7(2): 37-43, 2024

Journal of Food and Bioprocess Engineering

Journal homepage: https://jfabe.ut.ac.ir

Original research

Combined effects of guar gum based edible coating and sonication on quality of fried potato slices

Fakhreddin Salehi [a, *], Mostafa Amiri [a], Sara Ghazvineh [a]

[a] *Department of Food Science and Technology, Faculty of Food Industry, Bu-Ali Sina University, Hamedan, Iran*

ABSTRACT

The selection of an appropriate edible coating and effective pretreatment before the frying process can prevent moisture loss and also reduce oil uptake during frying. As a non-thermal pretreatment, ultrasound offers a wide range of applications in frying processes, especially in reducing oil absorption. In this study, the effect of guar gum based edible coating and ultrasonic pretreatment on the quality parameters of fried potato slices (FPS) was investigated. The frying time, moisture content, oil uptake, texture hardness, surface area change, surface color parameters (lightness, redness, yellowness, and total color change), and sensory attributes were assessed after the frying process. Edible coating with guar gum and ultrasonic pretreatment significantly increased the frying time of the slices ($p<0.05$). Ultrasonic power (75 W or 150 W) did not have a significant impact on changing the moisture content of fried potato pieces ($p>0.05$). The guar gum based edible coating inhibits the oil uptake in samples by reducing water evaporation. The highest (26.36%) and lowest (10.74%) oil uptake were for the uncoated and coated-high-power-sonicated (150 W) FPS, respectively. The ultrasound pretreatment significantly decreased the hardness of fried potato pieces ($p<0.05$). The low and high intensity ultrasonic pretreatment (75 W and 150 W, respectively) significantly decreased the crust area change of FPS ($p<0.05$). The minimum redness, yellowness, and total color change indexes were for the coated and high-power sonicated (150 W) samples. The highest appearance, odor, texture, flavor, and overall acceptance were for the coated and high-power sonicated (150 W) sample.

Keywords: Color parameters; Hardness; Oil uptake; Sensory attributes; Ultrasound.

Received 25 Dec 2024; Received in revised form 20 Feb 2025; Accepted 11 Mar 2025

1. Introduction

Potato is an important tuber for human consumption, an important source of energy and has good nutritional value for human health. Deep-fat frying is the most commonly used technique for potato processing, therefore fried potato is the main processed potato product (Dourado et al., 2019; Salehi et al., 2021; Salehi et al., 2024b). Frying is a common cooking technique that uses fat or oil as a heat transfer medium and in direct contact with food products at temperatures above the boiling point of water (Ananey-Obiri et al., 2018; Salehi et al., 2024b). An appropriate deep-fat frying temperature varies based on the thickness and type of food being fried, but typically falls within the range of 175–190 °C (Dangal et al., 2024). The more oil absorbed by these products, the lower their shelf life and quality, and the lower the acceptance of the processed food by the consumer. Furthermore, high consumption of edible oils leads to various health problems. Purchaser demand for high-quality, healthy products has led to incessant efforts to produce fried products with lower fat content (Salehi, 2020; Dehghannya and Ngadi, 2023).

During the deep-fat frying method, oil not only serves as a heating medium but also absorbs into food products, increasing the total fat content (Ananey-Obiri et al., 2018). Various pre-treatment steps prior to frying produce highly efficient products that absorb less oil and are easier to fry. New pre-treatment processes such as drying, edible coating, and sonication, as well as advances in deep-frying technology, can help minimize oil consumption. Varying the frying medium, frying method, and surface properties, and even the application of coatings can reduce or control the final fat content of fried foods (Salehi et al., 2024b; Salehi et al., 2025). Selection of an

*Corresponding author.
E-mail address: *F.Salehi@basu.ac.ir* (F. Salehi).
https://doi.org/10.22059/jfabe.2025.387612.1192

appropriate pretreatment before the frying process can prevent moisture loss and also reduce oil uptake during frying (Ananey-Obiri et al., 2018; Salehi, 2020; Salehi et al., 2024b). Edible coatings reduce the permeability to oxygen, carbon dioxide, vapor, and reduce the transfer of moisture and solutes (Salehi, 2020). Edible coatings reduce moisture loss and maintain surface integrity, resulting in a firmer crust with fewer voids, while at the same time preventing water and steam escape, thereby improving the quality of fried food products (Manoharan et al., 2024). Researchers have paid great attention to applying polysaccharide-based edible coatings to food products because these polysaccharides offer a variety of advantages, including being highly environmentally benign, insolubility in non-polar solvents, high solubility in water, non-toxicity, and being able to form tasteless, odorless, and colorless coatings (Eranda et al., 2024). Guar gum is a biopolymeric polysaccharide composed of a mannose backbone and galactose side groups. Due to its long polymer chains, high molecular weight and easy availability, it could be a potential alternative for producing biodegradable edible coating or packaging materials from renewable resources (Goswami et al., 2024; Salehi et al., 2024d).

