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Assessment of application of pectin, whey protein concentrate, soy protein isolated and methyl cellulose films to improve quality of potato strips

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Abstract

Deep-fat frying is a method widely used in the preparation of tasty food with an attractive appearance. However, oil uptake in fried foods has become a health concern. To meet the recent trends and consumer demand for low-fat products, there exists a need for reducing oil uptake during deep-fat frying. Recent studies have experimented with the use of edible coatings and films as barriers to the incorporation of oil during the frying process. Our objective was to evaluate the moisture retention and fat reduction capabilities of different edible film coatings (Methyl cellulose, Pectin, Whey protein isolate and Soy protein isolate) during deep-fat frying. Potato strips (size 0.8*0.8*8 cm) were used as the model food system. Oil uptake and moisture content were measured. Textural and colorific changes in fried potato strips were followed by the parameter maximum force (MF) and L*, a*, b*. What has emerged is that the using of edible coatings is an effective technique for reducing the oil contents and water retention of potato crisps. And also results showed that using of the coatings caused improving in texture and color qualities.

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Introduction

Potato (*Solanum Tuberosu*) is one of the world major agricultural crops and it is consumed daily by millions of people from diverse cultural backgrounds. Potatoes are grown in approximately 80% of all countries and worldwide production stands in excess of 300 million tons/year, a figure exceeded only by wheat, maize and rice (Duran, 2007). Deep-fat frying is a widely used food process, which consists basically of immersion of food pieces in hot vegetable oil. The high temperature causes partial evaporation of the water, which moves away from the food and through the surrounding oil, and a certain amount of oil is absorbed by the food. Frying is often selected as a method for creating unique flavors and texture in processed foods that improve their overall palatability (Pedreschi *et al.,* 2007; Moyano and Pedreschi, 2006). During the frying process, the physical, chemical, and sensory characteristics of the food are modified. Texture, color and oil content are the main quality parameters of French fries. Good quality French fries must have a crispy crust of about 1–2 mm, where most of the oil is located, and a moist, soft center, like a cooked potato. French fry color is the result of the Millard reaction which depends on the content of superficial reducing sugars and the temperature and time of frying (Bunger *et al.,* 2003). The reduction of the lipid content in fried foods is required mainly owing to its relation with obesity and coronary diseases (Suarez *et al.,* 2008). The repeated use of frying oils also can produce undesirable constituents that not only compromise the quality of the food but also pose a potential hazard to human health and nutrition. The chemical reactions that contribute to these undesirable constituents include hydrolysis, oxidation, and polymerization of the triacylglycerol (Holownia *et al.,* 2001). High oil content is therefore a major factor affecting consumer acceptance of oil-fried products today and the low fat food products are becoming more popular (Maitran *et al.,* 2007). Food coatings may become a good alternative to solve this problem. The main coating materials are formed from proteins, cellulose derivatives, alginates, pectin, starch and other polysaccharides (Freitas *et al.,* 2009). Edible films and coatings are usually used to control moisture transfer, limit gas transport, retard oil and fat migration, prevent solute or flavor absorption, carry food additives such as antimicrobial agents and antioxidants, and improve structural integrity of foods(Kokoszka *et al.,* 2010; Carvajal *et al,.* 2009; Ozdemir and Floros., 2008; Seydim and Sarikus,. 2006; Rhim *et al,* 2002). Recent studies have experimented with the use of edible coatings and films as barriers to the incorporation of oil during the frying process. Mallikarjunan *et al* (1997) were determined the effectiveness in moisture retention and reduction of fat uptake of different edible coatings (corn zein (CZ), hydroxypropyl methyl cellulose (HPMC) or methyl cellulose (MC)) in moisture retention and reduction of fat uptake. Garcia *et al* (2002) were used MC and HPMC in coating formulations to reduce oil uptake in deep-fat frying potato strips and dough discs and results showed that MC coatings were more effective in reducing oil uptake than HPMC ones. Albert and Mittal (2002) compared eleven hydrocolloid materials for their film forming ability, suitability for fried foods, and water and fat transfer properties. Freitas *et al* (2009) investigated the influence of the use of three hydrocolloids (pectin, whey protein and soy protein isolate) as coatings in the deep-fat frying of preformed products made from cassava flour and from cassava purée. The objective of this study was to determine the effects of four different edible coatings (methyl cellulose, pectin, whey protein and soy protein isolate) on the oil content reduction, water content level, color and texture of the potato strips during frying.

