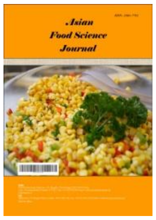

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Effect of Propolis Coating on Oil Uptake and Quality Properties of Fried Potato (*Solanum tuberosum*) Strips

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Authors' contributions

This work was carried out in collaboration between both authors. Author SJ designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author PM managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The use of edible coatings is a suitable method to reduce oil uptake in fried foods. In this research, the effects of propolis gum on the physicochemical properties of fried potato strip were evaluated.
The propolis coating was performed at three concentrations 1%, 1.5%, 2% w/v. Potato strips were dipped in the coating solutions followed by air drying. Viscosity of coating was measured in two shear rate 0.048 and 62.11 1/s. The treatments were fried in canola oil and analyzed for fat uptake and moisture retention.
One-way analysis of variance (ANOVA) was used and mean comparison was performed by Duncan's new multiple range test.
The results showed that by increasing in shear rate, viscosity of coating was decreased. By increasing in propolis concentration, the coating pick up, moisture content, frying yield, were increased while oil uptake were decreased.
According to the results, 2% concentration propolis gum reduced oil absorption in fried potato strips. Due to their facility to use, propolis gum suggested for coating and usage in industrial potato fries production.

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1. INTRODUCTION

Deep-fat frying is widely used in food preparation, which consists basically of immersion of food pieces into hot oil. During frying, interactions between oil and the product resulted in numerous physical, chemical and structural changes [1]. It involves two mass transfers in opposite directions within the food being fried: water and soluble materials escape from the core to the crust during frying and the water in the crust evaporates and moves out of the food, whereas oil penetrates the product [2]. One of the important quality attributes of deep fat fried products is the amount of oil content in these products. Fried food with low fat content, can hard texture edible coating have long been known to protect perishable food, from deterioration by retarding dehydration suppressing respiration, improving texture quality, helping to retain volatile flavor compounds and reducing microbial growth. Another application of edible films of coating is as barrier to lipid absorption by food during deep fat frying.

Oil uptake in fried foods has become a health concern, high consumption of lipids been related to obesity and other health problem such as coronary heart disease. Reducing the fat content of fried food by application of coating is an alternative solution to comply with both health concerns and consumer preferences [3].

Edible coating is defined as thin layers of edible materials that usually applied as a liquid of varying viscosity to the surface of food product by spraying, dipping, brushing or other methods. Coating can protect food product from moisture migration, microbial growth, light induced changes and oxidation of nutrients.

There are some studies showing the basic ingredients that contribute better covering characteristics and final texture of fried products [4].

Increased consumer awareness of the necessity to reduce the fat content in their diets has prompted intensive research on ways to reduce the amount of fat absorbed during frying. The use of hydrocolloids has been found to be effective [5]. A gel develops when the food substrate is immersed into the hot oil, supporting the adhesion of the coating film to the product. This coating acts as a physical barrier and makes the surface stronger and more brittle, with fewer small pores, decreasing vaporization and trapping moisture inside. The resulting product is tender and juicy on the inside and at the same time crisp and brittle on the outside, with a less greasy texture. This technique has become increasingly important in recent years, using various hydrocolloids [6].

There are many works in the literature on reducing the oil uptake by coating. Scientists researched on edible coating by mathematic modeling [7]. A model was developed on the heat, mass and fat transfer [8]. According to results there was reduction in the oil content and well as improvement in the quality of the chips due to the application of coating materials [9]. The materials used for the study were pectin guar gum and CMC solution. It was investigated the effects of several hydrocolloids, including gellan gum, CMC, pectin. Several groups were different effect on reduce oil migration [10]. Hydrocolloids with thermal gelling or thickness properties have been tested. Researchers resulted cellulose derivatives for coating formulations to reduce the oil uptake of fried products [3].

