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Effect of Basil Seed Mucilage Coating on the Oil Absorption and Physical Characteristics of Fried Zucchini Slices

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ABSTRACT: In this study, the efficiency of Basil seeds mucilage (BSM) as an edible coating (three concentrations of 0.5, 1.0, and 1.5%) and the temperature of frying oil (three concentrations of 155°C, 170°C, and 185°C) on reduces oil absorption and moisture retention of zucchini slices during the frying process were investigated. The color index includes a* (redness), b* (yellowness), L* (lightness), and color change intensity (ΔE) was used to determines the appearance changes of fried zucchini slices. The BSM coating treatment reduced the oil absorption of fried zucchini slices by approximately 22.48%. Increasing the BSM concentration from 0.0% to 1.5% significantly decreased the oil absorption of zucchini slices from 8.96% to 6.94% (P<0.05).On the other hand, the moisture content of the samples increased from 83.9% to 86.88% with increasing gum concentration (P<0.05). The lowest ΔE and surface shrinkage (%) values were obtained for zucchini slices treated with 1.5 % BSM and fried at 155°C. By increasing the BSM concentration from 0.0% to 1.5% significantly decreased the percentage change in surface area of fried zucchini slices from 33.13% to 26.41% (P<0.05). The appropriate coating suspension and frying temperature to reduce oil absorption and moisture retention of fried zucchini slices were 0.5% BSM and 155°C, respectively.

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

Introduction

Frying is a rapid process, resulting in a sterile, dry product with a relatively long shelf life. During the frying process, the food is immersed in an oil bath with a temperature above the boiling point of water, resulting in a countercurrent flow of water vapor and oil on the surface of the product (Ouchon & Pyle, 2004). In recent years, there is a strong desire to reduce the amount of oil consumed when frying food in oil. Gum-based edible coatings offer a technology that prevents oil absorption during the frying process (Yadegari *et al.*, 2020; Kurek *et al.*, 2021; Salehi *et al.*, 2021; Xie *et al.*, 2022). For example, Jouki and Khazaei (2022)investigated on the impacts of active batter coatings enriched by quince seed gum and carvacrol microcapsules on oil absorption and quality loss of nugget during frying. The results of this study showed that the highest reduction in peroxide value and thiobarbituric acid were 41.85 and 37.04% for the quince seed gum coated samples containing 1% carvacrol microcapsules. In another study, Li *et al.* (2022) studied on the effect of chitosan coating on oil absorption, water migration, starch structure and morphology of french fries.

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The results of this study demonstrated that the chitosan coating reduced oil penetration into fries by reducing water migration and increasing starch ordered structure and morphological integrity.

Basil seeds (*Ocimum basilicum* L.) contain a large amount of mucilage (gum).When soaked in water, it develops beneficial properties that make it suitable for a variety of fried foods. Several functional properties of the extracted mucilage that is usually known as Basil seeds mucilage (BSM), including biodegradable properties, environmental friendliness, low extraction and production costs, ready availability, hydrophilic nature, and appropriate rheological characteristics, caused high interest to more application as coating material (Amini *et al.*, 2021). This mucilage has suitable physical properties as an edible coating for enhancement of the appearance quality of fried food products. Also, BSM can lower the absorption of oil from fryer vats (Salehi, 2020).

The surface color measurements of fried food products can be used indirectly to determine the color change, since they are simpler and faster than chemical analysis (Salehi, 2020). Kurek *et al.* (2021) investigated on the efficiency of coatings treatment with carboxy methyl cellulose (CMC), chitosan, pectin and arabic gum, and natural antioxidants on fresh-cut potato's color, pH, moisture content, stability and oil absorption after deep-fat frying. The authors reported that the coatings significantly decreased oil content in deep-fat fried potato strips, without effecting L*, b*, whiteness index, and color change intensity (ΔE). Daraei Garmakhany *et al.* (2008) studied on the impact of hydrocolloids (carboxymethyl cellulose, xanthan, tragacanth and guar) as coating agents on the quality of oil absorption of potato chips. The most effective coating agent reduced the oil absorption about 49.71-57.03%. In addition, Salehi *et al.* (2022b) reported that the hydrocolloid coating of zucchini slices (with wild sage seed mucilage) decreased the amount of oil uptake by samples about 21.80%. Also, hydrocolloid coating treatments and concentration considerably reduced the moisture loss of zucchini slices.

