Journal of Food Biosciences and Technology,
Islamic Azad University, Science and Research Branch, Vol. 12, No. 2, 15-22, 2022
DOI: 10.30495/JFBT.2022.19332 https://dorl.net/dor/20.1001.1.22287086.2022.12.2.2.3

Influence of Frying Conditions and Wild Sage Seed Mucilage Coating on the Physical Properties and Oil Uptake of Zucchini Slices during Deep-Fat Frying

F. Salehi [a*], ***A. Haseli*** [b], ***A. Roustaei*** [b]

[a] Associate Professor of the Faculty of Agriculture, Bu-Ali Sina University, Hamedan, Iran.
[b] BSc Student of the Faculty of Agriculture, Bu-Ali Sina University, Hamedan, Iran.

Received: 12 March 2021 Accepted: 26 October 2021

ABSTRACT: Application of gums-based edible coatings to food products before frying is a technique that can improve the nutritional quality and sensory parameters of fried products. In this study, the effect of wild sage seed mucilage (WSSM) concentration at three concentrations of 0.5, 1.0 and 1.5% as edible coatings and frying temperature at three degrees of 155°C, 170°C and 185°C on the oil uptake and color change kinetics of zucchini slices during frying process have been studied. The color indexes include a* (redness), b* (yellowness), L* (lightness), and color change intensity (ΔE) were used to calculate appearance changes of fried zucchini slices. WSSM Coating treatments decreased the oil uptake of fried zucchini slices about 21.80%. By increasing WSSM concentration from 0.0% to 1.5% significantly decreased the oil uptake of zucchini slices from 8.96% to 7% ($P<0.05$), while the moisture content of samples were increased from 83.97% to 86.18% with increasing gum concentration ($P<0.05$). The average ΔE index of fried zucchini slices increased from 30.45 to 65.63 with increasing frying temperature from 155°C to 185°C. The average surface change values of fried zucchini slices was 33.13% for the uncoated samples, in comparison 30.40%, 29.36%, and 27.97% were found for fried slices coated with 0.5, 1.0 and 1.5% WSSM, respectively. The best coating suspension and temperature frying for reducing the oil uptake of fried zucchini slices was 1.5% WSSM and 155°C, respectively.

Keywords: Color Indexes, Frying Process, Surface Change, Wild Sage Seed Mucilage.

Introduction

Wild sage (*Salvia macrosiphon* L.) is the mucilaginous native plant and its seeds have a high amount of mucilage (gums) with outstanding useful characteristics that are comparable with marketable food gums. Wild sage seed mucilage (WSSM) is gums extracted from these seeds using water (Salehi, 2017). Application of these seeds gums as edible coatings for food products protection and preservation have particular importance that include biodegradability, eco-friendliness, accessibility and a suitable price (Salehi, 2020a).

Frying process happen during the immersion of foods in fat/oil at a temperature between 150 ºC to 200ºC, where a simultaneous heat and mass transfer phenomena take place that caused physico-chemical and color changes in fried foods. High fat/oil content (high-calorie) of most fried foods decreased their quality and shelf-life and causes a decrease

* Corresponding Author: F.Salehi@Basu.ac.ir

in fried foods overall acceptability (Liberty *et al.*, 2019; Zhang *et al.*, 2020). The oil uptake and high fat/oil content problem associated with fried foods can be reduced using polysaccharides (gums) as edible coatings. Application of gums-based edible coatings to food products before frying is a technique that can improve the nutritional quality and sensory parameters of fried products (Ashrafi Yorganloo & Gheybi, 2019; Salehi, 2020b).

Edible coating has been used as one of the methods to modify product appearance. The surface color and appearance quality of the fried agricultural products are one of the highest significant quality factors for the acceptance of these products. In addition, process variables include fryer type, frying temperature and condition, sample pretreatment and edible coatings are expected to affect the color and surface of the fried products (Liberty *et al.*, 2019; Salehi, 2020b). Ashrafi Yorganloo and Gheybi (2019) reported that the color indexes and quality of french fries slices containing carboxyl methyl cellulose coatings were better than the french fries containing okra mucilage and samples without any coating.

Modification of foods surface has proven to be highly effective method in decreasing oil uptake. Therefore, the target of this study was to investigate the effect of WSSM as edible coatings on the oil uptake, appearance and color indexes (L*, a*, b* and ΔE) of fried zucchini slices.