Propolis is a natural substance collected by honey bees from various plants such as, poplar, palm, pine, conifer secretions, gums, resins, mucilage and leaf buds [11]. Propolis is a chemically very complex resinous consists of flavonoids and phenolic acids and their esters, waxes, essential oils, pollen and various organic compounds [12]. As a good source of polyphenols with multiple biological activities, propolis has high potential to be used as active agent and can be incorporated into films. Limited research on incorporation of propolis to enhance properties of edible films and coatings has been published [13]. Also, there is no published information about the use of propolis gum as coating materials to reduce moisture loss and fat uptake of potato strips during deep-fat frying. Therefore, in this study the influence of propolis gum as edible coating on fried potatoes was investigated.

2. MATERIALS AND METHODS

2.1 Materials

Potato tubers (*Solanum tuberosum* L.) from Agrya cultivar were purchased from a local market in Mazandaran, Iran. They were stored at 8°C and 93–95% relative humidity. Two weeks before frying they were moved to ambient temperature [14]. Propolis was collected from a place near the city of Sari in late winter. Canola oil provided from (Kesht & Sanat -shomal) company, Mazandaran, Iran. All chemicals were from Merck Co.

2.2 Sample Preparation

In order to determine the appropriate concentration of propolis, Suspensions with 3 different concentrations of 1, 1.5 and 2% were prepared. 90 grams of propolis mixed in 400 ml hot water and then for 15 minutes at 20°C was centrifuged at 7000 rpm. Supernatant was collected in a tube and dried in an oven at 103 ° C. For the preparation of colloidal suspensions of boiled distilled water were used and 10 and 20 grams of propolis dissolved in 1 liter of water suspension was prepared. Each sample coated in three separate treatment with 1, 1.5 and 2 percent of samples were used .The potato tubers were washed, hand-peeled and cut with a manual operated potato-cutting device into 5*1*1 cm strips. The strips were divided into three portions. The first portion was blanched in water at 70°C for 10 min, while the second and third portions were blanched in 0.5% aqueous solution of calcium chloride and in 1% citric acid solution, respectively, at the same temperature/time conditions [14]. After blanching, the potato strips were immediately immersed in different aqueous solution of propolis gum at ambient temperature for two minutes. Then, the strips were drained and dried in a convection oven at 155°C for 3 min to reduce the surface water.

2.3 Frying

Frying was carried out in a thermostatically temperature-controlled fryer (Molinex-Supremia). The strips were fried at 180±5°C for 2 minutes in canola oil with a constant product weight/oil volume ratio of 1:5. The initial temperature of the potatoes before entering the fryer was 25°C [15]. After the test each treatment, used oil with the aim of experiments was stored in order to oxidative stability and color changes. 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 [16]. All fried samples were allowed to cool to room temperature and analyzed for moisture and fat content, frying yield viscosity and coating pick up calculations. Samples were run in triplicate and the present results are the average of the obtained results.

2.4 Rheological Measurements

The steady shear rheological measurements were conductedusing a controlled-stress rheometer (Physica MCR 301, Anton Paar GmbH and Stuttgart, Germany) equipped with a cone and plate geometry (CP40_4, 39.958 mm in diameter, angle 4_ and gap size of 49 lm). The samples were loaded onto the lower plate of the rheometer equilibrated at 20°C and a thin layer of low-density silicone oil was used around the plate to prevent evaporation. All samples were allowed to equilibrate at the measuring temperature for 10 min before the start of the test. Data were recorded with the Rheoplus software, version 2.65 (Anton Paar Germany GmbH). Linear steady shear stress sweeps were obtained over a range of shear rates (101–103 1/s) at 20±0.1°C. A temperature sweep test (5–85°C) was performed also on 1% BSG using oscillatory dynamic mode of rheometer at 0.5% strain and frequency of 1 Hz. Rheological measurements were made in triplicate and the average reported. The data were plotted in the logarithmic scale based on viscosity as a function of shear rate [17]. Rheological behavior of propolis solution including 0.1, 1.5 and 2% concentration were investigated.

