Investigation of the quality of refined soybean oil after the short-term domestic frying process of breading nuggets

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ABSTRACT

Frying is one of the most attractive food preparation techniques and has been in use for centuries. It refers to a gastronomic practice that is widely accepted around the world and used both in the industrial area and domestically. It is worth noting that this preference of consumers for fried foods is due to their unique sensory properties, such as taste, aroma and texture. However, with the high temperature that is used in the cooking method, the chemical composition of the frying oil can be modified. The reactions that occur in vegetable oils during frying (hydrolytic processes) are associated with several mechanisms, such as reactive species, chemical formation of the lipid, medium and method, inducing the speed and nature of frying. The purpose of this work is to investigate the characteristics of the vegetable oil most used by the population (refined soybean oils) used in the domestic method of short-term frying, using the electric fryer for domestic use and conventional method. Nugget-type breaded products were used because they are a convenient product, widely consumed in industrialized countries. Short-term domestic frying was done over the course of three days, with a period of one week. After each frying, the refined oil was researched. The methodology is based on bromatological evaluations of quality research using acidity analyses, where the content of free acidity, compounds formed by hydrolytic rancidity, was verified. According to the results, the samples of fresh soybean oil were within the regulatory limits. However, soon after the short-term frying process, there was an increase in the free fatty acid content of both short-term domestic frying using soybean oil. In addition, there was no considerable difference in the increase in the value of fatty acids in relation to both domestic frying techniques. However, as a rule, the oil showed an excellent thermal quality, bromatological analyses showed that it is necessary to be cautious when reusing short-term frying oils. It is analyzed that the electric fryer is efficient in the quality of the oil in terms of preservation in contrast to the conventional method, possibly for the reason of temperature control and better sealing effectiveness.

Keywords: Soybean oil quality, Home frying, Bromatology, Acid value.

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INTRODUCTION

The frying process is one of the most attractive ways of preparing food. This is one of the ways used in cooking, where it is well known and used in industry and domestically. Fried foods are foods accepted by consumers, as they have different sensory characteristics, such as texture, appearance and flavor. The frying process is the public's preference in the home environment, as this cooking method has a more economical value, as well as being more practical, thus bringing the reason for its favoritism (Nhatave, 2015; Wang, 2016; Ruixue, 2016; Jesus, 2019).

However, the high temperatures used in soybean oil in the frying process are capable of impairing the chemical stability of this oil. The oil used in the frying process when heated repeatedly, is called discontinuous frying, this process of heating and reheating is usually used because of the way to reduce costs. The process occurs when high temperatures cause chemical decomposition, causing losses of sensory as well as nutritional qualities (Farhoosh, 2012; Millin, 2016; Multari, 2019; Jesus, 2019). During the frying process, the temperature favors the loss of water from the food, where this water is absorbed by the oil, in this way the oil undergoes a chemical decomposition through the pathways that occur in the oil, such as the hydrolysis that the oil undergoes because of this absorption of this water (Nhatave, 2015; Ruixue, 2016; Multari, 2019). Thus, the soybean oil used in this frying process undergoes changes, such as hydrolytic rancidity, that is, with the increase in fatty acids due to the hydrolysis of the triacylglycerols of the oils, the oils become more vulnerable to the loss of soluble fatty acids, vitamins and essential fatty acids, causing food insecurity (Lee, 2012; Calixto, 2013; Coradi, 2017; Dodo, 2022).

Brazil, one of the important producers of soybeans, and as a result the population uses the oil in the frying process (Nhatave, 2015; Jesus, 2019). In 2022, exports in the Brazilian country reached more than 2.16 million soybean oils (CONAB, 2022). Chicken nuggets breaded foods are also widely consumed by the population, as they also present practicality and sensory pleasure after the frying process (Nazário, J., Fontana, M., 2014). Thus, the food industry has invested in technologies and advanced in the creation of products that respond to consumer needs, such as chicken-based breaded products (Lima, et al., 2022). Nugget-type breaded products can be made by different parts of the chicken, such as a portion of meat with bone and skin, without bone and skin, as well as a whole piece, or processed, but usually nuggets are produced with ground muscle (Araújo, 2021).

Short-term frying is used recurrently in homes because of its functionality and through the acceptance of the palate, especially chicken breading like nuggets. Often, in homes, this cooking process is usually done in a short period of time, where this oil is saved to be reused in another frying later. On the other hand, this practice of reuse can lead to an acceleration of oil deterioration (Farhoosh, 2012; Lee, 2012; Choe, 2007).