Materials and Methods

- *Zucchini slices preparation*

Zucchinis were purchased from a local market from Hamedan, Iran. Slices of zucchini with 1 cm thickness were prepared with the aid of a knife and a cylindrical steel-made cutter (d=3.35 cm). The initial and final (fresh and fried) moisture content (MC) of zucchini slices were measured at 105°C for 5 h and its initial MC was 93%.

- *Gum extraction*

Wild sage seeds were purchased from a local market from Hamedan, Iran. These seeds were screened and all seeds impurities were removed. The pure seeds were immersed in water for 20 min at a seed/water portion of 1:20 at 25°C. The extracted mucilage was separated from the inflated seeds by passing the seeds through an extractor with a rotating disc that scratched the mucilages layer on the seeds surface (Salehi, 2017; Amini *et al.*, 2021).

- *Coating of zucchini slices*

The aqueous solutions of WSSM at three concentrations of 0.5, 1.0 and 1.5% (w/w) were used to coat the fresh zucchini slices before frying. The fresh zucchini slices were immersed for 1 minute in these aqueous solutions.

- *Frying condition*

The frying process of zucchini slices was carried out in a mini fryer (Delmonti, DL630, Iran) containing refined edible oil (Bahar frying oil, Iran). The fryer was equipped by thermo controller system (Lutron, TM-916) with K type thermocouple with temperature control of ±0.1°C. The frying process of zucchini slices were performed at three different oil temperatures of 155, 170 and 185 ºC for 5 minutes. All frying periods and conditions were carried out in triplicate order.

- *Color measurement*

In order to investigate the influence of coatings type on the color indexes (image analysis) of uncoated and coated zucchini slices, Image J software (V. 1.42e, USA) was used. Sample figures were obtained with HP Scanjet-300 scanner. Lightness

(L^*), redness (a^*) and yellowness (b^*) were calculated in this research. The estimation of color changes intensity (ΔE) for the total color difference was calculated according to equation 1 (Salehi, 2019):

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \qquad (1)$$

The changes in the area (surface) of the zucchini slice during frying process was estimated using equation 2:

$$\Delta A = \frac{A_0 - A_t}{A_0} \times 100 \qquad (2)$$

Where ΔA is the surface changes (%), A_0 and A_t (cm^2) are the area of fresh and fried zucchini slices, respectively.

Results and Discussion

Edible coatings applied to fruits and vegetables slices before frying is a technology that can improve the appearance and sensory qualities of fried products. Figure 1 shows the effect of coatings with WSSM and frying temperature on the MC of fried zucchini slices. There was significant difference between coated zucchini slices and control sample in MC ($P<0.05$). The results showed that WSSM coating could reduce moisture loss of deep fried zucchini slices. The coated zucchini slices had higher MC due to the inhibitory influence of the WSSM as compared to the control sample. In addition, the average MC of fried zucchini slices decreased from 87.77% to 82.54% with increasing frying temperature from 155°C to 185°C.

Gum-based edible coatings have been useful in reducing oil uptake in deep-fat fried foods (Sothornvit, 2011). Figure 2 shows the effect of coatings with WSSM and frying temperature on the oil uptake of fried zucchini slices. WSSM Coating treatments decreased the oil uptake of fried zucchini slices about 21.80%. With increasing WSSM concentration from 0.0% to 1.5% significantly decreased the oil uptake of zucchini slices from 8.96% to 7.00% ($P<0.05$), while the moisture content of samples were increased from 83.97% to 86.18% with increasing gum concentration ($P<0.05$). These results are consistent with the findings of Naji Tabasi and Mahdian (2017) for low oil uptake of coated potato chips with Persian gum during deep fat frying, Karimi and Kenari (2016) for low oil uptake and high MC of coated potato strips with Basil seed gum and salep during deep fat frying, and Izadi *et al.* (2015) for low oil uptake and high MC of coated shrimp with carboxyl methyl cellulose, guar, tragacanth and zedo gums during deep fat frying. Khazaei *et al.* (2016) reported that edible coating with Basil seed gum and thymol could decrease the moisture loss and oil uptake of fried shrimps by about 13.9% and 34.50%, respectively. In another study, Eslampour and Hosseini (2017) reported that the bitter almond gum and gelatin could decrease moisture loss and oil uptake of potato slices during deep fat frying process.

