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The effect of using different oils and paper towel in vegetable oil absorption of fried recipes

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ABSTRACT

This work determined the effect of using different vegetable oils (soybean, corn, sunflower or canola) and paper towel in oil absorption of nine fried recipes. The paper towel significantly reduced oil absorption in chicken breast, shrimp with garlic, cioba steak, French fries and cheese samosa. Preparations protein-rich absorbed less soybean and corn oils, while starch-rich ones absorbed less of the sunflower and canola oils, with the exception of French toast. Results indicated that food composition of the tested recipes was an important factor influencing oil absorption, as well as the types of oil tested and the use of paper towel.

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Introduction

Frying is very popular all over the world as a common cooking method for preparing foods for households and industrial uses (Lim, Jeong, Oh, & Lee, 2017). By creating unique sensory characteristics in texture, taste, appearance, and odor, frying makes food desirable and tasty, as part of affective memory and eating habits of consumers. In addition, the operational process of frying is simple, making the practice very widespread in domestic, industrial and commercial scale. Therefore, there are numerous recipes that can be made through this process (Teruel et al., 2015).

There are basically two main methods of frying: shallow frying and deep fat frying. In the first method, a sufficient amount of oil is used to partially cover the food, while in the second method the food is totally covered by the oil. Deep fat frying is also classified as continuous (oil heated only once) and discontinuous (the oil is heated repeatedly) (Freire, Mancini-Filho, & Ferreira, 2013).

However, the frying process raises the caloric amount of the recipe because the oil migrates into the food, occupying the spaces resulting from the loss of steam and moisture of the product. Therefore, eating excessive fried recipes may increase caloric intake, which can lead to obesity and coronary problems

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(Jorge & Lunardi, 2004). In addition, because the oil becomes an ingredient of the product, a frying medium of high quality is necessary (Cella, Regitano-D'arce, & Spoto, 2002), avoiding the use of oxidized and potentially carcinogenic oils.

Frying can also affect the nutritional quality of food since the process is based on high temperatures. This changes the structure of labile nutrients, some water-soluble molecules and unstable vitamins such as thiamine and riboflavin can be lost with evaporation and degradation, respectively (Bordin, Kunitake, Aracava, & Trindade, 2013).

According to Smith, Clifford, Creveling, and Hamblin (1985), the oil absorption by the food is influenced by several factors, such as food type, oil type and frying time, so this rate can vary from 10% to 60%. An important point for oil absorption is the surface/volume ratio of the food in contact with the frying medium. Foods with a high surface/volume ratio, absorb more lipids than foods that contain a lower ratio. Another issue that influences oil absorption is the quality of the oil. The reuse of the oil increases the viscosity of the frying medium, consequently increasing the cooking time and bringing greater absorption of oil by the food (Jorge & Lunardi, 2004). The frying method also influences this absorption, in which deep fat frying is the procedure that most adds oil to the preparation (Freire et al., 2013).

Although frying is a simple process to be executed, it causes transfer of heat and mass to the food, causing complex physical-chemical changes (Rios, Pereira, & Abreu, 2013). Few data have shown oil absorption in preparations using different oils, and most of the studies focus on the lipid content absorbed by potato chips. Moreover, there is no data on the common habit of using the paper towel after frying to reduce the absorption of residual oil from the preparations. Thus, the objective of this work is to analyze the absorption of soybean, corn, sunflower and canola oil used for frying of various preparations, by deep fat or shallow frying, without and with the use of paper towel after frying.

Material and methods

Fried samples and oil absorption

Fat absorption was evaluated in nine fried preparations popularly consumed in Brazil. Rump steak, chicken breast, shrimp with garlic, and cioba steak were submitted to shallow frying. French fries, chicken thigh, breaded chicken, cheese samosa and French toast were prepared by deep fat frying. The quantities of ingredients used in the preparations was estimated using *per capita* values, proposed by Araújo and Guerra (2007). These quantities were adjusted after pilot experiments, resulting in the *per capitas* and portions listed in Table 1. The pilot experiments performed also allowed the

Table 1. Recipes fried by shallow frying and deep fat frying, portion sizes (in grams and home measures) and *per capita* of oil used.

