Effect of Edible Coatings on the Reduction of Oil Uptake in Sweet "Churros"

G. Rossi Márquez[#1], C.A. Dávalos Saucedo[#2], M.J. Briones Reyes[#3], I. Zarguili[*4]
[#]Tecnológico Nacional de México: Instituto Tecnológico José Mario Molina Pasquel y Henríquez, Academia de Investigación, Unidad Académica Lagos de Moreno, Jalisco, México.
[*]Laboratoire Procédés, Matériaux et Environnement (LPME), Faculty of Sciences and Technologies of Fès, University of Sidi Mohamed Ben Abdellah, Morocco.
[1]giovanna.rossi@lagos.tecmm.edu.mx, [2]cristian.davalos@lagos.tecmm.edu.mx, [3]manuel.briones@lagos.tecmm.edu.mx, [4]ikbal.zarguili@usmba.ac.ma

***Abstract*-- Fried products are consumed worldwide but have the disadvantage of high oil content. Edible coatings are an alternative to solve this problem. This project prepared a protein/carbohydrate solution using whey protein isolate and pectin from *Citrus* at a 4:1 relation (protein/carbohydrate). The edible coating was applied on the sweet "churros" before frying and let drain for 10 min. After the frying process, the water loss and fat uptake were measured according to the AOAC standard methods (950.46 and 960.39, respectively). Results have shown that the coating decreases water loss during frying, creates a barrier that protects the food, and significantly reduces the fat uptake by the product. These results demonstrated the feasibility of using natural components to reduce the oil content in fried food, thus, obtaining a healthier product.**

Keywords: edible coating, fried food, whey protein.

I. Introduction

Sweet "churros" is a typical street food in Mexico prepared using a soft dough that must be fried and covered with sugar before consumption. It is widely consumed but has the problem of having a high-fat content that can conduce health problems such as high blood cholesterol, high blood pressure and heart diseases [1] [2], and the frying process can produce some toxic compounds associated with different conditions such as cancer, Alzheimer, Parkinson [3].

The deep frying process conduces to a fat uptake by the product due to a complex phenomenon that involves mass transfers, where the water and soluble materials inside the food escape from the core to the surface, leaving pores that the oil can penetrate the food [4] [5] [6]. A valid alternative to reduce this effect is the application of edible coatings [4] [7] that can be produced using naturals components such as proteins [8] [9], carbohydrates [10] [11], lipids or a mix of them [4] [9] [12].

Edible coatings are applied on the food surface and can act as a barrier that avoids water loss and oil uptake during frying [4] [13]. In this project, a protein coating was applied on the "sweet" churros before frying to reduce water loss and fat uptake.

II. Materials & Methods

A. *Preparation of Coating Solutions (CS)*

Whey protein isolate (WPI) was used as a protein component. The coating solution was prepared by dissolving 15 g of WPI and 21 ml of sorbitol (as plasticizer) into 250 ml of distilled water. Afterwards, the solution was heated at 80°C for 25 min, then let cool at room temperature and keep at 5°C until use.

B. *"Sweet" Churro preparation and coating process*

The dough was prepared by mixing 500 g of churro flour and 520 ml of water and pour into a pastry bag. Churro dough was cut into 1 cm cubes and then immersed for 60 sec in distilled water (control) or CS. Samples were put to drain on a rack for 5 min before frying.

C. *Frying process*

Canola seed oil (Vita, Mexico) was poured into a temperature-controlled deep-fryer apparatus (RCA RC-DF303, USA). Oil was preheated at 200°C before frying and replaced with fresh oil before each replicate. Samples were fried for 5 min (golden brown surface coloration) and then were let to drain on paper towels for 5 min to remove the excess oil from the surface. Samples were fried in random order.

D. *Water content*

Water content was determined after samples were cooling, as described by Rossi-Márquez et al. [4], drying the samples down to a constant weight in a convection oven at 105 °C (AOAC 1990a). Water content (in percentage) was calculated as follows:

$$wc\ (\%) = \frac{wet\ weight - dry\ weight}{wet\ weight}\ x\ 100 \tag{1}$$

The reported results are the mean of three determinations.

E. *Oil content determination*

Fried churro samples were ground, and the oil content was determined using the Soxhlet extraction method with hexane as solvent (AOAC 1990b) as described by Rossi-Márquez et al. [4]. Analysis was performed using the following calculations:

$$Comp = \frac{(Comp\ loss_c)-(Comp\ loss_{nc})}{Comp\ loss_{nc}} \quad (2)$$

$$Oil\ uptake\ reduction = \frac{(oc_f*m_f-oc*m)}{m_d} \quad (3)$$

$$Barrier\ index = \frac{oil\ uptake\ reduction}{Decrease\ of\ water\ loss} \quad (4)$$

Where *nc*, *c*, *f* and *d* subindex means non-coated, coated, fried and dry correspondingly, *Comp* means component which can be either water or oil, *oc* refers to oil content, and *m* means mass. To obtain the increment or reduction of specific components (water or oil), it is adequate to use Eq. 2, then the resulting sign - or + indicates a reduction or increment, respectively.