Lightness (L*) index is an important parameter in the fried products as it is common the first quality characteristic evaluated by consumers when estimate the foods acceptance. The loss of L* values gives the darker color and appearance of the fried products (Seerangurayar *et al.*, 2019). Figure 3 indicates the effect of WSSM coating on the lightness of fried zucchini slices. The results showed that coating type has a considerable effect on the L* parameter ($P<0.05$). The average L* index values of fried zucchini slices increased from 42.8 to 55.10 with increasing WSSM concentration from 0.0% to 1.5%. The lightness index of the

fried zucchini slices containing WSSM coating were better than the slices without any coating. Low L* values demonstrates a dark color and are it is related to browning reactions. The highest L* value (76.76) was for the coated zucchini slices with 1.5% WSSM that was fried at 155°C. In addition, the average L* index values of fried zucchini slices decreased from 70.19 to 35.90 with increasing frying temperature from 155°C to 185°C. Generally, a high L* index is desired because that means low dark fried foods, which is acceptable for fried zucchini slices. Bouaziz *et al.* (2016) used almond gum as an edible coating to enhancing the quality characteristics of potato chips during frying process. The authors reported that the coated slices have a significantly lighter color (high L* index) and were significantly yellower (high b* index) than the uncoated products. The L* value was 58.2 for the uncoated slices, while it was 88.3 and 87.5 for fried slices coated with almond gum and arabic gum, respectively.

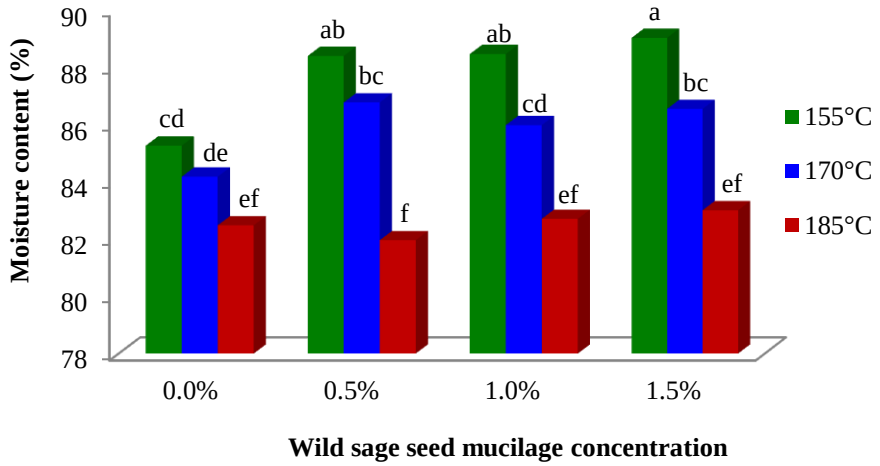

Fig. 1. Effect of Wild sage seed mucilage coatings and frying temperature on the moisture content of fried zucchini slices.

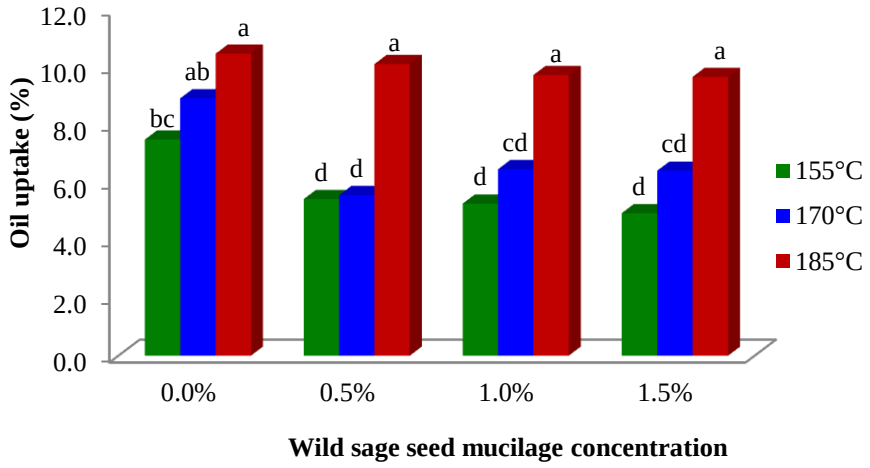

Fig. 2. Effect of Wild sage seed mucilage coatings and frying temperature on the oil uptake of fried zucchini slices.