Recipes	Portion (g)	Home measure	*Per capita* of oil (mL)
Shallow frying			
Rump steak	85	1 medium steak	16
Chicken breast	90	1 medium fillet	16
Shrimp with garlic	100	7 large units	16
Cioba steak	120	1 large steak	16
Deep fat frying			
French fries	65	2 picks	150
Chicken thigh	65	2 small units	200
Breaded chicken	120	1 large fillet	200
Cheese samosa	85	2½ medium units	250
French toast	50	2 medium units	250

determination of the standard time for each preparation, and the amount of each ingredient in order to always reach a medium portion at the end of the frying. The temperature of oil before submission of preparations was 160°C.

Two aluminum pans were used for frying, one for deep fat frying with 23 cm of diameter, 16.1 cm of height, and 741.5 g of weight; and the other for shallow frying with 25.5 cm of diameter, 6.4 cm of height, and 266.1 g of weight.

The oil temperature was controlled with a thermometer (Incoterm®) (Scale – 50–300°C, resolution of 1°C). A scale (HZT®) with a sensibility of 0.1 g and capacity for 3.1 kg was used to weight the ingredients, preparations, containers and paper towel.

Experiments were performed in triplicate, using soy, corn, sunflower, and canola oils. There were 96 samples in shallow frying and 120 in deep fat frying, totalizing 216 samples. The oil was subsequently changed to perform each experiment.

After the samples were prepared, they were subjected to two different conditions: in the first, the preparation was allowed to rest for 10 min on paper towel on a dish, while in the second the preparation was resting for the same time only on a dish. Both dishes and paper towels were weighed before and after the stipulated time.

For the calculation of *per capita* Oil Absorption in grams, since unabsorbed oil was observed on the dishes used to accommodate the recipes after the frying process, a formula, adapted from Phillipi (2006), was used, as follows:

Per capita oil absorption (g) = initial weight of oil (g) – final weight of oil (g) – weight of oil absorbed in the paper towel (g) – weight of unabsorbed oil present in the dish (g)

The percentage of Oil Absorption (%) of the recipe was determined using the following formula, proposed by Phillipi (2006):

$$Oil\ Absorption(\%) = (amount\ of\ absorbed\ oil/final\ weight\ of\ recipe) \times 100$$

Statistical analysis

Values are shown as mean (standard deviations). The Student's *t*-test was used to compare mean oil absorption without and with the use of paper towel, and the mean oil absorption in shallow frying and deep fat frying. One-way ANOVA and Tukey's post-hoc test were used to compare the oil absorption in the same recipe using the different vegetable oils. For all tests used, p values less than 0.05 were considered significant. The analysis was performed using the GraphPad Prism version 5 program.

Results

Mean *per capita* oil absorption and percentage of oil absorption in deep fat and shallow fried recipes, using or not paper towel is shown in Table 2. Shallow fried recipes presented mean oil absorption of 7.4 (1.3)%, while deep-fried recipes of 15.0 (2.4)% (*t*-test, $p < 0.0001$) (Table 2).

In shallow fried recipes, mean oil absorption ranged from 4.9% (cioba steak) to 13.1% (rump steak) (Figure 1). The paper towel significantly reduced oil absorption after frying in the chicken breast fried in corn and sunflower oils (*t*-test, $p < 0.01$), shrimp with garlic fried in sunflower and canola oils (*t*-test, $p < 0.05$), and cioba steak fried in sunflower oil (*t*-test, $p < 0.05$). In the other shallow fried recipes, the use of paper towel after frying did not significantly influence the final oil absorption.

In deep fat fried preparations (Figure 2), the oil absorption varied from 7.6% (chicken thigh) to 43.2% (French toast). The paper towel significantly reduced residual oil absorption after frying in the French fries fried in corn and canola oils (*t*-test, $p < 0.01$), and cheese samosa fried in soybean oil (*t*-test, $p < 0.001$). In

Table 2. Mean *per capita* (g) and percentage (%) of oil absorption in shallow fried and deep fat fried recipes, using soybean, corn, sunflower and canola oils with or without paper towel after frying.

