Food Hydrocolloids 83 (2018) 265–274

Contents lists available at ScienceDirect

Food Hydrocolloids

journal homepage: www.elsevier.com/locate/foodhyd

Simultaneous inhibition of acrylamide and oil uptake in deep fat fried potato strips using gum Arabic-based coating incorporated with antioxidants extracted from spices

Rasha Mousa Ahmed Mousa [a, b, *]

[a] *Home Economic Department, Faculty of Specific Education, Assiut University, 71516 Assiut, Egypt*
[b] *Biochemistry Department, Faculty of Science, University of Jeddah, P.O. 80327, 21589 Jeddah, Saudi Arabia*

ARTICLE INFO

Article history:
Received 14 October 2017
Received in revised form
14 April 2018
Accepted 5 May 2018
Available online 8 May 2018

Keywords:
Hydrocolloid coating
Antioxidants
Fried potatoes
Acrylamide
Oil uptake
Sensory

ABSTRACT

Modified hydrocolloid gum Arabic (GA) layers on potato strips have been easily prepared by incorporating individual, binary or ternary combinations of antioxidants extracted from widely used spices (black pepper, red chili, turmeric, coriander and cumin) with gum Arabic before deep-frying. The methodological approach for antioxidants incorporation with GA has been firstly investigated to reduce simultaneously acrylamide (AA) and oil uptake in the final deep fat fried potato strips (DFFPS). Results revealed that the antioxidant capacity of markers and their adsorbed amounts are limiting factors for the efficiency of modified GA layer. It is interesting to observe that the use of antioxidants in ternary combinations improved markedly the performance of GA for the inhibition of AA giving values in the range of 112.1 ± 4.5 to 560.4 ± 6.6 μg/kg that are very close or lower than the acceptable EU benchmark level 500 μg/kg AA in DFFPS. The addition of ternary mixtures (1.5%, w/v) of red chili, turmeric and coriander into the GA (1%, w/v) coating solution (1:2, w/v) for 60 min at ambient temperature has been identified as the most promising inhibitor of AA formation (reduction up to 88%) and oil uptake (reduction up to 84.1%). However, non-modified GA layer attenuated only 20% of AA formation (747.2 ± 9.0 μg/kg) and 45.8% of oil uptake compared with the control sample. These results could be attributed to the formation of modified GA hydrocolloid coating on potato strips with the highest antioxidant capacity (485.3 ± 8.2 TE/100 g) and highest recovery by markers capsaicin, curcumin and linalool. Scanning electron microscope (SEM) photographs confirmed the formation of a rigid (thermal gelation and/or crosslinking) network during frying that has to help cement the cell wall of potato tissue. Furthermore, texture, color and sensory analyses indicated that the proposed GA modified coating had maintained the overall acceptability of DFFPS products.

1. Introduction

Deep fat frying is extensively used for the preparation of fried potatoes in a fast cooking method (Garcia, Ferrero, Bertola, Martino, & Zaritzky, 2002; Chiou, Kalogeropoulos, Salta, Efstathiou, & Andrikopoulos, 2009) at restaurants or homes. It is a complex process including heat transfer and mass transport mechanisms during deep-frying such as surface browning, rapid water evaporation and oil absorption or degradation (Moreira, Castell-Perez, & Barrufet, 1999). However, acrylamide (AA) formation and oil uptake (OU) are the predominant problems manifesting by deep fat frying (Zeng et al., 2010; Kurek, Scetar, & Galic, 2017; Amaral, Achaerandio, Benedetti, & Pujol, 2017). AA is a potential carcinogen and genotoxin which forms as a result of the Maillard reaction between asparagine and reducing sugars (fructose or glucose). Recently, EU commission regulation, 2017/2158 establishes mitigation measures and benchmark levels for the reduction of the presence of AA in food (EU commission regulation, 2017). It was recommended that AA must be less than 500 μg/kg in deep fat fried potato strips (DFFPS). As well, high values of OU in DFFPS are not recommended which has become a health related issue mainly associated with obesity, high blood cholesterol, high blood pressure and heart diseases (Rosenheck, 2008). The main reasons for high OU during frying process are the escaping of water from the crust