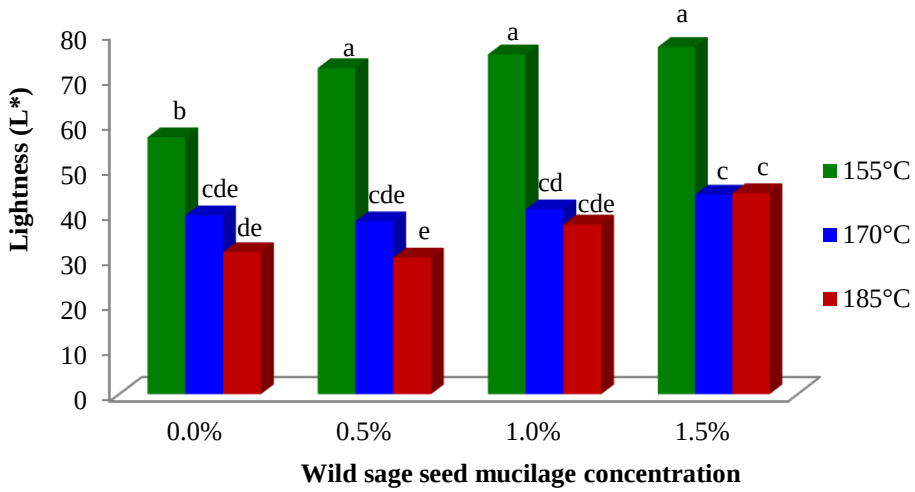

Fig. 3. Effect of Wild sage seed mucilage coatings and frying temperature on the lightness (L*) of fried zucchini slices.

The effect of WSSM coatings and frying temperature on the redness (a*) and yellowness (b*) of fried zucchini slices was reported in Table 1. The a* index value was an indicator of browning (color changes) during frying of foods. The a* value shows redness for fried foods and the influence of WSSM concentration (0.5, 1.0 and 1.5%) and frying temperature (155°C, 170°C and 185°C) on the a* value of fried zucchini slices was reported in this table. The average a* index values of fried zucchini slices decreased from 20.79 to 17.06 with increasing WSSM concentration from 0.0% to 1.5%, but, it was increased from 5.90 to 24.71 with increasing frying temperature from 155°C to 185°C. In general higher yellowness index values give more yellow foods that is desirable for deep-fat fried foods (Salehi, 2018). The average b* value of fried zucchini slices was 38.91 for the uncoated samples, while it was 36.32, 37.05 and 32.82 for samples coated with 0.0, 0.5, 1.0 and 1.5% WSSM, respectively. b* is also affected by the oil temperature. As shown in this table the average yellowness index of fried zucchini slices decreased from 43.41 to 27.94 with increasing frying temperature from 155°C to 185°C.

The color and surface changes data could be used to estimate both physico-chemical and quality characteristics in food products (Salehi & Hosseini Ghaboos, 2019). In Figure 4 color change intensity (ΔE) of fried zucchini slices values were reported as functions of WSSM concentration and frying temperature. The highest ΔE values were for the uncoated zucchini slices and their lowest values were for the coated zucchini slices with 1.5% WSSM. The color change intensity value was 58.23 for the uncoated samples, while 53.42, 48.20 and 47.41 were found for fried samples coated with 0.0, 0.5, 1.0 and 1.5% WSSM, respectively. As shown in this figure the average ΔE index of fried zucchini slices increased from 30.45 to 65.63 with increasing frying temperature from 155°C to 185°C.

Surface change % (shrinkage) is a common phenomenon during frying process. In Figure 5 area change is reported as functions of WSSM concentration and frying temperature. The average surface change values of fried

Table 1. Effect of Wild sage seed mucilage coatings and frying temperature on the redness (a*) and yellowness (b*) of fried zucchini slices

Mucilage concentration	Temperature (°C)	Redness (a*)	Yellowness (b*)
0.0	155	17.26 ^{c}	46.76 ^{a}
	170	19.48 ^{bc}	35.58 ^{bc}
	185	25.65 ^{a}	34.40 ^{bc}
0.5	155	2.04 ^{d}	43.56 ^{ab}
	170	20.24 ^{bc}	41.38 ^{abc}
	185	25.79 ^{a}	24.01 ^{d}
1.0	155	1.14 ^{d}	42.81 ^{ab}
	170	22.02 ^{ab}	36.88 ^{abc}
	185	24.87 ^{a}	31.46 ^{cd}
1.5	155	3.17 ^{d}	40.48 ^{abc}
	170	25.49 ^{a}	36.05 ^{bc}
	185	22.52 ^{ab}	21.91 ^{d}