		Shallow fried oil absorption		Deep fat fried oil absorption	
Oil	Paper towel	*Per capita* (g) Mean (SD)	% Mean (SD)	*Per capita* (g) Mean (SD)	% Mean (SD)
Soybean	Yes	7.0 (9.8)	5.3 (0.9)	16.7 (2.6)	17.0 (1.9)
	No	7.7 (0.9)	5.5 (0.6)	18.8 (1.5)	20.9 (2.4)
Corn	Yes	7.1 (1.2)	5.8 (1.1)	19.2 (1.9)	19.3 (1.5)
	No	8.1 (0.4)	6.7 (0.4)	18.2 (2.9)	22.1 (3.1)
Sunflower	Yes	7.7 (2.9)	8.0 (1.4)	11.8 (2.7)	17.7 (4.3)
	No	8.3 (0.8)	10.8 (1.0)	13.5 (3.00)	20.1 (4.19)
Canola	Yes	7.4 (4.2)	7.6 (1.1)	10.0 (2.19)	14.1 (3.3)
	No	9.4 (3.9)	9.8 (4.1)	12.1 (2.17)	17.8 (3.2)
Total	Yes	7.3 (2.3)	6.7 (1.1)	14.3 (2.3)	17.0 (2.8)
	No	8.4 (1.5)	8.2 (1.5)	16.2 (2.4)	20.2 (3.2)
	Yes/No	7.8 (1.9)*	7.4 (1.3)*	15.0 (2.4)*	18.6 (3.0)*

*t-test, $p < 0.0001$, comparing shallow fried and deep fat fried recipes.

