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

Toktam Mohammadi-Moghaddam a,*, Ali Firoozzare b, Somayeh Helalian c

a Department of Food Science and Technology, Neyshabur University of Medical Sciences, Neyshabur, Iran
b Department of Agricultural Economics, College of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran
c Department of Food Science and Technology, Professional and Technical College Girls, Neyshabur, Iran

ARTICLE INFO

Keywords:
Roasting
Spice
Sunflower seeds
Texture

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 seeds. 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 that 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 Ns 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 (Ozdemir & Devres, 2000; Pittia, Dalla Rosa, & Leric, 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 (Tailey, Brummet, & 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.

* Corresponding author.
E-mail address: MohammadiT@nums.ac.ir (T. Mohammadi-Moghaddam).

https://doi.org/10.1016/j.jfochx.2021.100130
Received 5 May 2021; Received in revised form 21 July 2021; Accepted 7 September 2021
Available online 22 September 2021
2590-1575/© 2021 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license

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; Demiri & Cronin, 2005; Gholami & Ansari, 2020; Gosszkiewicz et al., 2020; Idrus & Yang, 2012; Kahyaoglu & Kaya, 2006; Madrigal et al., 2019; Moghaddam, Razavi, Sazgarnia, & Taghizadeh, 2018; Mosayebi, Kashaninejad, & Najafian, 2018; Olatidoye, Shittu, Awonorin, Ajisegiri, & Akin, 2019; Sakik, 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, black plum peel, black pepper 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 Sharh, 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 (20% solids and it was a red water solution, so the seeds containing the hibiscus tea solution 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

| Kind/Percent | 4% | 6% |
|--------------|----|----|
| Red pepper   | 3.95 ± 0.12b | 2.75 ± 0.10b |
| Paprika      | 1.9 ± 0.011c | 2.72 ± 0.10b |
| Hibiscus tea | 2.94 ± 0.10d | 4.99 ± 0.14b |
| Curry powder | 3.65 ± 0.11bc | 3.05 ± 0.13bd |
| Sistani wrench | 3.33 ± 0.14d | 2.85 ± 0.10b |
| Black plum peel | 3.39 ± 0.10d | 2.98 ± 0.11d |
| Caraway      | 3.64 ± 0.13c | 2.94 ± 0.08d |
| Fennel       | 4.22 ± 0.15d | 3.06 ± 0.12d |
| Vegetables   | 3.05 ± 0.11d | 3.22 ± 0.10d |

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 ≤ 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.
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 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

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

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/m³, respectively.

**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 paprika 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.
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

T. Mohammadi-Moghaddam: Investigation, Writing - original draft, Writing - review & editing. Ali Firoozzade: 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.

Acknowledgements

We would like to thank the Neyshabur University of Medical Sciences for funding the project.