* Home Economic Department, Faculty of Specific Education, Assiut University, 71516 Assiut, Egypt.
E-mail address: rshmousa73@gmail.com.

https://doi.org/10.1016/j.foodhyd.2018.05.007

followed by the migration of water in the core of the product to the crust giving a weakened crust with empty pores. Recently, natural antioxidants or hydrocolloids have attracted an increasing attention owing to their potential for the mitigation of AA and OU in frying foods (Gao et al., 2017; Eca, Sartori, & Menegalli, 2014; Zeng et al., 2010; Zeng et al., 2009; Murcia & Martinez-Tome, 2001; De'Nobili, Perez, Navarro, Stortz, & Rojas, 2013). The addition of natural spices extraction containing antioxidants resulted in a reduction of AA contents up to 75% (Eca et al., 2014). On the other hand, AA formation could also be inhibited by hydrocolloids such as pectin, alginic acid and xanthan gum up to 50% in model systems (Amaral et al., 2017). Other hydrocolloids such as sodium alginate, inulin, corn zein, starch, sodium caseinate, soy protein isolate, vital wheat gluten, whey protein isolate and powdered cellulose or its derivatives were also used to reduce OU up to 65% (Garcia et al., 2002; Holikar, Annapure, Singhal & Kulkarni, 2005; Feeney, Haralampu, & Gross, 1993; Mousa, 2016; Amaral et al., 2017). In these processes, hydrocolloids formed protective layers on the surface of sample during the initial stages of frying due to thermally induced gelation above 60 °C. This protective layer inhibited the loss of water and changed the surface structure of treated potatoes. Thereby adequate moisture within the sample was maintained and the surface permeability was reduced so the water couldn't be replaced by oil (Funami, Funami, Tawada, & Nakao, 1999). Moreover, hydrocolloid coating could interfere with the molecular interactions that occur during the formation of AA and subsequently could reduce AA content in DFFPS (Kurek et al., 2017). Still, the effectiveness of hydrocolloid coating is not satisfied for consumers. Other trends in hydrocolloid coating have investigated to develop their functionality through incorporation of antioxidants (Leon & Rojas, 2007; Eca et al., 2014). However, literature contained a little information on how these protective layers could simply prepare and could improve the quality of DFFPS with a high commercial impact.

Gum Arabic (GA), a natural polysaccharide derived from exudates of Acacia senegal and Acacia seyal trees, is a commonly used food hydrocolloid. It had unique characteristics due to its high solubility, commercial available, least viscosity among gums, good film forming, emulsification, non-toxic and biocompatible (Krishnadev & Gunasekaran, 2017; Shahgholian & Rajabzadeh, 2016). Additionally, GA could have antioxidant properties due to the presence of amino acids in its building block (Montenegro, Boiero, Valle, & Borsarelli, 2012). In fact, GA composed of three fractions viz: arabinogalactan-protein, arabinogalactan, and glycoprotein comprising 10.4%, 88.4% and 1.24% of the total volume (Williams & Phillips, 2009). The arabinogalactan molecules are responsible for the coating properties of the gum, while the protein-containing portions, in particular the glycoprotein molecules, lead to its emulsification abilities. It is expected that the functionality of GA could be improved by incorporating natural antioxidants (Patel, ten-Hoorn, Hazekamp, Blijdenstein, & Velikov, 2013). Moreover, GA could overcome the solubility, stability and bioavailability issues of antioxidants. For instance, curcumin (strong natural antioxidant) is insoluble in aqueous medium and has poor stability towards oxidation, light, alkalinity, heat and enzymes. However, curcumin stability and solubility were significantly improved by incorporating it with GA (Shahgholian & Rajabzadeh, 2016; Sarika & Nirmala, 2016). Hydrocolloid-antioxidant interactions through hydrophobic and/or hydrogen bonding could significantly improve the organoleptic, functional and nutritional properties of DFFPS (Kurek et al., 2017). However, the effect of GA-natural antioxidant incorporation on the quality properties of DFFPS and their sensory attributes are not studied till now and more investigations need to be done.