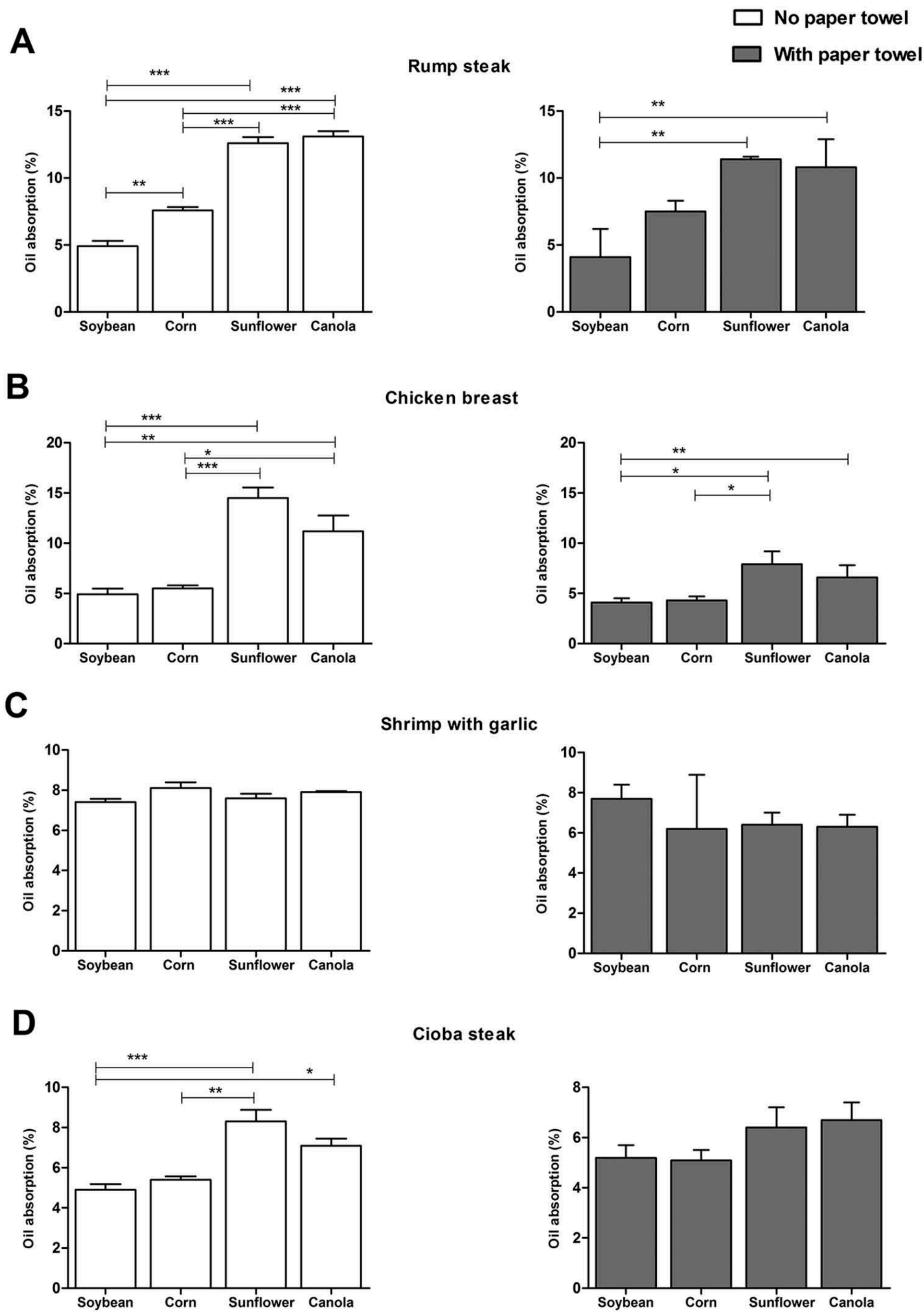

Figure 1. Mean oil absorption (%) of shallow fried recipes in soybean, corn, sunflower, and canola oils, without and with the use of paper towels after frying. (a) Rump steak; (b) chicken breast; (c) shrimp with garlic; (d) Cioba steak. *t*-test, *$p < 0.05$, **$p < 0.01$ and ***$p < 0.001$.

