Effect of Vacuum Frying on the Bromatological and Sensory Properties of Empanadas

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Abstract

The consumption of empanada in Colombia and more specific in the Atlantic Coast is very desired. This high consumption leads to concern about the quality of the fried food that is consumed, so the aimed of this research is to determine the bromatological and sensorial properties of meat empanadas made of corn fried in vacuum. For this, A factorial design \(3^2\) was performed where the factors were temperature and time and the levels were 120ºC, 130ºC, 140ºC and 60ºC, 90ºC and 150ºC, respectively. fried empanadas were tested for % moisture, % fat, % protein, % carbohydrates and % ash for bromatology tests and color, oiliness and general acceptance for sensory tests which were made 30 semi-trained panelists. T9 showed the best results for % moisture, % fat and % carbohydrates, while T1 obtained the highest % protein. In the sensory evaluation, T1 and T2 had the highest scores.

Keywords: Oil absorption, native food, corn, fried

1. Introduction

Frying is defined as the cooking of food by immersion in oil or edible fat at temperatures above 100ºC. This is a process of heat and mass transfer [1]. It is one
of the most used, oldest and simplest methods of cooking, this one has greater approval on the part of the consumers for the texture, flavor, smell, color and its fast preparation. However, the high consumption of fried foods can bring risks to health thanks to its high caloric content [2, 3]. In addition, considering that part of the oil used as heat transfer medium is absorbed by the food, becoming an ingredient of the product [4, 5].

An alternative to reduce the high content of oil, reduce surface burns and reduce oxidation of oil, is frying in vacuum, a process that is carried out in a closed system at low pressures below atmospheric pressure (101.3 KPa), decreasing the boiling point of water, which causes the temperatures used in this process to be substantially reduced. The low temperature and the small exposure to oxygen are one of the variables that brings most of the benefits of fried foods [6-8]. Frying under vacuum is an option to conventional frying, because it offers better benefits such as improving the quality of food, low oil absorption and reduces oil oxidation due to operating at low temperatures. This adds several characteristics to the final product, as well as the preservation of thermolabile nutrients, color, natural flavors and less oil degradation [9]. In general, vacuum frying has shown significant benefits in the quality of the final product and a viable alternative for frying by immersion for first quality products. It has also opened new categories for the development of new products, which were not viable with traditional frying technology [10].

The empanada is a traditional food of much consumption in Colombia and Latin America, this can have a circular, semicircular and triangular shape. The dough can be made from wheat or corn flour and is made from wheat flour or corn flour, salt and water, and can also be filled with chicken, meat, cheese, among other ingredients. The empanadas can be baked or fried for consumption. The effect of vacuum frying on many dietary matrices but not on traditional foods such as empanada has been studied, for this reason the objective of this study was to determine the effects of frying in vacuum on the bromatological and sensorial properties of corn empanadas filled with meat.

2. Methodology

2.1. Raw material and frying process by vacuum immersion

Meat-filled corn empanadas were used, which were purchased in a local market and stored properly at a temperature of 6 ± 1°C, and then transported to the laboratory for frying and subsequent analysis.

The vacuum frying of the corn empanadas was carried out using palm oil in a GASTROVAC® unit (International Cuisine, Barcelona) measuring 40 × 26 × 46 cm, maximum capacity of 10.5 L and voltage 220 V. The process pressure was 30 kPa absolute and the frying temperatures tested were 120 °C, 130 °C and 140 °C.
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with times of 60 s, 90 s and 150 s. First the oil was heated to the set temperature, three samples were placed in a basket, the lid was closed and the vacuum pump was activated, when the desired pressure was reached, the basket was lowered and immersed in the oil. The product / oil ratio was 1:100 p/v. Once the frying time was completed, the basket was lifted, the pump was left on for a minute, then the vacuum was broken and the equipment was turned off by removing the samples, which were drained in a metal mesh basket at room temperature of 30 ± 2 °C.

2.2. Experimental design

For the vacuum frying process of the empanadas, a completely randomized block experimental design (DBCA) was used under a $3^2$ multilevel factor structure, where there are two factors with three levels each and making two replicas of each treatment, for have a total of 27 experimental runs. The factors chosen with their respective levels were temperature (120 °C, 130 °C and 140 °C) and time (60 s, 90 s and 150 s). The response variables were: % humidity, % oil, % protein, % carbohydrates and sensory perceptions: color, oiliness and general acceptance.