Materials and methods

Materials

Potato tubers (Solanum tuberosum L. cv. Agria) were purchased from a local market in Mashhad, Iran. Prior to investigations they were stored at 8°C and 93–95% relative humidity. Analytical grade solvent n-hexane (85% purity) was purchased from Merck. Vegetable oil (the frying oil used in this study) was also purchased locally.

Film preparation

Pectin films

The films were prepared by slowly dispersing 4, 8 and 12 g of pectin in 400 ml of distilled water at high velocity in a mixer. The solutions were heated at 90 °C for 10 min with constant stirring. Aliquots were distributed in 11cm diameter plates, and the films dried at room temperature (25 °C) for 48 h (Freitas *et al*, 2009).

Whey protein concentrated films

Aqueous solutions of 5, 6, and 7 % (w/w) WPC were prepared by stirring dry WPC (Whey protein concentrate) powder in distilled water on an Erlenmeyer flask shaker at 180 rpm for 1 h until the WPI was completely dissolved. Solutions were placed in a water bath (model) at 90 °C and kept there for 30 min to denature the protein. Solutions were then cooled to room temperature, and Glycerol (50%, w/w) were added to plasticize the films. Solutions were stirred again on the shaker at 140 rpm for 10 min to reach to steady state solutions. Solution aliquots distributed in 11cm diameter plates, and the films allowed drying at room temperature (25 °C) for 24 h (Ozdemir and Floros, 2008).

Soy protein isolated films

Film-forming solutions were prepared by dissolving slowly SPI (Soy protein isolated) in distilled water (5, 6, 7 w/w %) under a 700 rpm with magnetic stirring for 20 min at room temperature. glycerin (a plasticizer), was then added at 50% (w/w) of SPI. Glycerin was added as a plasticizer to overcome film brittleness and to obtain freestanding films. After adjusting the pH values of the solutions to 10±0.1with 1 M sodium hydroxide they were heated under magnetic stirring at 70 °C for 20 min at 200 rpm, then solutions were cool down to room temperature (20±2 °C). Solutions were poured onto a series of Petri dishes (diameter 11 cm) (Rhim *et al*., 2002).

Methyl cellulose

Disperse 2% MC (Methyl cellulose) in 33% hot water (70 °C), add 65% cold tap water, MC has to be added slowly and solution thickened with the addition of cold water. Coating had some holes after frying, therefore, addition of a plasticizer was necessary. For plasticizer, heat 70-g tap water to over 70 °C, add 6 g glycerin, while stirring slowly add 4 g MC very slowly, thicken solution by adding slowly 130 g ice cold water. Then solutions were cool down to room temperature (20±2 °C). Solutions were poured onto a series of Petri dishes (diameter 11 cm) (Albert and Mittal, 2002).

Potato strips preparation

Potatoes were taken out of storage 12 h before frying to let them reach room temperature and for the reducing sugar contents to decrease. The potato tubers were washed, hand-peeled and cut with a manual operated potato-cutting device into a 1 * 1 * 8 cm strips. The strips were blanched in hot steam 100 ° C for 4 min. After blanching, the potato strips were immediately immersed in aqueous solutions of edible coatings at room temperature for two minutes.

Frying

Frying was carried out in a thermostatically temperature controlled fryer (FR-M, Gorenje, Slovenia) having a capacity of 3 litre of oil. The strips were fried at 180± 10 °C for 6 min in sunflower oil, as well as palm oil and vegetable oil with a constant product weight/oil volume ratio of 1:6. Because so much oil is removed along with the fried potatoes, after each frying the oil level was checked and replenished. There were volume indications on inner walls of the fryer. Because we had 12 different batches of treated potato strips (3 * coatings percent +4 * hydrocolloid type), the oil was changed after each batch of treated strips. All fried samples were allowed to cool to room temperature and analyzed for oil content. All experiments were run in triplicate and the present results are the average of the obtained results.

Quality attributes

To evaluate whether four coatings application affected the quality attributes, color and texture parameters of coated and uncoated fried potato strips samples were analyzed.

Colorimetric measurements

Color characterization of different coated and uncoated samples of this study was carried out by using a flatbed scanner (model). Images were saved as a JPG format for further applications. Pieces with 400*200 pixels Dimension separated from the center of each strips by using the Image J software. The three color parameters L*, a*, b* of the samples were generated by using Image J software.