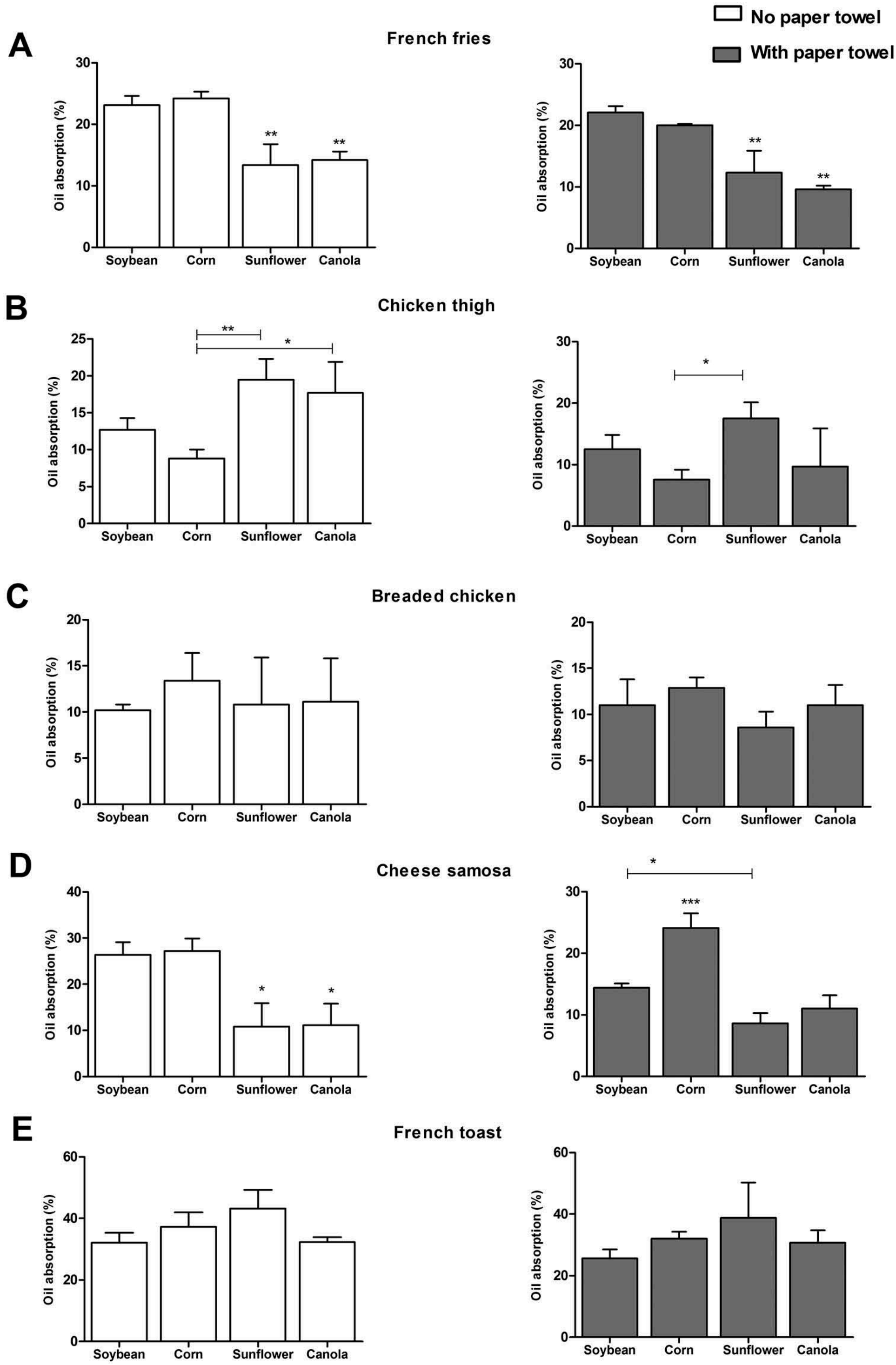

Figure 2. Mean oil absorption (%) of deep fat fried recipes in soybean, corn, sunflower, and canola oils, without and with the use of paper towels after frying. (a) French fries; (b) chicken thigh; (c) breaded chicken; (d) cheese samosa; (e) French toast. *t*-test, $*p < 0.05$, $**p < 0.01$ and $***p < 0.001$.

the other deep fat fried recipes, the use of paper towel after frying did not significantly influence the final oil absorption.

When comparing the oil absorption in the same recipe using the different types of oils, in general, the protein-rich preparations (rump steak, chicken breast and cioba steak) absorbed less soybean and corn oil (Figure 1), while those rich in starch (French fries and cheese samosa) absorbed less of the sunflower and canola oils, with the exception of the French toast (Figure 2). In the shrimp with garlic, breaded chicken, and French toast oil absorption did not vary significantly according to the types of oils used.

Discussion

Several factors may interfere with oil absorption in fryings, such as food composition, oil quality, handling of the frying process (including time and temperature), and food pre-preparation (Bordin et al., 2013). Thus, it is relevant, from the dietary attention point of view, to understand the effects of these variables, aiming to create strategies to reduce fried oil intake and maintain its quality. To our knowledge, there are no studies investigating oil absorption in the preparations tested here, focusing on the use of different vegetable oils and also the effectiveness of using paper towels after frying.

In addition to the factors mentioned, the frying type, the type of oil used, use or not of paper towel and food microstructure may also influence oil absorption by the food during the process of frying (Del Ré, Coltro, Manente, Marti, & Jorge, 2003), and these factors were observed in our experiments.

In the present study, shallow fried recipes presented lower oil absorption when compared to deep fat fried preparations. This result demonstrates that the frying method influences the amount of oil absorbed by the food. In shallow frying, a limited amount of oil is in contact with the surface of the food and, therefore, the oil absorption is limited. In deep fat frying, the product is submerged in the oil and is therefore exposed to a greater amount of fat.

Analyzing Figures 1 and 2, regardless of the type of frying, whether shallow or deep fat, soybean and corn oils were less absorbed in protein-rich preparations (rump steak, chicken breast, and cioba steak), while the sunflower and canola oils were less absorbed in starch-rich preparations (French fries and cheese samosa), except in the French toast. Bread, the basic ingredient of the French toast, due to its highly porous structure, allows a great absorption of oil, independent of the oil used in the frying process.