To date, there are relevant gaps in knowledge about the chemical changes of fried foods for short periods, in addition to the storage of oil in a domestic situation, using the traditional form of frying (with pan and stove) and domestic electric fryer, in contrast to commercial circumstances, about which a lot of knowledge is obtained. Thus, with this study, the purpose of this study is to analyze the changes in the chemical quality of soybean oil after being used in short-term domestic frying with chicken nuggets, as well as to analyze the quality of this oil after the storage process at the domestic level and be reused. It is worth mentioning that it also plans to ascertain and compare the chemical quality of two frying techniques used in the home kitchen - traditional method and domestic electric fryer.

MATERIALS AND METHODS

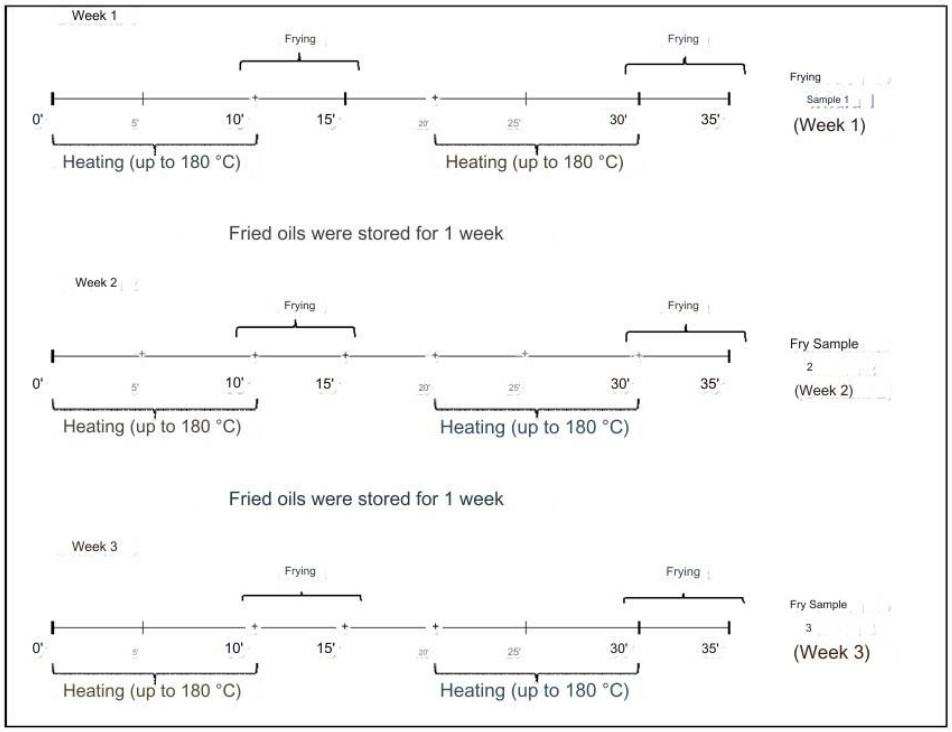
SAMPLES

The samples of refined soybean oils were purchased in the local market in the city of Rio de Janeiro, the soybean oils belonged to the same brands and were obtained in the same trade. Thus, six units of the same soybean oil manufacturing batch were purchased, where sampling methods were used to obtain reliable aliquots of these samples in each batch for the execution of the frying test. After the frying tests, the soybean oil samples were preserved in amber glass bottles, where they were protected from light, in a nitrogen atmosphere and at a temperature of -18ºC until the analysis was performed. Nuggets (Sadia®, Brazil) were purchased at local markets in Rio de Janeiro, Brazil. Before beginning the analyses and experiments, the purchased nuggets were fully thawed and the rest of the water was dried with a clean cloth.

FRYING EXPERIMENTS AT 180 °C

Soybean oils were used in short-term frying experiments at 180 ± 1 °C with chicken nuggets. In this way, two frying methods were used: a domestic electric fryer with a capacity of 1000 mL of oils (Philco®, Brazil) and frying in a stainless steel frying pan with a capacity of 1500 mL and 16 cm (Tramontina®, Brazil). Right after leveling 1000 mL of soybean oil for 10 minutes at 180 °C in cabin frying methods, the nuggets went to the frying process for a time of 5 minutes in portions of 200 g. It is noteworthy that each serving of nuggets showed plausible appearance and texture after the established time of 5 minutes. After one serving of nuggets, the volume of oil was replenished to 1000 mL with 50±1 mL and another 10 minutes to reheat the oil back to 180 °C, then another portion of nuggets was placed to fry for 5 minutes and after that aliquots of oils (50 mL) were removed (Fig. 1). Then, all the oils were stored in glass jars at room temperature for a time of one week, replicating a home storage. It is noteworthy that this sequence was repeated three times. Therefore, the frying process with a domestic electric fryer had temperature control.

Figure 1. Experimental design of immersion frying tests using conventional technique with stainless steel pan and electric fryer.