Ultrasound consists of sound waves with frequencies outside the range of human hearing (Salehi et al., 2024a). The use of ultrasound as a treatment is an appropriate non-thermal technique to improve productivity and the use of this process causes less damage to the physicochemical and qualitative properties of the food products (Salehi, 2023; Roobab et al., 2024). When ultrasound is applied to liquid media, cavitation processes are triggered, producing micro-mechanical shocks through the formation, expansion, and collapse of bubbles during compression. These effects disrupt cellular structures, improve mass transfer, shorten processing times, saving energy, and increase product quality. Also, increasing ultrasonic power might lead to disruption of cellular and alter the permeability of cell membranes (Zhang et al., 2021; Manoharan et al., 2024). Su et al. (2018) examined the combination of ultrasound (0 W, 300 W, 600 W) and microwave (0 W, 600 W, 800 W) in vacuum frying of purple-fleshed sweet potatoes and found that it could reduce oil uptake by about 16-34%. In the literature there are no articles on the use of guar gum based edible coatings and ultrasonic pretreatment to reduce oil uptake during frying of potato slices. So, this study aimed to examine the effects of edible coating and ultrasound pretreatment (75 W and 150 W) on the physicochemical characteristics, quality, and sensory properties of fried potato slices (FPS).

2. Material and Methods

2.1. Preparation of potato slices

Potatoes of the Santa variety were prepared from Kabudrahang city (Hamedan province, Iran), with medium size and uniform shape. Potatoes were washed with water (20 °C), and then to carry out the frying process, they were first cut into slices with a thickness of 0.5 cm by an industrial slicer (Girmi, model AF-23, Italy) and then using a round metal mold (d=3.6 cm), cylinder-shaped cuts were made from them.

2.2. Edible coating and ultrasonic pretreatment

Guar gum was purchased from Abdullabhai abdul kader, India. Guar gum dispersion (1%, w/v) was used for the edible coating of fresh potato slices. Control samples (uncoated potato slices) were submerged in distilled water for 5 min. Coated samples were submerged in the guar gum dispersion for 5 min. Coated-US75 and coated-US150 samples were submerged in the guar gum dispersion and sonicated for 5 min at low (75 W, 40 kHz) and high (150 W, 40 kHz) powers, respectively, in an ultrasound bath (Backer vCLEAN1-L6, Iran) (Salehi et al., 2024b; Salehi et al., 2025).

2.3. Frying potato slices

After edible coating and ultrasound pretreatment, the potato slices were fried by a Delonghi fryer (F18, 1800 W, Italy) at a temperature of 160 °C, and the frying time of each sample was recorded. For deep frying, liquid frying oil (Sunflower-Soya, palm-free, Varamin, Iran) was used (Salehi et al., 2024b; Salehi et al., 2025). To control the temperature of the fryer, a Lutron (TM-916, Taiwan) two-channel contact digital thermometer with a temperature range of -50 to 1230 °C (±0.1 °C) and a K-type temperature thermocouple with a thickness of one millimeter were used.

2.4. Determination of moisture content and oil uptake

The moisture content (%) and oil uptake (%) of FPS were calculated according to the method described by Salehi et al. (2021). The moisture content of raw and FPS was calculated after drying in an oven (K.M 55, Pars Azma Co., Iran) at 104 °C for 4 hours. The weight changes of the samples were measured by a laboratory scale (±0.01g, LutronGM-300p, Taiwan).

2.5. Texture analysis

Hardness is used to evaluate changes in the quality of fried foods. The effects of edible coating and sonication on the hardness of FPS were determined using a Texture analyzer (Santam, STM-5, Iran). The measurement was taken using a 2.5 cylindrical probe with a 2.5 mm diameter and a test speed of 1 mm/s. Therefore, the maximum force that could break through the skin of a FPS was measured in Newton (N) (Salehi et al., 2024b).

2.6. Color and area determination

Color is an essential qualitative characteristic that impacts the marketability of the FPS. In this study, a scanner (HP, Scanjet300, China) and ImageJ software (version 1.42e, USA) were used to determine the surface color and area of the FPS. The parameters (L*, a*, and b*) were measured to determine the total color changes (ΔE) in the FPS concerning treatments (Salehi et al., 2024c). The surface area changes of FPS was calculated according to the method described by Eftekhari et al. (2023).

2.7. Sensory evaluation of the fried product

A panel of 20 trained panelists, who were non-smokers, was selected from staff/students of the Department of Food Science and Technology, Bu-Ali Sina University, according to their initial performance in pre-testing. To ensure a comprehensive evaluation, a preliminary session was held prior to the test during which the panel members could discuss and clarify each attribute of the products to be assessed. The FPS were served on white dishes at 25 °C and coded with 3-digit blind numbers. The 9-point hedonic scale method (1 = dislike extremely to 9 = like extremely) was used for estimating the sensory attributes of FPS. The sensorial attributes evaluated included overall appearance, odor, texture, flavor, and overall acceptance.

2.8. Data analysis

All experiments were carried out in triplicate (n = 3). The mean values were expressed as results ± standard deviation (Mean ± SD). Duncan test and one-way analysis of variance were performed using SPSS 21.0 software. Differences were considered statistically significant if $p < 0.05$.