2.5 Water Content

Water content (WC) was determined by weight loss of fried products, upon drying in an oven at 105°C until a constant weight was reached. Relative increase of water retention% (WR) in the coated product relative to the uncoated one was calculated as follows: where WC-coated and WC-uncoated are the water contents of the coated and uncoated samples, respectively. For each coating formulation, results were obtained using all samples from at least three different batches [18].

2.6 Fat Content % (Soxhlet Method)

The fat content (FC) of the fried products was determined on dried samples using continuous Soxhlet extractions. The extraction time was 16 hours. The oil uptake decrease % (OU) in the coated product relative to the uncoated one was calculated as follows: OU = (FC after coating – FC before coating) x 100 (III) FC before coating [19].

2.7 Coating Pick-up Calculations

Coating pick-up was calculated from the difference between coated weight and non-coated weight of raw potato sample [20].

2.8 Frying Yield Calculations

Percentage of frying yield was obtained by considering the weight of the fried potato strips and the raw potato strips after coating [21].

2.9 Statistical Analysis

One-way analysis of variance (ANOVA) was used and mean comparison was performed by Duncan's new multiple range test. Statistical analysis was prepared using the SPSS statistical software (version 22.0) for Windows (SPSS Inc. Chicago, IL).

3. RESULTS AND DISCUSSION

3.1 Viscosity

The viscosity of samples significantly increased with a greater propolis concentration (Figs. 1 and 2). A strong effect of gum concentration on the apparent viscosity of the propolis solution showed a 0.2 to 1.8 pa/s among different shear rate. The viscosities of propolis solution observed with different concentration and shear rate. In shear rate 62.11(s^{-1}) viscosities of propolis solutions containing 1%, 1.5% and 2% were 0.2 Pa/s, 0.7 Pa/s and 1.3 Pa/s, respectively. In other hands, the shear rate 0.048 to 62.11 (s^{-1}) viscosity decreased. It is seen that with increasing shear rates, the viscosity of samples under investigation declined to represent the behavior of non-Newtonian shear thinning [17]. Results are in agreement with those reported researches such as Gutoff & Cohen & Daraei Garmehkhani et al. [22,20]. However, comparing the viscosities of propolis solutions at same concentrations showed no significant (p = 0.05) differences, but they were significantly higher than for two shear rate.

3.2 Coating Pick-up

Nowadays edible films have different applications, and their use is expected to be expanded with the development of Active Coating Systems. This second generation of coating materials can use chemicals, enzymes or microorganisms that prevent, for example, microbial growth or lipids oxidation in coated food products [23]. As it can be seen in Fig. 3, 2% propolis gum with 21% coating has the highest amount of coating pick up (p=0.05). Minimum coating pick up was related to control sample that can be because of its lower gel formation ability. The higher amount of coating pick up in propolis gum may be due to ability of thick gel formation. It can be noted from the table that with the increase in the concentration of the coating materials the coating pick-up percentage also increased in most cases. This may be attributed to the differences in adequate concentrations of coating formulations, among other causes, to differences in adhesion between substrate and coating suspension, surface characteristics of the sample and frying conditions [8]. Generally, coating with hydrocolloids increased the coating pick up final products compared with uncoated samples which is in agreement with the results reported [8,20,24]. In general, by increasing the gum concentration, the coating percentage was increased (Fig. 3).

3.3 Frying Yield

Frying yield increased significantly (p = 0.05) in samples coated with various hydrocolloids. As shown in Fig. 4, 2% propolis gum had the highest frying yield values, and uncoated samples showed the smallest values. This is attributed to the quality of coating on the potato strips and the water retention capacity of hydrocolloids, which could hinder water vaporization and consequently lead to a higher yield of fried potatoes [14]. Overall, in our experiments the frying yield and moisture content values followed the same trend.