Texture analysis

Breaking force of samples was measured by puncture test using a texture analyzer (CNS Farnell) with a 5 kg cell. Samples were punctured with a cylindrical plunger (2 mm diameter) at 0.5 mm/s. Maximum force at rupture was determined from the force–deformation curves. Samples were allowed to reach room temperature before performing the tests (Garcıa *et al*, 2002).

Water content

Water content of potato strips was determined by weight loss after drying 2 g samples of potato strips in a forced air oven at 105 °C for 24 h (AACC, 1986). The test was performed in triplicates. Relative variation of waterRetention % (WR) in the coated product relative to the uncoated one was calculated as follows:

$$WR = \left[\frac{WC\ coated}{WC\ uncoated} - 1\right] \times 100 \qquad (1)$$

Oil uptake

Oil content was measured by Soxhlet extraction using n-hexane. The extraction time was 5 h .The test was performed in triplicates and average values taken. Oil uptake relative variation % (OU) in the coated product relative to the uncoated one was calculated as follows:

$$OU = [\frac{LC\ coated}{LC\ uncoated} - 1] \times 100 \qquad (2)$$

Sensory analysis

Untrained panel sensory analysis was carried within a group of 10 persons. The tests of the samples with treatment and without treatment were evaluated.

Statistical analysis of the data

All data were analyzed using the Analysis of variance (ANOVA) was performed to compare mean values of different coatings and control samples. The Duncan multiple range test was applied to determinate differences among means at a 5% significance level.

Results and discussions

Effect of coating formulation on water retention

Table 1 shows the moisture content and water retention of the products after the final frying. Results showed that using edible films for frying of the potato strip caused increasing in moisture contents and water retention percentage of the products. The Methylcellulose films showed the best results with respect to the efficiency of the edible coatings in increasing moisture content and water retention during the frying process of the potato strips. Pectin had lower moisture content than MC and after pectin, SPI and WPC had the lowest moisture content and water retention percentage. The moisture increase due to coating was proportional to the increase in concentration of the films (except SPI), indicating greater moisture retention by the thicker films. Freitas *et al.* (2009), obtained similar results regarding to the type of film used for a product from potato, whey protein and soy protein isolate having the lowest moisture content.

Effect of coating formulation on oil absorption

The fat content and the reduction in oil uptake of coated and uncoated potato strips are shown in Table 1. A reduction in fat uptake was observed for deep-fat fried coated potato strips samples .The surface layer of coated samples absorbed less oil compared to control samples. Edible films as gel-forming compounds forms a fine net structure which prevents the oil migration in the potato tissue during the frying process. Among all films tested, WPC 7% and MC 2% provided the lowest fat content and highest reduction in oil uptake during frying. And also SPI exhibited the lowest barrier properties to reduction in fat uptake during deep fat frying. Holownia *et al.* (2000) reported that MC and HPMC films applied on chicken strips decreased oil uptake and the degradation of frying oil, extending thus the useful life. Albert and Mittal (2002) obtained similar results regarding to the type of film used for a product from potato, whey protein being the best material to reduce fat absorption. Similar results were obtained by Rimac *et al.* (2004) working on deep-fat fried potato strips coated with plasticized CMC films.

Table 1. Effect of coating formulation on barrier properties of fried potatoes.

Coating formulation	Moisture (g/100g)	Water retention (%)	Fat content (g/100g)	Oil uptake reduction (%)
Control	57.32±0.74[a]	-	15.14±1.16[g]	-
2% MC[2]	66.80±0.60[ef]	16.53±1.00[de]	4.83±1.04[b]	68.08±2.14[f]
3% MC	68.23±0.16[fg]	19.02±0.26[ef]	7.08±0.46[c]	53.22±1.65[d]
4% MC	68.82±0.50[g]	20.05±0.83[f]	7.58±1.12[c]	49.92±2.23[cd]
1% PEC	64.84±0.57[cd]	13.1±1.07[cd]	7.21±0.46[c]	52.33±1.48[d]
2% PEC	65.98±0.50[de]	15.1±0.43[d]	8.33±0.28[cd]	44.96±1.74[c]
3% PEC	66.80±0.39[ef]	16.53±0.71[de]	9.63±1.20[de]	36.38±2.04[bc]
5% SPI	61.60±1.28[b]	7.46±1.38[bc]	11.38±1.14[f]	24.82±2.14[a]
6% SPI	61.04±1.31[b]	6.48±1.28[b]	10.35±0.73[ef]	31.64±1.62[b]
7% SPI	59.26±0.67[a]	3.38±0.93[a]	11.35±0.78[f]	25.04±1.44[a]
5% WPC	64.08±1.14[c]	11.78±1.35[c]	5.94±0.36[b]	60.77±1.78[e]
6% WPC	64.73±1.19[cd]	12.91±1.57[cd]	5.73±0.42[b]	62.12±2.46[ef]
7% WPC	66.67±1.21[ef]	16.31±1.25[de]	4.36±0.38[a]	71.2±2.18[f]