Coatings that reduce the fat content of fried foods are an alternative option to reach both health concerns and consumer demand (Ali *et al.*, 2021). The aim of this study was to investigate the moisture content, oil absorption, and rate of color change and shrinkage during frying of zucchini slices coated with BSM gum.

Materials and Methods

- *Zucchini slices preparation*

Zucchinis were harvested in a patch located in Hamedan, Iran. Zucchinis were hand-peeled, cut with a cylindrical-shaped mold and steel cutter into cylindrical slices with 1 cm thickness and 3.35 cm diameter.

- *BSM powder preparation*

Basil seeds were prepared from a local market from Hamedan, Iran. First, Basil seeds were soaked in distilled water with a seed to water ratio of 1:20, at 25°C for 20 minutes. The gum extract was separated from the swollen seeds by passing these seeds through the extractor (Panasonic, MJ-J176P, Japan). The extracted gum was then dried in an oven (Shimaz, Iran) at 60°C and finally the dried gum was milled, sieved, packaged, and stored dry at 20°C (Amini *et al.*, 2021; Satorabi *et al.*, 2021).

- *Coating of zucchini slices*

BSM gum was used to coat the fresh zucchini slices before frying. BSM solutions at 3 levels of 0.5, 1.0, and 1.5%

(w/w) were prepared at 25°C and then zucchini slices were immersed for 1 min in these solutions.

- ***Frying condition***

Fresh refined sunflower oil (Bahar frying oil, Iran) was used as the frying medium for each frying batch. Zucchini slices were soaked in the BSM solution for 60s, then placed on the sample holder and immersed in hot oil inside a mini-fryer (Delmonti, DL630, Iran). It was then fried at 155°C, 170°C, 185°C for 5 minutes and cooled at 20°C for 4 minutes. Additionally, a K-type thermocouple (thermo controller, ±0.1°C, Lutron, TM-916) with a response time of 1 second was used for temperature measurement.

- ***Moisture content and oil absorption***

The moisture content of fresh zucchini slices and fried zucchini slices was estimated by gravimetric method (using a digital balance, ±0.01g, LutronGM-300p, Taiwan) in triplicates order. Moisture content was calculated from the weight loss after drying the sample in a forced air oven (Shimaz, Iran) at 105°C to constant weight. Total oil content (oil absorption (%)) of zucchini slices was estimated by comparison of total solid method (the difference between total solids of samples before and after frying process). The determinations were made in triplicate and mean value was reported(Salehi *et al.*, 2022a).

- ***Color and shrinkages***

The color of the zucchini slices (untreated-control and treated samples) was measured using a scanner (HP, Scanjet-300, China). Color was measured for three zucchini slices of each condition and average readings were taken at different locations on the surface of each zucchini slices for each experimental condition. The color was expressed in terms of L^*value [lightness, ranging from zero (black) to 100 (white)], a^*value [ranging from +120 (red) to −120 (green)], and b^*value [ranging from +120 (yellow) to −120 (blue)], using Image J software (version 1.42e, USA) (Salehi *et al.*, 2022a).The ΔE (color changes intensity) values for the total color difference was determined using equation 1:

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

The shrinkage (area surface) change of the zucchini slices during frying procedure were determined using equation 2:

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

where, ΔA is the shrinkages change (%), and A_0 and A_t (cm^2) are the area of the fresh zucchini slices and the fries samples at frying period of *t*, respectively(Salehi *et al.*, 2022b).

- ***Statistical analysis***

Statistical analysis of the results was performed using the SAS software (SAS 9.1 Institute, Inc.). All frying experiments and samples analysis were carried out in triplicate.

Results and Discussion

The average moisture content of fresh zucchini slices was 93%. Figure 1 demonstrates the influence of coatings with BSM and fryer oil temperature on the moisture content of fried zucchini slices. There was a significant difference between treated zucchini slices and control sample in the moisture content. The results demonstrated that BSM coating could increase moisture retention of deep-fried zucchini slices. The treated zucchini slices had higher moisture content due to the inhibitory effect of the BSM compared to

the untreated samples. In addition, the average moisture content of fried zucchini slices decreased from 87.84% to 84.17% with increasing fryer oil temperature from 155°C to 185°C.

