Water Barrier Edible Coatings of Fried Foods
Raffaele Porta*, Loredana Mariniello, Angelo Sorrentino, Valeria C.L. Giosafatto, Giovanna Rossi Marquez, Marilena Esposito and Prospero Di Pierro
Department of Food Science, University of Naples “Federico II”, Portici, Napoli, Italy

Frying is known as one of the oldest food cooking processes dating back as early as sixteen centuries B.C., being still widespread utilized today at both domestic and industrial scale, because of its ability to enhance flavour and texture of numerous foods. Fried products are appreciated everywhere because of their improved palatability [1], consumers generally like eating foods with soft core and crispy surface, even though significant geographical differences exist due to the different raw material availability and the multiple cultural habits. Nowadays, they occur in the traditional cuisines of practically every part of the world. Furthermore, also several mass consumption products have fried versions, and worldwide fast food companies provide every day literally tons of fried foods, such as french fries, doughnuts, chicken, onion rings, etc.

Food deep frying induces several changes in both chemical and physical properties of the different components, including protein denaturation, starch gelatinization, water vaporization and crust formation [2,3], and foods normally absorb great amounts of oil during cooking. Thus, during the last ten years, there has been an increased interest in the scientific community to investigate new ways to reduce fat uptake by foods during frying. In fact, high oil content associated with many different diet products is indicated to be one of the most significant cause of high blood cholesterol level and pressure, and as a consequence of the increased incidence of both obesity and coronary heart diseases [4-6]. To this aim, health authorities as well as mass media advise of the desirability to decrease the proportion of fat in the average diet, and to develop food products containing low fat content. As oil uptake is the major nutritional critical point of deep frying, reaching in some cases even half of the total weight of the product [7,8], the main challenge in this field appears to realize a frying process improvement by controlling and lowering the final fat content of different foods subjected to such cooking procedure [9].

Deep fat frying is a process of heating and drying of food through the contact of the latter with oil at high temperature (170-210°C). The process involves simultaneous heat and mass transfer because heat transferred from oil into food determines the evaporation of the internal product moisture [10]. This phenomenon results in the formation of a capillary trail, increasing the porosity of the fried food and allowing oil to enter into the internal sections of the product, during both its frying and its cooling after frying (Figure 1A) [10,11]. Native moisture is an important attribute of food material influencing oil uptake. Elevated water content, in fact, leads to a higher water loss by food during frying, consequently producing in it a greater number of pores that facilitate oil penetration [12]. These transferring processes are well correlated and respond to kinetic models for moisture loss and oil uptake, previously described for either breadcrusted or differently coated products [1,11-18]. Ngadi et al. [19] effectively decreased fat uptake by chicken nuggets by just reducing original water content precooking samples in microwave, whereas air drying pretreatment for reducing moisture was the successful method described by Krokida et al. [16], for lowering oil uptake by potato products.

Several approaches have been proposed so far for reducing fat absorption during frying. It is well known that often foods-especially fish, poultry, cheese, and vegetables-are coated by breading [20,21]. Food science research tries to prevent high fat absorption by testing different coating procedures, such as the application of edible films to food products prior to frying. This procedure also represents an alternative method for avoiding changes in the quality, as well as sensory properties of food, and for increasing its texture [22-24]. The use of edible films was proposed in the late sixties, originally to extend the shelf life of meat and later on to improve the quality of various fresh, frozen and manufactured food items. The main function that an edible film is able to perform is to hinder moisture migration, and this effect is mostly important for maintaining optimum quality in multi-phase foods [25]. Therefore, edible coatings can be effective also to decrease fat absorption and frying loss (Figure 1B) [26,27], although product
quality in this case is strictly affected by the frying time and physical-chemical characteristics of the used coating material [28].

Different film ingredients and additives have been tested with the aim to reduce the amount of oil absorbed by fried food, and several coating and batter formulations using various types of biopolymers have been patented [8]. Among these, hydrocolloids are the main category of functional agents that have been used for the past forty years [29]. Hydrocolloids are defined as water-soluble polymers, able to confer viscosity and gelate aqueous system retaining water in food systems [30]. They are extensively used in numerous food and beverage products, mostly as thickening, gelling, stabilizing and emulsifying agents. But in addition, hydrocolloids were shown to play an additional role in fried food development by forming on their own a fine invisible coating, able to prevent excessive oil absorption during the frying process. Thus, they are gaining an increasing interest also as food coatings for their barrier properties to gas/moisture, and their satisfying mechanical features [31]. Because these polymers are highly hydrophilic, they present only a limited permeability to moisture, whereas they behave as very effective oxygen and carbon dioxide barriers and protect against lipid oxidation [25]. Thus, a variety of foods have been tested after their surface modification by hydrocolloid coatings to prevent moisture loss, to extend their shelf-life, and also to reduce oil uptake during frying [8,32,33].

Not only polysaccharides, such as hydroxypropylcellulose, methylcellulose, pectins, alginate, carrageenan and various gums, but also several proteins and lipids have been analyzed with different advantages and disadvantages, as oil barrier materials of a variety of foods over the past twenty five years [4,8,23,25,29,34-55]. Hydrocolloid films are usually applied in liquid form by dipping or spraying the food item or part of it, using a solution or a dispersion of the polymer(s). To achieve a continuous layer of film, the solvent is afterwards eliminated through thermal treatment or irradiation. Both the composition of the film-forming mixture and the environmental conditions (temperature, humidity, etc.) markedly influence the coating features [25,43,56]. Uniformity of thickness of the barrier, as well as porosity and permeability of the latter are strictly dependent on its flexibility and cohesive strength. Furthermore, it is noteworthy that different foods show different responses to the same type of coating material. In fact, whether surface roughness generally represents a critical factor in oil absorption by all kinds of foods, other food-related characteristics such as crust microstructure may explain the specific behaviour of the different product categories [57]. In particular, in the case of frying applications, the integrity of the coating strictly depends on the product, since many foods are known to increase their volume and to change their shape, during and after frying. The addition of plasticizers as sorbitol, glycerin or other agents, almost always facilitates and to change their shape, during and after frying. The addition of plasticizers as sorbitol, glycerin or other agents, almost always facilitates

In conclusion, even though hydrocolloid coatings have shown to effectively alter the water-holding capacity of a variety of fried foods by trapping moisture inside and preventing the replacement of water by oil, most of the studies provided results limited to the food oil content, and rarely investigated the correlation between heat/mass transfer and fat uptake. In addition, it would be desirable that future investigations will include rigorous sensory analysis of the final products, since unfortunately, the existing literature includes only descriptive results or hedonic tests carried out generally with a small number of consumers. Also for these reasons, despite the numerous laboratory researches and the potential market for reduced-fat food production, there have been so far only few applications of this technique in industry. Hence, further valuable experimental data devoted to create simple processes using hydrocolloid coatings for different fried foods and responding to the real-life needs, are strongly desirable.

References