All mean scores bearing different superscripts in columns are significantly different on application of Duncan's New Multiple Range Test (P< 0.05).

Table 2. Effect of coatings on color parameters of fried potato samples.

color (Hunter units)	*L**	*a**	*b**
Control	75.14±0.78 [b]	-0.27±0.96 [e]	44.169±1.44 [cde]
MC 2%	96.80±0.94 [ef]	-10.03±0.86 [bc]	35.77±2.52 [bc]
MC 3%	94.33±0.80 [d]	-7.82±0.28 [cd]	31.75±2.18 [ab]
MC 4%	96.37±0.66 [def]	-9.34±0.80 [c]	35.95±1.60 [bc]
PEC 1%	82.56±1.64 [c]	-2.12±1.72 [e]	53.88±1.17 [f]
PEC 2%	82.65±0.75 [c]	-6.69±1.23 [d]	50.59±2.15 [def]
PEC 3%	77.49±0.62 [b]	-4.77±0.74 [de]	53.61±0.41 [f]
SPI 5%	98.46±0.24 [f]	-8.11±0.27 [cd]	25.65±1.75 [a]
SPI 6%	95.47±1.09 [de]	-9.96±0.82 [bc]	41.64±2.45 [cd]
SPI 7%	97.34±0.53 [ef]	-12.13±1.26 [ab]	43.23±2.03 [cde]
WPC 5%	84.26±0.46 [c]	-10.09±0.68 [bc]	72.94±1.34 [g]
WPC 6%	82.35±0.80 [c]	-13.37±0.92 [a]	51.67±2.13 [ef]
WPC 7%	71.55±0.58 [a]	-7.21±0.84 [cd]	58.07±1.44 [f]

All mean scores bearing different superscripts in columns are significantly different on application of Duncan's New Multiple Range Test (P< 0.05).

Texture

Maximum force (MF) is defined as the force at which the punch penetrates the outer layer of the surface of fried potato slices and could describe properly the crispness of fried potato strips. Figure 1 shows breaking force results for potato strips with and without coatings. In all cases, the maximum force to puncture the samples increased, due to presence of edible films layers. Coating did not significantly (P<0.05) modify texture of SPI and Pectin samples compared to control. But WPC and MC showed a significant (p<0.05) effect on keeping texture of potato strips samples. Among all the films MC had the best result and SPI had the lowest rate of maximum force. Instrumental results of breaking force agree with sensory analysis data. Similar results were obtained by Rayner *et al.* (2000) working on deep-fat fried potato discs coated with plasticized soy protein films. Besides, Funami *et al.* (1999) working on doughnuts found that MC addition had no effect on breaking stress of the samples.

Table 3. Effect of coatings on sensory analysis of fried potato samples.