3. Results and Discussion

3.1. Frying time of potato slices

Fig. 1 demonstrates the effect of edible coating and sonication on the frying time of potato slices. Edible coating with guar gum increased the frying time of the slices from 247s to 287s, although this increase was not significant (p>0.05). The ultrasonic pretreatment significantly prolonged the frying time of potato slices (p<0.05). Ultrasonic power (75 W or 150 W) did not have a significant effect on changing the frying time of potato slices (p>0.05).

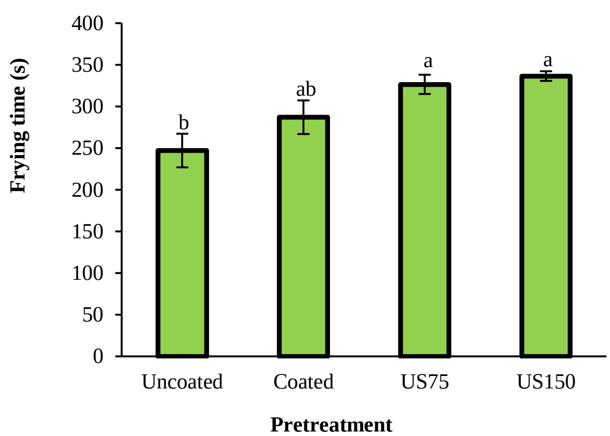

Fig. 1. Impact of guar gum based edible coating and sonication on frying time of potato slices. Mean ± SD, n = 3, where: US75= coating + 75 W ultrasonic power; US150= coating + 150 W ultrasonic power; different letters above the columns denotes significant difference (p < 0.05), whereas the same letter indicates the mean differences are not significant (p > 0.05).

3.2. Moisture content

The moisture content of raw potato slices was 84.85%. The effect of edible coating and ultrasonic treatment on the moisture content of FPS is shown in Fig. 2. The minimum and the maximum moisture content values were for the uncoated and coated-sonicated (US150) FPS, respectively. Edible coating with guar gum significantly increased the moisture content of the fried slices (p<0.05). Ultrasonic pretreatment also significantly increased the moisture content of FPS (p<0.05). Cracks and voids appeared on the surface, which also improved water diffusion by providing more channels. Thus, ultrasonic pretreatment promoted water loss. Improving mass transfer leads to the generation of high vapor pressure in the inner core of the samples, making it easier to remove the strongly attached water (Zhang et al., 2021). Ultrasonic intensity (75 W or 150 W) did not have a significant impact on changing the moisture content of FPS (p>0.05). Zhang et al. (2021) results showed that ultrasonic pretreatment caused surface erosion of starch granules and higher power led to disorganization of starch structure. Furthermore, the percentage of bound and immobilized water was changed after sonication.

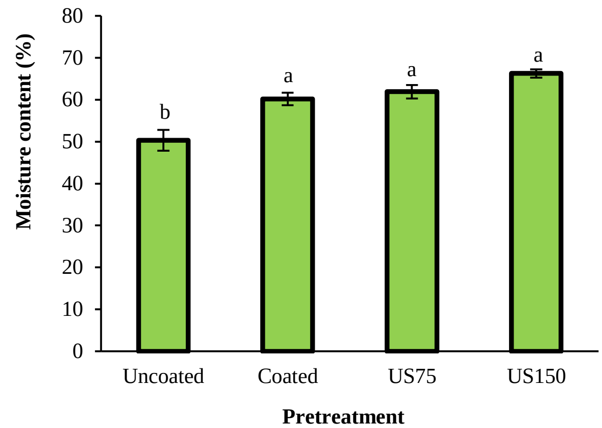

Fig. 2. Impact of guar gum based edible coating and sonication on moisture content of fried potato slices. Mean ± SD, n = 3, where: US75= coating + 75 W ultrasonic power; US150= coating + 150 W ultrasonic power; different letters above the columns denotes significant difference (p < 0.05), whereas the same letter indicates the mean differences are not significant (p > 0.05).

3.3. Oil uptake

Edible coatings act as gelling compounds, forming a network of structures that seal the pores on the food surface, preventing oil absorption during frying. Variations in the properties of edible coating material, such as gel strength and viscosity, affect the water-holding capacity and ultimately reduce the oil absorption of the coated product. The effect of hydrocolloids in reducing the surface tension of water affects oil absorption. Also, edible coating reduces the pores and roughness on the crust of fried food products and prevents oil penetration into the sample (Li et al., 2023; Manoharan et al., 2024). Several studies have confirmed that the oil content of fried food products is highly correlated with the water level of the sample, with higher moisture retention corresponding to lower oil uptake (Salehi et al., 2021; Salehi et al., 2022). Fig. 3 demonstrates the impact of edible coating and sonication on the oil uptake of FPS. The highest and lowest oil uptake were for the uncoated and coated-sonicated (150 W) FPS, respectively. Edible coating with guar gum significantly decreased the oil uptake of the fried slices (p<0.05). Also, high-intensity ultrasonic pretreatment (150 W) significantly decreased the oil uptake of FPS (p<0.05). Consistent with the results of this research, Zhang et al. (2021) reported that low-power ultrasonic pretreatment (360 W, 20 kHz for 60 min) reduced the contents of penetrated surface oil and structure oil by 27.31% and 22.25%, respectively.