2.3. Bromatological analysis

Moisture was carried out according to method 930.15. For the determination of the fat content, method 920.39 was used, the protein was determined through method 984.13, ash by method 942.05. All these methods are from the AOAC in its 2012 version. All measurements were made in triplicate. The carbohydrate content was obtained as the difference from the other nutrients determined using equation 1:

$$\text{Carbohydrate} \% = 100 - (\text{moisture} \% + \text{fat} \% + \text{protein} \% + \text{ash} \%)$$

The oil absorption were carried out according to the results obtained from % fat.

2.4. Sensory analysis

For the sensory evaluation of the attributes of color, oiliness and general acceptance, a five-point hedonic scale was used, which ranged from "I like it a lot" (5) to "dislike me a lot" (1). The samples were presented in a randomized order and a semi-trained panel of 30 people were used, to which they were given whole samples of empanadas, taking into account the experimental design treatments.

2.5. Statistical analysis

The results were expressed as the mean with their respective standard deviation and were compared using analysis of variance (ANOVA) and tests of multiple comparisons through the LSD test with a level of significance of 5%. The statistical
program STATGRAPHICS Centurión XVI.I in Windows 10 was used. The coded experimental matrix used for frying the corn empanadas is shown in Table 1.

Table 1. Coded experimental matrix

<table>
<thead>
<tr>
<th>Treatments</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
<th>T7</th>
<th>T8</th>
<th>T9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
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<td></td>
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<td></td>
<td></td>
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<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>130</td>
<td>130</td>
<td>130</td>
<td>140</td>
<td>140</td>
<td>140</td>
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<tr>
<td>Time (s)</td>
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<tr>
<td>60</td>
<td>90</td>
<td>150</td>
<td>60</td>
<td>90</td>
<td>150</td>
<td>60</td>
<td>90</td>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>

3. Results

It can be observed with respect to moisture content in the 9 treatments, that there are statistically significant differences (p <0.05). In addition, it is evident that T1 is the sample with the highest moisture content, while T9 is the sample with the lowest percentage of this parameter, for which it can be affirmed that T9 was the best treatment, since the lower the humidity, the higher it's the empanada crunchiness.

Table 2. Bromatological analysis of the different vacuum fried treatments

<table>
<thead>
<tr>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
<th>T7</th>
<th>T8</th>
<th>T9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48.81±0.32 a</td>
<td>37.74±0.32 b</td>
<td>30.59±0.32 c</td>
<td>44.21±0.32 d</td>
<td>36.39±0.32 e</td>
<td>30.30±0.32 f</td>
<td>43.22±0.32 g</td>
<td>35.64±0.32 h</td>
<td>29.36±0.32 i</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Protein</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5.71±0.14 a</td>
<td>5.15±0.14 b</td>
<td>4.76±0.14 c</td>
<td>5.52±0.14 d</td>
<td>5.04±0.14 e</td>
<td>4.65±0.14 f</td>
<td>5.35±0.14 g</td>
<td>4.95±0.14 h</td>
<td>4.49±0.14 i</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Carbohydrates</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>37.43±0.51 a</td>
<td>42.77±0.51 b</td>
<td>46.02±0.51 c</td>
<td>38.45±0.51 d</td>
<td>44.1±0.51 e</td>
<td>47.87±0.51 f</td>
<td>39.62±0.51 g</td>
<td>45.05±0.51 h</td>
<td>49.95±0.51 i</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ash</th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.88±0.12 a</td>
<td>2.03±0.12 b</td>
<td>2.15±0.12 c</td>
<td>1.92±0.12 d</td>
<td>2.19±0.12 e</td>
<td>2.27±0.12 f</td>
<td>2.07±0.12 g</td>
<td>2.29±0.12 h</td>
<td>2.36±0.12 i</td>
</tr>
</tbody>
</table>

The empanadas moisture was reduced by the evaporation that occurred in this process [11]; the moisture percentage is affected by temperature and time, as indicated by Tirado et al., [12] and Dobarganes et al., [13]. For the protein parameter, the T1 sample had the highest percentage among all and obtained a statistically significant difference (p <0.05) with respect to the others and T9 had the lowest percentage (4.49 ± 0.27), it can be noted that the protein was affected by the increase in time and temperature as indicated by Henry [14], in this process the quality of these is reduced and some amino acids are lost. For carbohydrates and ashes content, T9 obtained the highest percentage (49.95 ± 0.17 and 2.36 ± 0.15, respectively); on the contrary, it was T1 who showed the lowest percentage (37.43 ± 0.51 and 1.88 ± 0.12, in order), in these parameters statistically significant differences (p <0.05) were found among all the samples. The increase in the percentage of carbohydrates can be due to the formation of amylose-lipid complexes [15]. In the parameters of moisture, carbohydrates and ashes it can be affirmed that the increase occurs with respect to the increase in temperature and time, contrary to what happens with the percentage of protein which decreases with the increase of the time and temperature variables.
Sensory analysis results of meat empanada can be observed in table 3, it is illustrated that the treatment with better qualification were T1 and T2, which did not have significant difference (p> 0.05) between them, but they have with other treatments, the results of this parameter of the empanadas were better valued than the fried samosas evaluated by Sakhale et al., [16] and Ata-Ur-Rehman et al., [17], in the same parameter.