Quality parameter	Color	Texture	Taste	Acceptance
Control	2.0±1.05 ^{a}	2.1±1.15 ^{ab}	1.8±0.56 ^{a}	2.1±0.96 ^{a}
MC 2%	2.1±0.99 ^{a}	2.3±0.98 ^{ab}	2.2±0.94 ^{ab}	2.2±0.94 ^{a}
MC 3%	2.2±1.03 ^{a}	2.3±0.76 ^{ab}	2.1±1.05 ^{ab}	2.1±1.06 ^{a}
MC 4%	2.4±0.96 ^{a}	2±1.04 ^{a}	2.3±0.82 ^{ab}	2.2±1.12 ^{a}
PEC 1%	2.2±0.88 ^{a}	2.1±0.83 ^{ab}	2.3±0.77 ^{ab}	2.2±1.04 ^{a}
PEC 2%	2.3±0.95 ^{a}	2.4±1.02 ^{ab}	2.4±1.12 ^{ab}	2.3±0.77 ^{a}
PEC 3%	2.7±1.12 ^{a}	2.4±1.12 ^{ab}	3±1.05 ^{b}	2.7±0.89 ^{a}
SPI 5%	2±0.94 ^{a}	2.4±0.92 ^{ab}	2.3±0.93 ^{ab}	2.4±0.55 ^{a}
SPI 6%	2.5±0.74 ^{a}	2.3±0.74 ^{ab}	2.6±0.76 ^{ab}	2.3±0.83 ^{a}
SPI 7%	2.7±1.02 ^{a}	3±0.86 ^{b}	2.9±0.74 ^{b}	3±0.96 ^{a}
WPC 5%	2.1±1.12 ^{a}	2.1±1.10 ^{ab}	2.3±1.08 ^{ab}	2.4±1.03 ^{a}
WPC 6%	2.2±0.84 ^{a}	2.3±0.96 ^{ab}	2.4±0.88 ^{ab}	2.5±0.98 ^{a}
WPC 7%	2.4±0.96 ^{a}	2.5±1.18 ^{ab}	2.8±0.72 ^{b}	2.7±1.12 ^{a}

All mean scores bearing different superscripts in columns are significantly different on application of Duncan's New Multiple Range Test (P< 0.05).

Colorimetric measurements

The evolution of the color parameters L* and a* and b* after frying of the coated potatoes and those of the control sample are shown in Table 2.With regard to color, potato strips showed significant differences (P<0.05) between uncoated samples and those with edible coatings. However, significant differences (P<0.05) in lightness parameter (L*) were found between the uncoated and coated samples and results showed that it was increased in all samples compared to the control. MC and SPI had higher lightness among all samples. Chromaticity a* decreased in all samples and it had significant differences (P<0.05) compared to the control and among all the samples. Chromaticity parameter b* was higher in WPC and Pectin compared to control and also it was lower in SPI and MC compared to the control sample. Also results agree with the sensory evaluation. Similar results were obtained by Garcia *et al.* (2002) working on deep-fat fried potato strips coated with plasticized MC films.

Sensory analysis

Untrained panel sensory analysis was carried within a group of 10 persons. The tests of the samples with coatings and without coatings were evaluated. Changes in sensory attributes including color, taste, firmness and overall preference of coated and uncoated fried potato strips are shown in Table 3. Results showed that using edible films on fried potato strips didn't have any significant differences (P<0.05) on sensory attributes compared to the control sample (with some exceptions). Among all the coatings, MC had the highest scores and it scores was more similar than other coatings to the control sample and SPI had the lowest scores.

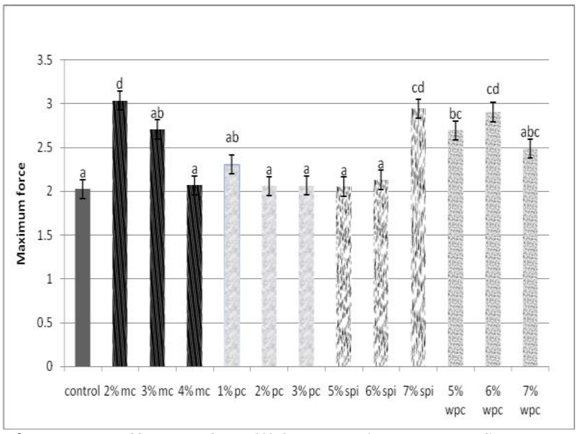

Fig. 1. Effect of edible coatings on firmness (Maximum force) of fried potato samples.

In conclusion, edible films were tested for their suitability as a coating material on fried foods, and their fat and water barrier properties. Most of the tested coatings decreased the fat uptake and also decreased the water reduction during frying of the products. Since the objective was to detect a coating that reduced fat absorption while maintaining or decreasing the moisture loss during frying, whey protein and MC were the material showing the best results, coatings also significantly improved the texture quality of fried potato strips. And also color of the coated samples didn't change after frying compared to the control sample. Sensory evaluation of quality of the products showed that using edible films didn't influence sensory characteristics of the fried coated potato strips and also didn't change acceptance by the consumers. Among the films tested, MC and WPC showed the most effective moisture and fat barrier properties.

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