Oil absorption is one of the most important quality parameters of fried food products. Figure 2 demonstrates the influence of coatings with BSM and fryer oil temperature on the oil absorption of fried zucchini slices. BSM Coating treatments decreased the oil absorption of fried zucchini slices about 22.48%. By increasing BSM concentration from 0.5% to 1.5% significantly decreased the oil absorption of zucchini slices from 9.28% to 8.15% (at 185°C), while the moisture content of samples was increased from 86.76% to 86.88% with increasing gum levels. Naji Tabasi and Mahdian (2017) and Karimi and Kenari (2016) also observed a similar trend of low oil absorption during frying of treated potato chips with Persian gum and treated potato strips with Basil seed gum and salep, respectively. Ali *et al.* (2021) confirmed that the edible coating prepared from garden cress mucilage could be a promising application for extending shelf-life and reducing the oil uptake of fresh-cut potato strips. In addition, Han *et al.* (2021) reported that the coating contents 1% methyl cellulose could reduce the oil content, hardness, and extent of browning and improve the physiochemical properties of chinese fried dough cake on 7 days of storage.

Figure 3 demonstrates the effect of BSM coating on the lightness (L*) index of fried zucchini slices. The results demonstrated that BSM concentration and fryer oil temperature have a significant influence on the L* index ($P<0.05$). The average L* index values of fried zucchini slices increased from 48.46 to 50.45 with increasing BSM concentration from 0.5% to 1.5%. The lightness index of the fried zucchini slices containing BSM coating was better than the slices without any coating. Low L* values demonstrate a dark color and are it is related to browning reactions (Maillard and caramelization reactions). The highest L* value (65.23) was for the treated zucchini slices with 1.5% BSM that was fried at 155°C and the lowest L* value was for the untreated zucchini slices that was fried at 185°C. In addition, the average L* index values of fried zucchini slices decreased from 62.81 to 38.13 with increasing fryer oil temperature from 155°C to 185°C.

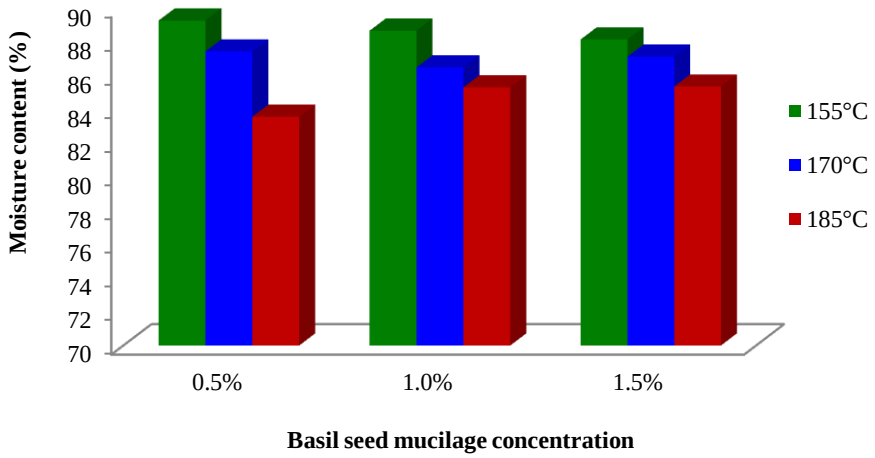

Fig. 1. Effect of Basil seed mucilage coatings and fryer oil temperature on the moisture content of fried zucchini slices.

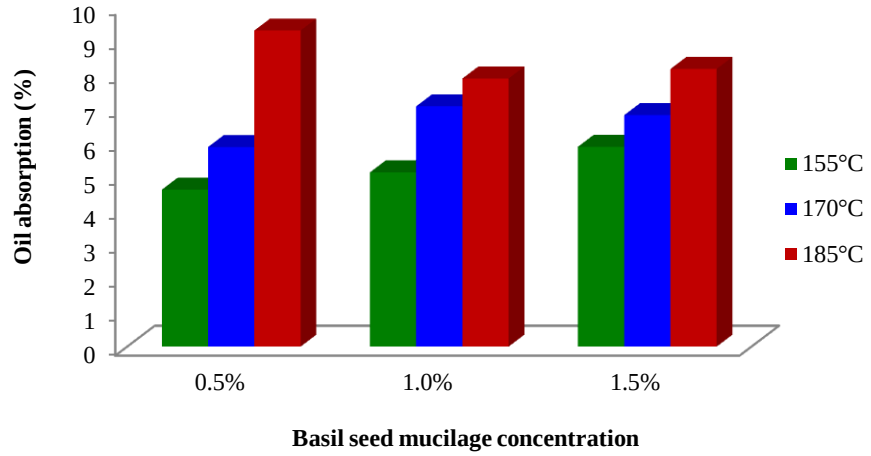

Fig. 2. Effect of Basil seed mucilage coatings and fryer oil temperature on the oil absorption of fried zucchini slices.