3.4 Moisture and Fat Content

Coating with hydrocolloids increased the moisture content of final products compared with uncoated samples which is in agreement with the results reported [10,25,6]. The lowest and highest moisture content was observed respectively for the potato fries coated with 0% 0 and 2% propolis gum (Fig. 5). Different gums concentration led to different water increase in fried samples (P=0.05). Beside, this difference not showed between 1.5% and 2% propolis gum. Also by increasing gum concentration, oil content decreased in all samples. Increase in water content due to coating, may be result of barrier properties of coating agents which prevent water loss during frying and by this mechanism water content of coated strips were higher than

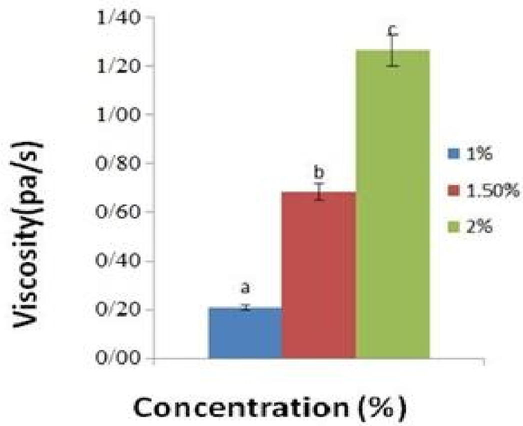

Fig. 1. Effect of addition different level propolis gum coatings on viscosity in shear rate (62.11 1/s)

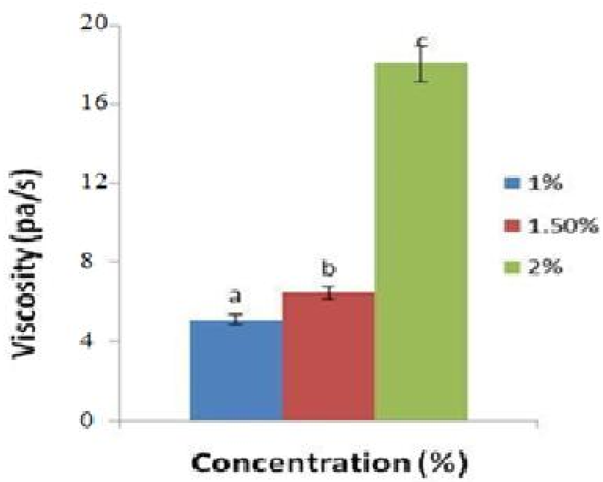

Fig. 2. Effect of addition different level propolis gum coatings on viscosity in shear rate (0.48 1/s)

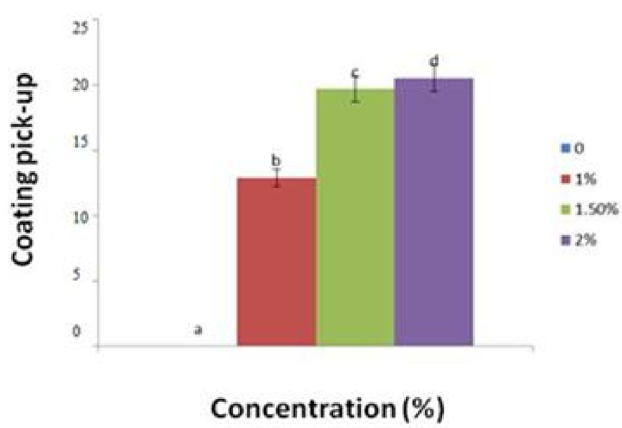

Fig. 3. Effect of addition different level propolis gum coatings on coating pick up