DEFINITION OF HYDROLYTIC STABILITY DURING FRYING AT 180 °C

The quality acidity index of the oils was defined in a fresh sample and during frying at 180 °C in the frying methods – domestic electric fryer and conventional method with stainless steel frying pan. Quality standards were determined by the acid index. The knowledge was made following the AOCS (2004) methods, represented below. For a better presentation of the effects, three analyses were performed in the blank test and the results were presented with mean and standard deviation.

Acid value

The definition of the acidity value ensures the neutralization of free fatty acids until the time of equivalence by an alkaline solution, with the use of an indicator. This knowledge defines the amount of free fatty acids in the samples of refined soybean oils. The studies were performed by titration with 0.1M factored alkaline sodium hydroxide (NaOH) solution with 1% phenolphthalein indicator and with samples previously dissolved in alcohol-ether solution (1:2 v/v). It should be noted that acidity corresponds to the number of milliliters of alkaline solution essential to neutralize the free fatty acids in 100g of oil, expressed by a percentage of oleic acid, calculated according to the equation below (Method Ca 5-40, AOCS, 2004):

$$AV\ (\%) = (Va - Vb) \times CF \times MW\ NaOH / m$$

Where:

Va = value of the 0.01 M NaOH white test used in titration;

Vb = test value of the 0.01 M NaOH samples used in titration;

CF = NaOH correction factor 0.01 M;

PM = peso molecular do NaOH;

m = weight of the sample quantity in g.

STATISTICAL ANALYSIS

Descriptive statistics were performed for the variables, with the purpose of calculating means, medians, standard deviation and estimating the regularity of the data. The conclusions were presented as mean ± standard deviation considering three independent replications. Multifactorial analysis of variance (MANOVA) was used to make a comparison between means; Considerable diversity between pairs of means was defined by Fisher's test. P results lower than 0.05 were seen to be statistically significant. Statistical analyses were performed using the Statistica 8.0 software (StatSoft®, Oklahoma, USA).

RESULTS AND DISCUSSION

The cooking method, frying, is used in modern cooking, but it has archaic origins dating back to the time of 1600 BC. As much as the orientation is to keep the temperature around 180°C in the food frying process, it is common for the temperature to exceed this limit in home frying, especially when the medium used is conventional, in which there is no temperature control (Omer, 2015).

During the frying process, the oil is modified and deteriorated, which can lead to changes in the sensory and nutritional characteristics of the foods used in cooking, various reactions occur through the frying process, such as hydrolysis and other processes, which can create chemical compounds that generate chronic diseases, such as cardiovascular diseases and various tumors (Farhoosh, 2012; Jesus, 2019). In this way, it is necessary to keep track of the changes in the quality of the oil used in this cooking process. The reactions are influenced by various situations, including exposure to oxygen, the ease of water that is released from the food to the soybean oil, the temperature (time, instrument used for frying, etc.), as well as the structure of the food that was used in the process (Farhoosh, 2012; Zula, 2022).

However, having an understanding of the oil in order to select the appropriate procedures is essential to relate the products resulting from this deterioration of the oil and the appearance of various diseases, such as atherosclerosis, Alzheimer's disease and inflammation in general

(Broncano, 2009; Farhoosh, 2012; Zula, 2022). Throughout the frying process, it provides the entry of water into the oil on account of the food, causing the hydrolysis of the fatty acids in the oil and these are represented by the acidity value. According to Brazilian legislation (ANVISA, 2005), but also the international guideline Codex Alimentarius for Vegetable Oils (WHO, 2015), the acceptable acidity limits in refined seed oils are 0.6%. However, when the oil is exposed to the frying process, the limits of the acidity value are raised to 0.9% (ANVISA, 2004). When it exceeds 0.9% of free fatty acids, it indicates that the oil needs to be discarded for safety reasons, since the production of chemical compounds that are harmful to health can cause harm to people who are consuming the food exposed to this oil (Broncano, 2009; Frankel, 2010; Jesus, 2019). It should be noted that, according to ANVISA (2004), heated oil is recommended to be discarded when the creation of foam and smoke is observed, as well as color changes (Coradi, 2017; Millin, 2016).

In addition, chicken nuggets breaded has brought interest to consumers and slaughterhouses, because breaded products have longer shelf life, reduced water loss and their way of preventing damage caused by freezing the food through breading and the way the food brings attractiveness after it has been cooked. Nuggets are a source of lipids and have many calories, and the way they are cooked can modify the nutritional characteristics and their energy value (Nazario, J., Fontana, M., 2014). It is necessary to say that the chemical composition of the nuggets is: water, citric acid, chicken broth, modified corn starch, salt, glucose, sodium phosphate, dimethylpolysiloxam, and oil (Fernandes, et al., 2020). Nazario and Fontana (2014) suggest that the consumption of nuggets should be moderate, as this food can help in weight gain and the evolution of cardiovascular diseases.