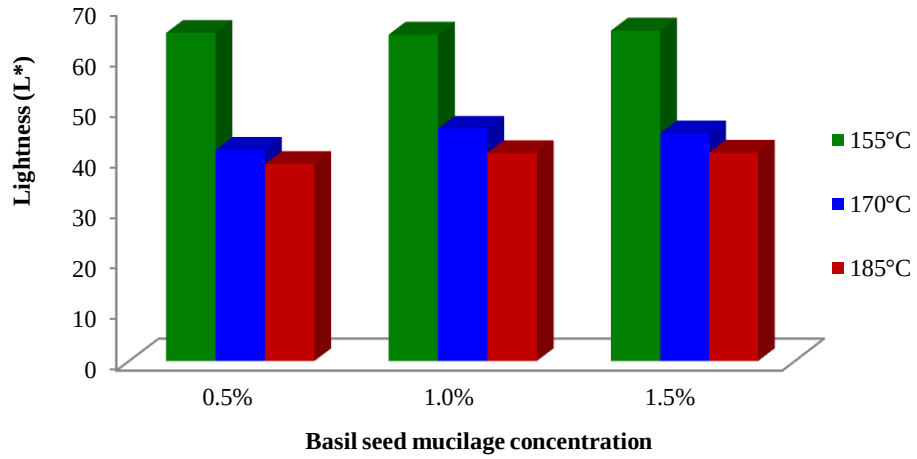

Fig. 3. Effect of Basil seed mucilage coatings and fryer oil temperature on the lightness (L*) of fried zucchini slices.

The effect of BSM treatment and fryer oil temperature on the redness (a*) and yellowness (b*) of fried zucchini slices was demonstrated in Table 1. The a* index value was an indicator of browning (color changes) during frying of foods. The a* value demonstrates redness for fried products and the influence of BSM concentration (0.5, 1.0 and 1.5%) and frying temperature (155°C, 170°C and 185°C) on the a* index of fried zucchini slices was reported in this table. The average a* index values of fried zucchini slices decreased with increasing BSM concentration, but, it was increased from 11.27 to 23.67 with increasing frying temperature from 155°C to 185°C. In general higher yellowness index values give more yellow foods that are desirable for deep-fat fried foods (Salehi, 2018). The average b* value of fried zucchini slices was 42.01 and 40.12 for samples treated with 0.5, 1.0 and 1.5% BSM, respectively. b* is also influenced by the oil temperature. As shown in this table the average yellowness index of fried zucchini slices decreased with increasing fryer oil temperature from 155°C to 185°C.

Table 1. Effect of Basil seed mucilage coatings and fryer oil temperature on the redness (a*) and yellowness (b*) of fried zucchini slices

Mucilage concentration	Temperature (°C)	Redness (a*)	Yellowness (b*)
0.5	155	9.73	47.18
	170	17.97	38.05
	185	22.23	39.51
1.0	155	8.76	46.27
	170	19.75	43.63
	185	22.64	36.14
1.5	155	9.35	45.94
	170	18.92	40.75
	185	24.15	33.67

In Figure 4 color change intensity (ΔE) of fried zucchini slices values were reported as functions of BSM concentration and frying temperature. The ΔE values were 52.46, 51.45 and 51.13 for fried samples treated with 0.5, 1.0 and 1.5% BSM, respectively. As shown in this figure the average ΔE index of fried zucchini slices increased from 38.77 to 63.66 with increasing fryer oil temperature from 155°C to 185°C. The highest ΔE value was for the untreated zucchini slices that was fried at 185°C and the lowest ΔE value was for the treated zucchini slices with 1.5% BSM that was fried at 155°C.Adrah *et al.* (2021) studied on the physicochemical changes of deep-fat-fried chicken drumsticks treated with quercetin-in-edible coating. The results of this study demonstrated that the L^* and b^* increased when quercetin was incorporated in the edible coating, while there was no significant variation in a^* values during storage.

In Figure 5 shrinkage of untreated-control and treated zucchini slices were demonstrated as functions of frying temperature and BSM concentration. The surface shrinkage values of fried zucchini slices was 33% for the uncoated slices, in comparison 30.26%, 27.16%, and 26.41% were found for fried slices treated with 0.5, 1.0 and 1.5% BSM, respectively. The highest surface change value was for the untreated zucchini slices that was fried at 185°C and the lowest surface change value was for the treated zucchini slices with 1.5% BSM that was fried at 155°C. Higher water loss (faster removal of moisture) during frying process resulted in considerable shrinkage in fried slices (Maity *et al.*, 2014). As shown in this figure the average surface change index of fried zucchini slices increased from 26.34 to 30.71 with increasing frying temperature from 155°C to 185°C. Higher shrinkage surface was seen in zucchini slices fried at 185°C which may be due to high water loss.

