors and colors can increase factory sales and respond to consumer diversity.

CRediT authorship contribution statement

Toktam Mohammadi-Moghaddam: Investigation, Writing - original draft, Writing - review & editing, Supervision. **Ali Firoozzare:** Writing - original draft, Writing - review & editing. **Somayeh Helalian:** Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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