It has been reported that microstructural changes during frying are a main factor in oil uptake, and most of the absorbed oil remains trapped on the crust of fried foods (Gallegos-Marin et al., 2020). The potato slices were immersed in distilled water and pretreated with ultrasound, which may compress the internal structure of the potato samples and prevent the infiltration of oil into the interior (Zhang et al., 2021). The average oil uptake was 26.36% for the untreated potato slices, while 16.49%, 11.74%, and 10.74% were found for coated slices with guar gum, coated-US75, and coated-US150 samples, respectively. In a study, Devi et al. (2020) reported that ultrasound can decrease the penetration of oil into fried food products. Lua et al. (2020) reported that using edible coating (ultrasonic pretreated methylcellulose batter) can decrease the oil content of fried products by 31%. Moreover, Oladejo et al. (2017) reported that using ultrasonic pretreatment can reduce the oil percentage of fried products by 65-75%.

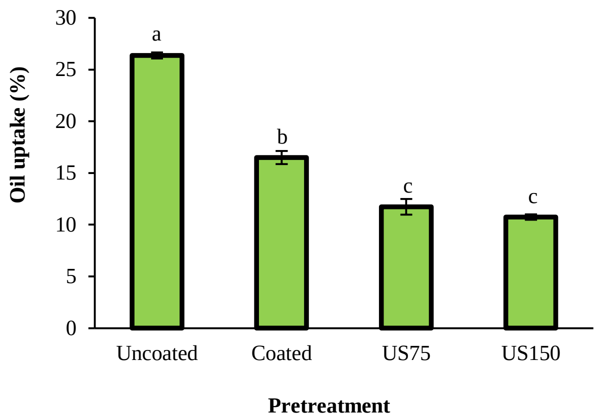

Fig. 3. Impact of guar gum based edible coating and sonication on oil uptake of fried potato slices. Mean ± SD, n = 3, where: US75= coating + 75 W ultrasonic power; US150= coating + 150 W ultrasonic power; different letters above the columns denotes significant difference ($p < 0.05$), whereas the same letter indicates the mean differences are not significant ($p > 0.05$).

3.4. Texture hardness

Deep-fat frying is an irreplaceable processing technique that gives fried products attractive properties such as a crispy taste, an attractive aroma and an appropriate color. The textural properties of fried products depend largely on the formation of the crust (van Koerten et al., 2015). Crispness, a textural characteristic of fried foods, is one of the main parameters influencing consumer acceptance of fried food products (Oloruntoba et al., 2022). Fig. 4 demonstrates the influence of edible coating and sonication on the texture hardness of FPS. The maximum and the minimum hardness values were for the untreated and coated-US150 samples, respectively. Edible coating of potato slices with guar gum before frying had no significant influence on the texture hardness of fried products ($p>0.05$). However, the ultrasound pretreatment significantly decreased the hardness of FPS ($p<0.05$). Of course, the ultrasonic intensity (75 W or 150 W) did not have a significant influence on changing the texture hardness of slices ($p>0.05$). Ultrasound is transmitted into the sample and strengthens its structure, making the surface harder and less susceptible to oil penetration. In this study, the average texture hardness was 0.96 N for the untreated potato slices, while 0.78 N, 0.60 N, and 0.56 N were found for coated, coated-US75, and coated-US150 samples, respectively. Su et al. (2018) studied the combination of ultrasound and microwave in vacuum frying of purple-fleshed sweet potatoes and found that it could reduce water activity and shrinkage, and improve the texture (crispness) and color of the fried samples.

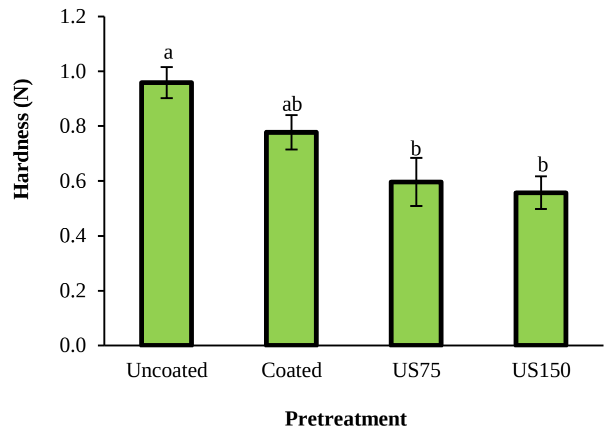

Fig. 4. Impact of guar gum based edible coating and sonication on texture hardness of fried potato slices. Mean ± SD, n = 3, where: US75= coating + 75 W ultrasonic power; US150= coating + 150 W ultrasonic power; different letters above the columns denotes significant difference ($p < 0.05$), whereas the same letter indicates the mean differences are not significant ($p > 0.05$).