A lower absorption of oil is attributed to those oils that have higher concentrations of saturated fatty acids in their composition (Bordin et al., 2013; Freire et al., 2013). However, in this study, the trend was confirmed only for starch-rich foods, which absorbed higher amounts of soy and corn oils, the richest in saturated fatty acids in the present study, with 15.2 in 100 g (TACO, 2011).

Jorge and Lunardi (2004) performed an experiment using three types of oils (corn, sunflower and soybean), frying binge (asterix) potatoes, julienne cut, at 175°C, with four frying times. The samples fried in soybean oil absorbed less oil compared to the other oils, followed by the sunflower and corn oils. Therefore, in the cited work, the oil type significantly influenced the final amount of oil absorbed in the fried products.

In the present work, the difference in relation to the type of oil was also verified in the French fries. However, the soybean oil was more absorbed, followed by the corn and sunflower oils. This difference in most absorbed oils in our study when compared to that of Jorge and Lunardi (2004) may have been due to the fact that the potatoes used in the present study were English potatoes, which would determine the formation of differentiated amylose-lipid complexes.

Jorge and Lunardi (2004) also showed that the longer the frying time, the greater the oil absorption in the binge potato, regardless of the oil used. In the present study, for a single recipe, the same preparation time was used, so the effect of the frying time on oil absorption was not evaluated.

Interestingly, the French toast was the preparation that most absorbed oil. However, it was the recipe that presented the shortest cooking time (2 min). Bread, the main ingredient of the French toast, is a porous food due to its ingredients, especially gluten, formed from gliadin and glutenin proteins of wheat, which promotes the extensibility and consistency of the dough and the retention of CO_2 produced in the fermentation process (Wang, Zou, Liu, Gu, & Yang, 2018). Thus, the porous structure of the bread may have interfered more in the final absorption of oil than the type of oil used.

Teruel et al. (2015) have shown that there are basically two countercurrent flows generated by the mass transfer between the food and the medium during the frying process: the water or steam flow from the food to the oil, and the oil entering the food at a rate that depends on the viscosity and surface tension of the oil used. Consequently, the food moisture is reduced as the process time increases. Further, the authors discuss that in deep fat frying, oil absorption is higher after the food is withdrawn from the oil, as a suction pressure gradient is generated from the surface to the inner side due to steam condensation inside the food. This is caused by the decrease in temperature, which is below the boiling point of the water at the end of the procedure.

Therefore, our hypothesis was that the use of paper towel could significantly decrease oil absorption after frying. However, this was true for part of the tested recipes: shrimp with garlic, chicken breast, cioba steak, French fries and cheese samosa, but not in all oils.

In relation to the moment of higher oil uptake, Ziaiifar, Courtois, and Trystram (2008) also stated that it occurs by capillary force at the moment of cooling the product after its withdrawal from the frying medium. The percolation happens as a result of this capillary force, dragging the oil present on the surface of the preparation through an interconnected network of pores, which were formed during the frying in oil.

This phenomenon may explain why the use of paper towel reduced oil absorption in the shrimp with garlic recipe in our study, once its shells was maintained during preparation. Due to its dense chitin and chitosan structure, which is not porous (Bezerra, 2015), oil migration to the interior of the sample is compromised, and the use of the paper towel is effective in the removal of surface oil. In the same way, the less porous structure of the chicken, which rapidly coagulates proteins during the frying process, does not allow high pore formation in the interior, leaving the oil concentrated on its surface, which may explain its effective removal with the use of the paper towel.

Thus, in the description of oil absorption, the microstructure of the food itself is a determining factor for such process. The so-called crust region plays a key role in the transfer of oil into the food and in the formation of porosity (Ziaiifar et al., 2008). Amylose-lipid complexes are created from the contact of the oil with the starch, mainly in the potato crust, allowing a greater concentration of oil in this region (Bordin et al., 2013). Thus, the reduction of the oil absorption promoted by the use of the paper towel after the frying of this preparation is also explained.