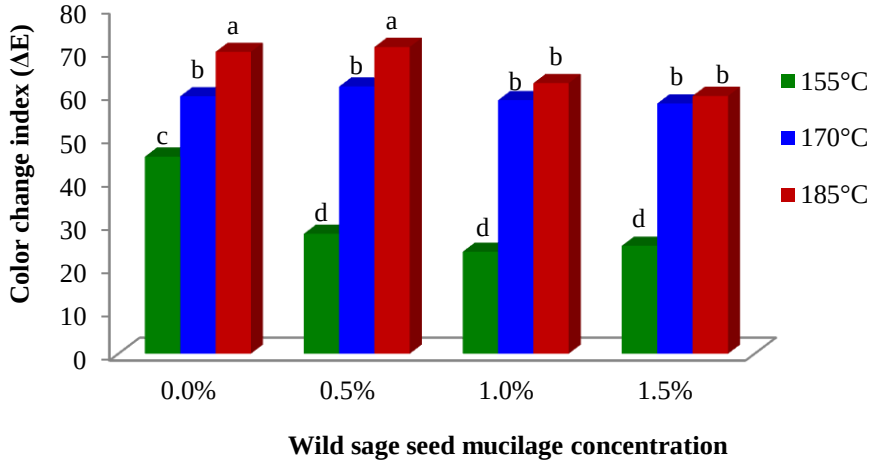

Fig.4. Effect of Wild sage seed mucilage coatings and frying temperature on the color change index (ΔE) of fried zucchini slices.

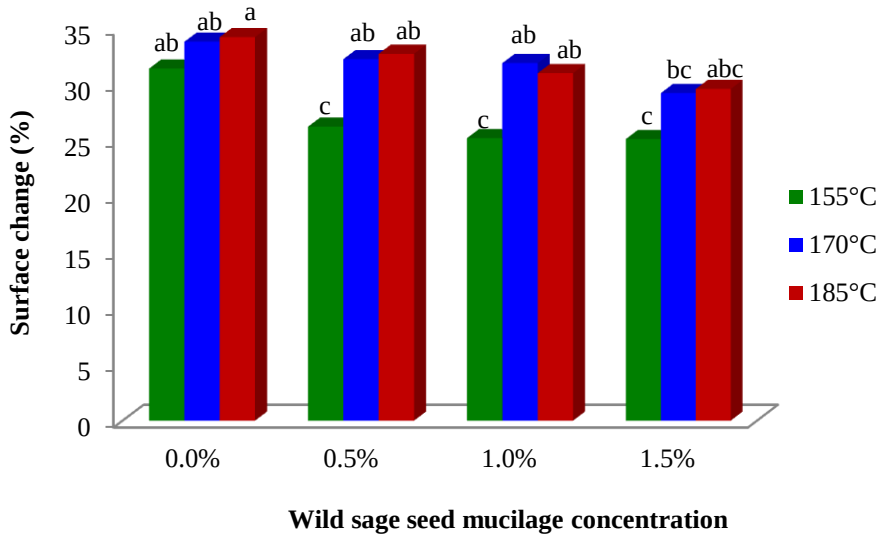

Fig.5. Effect of Wild sage seed mucilage coatings and frying temperature on the surface change (%) of fried zucchini slices.

zucchini slices was 33.13% for the uncoated samples, in comparison 30.40%, 29.36%, and 27.97% were found for fried slices coated with 0.0, 0.5, 1.0 and 1.5% WSSM, respectively. The highest surface change value (34.21%) was for the uncoated zucchini slices that was fried at 185°C and the lowest surface change value (25.12%) was for the coated zucchini slices with 1.5% WSSM that was fried at 155°C. Higher water loss (faster removal of moisture) during frying process resulted in considerable shrinkage in fried slices. As shown in this figure the average surface change index of fried zucchini slices increased from 26.99 to 30.87 with increasing frying temperature from 155°C to 185°C. High surface change was seen in zucchini slices fried at 185°C which may be due to high water loss.

Conclusion

In this study, the influence of WSSM concentration at three concentrations of 0.5, 1.0 and 1.5%, and frying temperature at three degrees of 155°C, 170°C and 185°C on the oil uptake and appearance changes of fried zucchini slices were studied. The results showed that coating with WSSM could reduce moisture loss and oil uptake during deep-fat frying of zucchini slices. The coated zucchini slices with 1.5% WSSM had highest moisture content (86.18%) and lowest oil content (7.00%) than the other zucchini slices. The L* index values of fried zucchini slices increased with increasing WSSM concentration, but it was decreased with increasing frying temperature. The a* index values of fried zucchini slices decreased with increasing WSSM concentration, but, it was increased with increasing frying temperature. The highest ΔE and surface change (%) values were for the uncoated zucchini slices and their lowest values were for the coated zucchini slices with 1.5% WSSM. By increasing WSSM concentration from 0.0% to 1.5% significantly decreased the surface change percent of fried zucchini slices from 33.13% to 27.97% ($P<0.05$). Therefore, the best coating suspension and temperature frying for reducing the oil uptake of fried zucchini slices and improving product appearance quality was 1.5% WSSM and 155°C, respectively.