3.5. Surface area change

Fig. 5 demonstrates the effect of edible coating and sonication on the crust area alteration of FPS. The highest and lowest crust area changes were for the untreated and coated-US150 samples, respectively. Edible coating with guar gum decreased the crust area change of the fried slices. Also, the low and high intensity ultrasonic pretreatment (75 W and 150 W, respectively) significantly decreased the crust area change of FPS ($p<0.05$). The average crust area change was 17.55% for the untreated potato slices, while 13.75%, 11.81%, and 11.77% were found for coated slices with guar gum, coated-US75, and coated-US150 samples, respectively. The effects of basil seed gum coating and sonication on the surface area change of FPS were studied by Salehi et al. (2024b). Their results showed that the edible coating containing basil seed gum and sonication significantly decreased the surface area change of the FPS ($p<0.05$).

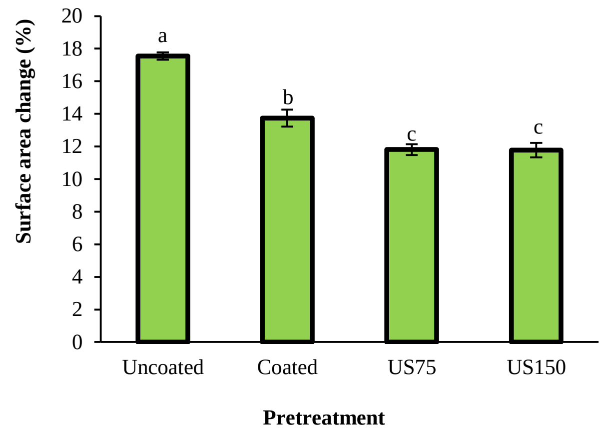

Fig. 5. Impact of guar gum based edible coating and sonication on surface area change of fried potato slices. Mean ± SD, n = 3, where: US75= coating + 75 W ultrasonic power; US150= coating + 150 W ultrasonic power; different letters above the columns denotes significant difference ($p < 0.05$), whereas the same letter indicates the mean differences are not significant ($p > 0.05$).

Table 1. Impact of guar gum based edible coating and sonication on crust color indexes (lightness, redness, yellowness, and total color change) of fried potato slices.

Pretreatment	Lightness	Redness	Yellowness	Total color change
Uncoated	61.63±1.44 ^{d}	4.16±0.54 ^{a}	37.01±1.71 ^{a}	23.31±0.48 ^{a}
Coated	65.81±1.63 ^{c}	3.16±0.41 ^{a}	28.99±1.58 ^{b}	16.08±1.41 ^{b}
US75W	70.65±1.50 ^{b}	2.79±0.77 ^{ab}	26.88±0.98 ^{bc}	12.47±1.60 ^{c}
US150W	74.67±1.67 ^{a}	1.64±0.61 ^{b}	25.05±0.52 ^{c}	6.77±0.56 ^{d}

Mean ± SD, n = 3, where: US75= coating + 75 W ultrasonic power; US150= coating + 150 W ultrasonic power; different letters in the superscript denotes significant difference ($p < 0.05$), whereas the same letter indicates the mean differences are not significant ($p > 0.05$).

Table 2. Impact of guar gum based edible coating and sonication on sensory attributes of fried potato slices.

Pretreatment	Appearance	Odor	Texture	Flavor	Overall acceptance
Uncoated	6.75±1.48 ^{a}	5.60±1.11 ^{b}	5.55±1.20 ^{c}	5.80±1.17 ^{c}	6.05±1.20 ^{b}
Coated	7.00±1.34 ^{a}	6.90±1.48 ^{a}	6.15±0.96 ^{bc}	6.55±1.16 ^{b}	6.60±0.86 ^{b}
US75W	7.15±0.91 ^{a}	7.30±1.00 ^{a}	6.45±0.86 ^{ab}	7.00±0.71 ^{ab}	6.68±1.05 ^{b}
US150W	7.60±1.16 ^{a}	7.40±1.28 ^{a}	7.15±1.28 ^{a}	7.45±1.20 ^{a}	7.75±0.99 ^{a}

Mean ± SD, n = 3, where: US75= coating + 75 W ultrasonic power; US150= coating + 150 W ultrasonic power; different letters in the superscript denotes significant difference ($p < 0.05$), whereas the same letter indicates the mean differences are not significant ($p > 0.05$).

3.6. Crust color indexes

Crust color is one of the key sensorial characteristics of fried food products. A product that has more lightness (L^*), more yellowness (b^*), and less redness (a^*) is more acceptable in terms of appearance acceptance by consumers and gets a higher quality score (Taiwo et al., 2007; Pathare et al., 2013). In this study, the average values of lightness, redness, and yellowness indexes for fresh potato slices were 77.20, -4.07, and 25.53, respectively. The impact of edible coating and ultrasonic treatment on the color parameters of FPS are detailed in Table 1. The minimum and maximum lightness index (L^*) were for the uncoated and coated-US150 samples, respectively. Edible coating of potato slices with guar gum before frying had a significant influence on the lightness index of fried products ($p<0.05$). In addition, sonication has a significant impact on the lightness index of FPS ($p<0.05$) and this pretreatment significantly increased the lightness index of FPS ($p<0.05$).