Table 3. Sensory analysis of the different vacuum fried treatments

<table>
<thead>
<tr>
<th></th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
<th>T7</th>
<th>T8</th>
<th>T9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>4,2±0,4</td>
<td>4,02±0,4</td>
<td>3,17±0,4</td>
<td>2,75±0,4</td>
<td>2,25±0,4</td>
<td>1,67±0,4</td>
<td>2±0,63</td>
<td>1,42±0,4</td>
<td>1±0,02</td>
</tr>
<tr>
<td>Oiliness</td>
<td>4,38±0,4</td>
<td>4,5±0,5</td>
<td>3,0±0,6</td>
<td>3,5±0,5</td>
<td>3,17±0,4</td>
<td>2,92±0,4</td>
<td>3,5±0,4</td>
<td>3,33±0,4</td>
<td>2,9±0,4</td>
</tr>
<tr>
<td>General acceptance</td>
<td>4,01±0,4</td>
<td>4,5±0,5</td>
<td>2,67±0,4</td>
<td>2,83±0,4</td>
<td>2,41±0,4</td>
<td>1,75±0,4</td>
<td>2,5±0,4</td>
<td>1,5±0,5</td>
<td>1±0,01</td>
</tr>
</tbody>
</table>

Among the other treatments (T3 to T9) there was a difference between them, except for the T6 and T7 that were similar between them. For the parameter of oiliness, there was a statistically significant difference (p < 0.05) between all the treatments, with the exception of T1 and T2, who in turn were the best score in this characteristic and, finally, the appearance had a statistically significant difference (p < 0.05), being the T1 and T2 treatments the ones with the highest qualification by the panelists, and finally the general acceptance had a statistically significant difference (p < 0.05) between T1 and T2 (they were the ones that obtained better score) and the other samples, the highest score obtained for this parameter was higher than that obtained by Kanchi et al., [18], Sakhale et al., [16] and Ata-Ur-Rehman et al., [17]. These three parameters had something in common, as the time and temperature increased the evaluation by the panelists was decreasing.

Fig. 1. Oil absorption kinetics of vacuum fried meat empanadas at different temperatures
In Figure 1 it can be seen that the percentage of oil absorption by the fried empanadas increased as the frying time increased. As you can see, at 60 s there was not a big difference, being 10.23%, 9.88% and 9.65% for the temperatures of 120 ºC, 130 ºC and 140 ºC, respectively. After 90 seconds of frying, the difference between oil absorption remained small among them (12.08%, 11.67% and 11.16% for temperatures of 120ºC, 130ºC and 140ºC, respectively), and finally at 150 s the absorption increases between the three temperatures evaluated, being 15.48% (120 ºC) the highest absorption, followed by 13.91% (130 ºC) and 13.11% (140ºC).

As can be seen in Figure 1, oil absorption was greater at the lowest temperature and the longest time, demonstrating that these two variables directly influence this parameter, according to what was said by Montes et al., [19], Pedreschi and Moyano [20] and Varela [21]. The phenomenon of oil absorption is mainly due to the replacement in the oil feed by the considerable moisture that is lost during frying [22]. Some studies about the absorption of oil claim that this phenomenon is due to the pressure gradient formed by the condensation of steam in the interior, adding to this factor the pressure variations during the cooling produced by the vacuum rupture [23, 24]. Similar results were presented in several studies [22, 25-27].

4. Conclusion

The absorption of oil was greater at the lower temperature, the longest time at 120 ºC was where the highest oil absorption was found and it is deduced that the higher the temperature and the higher the temperature. Of the 9 treatments we can verify that the best sensory results were T1 and T2, while for the bromatological analyzes in the parameters of moisture, carbohydrates and ash it was T9 that obtained the best results, while T1 was the treatment with the highest percentage of protein.

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