Therefore, the aim of this work was to study the effect of pre-coated modified layer prepared by gum Arabic solution mixed with individual, binary or ternary mixtures of spices containing antioxidants on the simultaneous reduction of AA and OU in DFFPS. The spices selected for this study could be easily obtained from the market such as black pepper, red chili, turmeric, coriander and cumin.

2. Materials and methods

2.1. Chemicals and samples

Acrylamide (AA, ≥99.8%) was purchased from Sigma (Steinheim, Germany). Peperine, capsaicin, curcumin, linalool, cuminaldehyde and 1-butyl-3-methylimidazolium bromide (BMImBr) were purchased from Sigma-Aldrich (St Louis, MO, USA). Methanol, hexane, acetonitrile, acetic acid, formic acid, magnesium sulfate and triethylamine phosphate were purchased from Fisher Scientific Co. (Tustin, Canada). Potatoes (Solanum tuberosum L.), Black pepper (Piper nigrum), red chili (Capsicum), turmeric (Curcuma longa), coriander (C. sativum L.), cumin (Cuminum cyminum L.), gum Arabic (GA) and palm oil were purchased from local market. Pure water was prepared using a Millipore water system (Millipore, Billerica, MA).

2.2. Preparation of deep fat fried potato strips (DFFPS)

Potatoes (Solanum tuberosum L.) were stored at 6–8 °C and 93–95% relative humidity in the dark room after purchasing. The tubers were firstly washed by water, then hand-peeled and cut into 10 mm × 10 mm × 60 mm strips by means of a domestic striper. The stripes were subsequently blanched in boiling water (90–95 °C) for 3 min (ratio of potato to water of 0.1 g/g). Blanching conditions could have an impact on AA formation (Amaral et al., 2017). Then, potato strips were divided into 28 equal portions (each contains 10 strips) as the following:

- Control (C) sample: The 1st portion of potato strips was soaked in distilled water (1:2, w/v) for 60 min at room temperature (25 °C) and then dried with paper towels.
- Treated control (TC) sample: The 2nd portion was soaked in a coating solution (1:2, w/v) of gum Arabic (GA, 1% w/v) for 60 min (soaking time) at room temperature (25 °C).
- Single spices (SS-1 → SS-5) samples: The 3rd –to 7th portions of potato strips were soaked in a solution (1:2, w/v) containing a mixture of 1% (w/v) GA + 1.5% (w/v) of a single spice (black pepper (SS-1), red chili (SS-2), turmeric (SS-3), coriander (SS-4) or cumin (SS-5)) for 60 min (soaking time) at room temperature (25 °C).
- Binary spices (SB-1 → SB-10) samples and ternary spices (ST-1 → ST-10) samples: The 8th to 27th portions of strips were soaked in solutions (1:2, w/v) containing 1% (w/v) GA mixed with variant spices in binary or ternary mixtures as indicated in Table 1 for 60 min (soaking time) at ambient temperature.
- Confirmation (CF) sample: The 28th portions of strips were soaked in a solution (1:2, w/v) containing 1% (w/v) GA mixed with 0.45 mg capsaicin, 19.2 mg curcumin and 10.15 mg linalool for 60 min (soaking time) at room temperature.

The pH value of all above coating solutions was determined by using a pH meter with a glass electrode (Model H198130, Hanna Instruments, Italy). After draining off the excessive liquid for 2 min, potato strips were subjected to the frying. Strips were fried by means of a temperature-controlled deep-fryer apparatus (GIRMI, Viterbo, Italy) in the preheated palm oil (at 170 °C, as usual in home and restaurants) separately for 5 min with flipping from side to side