The highest and lowest redness index (a^*) were for the uncoated and coated-US150 samples, respectively. Edible coating with guar gum decreased the redness index of the fried slices. Also, compared to the control sample (uncoated), the high intensity ultrasonic pretreatment (150 W) significantly decreased the redness index of FPS ($p<0.05$). The average redness index was 4.16 for the untreated potato slices, while 3.16, 2.79, and 1.64 were found for coated slices with guar gum, coated-US75, and coated-US150 samples, respectively.

Throughout deep-fat frying, the rapid transfer of heat from the oil to the product causes its water to evaporate and migrate, turning the FPS into a product with crispy, golden skin, and soft core (Liu et al., 2021). The highest and lowest yellowness index (b^*) were for the uncoated and coated-US150 samples, respectively. Edible coating with guar gum significantly decreased the yellowness index of the fried slices ($p<0.05$). Also, compared to the control sample (uncoated), the low and high intensity ultrasonic pretreatment (75 W and 150 W, respectively) significantly decreased the yellowness index of FPS ($p<0.05$). The average yellowness index was 37.01 for the untreated potato slices, while 28.99, 26.88, and 25.05 were found for coated slices with guar gum, coated-US75, and coated-US150 samples, respectively. Al Faruq et al. (2019) reported that the utilization of ultrasound increases the texture crispiness and creates a desirable yellow color in the product.

The Maillard reaction causes the color of fried foods to change during frying. The color intensity depends on the amount of reducing sugars, amino acids, and proteins on the product surface, the frying temperature, edible coating, and the pretreatment method (Graham-Acquaah et al., 2015; Salehi et al., 2022). As well, the influence of edible coating and sonication on the total color change (ΔE) of FPS is reported in Table 1. The maximum and the minimum ΔE values were for the untreated and coated-US150 samples, respectively. Edible coating with guar gum significantly decreased the ΔE of the fried slices ($p<0.05$). Also, the ultrasonic pretreatment significantly decreased the ΔE of FPS ($p<0.05$). By sonicating raw potato slices, cooking times are reduced, non-enzymatic reactions are prevented and the color of the final product is maintained. The ΔE values were 23.31 for the untreated potato slices, while 16.08, 12.47, and 6.77 were found for coated slices with guar gum, coated-US75, and coated-US150 samples, respectively.

3.7. Sensory evaluation

Some food properties resulting from the frying process are considered desirable, but others are harmful to human health. The main challenge is therefore to reduce the formation of undesirable properties without compromising the sensory properties (Dourado et al., 2019). Ultrasound can induce various physicochemical effects such as cavitation, shear forces, and thermal impacts, which can modify the structural properties of food products (Roobab et al., 2024). The influence of edible coating and sonication on the sensory attributes of FPS was reported in Table 2. The highest appearance, odor, texture, flavor, and overall acceptance were for the coated-US150 sample. Edible coating with guar gum and ultrasound pretreatment increased the sensory acceptance of the fried slices. The average overall acceptance was 6.05 for the untreated potato slices, while 6.60, 6.68, and 7.75 were found for coated slices with guar gum, coated-US75, and coated-US150 samples, respectively. As a result, the use of ultrasound pretreatment results in high-quality FPS. The influence of basil seed gum coating and sonication on the sensory attributes of FPS was examined by Salehi et al. (2024b). Their results showed that the edible coating and sonication significantly improved the sensory attributes of the FPS ($p<0.05$). In addition, Zhang et al. (2021) found that the quality of potato chips was significantly improved by using ultrasound before frying.

4. Conclusion

Ultrasonic treatment before frying, as a non-thermal technique, has been shown to offer great potential to reduce the oil uptake in fried food products. In current work, the impact of edible coating and sonication on the frying time of potato slices, and moisture content, oil uptake, texture hardness, surface area change, color indexes, and sensory attributes of FPS were examined. Edible coating with guar gum and high power sonication (150W) significantly increased the frying time of the slices from 247s to 337s ($p<0.05$). Edible coating with guar gum and sonication significantly increased the moisture content and significantly decreased the oil uptake of the FPS ($p<0.05$). The ultrasound pretreatment significantly decreased the hardness of FPS ($p<0.05$). The low and high intensity ultrasonic pretreatment (75W and 150W, respectively) significantly decreased the crust area change of FPS ($p<0.05$). Edible coating of potato slices with guar gum before frying had a significant effect on the lightness index of fried products ($p<0.05$). The highest and lowest redness, yellowness, and total color change indexes were for the uncoated and coated-US150 samples, respectively. Edible coating with guar gum and ultrasound pretreatment improved the sensory acceptance of the fried slices. In the future, both edible coating with guar gum and ultrasonic pretreatment can be used to coat other food products before frying.

