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Review

Edible coatings minimize fat uptake in deep fat fried products: A review

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ABSTRACT

In the past decades, edible coatings are successful used as a tool to reduce the fat uptake in deep fat fried food products. Significant interests is captured by the scientific society and the food industry sector in order to find the adequate formulation design, film forming polymer properties, components to improve adhesion and active properties. Hydrocolloid coatings can reduce the excessive oil uptake due to their interesting thermogelling properties and at the same time they are invisible and have no negative influence on the sensory attributes of fried foodstuff. Even more, fried products have low fat content with improved nutritional values, higher crispiness and better palatability. This article emphasizes the importance of adequate formulation design for a given product and its action mechanism. Different edible coating materials and their effectiveness on fried food are reviewed. Food items, such as potatoes, meat, fruit and vegetables are covered. Synergistic action with other pre-treatment technologies is also described. It is to expect that edible oil barrier coatings will become an essential strategy for launching healthier fried products and therefore they might be interesting for increasing the profit margins for snack industry.

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1. Introduction

Nowadays, development in food preservation has undergone a new research renaissance. Edible films and coatings that can be directly consumed with the food are in the service of modern food preserving systems given the changes in the lifestyle of consumers. Deep fat frying takes a big part of food market and is still a culinary method widely used at the domestic, commercial and industrial level. Deep fried foods may be tasty, with improved appearance, aroma, flavour and texture (crispness); but the main problem is that after frying, fried products may contain up to 50% of fat of the total product weight. Additionally, some of lipids were even not in the food before frying. Particularly, saturated fat and trans fat in deep fried foods are key dietary contributor to the high incidence of cardiovascular diseases (high cholesterol and heart disease) and higher risk for certain cancers and obesity (Hu, Manson, & Willett, 2001). Deep fried foods may also contain acrylamide, a potential procarcinogen (Mesías, Holgado, Márquez-Ruiz, & Morales, 2017). All above mentioned marks these products as definitely not good for human health. Customer's awareness of healthy diet is starting to weigh on customers' choices and prompting latest research trends. Thus food technologists are continuously making efforts in order to find innovative solutions to decrease the fat content of fried foodstuff.

Excellent reviews are published in the scientific literature describing the formation and toxicity of acrylamide in fried products (Capuano & Fogliano, 2011; Krishnakumar & Visvanathan, 2014; Luning & Sanny, 2016; Morales, Capuano, & Fogliano, 2008; Medeiros, Mestdagh, & De Meulenaer, 2012; Riboldi, Vinhas, & Moreira, 2014). According to authors, it is very likely that complete elimination of acrylamide from fried products is difficult to achieve. In that case, the ALARA principle (as low as reasonably or technically achievable) should be applied by the different actors.

Absorption of oil is influenced by a variety of factors. These consider oil quality, frying temperature, frying time, various pretreatments and the food composition. Currently methods that are proposed in order to reduce the fat absorption include modification of frying techniques by monitoring of frying temperature and oil degradation (i.e. draining and shaking of fried products) (Bouchon, Aguilera, & Pyle, 2003; Mah, Price, & Brannan, 2008; Math, Velu, Nagender, & Rao, 2004; Mellema, 2003), reducing the surface area exposed to oil (altering food surface) (Goni, Bravo, Larrauri, & Saura Calixto, 1997; Moreira & Barrufet, 1998) or using edible coatings as lipid barriers. Hydrocolloid edible coatings reduce the oil content of deep-fat-fried food either acting as a lipid barrier when formed as thin films and dried before frying or by their gelation properties during heating (Kulp, 1990). Some of commercially available coatings are Fry Shield™ - calcium pectinate that is aimed to reduce fat uptake during frying fish, potatoes, and other vegetables and Seal gum, Spray gum™ - calcium acetate that prevents darkening of potato during frying.

In this review, the focus is given on the literature overview of edible coatings currently used for minimizing the oil uptake and their mechanism of action. Furthermore, examples of edible coatings applied on different food will be given in details in order to illustrate the possible issues concerning novel trends in minimizing oil uptake in fried food.

2. Edible coatings and their mechanism of action

An edible coating is defined as a thin layer of edible material, generally not exceeding 0.3 mm, applied to the food surface in addition to or as a substitution for natural protective coatings (Embuscado & Huber, 2009). They can be used as thin coatings or as thicker batter formulations. Edible coatings are generally classified according to the molecular structure of film forming molecule. Hydrocolloids are mainly used for frying applications due to good gelling attributes. Polysaccharides (cellulose derivate, corn starch, carrageenan, pectin, gums) and proteins (egg white, gelatin, sodium caseinate, soy protein, wheat gluten, whey protein) can be used as base components, alone or in a mixture. Functional components in the coating contribute to a product's added value and serve as a shield to control the diffusion of moisture and fat in fried food. Plasticizers are important in design because they improve the flexibility and handling, maintaining integrity and reducing number of pores and cracks in the polymeric matrix that can be formed during the coating process or during frying.

Some proteins such as serumalbumin and ovalbumin; polysaccharides such as high methoxyl pectin, acacia gum, high fructose corn syrup/dextrose/fructose/sucrose, gelatinized amylose, microcrystalline cellulose, xanthan gum and locust bean gum (Albert & Mittal, 2002) are less intensive studied coating materials. This under-utilized agricultural commodities contribute to interesting opportunities for creating new market outlets (see Fig. 1).

Edible coatings are able to form a barrier to moisture, oxygen, ultraviolet light and solute movement in the food (Guilbert, Gontard, & Gorris, 1996). The fact that it's edible is the best proof of its harmless nature. They must also be acceptable to consumers maintaining the original taste, texture, and product appearance and they should not be detectable to consumer's tongue. Regarding deep fat fried products, the most important function of an edible coating is that it resists to the absorption of oil and to the migration of water to and from the fried foodstuff. A great insight in the explanation of mechanism and reduction of fat uptake is given by Mellema (2003) and Kim, Lim, Bae, Lee, and Lee (2011). The mechanism of oil uptake is associated with the heat transfer and the migration of oil droplets in the voids leftover the evaporation of the water (Fig. 2). Possible explanations rely on thermogelling, crosslinking and changes of hydrophobicity. During frying process, in the first step water escapes from the crust and in the second step the water in the core of the product migrates to the crust. This results in formation of weakened crust with empty pores that are free to be filled with the fat that migrates from frying medium. Unfortunately, this provides flavours and fatty nutrients. The quantity of oils absorbed in food during frying depends on the initial moisture content of the surface of frying food stuff, on its size and the shape. It is generally recognized that oils are absorbed by water evaporation and by water condensation (Mellema, 2003). Accordingly, pre-drying of foods is a common way to reduce the fat uptake (Krokida, Oreopoulou, Maroulis, & Marinos-Kouris, 2001). If the water losses are reduced, then the oil uptake is also reduced. Edible barrier coating makes protective layer by means of reducing loss of water and by changing the surface structure. During frying it can form more brittle and stronger surface with fewer voids that prevents water and steam escape from the porous surface. Thereby