ACIDITY LEVEL

The acidity index corresponds to the free fatty acids in the samples that were taken from the oxidation of triglycerides. Refined seed oils are more subject to degradation, this is because they are more prone to rancidity, since unsaturated fatty acids will prevail in their composition. Thus, soybean oils with high acidity values reveal high levels of free fatty acids. Decomposition alters the concentration of hydrogen ions, both by hydrolysis and fermentation. Although processing and storage take place chemical and enzymatic reactions (hydrolytic rancidity), because of the water that comes into contact with the oil and will interact with the triacylglycerol, hydrolysis occurs and causes acidification of the environment. Therefore, this acidification modifies the sensory qualities of the oils, such as taste and odor, in addition to the nutritional change that occurs a loss (Lee, 2012; Akil, 2015; Ramalho, 2006; Clemente, 2019).

It is worth mentioning that soybean oil is indicated to have its acidity presented in oleic acid less than or equal to 0.6% (ANVISA, 2015; WHO, 2015), if they are not exposed to warming.

However, when soybean oil is exposed to heat, values up to 0.9% are accepted (ANVISA, 2004). The fresh samples of soybean oil and they were consistent with the upper limit of the acidity value, which showed less than 0.01% (TABLE 1). According to Gunstone (2008), he indicated that the free fatty acid content of refined seed oils would need to be less than 0.1% because most of the free fatty acids from crude oils are removed during the refining process. In fresh soybean oil, its fatty acid content is 0.028%, which are similar to the value of free fatty acids for fresh oil mentioned by Gunstone (2008). The acidity result increased considerably from the fresh sample to the end of the experiments of the short-term frying process (week 3) in the total of the soybean oil samples. Thus, this shows that the components of triacylglycerol were undergoing hydrolytic degradation (Gupta, 2005; Liu, 2018).

0,042bB ± 0,02

Refined Soybean Oil				
Frying techniques	Fresh sample	Frying Sample 1 (Week 1)	Frying Sample 2 (Week 2)	Frying Sample 3 (Week 3)
Conventional	$0,028^{aA} \pm 0,00$	$0,043^{bA} \pm 0,02$	$0,057^{cA} \pm 0,00$	$0,057^{cA} \pm 0,00$
Home electric fryer	$0,028^{aA} \pm 0,00$	$0,028^{aB} \pm 0,00$	$0,042^{bB} \pm 0,02$	$0,042^{bB} \pm 0,02$

The results are expressed as mean ± standard triplicate derivation.
Superscript letters indicate a significant difference between the week of frying and between the frying techniques (MANOVA repeated measures): ^{ab} Differences in the same line (week effect); $^{AB:}$ Differences in the same column (between techniques).

The result of the acidity of the soybean oil used in the frying procedure in the conventional fryer were the same until the first week of frying, from the second week of frying there was an increase, remaining constant until the end of the heating experience. On the other hand, the acidity values in the conventional frying methods were 0.057 in the third week of the experiment, i.e., much lower than the maximum limit recommended by the legislation for fresh refined oil, as well as for heated refined oil (ANVISA, 2004). In the conventional process, it was found that the triacylglycerols broke more quickly, due to the lack of temperature control, which is existing in the electric fryer. Akil (2015) ascertains the acidity values of oils after short-term frying using the domestic electric fryer. The results certify that the soybean oil used in both techniques is more resistant to short-term frying. Sebastian (2014) investigated the samples of soybean oil used in frying in twenty commercial restaurants, collected 500 mL of the oil from each of the restaurants to analyze. It should be noted that fifteen samples collected showed unsatisfactory results, as their values were the highest for disposal (4.3% is the highest value). The study followed the short-term fried foods at the domestic level, showing values with satisfactory results of the greed index, being able to show

consumers that for their health safety the ideal was to produce their fried foods in the domestic environment.

In general terms, frying using the electric fryer had its heating contained, because in addition to the instrument being more sealed, its temperature remains more stable and did not oscillate, unlike the conventional technique, which is not well sealed and the temperature fluctuates, causing an increase in fatty acids in the triacylglycerol oil. Overall, this is able to clarify the behavior of the oils in the electric fryer. The study done by Nazarbakhsh (2014), observed that the acidity value is lower for the samples of the electric fryer than compared to the conventional technique, using canola oil. These studies collaborate and show the success of the electric fryer, as there is less stability of soybean oil during frying, highlighting its efficiency in preserving the characteristic of soybean oil compared to the conventional method.

CONCLUSION

Soybean oil is for consumers more attractive for short-term frying. Thus, with the results obtained, it was analyzed that the soybean oil in the domestic environment there was an increase until the end of the experiment (week 3) but it did not exceed the allowed limit, but the electric fryer had a greater control in the temperature. Thus, it can be said that soybean oil showed the creation of few free fatty acids and conserving unsaturated fatty acids. Consequently, the study indicates the use of the electric fryer for the frying process, as long as the consumer pays attention to signs of discarding this oil, such as smoke and foam.

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