Funding

This research was supported by a grant from the Bu-Ali Sina University, Hamedan, Iran (Grant No. 402174).

Conflict of interest

The authors declare that there is no conflict of interest.

References

Al Faruq, A., Zhang, M. & Adhikari, B. (2019). A novel vacuum frying technology of apple slices combined with ultrasound and microwave. *Ultrasonics Sonochemistry* 52, 522-529. https://doi.org/10.1016/j.ultsonch.2018.12.033

Ananey-Obiri, D., Matthews, L., Azahrani, M.H., Ibrahim, S.A., Galanakis, C.M. & Tahergorabi, R. (2018). Application of protein-based edible coatings for fat uptake reduction in deep-fat fried foods with an emphasis on muscle food proteins. *Trends in Food Science & Technology* 80, 167-174. https://doi.org/https://doi.org/10.1016/j.tifs.2018.08.012

Dangal, A., Tahergorabi, R., Acharya, D.R., Timsina, P., Rai, K., Dahal, S., Acharya, P. & Giuffrè, A.M. (2024). Review on deep-fat fried foods: physical and chemical attributes, and consequences of high consumption. *European Food Research and Technology* 250(6), 1537-1550. https://doi.org/10.1007/s00217-024-04482-3

Dehghannya, J. & Ngadi, M. (2023). The application of pretreatments for producing low-fat fried foods: A review. *Trends in Food Science & Technology* 140, 104150. https://doi.org/10.1016/j.tifs.2023.104150

Devi, S., Zhang, M., Ju, R. & Bhandari, B. (2020). Water loss and partitioning of the oil fraction of mushroom chips using ultrasound-assisted vacuum frying. *Food Bioscience* 38, 100753. https://doi.org/10.1016/j.fbio.2020.100753

Dourado, C., Pinto, C., Barba, F.J., Lorenzo, J.M., Delgadillo, I. & Saraiva, J.A. (2019). Innovative non-thermal technologies affecting potato tuber and fried potato quality. *Trends in Food Science & Technology* 88, 274-289. https://doi.org/10.1016/j.tifs.2019.03.015

Eftekhari, A., Salehi, F., Gohari Ardabili, A. & Aghajani, N. (2023). Effects of basil seed and guar gums coatings on sensory attributes and quality of dehydrated orange slices using osmotic-ultrasound method. *International Journal of Biological Macromolecules* 253, 127056. https://doi.org/10.1016/j.ijbiomac.2023.127056

Eranda, D.H.U., Chaijan, M., Panpipat, W., Karnjanapratum, S., Cerqueira, M.A. & Castro-Muñoz, R. (2024). Gelatin-chitosan interactions in edible films and coatings doped with plant extracts for biopreservation of fresh tuna fish products: A review. *International Journal of Biological Macromolecules* 280, 135661. https://doi.org/10.1016/j.ijbiomac.2024.135661

Gallegos-Marin, I., Méndez-Lagunas, L.L., Rodríguez-Ramírez, J. & Martinez-Sánchez, C.E. (2020). Influence of osmotic pretreatments on the quality properties of deep-fat fried green plantain. *Journal of Food Science and Technology* 57(7), 2619-2628. https://doi.org/10.1007/s13197-020-04298-5

Goswami, M., Mondal, K., Prasannavenkadesan, V., Bodana, V. & Katiyar, V. (2024). Effect of guar gum-chitosan composites edible coating functionalized with essential oils on the postharvest shelf life of Khasi mandarin at ambient condition. *International Journal of Biological Macromolecules* 254, 127489. https://doi.org/10.1016/j.ijbiomac.2023.127489

Graham-Acquaah, S., Ayernor, G.S., Bediako-Amoa, B., Saalia, F.S., Afoakwa, E.O. & Abbey, L. (2015). Effect of blanching and frying on textural profile and appearance of yam (*Dioscorea rotundata*) french fries. *Journal of Food Processing and Preservation* 39(1), 19-29. https://doi.org/10.1111/jfpp.12204

Li, Y., Bai, X., Zhao, M., Wang, H., Feng, J., Xia, X. & Liu, Q. (2023). Sodium alginate edible coating to reduce oil absorption of French fries with maintaining overall acceptability: Based on a water replacement mechanism. *International Journal of Biological Macromolecules* 236, 124042. https://doi.org/10.1016/j.ijbiomac.2023.124042

Liu, Y., Tian, J., Hu, B., Yu, P. & Fan, L. (2021). Relationship between crust characteristics and oil uptake of potato strips with hot-air pre-drying during frying process. *Food Chemistry* 360, 130045. https://doi.org/10.1016/j.foodchem.2021.130045

Lua, H.Y., Naim, M.N., P. Mohammed, M.A., Hamidon, F. & Abu Bakar, N.F. (2020). Effects of ultrasonicated methylcellulose coating on French fries during deep frying process. *Journal of Food Process Engineering* 43(2), e13332. https://doi.org/10.1111/jfpe.13332