References

Adeleke, B. S., & Babalola, O. O. (2020). Oilseed crop sunflower (Helianthus annuus) as a source of food: Nutritional and health benefits. Food Science & Nutrition, 8(9).
Bagheri, H., Kashaninejad, M., Aalam, M., & Ziaiifar, A. (2019). Optimization of Hot Air Roasting of Peanut Kernels Using Response Surface Methodology.
Bagheri, H., Kashaninejad, M., Ziaiifar, A. M., & Aalam, M. (2019). Textural, color and sensory attributes of peanuts roasted by infrared roasting method. Information Processing in Agriculture, 6(2), 255–264.
Boge, E. L., Boytston, T. D., & Wilson, L. A. (2009). Effect of cultivar and roasting method on composition of roasted soybeans. Journal of the Science of Food and Agriculture, 89(5), 821–826.
Bourne, M. (2002). Food texture and viscosity: Concept and measurement. Elsevier.
Costell, I., Tarrrega, A., & Bayarri, S. (2010). Food acceptance: The role of consumer perception and attitudes. Chemosensory Perception, 2(1), 42–50.
Delic, I., Rad, M., Stojaslijevic, T., Vacuvac, N., Dutina, B., Ivic, M., … Milic, B. (1971). Physical characteristics and chemical composition of decelulosed sunflower meal. Srvjerna Poljoprivreda Pasebu Izdanje, 10, 1.
Demir, A. D., & Cronk, K. (2005). Modelling the kinetics of textural changes in hazelnuts during roasting. Simulation Modelling Practice and Theory, 13(2), 97–107.
Dijksterhuis, G. B., & Piggott, J. R. (2000). Dynamic methods of sensory analysis. Trends in Food Science & Technology, 11(8), 284–290.
Earle, F. R., Vanetten, C. H., Clark, T. F., & Wolff, I. A. (1968). Compositional data on sunflower seed. Journal of the American Oil Chemists’ Society, 45(12), 876–879.
FAO. (2020). Food and agriculture organisation of the United Nations.
Filho, J. G., & Egea, M. B. (2021). Sunflower seed byproduct and its fractions for food application: An attempt to improve the sustainability of the oil process. Journal of Food Science, 86(5), 1497–1510.
Franco, R., Iiepi, L., & Taverna, M. (2018). Sunflower oil functional properties for specialty food. Nutrition & Food Science International Journal, 5(4), 4–7.
Gholami, Z., & Anzai, S. (2020). Effects of roasting conditions on physicochemical properties of the watermelon seed. Iranian Journal of Chemistry and Chemical Engineering (IJCCE).
González-Cerdecemos, A., Koboldzvejczyk, E., & Ratajczyk, F. (2020). Comparison of microwave and convection method of roasting sunflower seeds and its effect on sensory quality, texture and physicochemical characteristics. Food Structure, 25, 100144. https://doi.org/10.1016/j.foodstruct.2020.100144
Gupta, R. K., & Das, S. K. (2000). Fracture resistance of sunflower seed and kernel to compressive loading. Journal of Food Engineering, 46(1), 1–8.
Idrus, N. M. F., & Yang, T. A. (2012). Comparison between roasting by superheated steam and by convection on changes in colour, texture and microstructure of peanut (Arachis hypogaea). Food Science and Technology Research, 18(4), 515–524.
Joyner, H. S. (1991). Rheology of Semisolid Foods. Springer.
Kawahygo, T., & Kaya, S. (2006). Modeling of moisture, color and texture changes in sesame seeds during the conventional roasting. Journal of Food Engineering, 75(2), 167–177.
Madrigal, M.-S., Rios, N. V. R., Ramos, A. Q., Lerma, A. S., Castillo, H. A. P., Hernández, P. O. A,... Zamora, G. M. (2019). Effect of roasting-drying process on physicochemical and structural characteristics of roasted-dried peppers ("Capsicum annuum L."). Agrociencia, 53(3), 319–335.
Mohammadi-Moghaddam, T., Razavi, S. M. A., Sargarnia, A., & Taghizadeh, M. (2018). Predicting the moisture content and textural characteristics of roasted pistachio kernels using Vis/NIR reflectance spectroscopy and PLSR analysis. Journal of Food Measurement and Characterization, 12(1), 346–355.
Mosayebi, M., Kashaninejad, M., & Najafian, L. (2018). Optimizing Physicochemical and Sensory Properties of Infrared-Hot Air Roasted Sunflower Kernels Using Response Surface Methodology. Journal of Food Quality, 2018.
Nandha, R., Singh, H., Garg, K., & Rani, S. (2014). Therapeutic potential of sunflower seeds: An overview. International Journal of Research and Development in Pharmacy & Life Sciences (IJRDPL), 3.
Nikousaleh, A., & Prakash, J. (2008). Effect of dry heat treatment of six spices on antioxidant activity of their water extracts. Food, 2, 139–144.
Olaidoye, O. P., Shittu, T. A., Awoonrin, S. O., & Ajasigere Akin, E. S. (2019). The influence of roasting conditions on volatile flavour compounds in raw and roasted cashew kernels (Anacardium occidentale) grown in Nigeria. Croatian Journal of Food Science and Technology, 11(1), 1–10.
Ozdemir, M., & Devres, O. (2000). Kinetics of color changes of hazelnuts during roasting. *Journal of Food Engineering*, 44(1), 31–38.

Pierce, R. (1970). *Sunflower processing technique*. Springer.

Pittia, P., Dalla Rosa, M., & Lerici, C. R. (2001). Textural changes of coffee beans as affected by roasting conditions. *LWT-Food Science and Technology*, 34(3), 168–175.

Saklar, S., Katnas, S., & Ungan, S. (2001). Determination of optimum hazelnut roasting conditions. *International Journal of Food Science & Technology*, 36(3), 271–281.

Saklar, S., Ungan, S., & Katnas, S. (2003). Microstructural changes in hazelnuts during roasting. *Food Research International*, 36(1), 19–23.

Soleimanieh, S. M., Eshaghi, M., & Vanak, Z. P. (2015). The effect of roasting method and conditions on physis chemical and sensory properties of sunflower seed kernels. *International Journal of Biosciences*, 6(7), 7–17.

Somogyi, L. P. (1996). *Major processed products*. Technomic Publishing Company, Incorporated.

Standardization, I. O. f. (2003). Sensory analysis—Guidelines for the use of quantitative response scales: ISO.

Szczesniak, A. S. (1987). Correlating sensory with instrumental texture measurements—an overview of recent developments 1. *Journal of Texture Studies*, 18(1), 1–15.

Talley, L., Brummett, B., & Burns, E. (1970). Utilization of sunflower in human food products. In *Proceedings of the Fourth International Sunflower Conference* (pp. 110–110).

Vincent, J. F. V. (2004). Application of fracture mechanics to the texture of food. *Engineering Failure Analysis*, 11(5), 695-704.

Wamble, A. (1969). Pilot plant processing of sunflower seed with conventional cottonseed processing equipment. *Oil Mill Gaz*, 73, 10.

Yang, Q., Kan, L., Wu, Y., Liu, Y., & Ouyang, J. (2019). Influence of nutritional components on the texture characteristics and sensory properties of cooked chestnut kernel. *Journal of Food Processing and Preservation*, 43(10). https://doi.org/10.1111/jfpp.14112

Zzaman, W., & Yang, T. A. (2014). Moisture, color and texture changes in cocoa beans during superheated steam roasting. *Journal of Food Processing and Preservation*, 38(3), 1364–1370.