Oil uptake in the volume base was calculated by considering the specific density value of the canola seed oil used (0.913 g/cm^3). Three replicates per sample were analyzed.

F. *Statistical analysis*

All the experiments were carried out three times, and the results were analyzed using the JMP version 8.0 software (SAS Institute, Cary, NC, USA). Statistical differences were obtained using the Tukey–Kramer test.

III. RESULTS & DISCUSSION

A. *Water content*

Applying the edible coating (CS) reduces the water loss during the frying process compared with the uncoated sample (table 1). This effect can be attributed to the presence of the protein coating that creates a barrier on the surface of the churro, avoiding water evaporation and reducing the possibility of creating pores inside the food.

TABLE I.
PROPERTIES OF FRIED SWEET CHURROS

Sample	Water loss reduction due to coating (g)	Water loss during frying (%)	Water increase due to coating (g)	Oil reduction due to coating (g)	Oil Uptake (g)	Oil uptake reduction (g)
Control	0.105 ± 0.001	48.96 ± 2.14	0.0953 ± 0.003	0.123 ± 0.012	0.359 ± 0.032	0.152 ± 0.003
Coated (CS)	0.0727 ± 0.009	44.95 ± 3.06	0.0785 ± 0.006	0.257 ± 0.015	0.28 ± 0.006	0.218 ± 0.005

These results agree with Rossi-Márquez et al. [4] and Nivedita et al. [14], who applied edible coatings to fried products, reducing water loss.

A. *Oil Uptake*

Once the churro was fried, the oil content was measured using hexane as solvent. As shown in Figure 1, the presence of the protein coating (CS) reduced 22 % of the amount of oil compared with the uncoated samples (US).

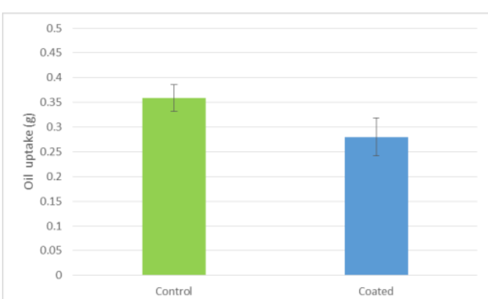

Fig. 1. Oil content after frying.

The barrier index was calculated to compare the effect of the coating against the oil uptake; the higher is the index, the better is the performance of the coating. Figure 2 demonstrates the ability of the protein coating to create a barrier on the churro surface that reduces the water loss preventing the oil entry to the food core. According to the literature [4] [15], to evaluate the effect of edible coatings on the oil uptake, it is recommended to apply water as a coating for the control sample. This process allows to match the amount of water applied with the protein coating to normalize the amount of water present in the churro. Moreover, analysis was made on the churro without any coating (water or protein) to make an adequate comparison between the samples and to solve the formulas used (data not shown). The effect of the water coating is reflected on the barrier index, where the reduction of oil uptake and the decrease of water loss were obtained from the analysis of a sample without any coating and the coated samples (water or protein coating). Hence, the barrier index was calculated for both samples, control and coated (CS).

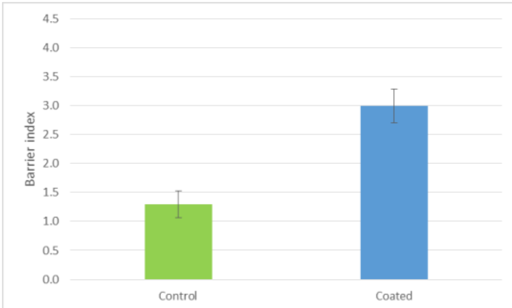

Fig. 2. Barrier index in coated sweet churros.

Preliminary sensory test using untrained judges showed that the presence of the coating did not affect the sensorial appreciation of the churros, indicating that the frying time was not affected by the protein coating.

IV. Conclusion

Edible coatings are an alternative to reduce the oil uptake in fried foods. Our results demonstrate that the presence of the protein coating creates a barrier on the food surface, reducing the water loss during frying and avoiding oil entry into the food core. Due to this effect, it is possible to produce a healthier product using natural ingredients such as proteins and carbohydrates, among others. More studies need to be done to test different coating times and using different coating ingredients. Also, a sensory test needs to be done, and it is recommended to evaluate the quantity of calories in the churro with or without the coating.

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