Moreover, the relation surface/volume may also determine oil absorption during frying. In general, it has been found that high surface/volume ratio preparations have a higher content of fatty acids from frying than those with a lower ratio (Paul & Mittal, 1997). To avoid differences due to this relation, in the present study, samples were tested using the same cut types/sizes and ingredients, aiming at the maintenance of this relation in the same preparation submitted to different types of oil.

Brock, Nogueira, Zakrzevski, Corazza, Corazza, and Oliveira (2008) measured the density values of different vegetable oils at room temperature. Soybean, corn, sunflower, and canola oils presented almost identical values, of 0.883, 0.875, 0.877, and 0.878 g/cm^3, respectively. Evaluating viscosity at 20°C, soybean oil had 59.0 mPa s, corn oil 67.6 mPa s, sunflower oil had 58.3 mPa s, while canola oil presented 73.1 mPa s. However, by increasing temperature, the viscosity decreased, showing an inversely proportional relation between temperature and viscosity. At 70°C, soybean and sunflower oils had 12.6 mPa s, corn oil 14.0 mPa s, and canola oil 14.5 mPa s, very similar values. They also analyzed the thermal conductivity under different temperatures. The measured variables were not different among the tested oils, despite the differences in chemical composition between them. These data suggest that viscosity or thermal conductivity of different oils do not explain oil absorption by food, once they were very similar between vegetable oils.

According to Kim, Nyun-Kim, Ho-Lee, Yoo, and Lee (2010), soybean, corn, sunflower and canola oils showed high amounts of unsaturated fats and low amounts of saturated fat. Taken altogether, these data suggest that the chemical composition of the food submitted to the frying can be one of the main determinants for the amount of oil absorbed during the frying process, independently of the type of vegetable oil used, once these have similar physicochemical characteristics and overall fatty acids composition.

The initial quality of the frying oil is another aspect that influences the incorporation of oil. This is due to the formation of degradation compounds, increasing the polarity and consequently leading to an increase in the viscosity of the oil. As the viscosity of the oil increases, cooking time increases, also increasing the amount of oil on the food surface. Thus, the penetration of oil into the food is facilitated (Del Ré & Jorge, 2007). However, in the present study, the interference of oil quality in the absorption by the food was likely very low, because oils that had not been submitted prior to cooking were used.

One of the limitations of the present study was that a more sensitive method for lipid determination in the recipes after frying was not performed. The most commonly used method for this purpose is Soxhlet's. However, this method is based on weighing, as well as the methodology used in the present study. The execution of a more refined methodology, such as gas chromatography, could have evidenced different lipid composition profiles in the preparations after frying with the different types of oils, according to food composition from both the oil used and recipe tested. Thus, we suggest further studies to be developed and conducted with this approach, once this is the first study to our knowledge to bring these data for different recipes and different oils.

Thus, data shown were important to elucidate oil absorption on usually consumed fried preparations and the effectiveness of the use of paper towels after frying. The reduction of the excessive intake of oils and fats is important when it comes to dietary care, regarding both nutrition commercial/institutional services and the domestic/individual level. Thus, knowledge of oil absorption in different recipes, using different oils, and paper towels is important to nutrition and culinary-related health professionals.

Conclusions

Deep fat fried preparations absorbed more oil than shallow fried preparations. The use of paper towel significantly reduced oil absorption in shrimp with garlic (in sunflower and canola oils), chicken breast (in corn and sunflower oil), cioba steak (in sunflower oil), French fries and cheese samosa (in soybean oil). This may be possibly explained because these were less porous foods, which reduced absorption by capillary force at the time of cooling. In protein-rich preparations, soybean and corn oils were less absorbed, while in the starch-rich sunflower and canola oils were less absorbed, except for French toast. Beyond the use of different oils and paper towel, our data suggest that composition characteristics of the food itself, and reactions between the type of oil used and components of the structure of the food crust are decisive factors for the absorption of oil during frying.

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