Conclusion

In this work, we investigated the effects of three levels of BSM concentration, 0.5, 1.0, and 1.5%, and three levels of frying oil temperature, 155, 170, and 185°C, on changes in oil absorption and color parameters of fried zucchini slices. As a result, we found that BSM coating improved water retention and reduced oil absorption when zucchini slices were fried. Zucchini slices treated with 1.5% BSM had the highest water content (86.88%) and the lowest oil content (6.94%) than the other samples. The L* index values of fried zucchini slices increased with increasing BSM concentration, but decreased with increasing frying temperature. The a* index values of fried zucchini slices decreased with increasing BSM

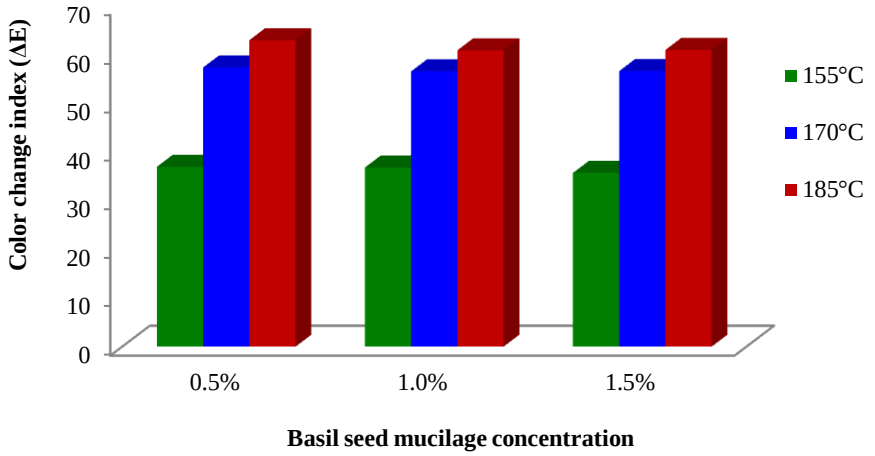

Fig. 4. Effect of Basil seed mucilage coatings and fryer oil temperature on the color change index of fried zucchini slices.

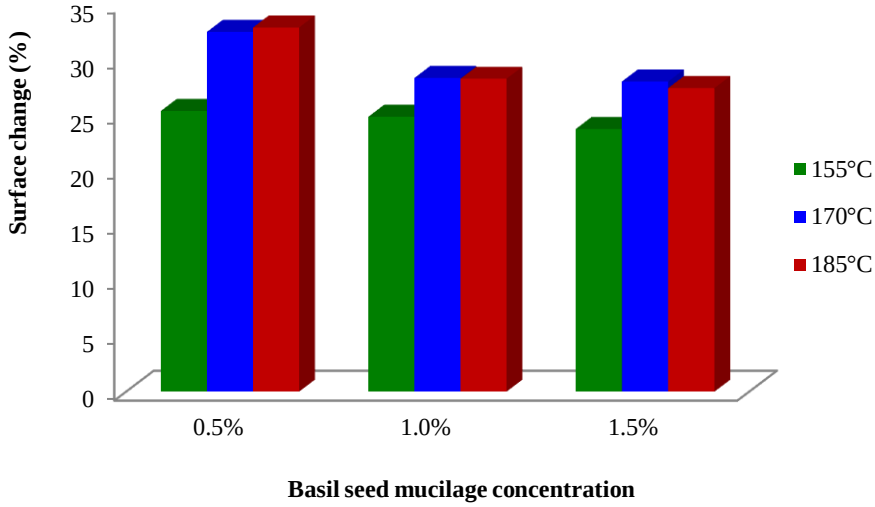

Fig. 5. Effect of Basil seed mucilage coatings and fryer oil temperature on the surface change (%) of fried zucchini slices.

concentration, but increased with increasing frying temperature. The highest ΔE and surface shrinkage values were obtained with untreated zucchini slices fried at 185°C and the lowest with treated 1.5% BSM zucchini slices fried at 155°C. Therefore, the optimal coating suspension and frying temperature to reduce the oil absorption of fried zucchini slices and improve the color parameters of the samples were 0.5% BSM and 155°C, respectively.

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