References

Amini, G., Salehi, F. & Rasouli, M. (2021). Drying kinetics of basil seed mucilage in an infrared dryer: Application of GA-ANN and ANFIS for the prediction of drying time and moisture ratio. *Journal of Food Processing and Preservation*, 45(3), e15258.

Ashrafi Yorganloo, R. & Gheybi, N. (2019). Effect of okra mucilage and cmc on the oil uptake and physicochemical properties of french fries during deep-fat frying. *Iranian Journal of Biosystems Engineering,* 50(1), 203-211.

Bouaziz, F., Koubaa, M., Neifar, M., Zouari-Ellouzi, S., Besbes, S., Chaari, F., Kamoun, A., Chaabouni, M., Chaabouni, S.E. & Ghorbel, R.E. (2016). Feasibility of using almond gum as coating agent to improve the quality of fried potato chips: Evaluation of sensorial properties. *LWT - Food Science and Technology,* 65, 800-807.

Eslampour, A. & Hosseini, E. (2017). The effects of coating with bitter almond gum and gelatin on the oil uptake reduction, physical and sensorial properties of deep fried potato slices. *Iranian Journal of Nutrition Sciences & Food Technology,* 12(4), 95-102.

Izadi, S., Ojagh, M., Rahkmanifarah, K., Shabanpour, B. & Sakhale, B.K. (2015). Production of low-fat shrimps by using hydrocolloid coatings. *Journal of Food Science and Technology,* 52(9), 6037-6042.

Karimi, N. & Kenari, R.E. (2016). Functionality of coatings with salep and basil seed gum for deep fried potato strips. *Journal of the American Oil Chemists' Society,* 93(2), 243-250.

Khazaei, N., Esmaiili, M. & Emam-Djomeh, Z. (2016). Effect of active edible coatings made by basil seed gum and thymol on oil uptake and oxidation in shrimp during deep-fat frying. *Carbohydrate Polymers,* 137(1), 249-254.

Liberty, J.T., Dehghannya, J. & Ngadi, M.O. (2019). Effective strategies for reduction of oil content in deep-fat fried foods: A review. *Trends in Food Science & Technology,* 92, 172-183.

Naji Tabasi, S. & Mahdian, E. (2017). The investigation of sage seed and persian gum coating effect on oil mass transfer and quality attributes of potato chips. *Research and Innovation in Food Science and Technology*, 6(2), 171-184.

Salehi, F. (2017). Rheological and physical properties and quality of the new formulation of apple cake with wild sage seed gum (*Salvia macrosiphon*). *Journal of Food Measurement and Characterization*, 11(4), 2006-2012.

Salehi, F. (2018). Color changes kinetics during deep fat frying of carrot slice. *Heat and Mass Transfer,* 54(11), 3421-3426.

Salehi, F. (2019). Color changes kinetics during deep fat frying of kohlrabi (*Brassica oleracea var. gongylodes*) slice. *International Journal of Food Properties,* 22(1), 511-519.

Salehi, F. (2020a). Edible coating of fruits and vegetables using natural gums: A review. *International Journal of Fruit Science,* 20(S2), S570-S589.

Salehi, F. (2020b). Effect of coatings made by new hydrocolloids on the oil uptake during deep-fat frying: A review. *Journal of Food Processing and Preservation*, 44(11), e14879.

Salehi, F. & Hosseini Ghaboos, S.H. (2019). Color changes kinetics and heat transfer during deep fat frying of garlic slice. *Journal of Food Biosciences and Technology,* 9(1), 45-52.

Seerangurayar, T., Al-Ismaili, A.M., Janitha Jeewantha, L.H. & Al-Habsi, N.A. (2019). Effect of solar drying methods on color kinetics and texture of dates. *Food and Bioproducts Processing*, 116, 227-239.

Sothornvit, R. (2011). Edible coating and post-frying centrifuge step effect on quality of vacuum-fried banana chips. *Journal of Food Engineering*, 107(3), 319-325.

Zhang, X., Zhang, M. & Adhikari, B. (2020). Recent developments in frying technologies applied to fresh foods. *Trends in Food Science & Technology,* 98, 68-81.