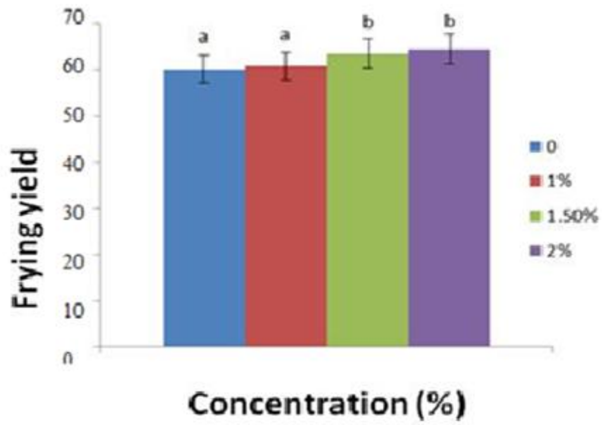

Fig. 4. Effect of addition different level propolis gum coatings on frying yield

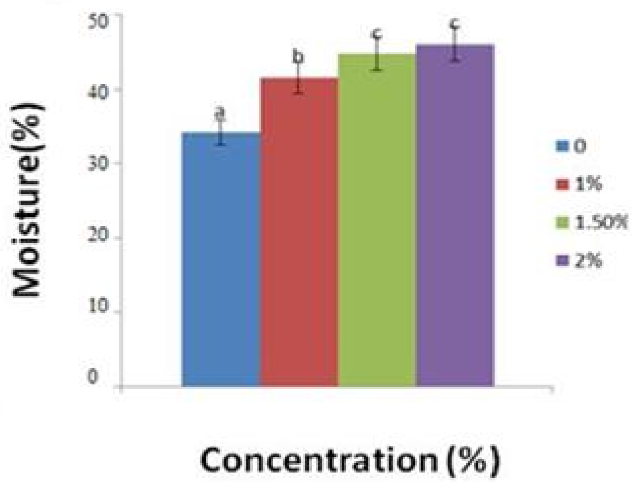

Fig. 5. Effect of addition different level propolis gum coatings on moisture

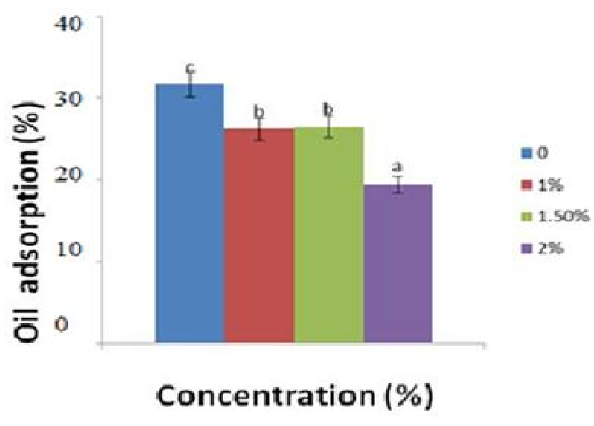

Fig. 6. Effect of addition different level propolis gum coatings on oil adsorption

non-coated potatoes. This is due to oil absorption that occurred as moisture was removed from food during frying process [26]. The increase in moisture content propolis coated sample might be due to the rehydration of the coated film during battering and penetration of moisture to the crust during frying process. The moisture content decreased after frying process due to removal of water by evaporation. Water starts evaporating as soon as the raw material is in contact with the oil [27]. It was reported that using many edible coating films were reduced fat absorption and improved moisture retention in starchy products and poultry products [28]. The microstructure of the crust is the main determining factor for oil uptake which takes place by a capillary mechanism. Coating make the surface stronger and more brittle with fewer small voids which reduces evaporation and leads to less oil uptake and alter the water holding capacity by trapping moisture inside and preventing the replacement of water by oil [2].

4. CONCLUSION

Using propolis gum in different concentration as coating films for potato strips reduced oil uptake during deep fat frying. The results showed that coating of potato french - fries with different concentration of propolis gum reduced the moisture loss of products during frying because of their barrier properties. Since moisture removal during frying is a key factor for oil uptake of fried products, coated samples have significantly lower oil uptake than uncoated ones. Among different studied gums propolis 2%, led to the lowest fat absorption. Among these treatments, propolis gum 2% due to their facility to use, suggested for coating and usage in industrial potato fries production.

Propolis gum could be used as protective coating that may enhance the shelf life of potato french-fries.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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