Manoharan, S., Dubey, P.K. & Sharma, M. (2024). Recent advances in deep-fat frying through pretreatments and edible coating to reduce oil absorption. *Journal of Food Process Engineering* 47(8), e14706. https://doi.org/10.1111/jfpe.14706

Oladejo, A.O., Ma, H., Qu, W., Zhou, C., Wu, B., Yang, X. & Onwude, D.I. (2017). Effects of ultrasound pretreatments on the kinetics of moisture loss and oil uptake during deep fat frying of sweet potato (*Ipomea batatas*). *Innovative Food Science & Emerging Technologies* 43, 7-17. https://doi.org/10.1016/j.ifset.2017.07.019

Oloruntoba, D., Ampofo, J. & Ngadi, M. (2022). Effect of ultrasound pretreated hydrocolloid batters on quality attributes of fried chicken nuggets during post-fry holding. *Ultrasonics Sonochemistry* 91, 106237. https://doi.org/10.1016/j.ultsonch.2022.106237

Pathare, P.B., Opara, U.L. & Al-Said, F.A.-J. (2013). Colour measurement and analysis in fresh and processed foods: A review. *Food and Bioprocess Technology* 6(1), 36-60. https://doi.org/10.1007/s11947-012-0867-9

Roobab, U., Chen, B.-R., Madni, G.M., Guo, S.-M., Zeng, X.-A., Abdi, G. & Aadil, R.M. (2024). Enhancing chicken breast meat quality through ultrasonication: Physicochemical, palatability, and amino acid profiles. *Ultrasonics Sonochemistry* 104, 106824.

https://doi.org/10.1016/j.ultsonch.2024.106824

Salehi, F. (2020). 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. https://doi.org/10.1111/jfpp.14879

Salehi, F. (2023). Recent advances in the ultrasound-assisted osmotic dehydration of agricultural products: A review. *Food Bioscience* 51, 102307. https://doi.org/10.1016/j.fbio.2022.102307

Salehi, F., Amiri, M. & Ghazvineh, S. (2024a). Effect of ultrasonic pretreatment on textural properties and sensory attributes of cooked faba beans. *Ultrasonics Sonochemistry* 110, 107040. https://doi.org/10.1016/j.ultsonch.2024.107040

Salehi, F., Amiri, M. & Ghazvineh, S. (2025). Effect of ultrasound combined with edible coating based on guar gum on the physicochemical quality and texture of fried zucchini slices. *Journal of Food Science* 90(1), e17608. https://doi.org/10.1111/1750-3841.17608

Salehi, F., Ghazvineh, S. & Amiri, M. (2024b). Effect of basil seed gum coating and ultrasound pretreatment on frying time, oil uptake, hardness, color indexes, and sensory properties of potato slices. *Ultrasonics Sonochemistry* 110, 107035. https://doi.org/10.1016/j.ultsonch.2024.107035

Salehi, F., Goharpour, K. & Razavi Kamran, H. (2024c). Effects of different pretreatment techniques on the color indexes, drying characteristics and rehydration ratio of eggplant slices. *Results in Engineering* 21, 101690. https://doi.org/10.1016/j.rineng.2023.101690

Salehi, F., Haseli, A. & Roustaei, A. (2022). Coating of zucchini slices with Balangu, Basil, and Wild sage seeds gums to improve the frying properties. *European Journal of Lipid Science and Technology* 124(2), 2100120. https://doi.org/10.1002/ejlt.202100120

Salehi, F., Roustaei, A. & Haseli, A. (2021). Effect of surface coating with seeds mucilages and xanthan gum on oil uptake and physical properties of fried potato strips. *Food Science & Nutrition* 9(11), 6245-6251. https://doi.org/10.1002/fsn3.2583

Salehi, F., Samary, K. & Tashakori, M. (2024d). Influence of organic acids on the viscosity and rheological behavior of guar gum solution. *Results in Engineering* 22, 102307. https://doi.org/10.1016/j.rineng.2024.102307

Su, Y., Zhang, M., Bhandari, B. & Zhang, W. (2018). Enhancement of water removing and the quality of fried purple-fleshed sweet potato in the vacuum frying by combined power ultrasound and microwave technology. *Ultrasonics Sonochemistry* 44, 368-379. https://doi.org/10.1016/j.ultsonch.2018.02.049

Taiwo, K.A., Baik, O.D. & Farinu, A.O. (2007). Kinetics of heat and mass transfer and color development of pre-treated sweet potatoes during frying. *Transactions of the ASABE* 50(1), 129-135. https://doi.org/10.13031/2013.22384

van Koerten, K.N., Schutyser, M.A.I., Somsen, D. & Boom, R.M. (2015). Crust morphology and crispness development during deep-fat frying of potato. *Food Research International* 78, 336-342. https://doi.org/10.1016/j.foodres.2015.09.022

Zhang, J., Yu, P., Fan, L. & Sun, Y. (2021). Effects of ultrasound treatment on the starch properties and oil absorption of potato chips. *Ultrasonics Sonochemistry* 70, 105347. https://doi.org/10.1016/j.ultsonch.2020.105347