ABSTRACT – The purpose of this study was to prepare traditional tofu and, then, apply smoking to evaluate the characteristics of the product and the processing effects. In order to prepare the standard tofu, the grains were blanched, macerated, grinded and centrifuged to form the soymilk, which was clotted (calcium sulfate) and pressed. Next, it was smoked at 42°C for two hours. The tofus were evaluated in regards to its yield, proximal composition, color and sensory acceptance. The tofu had a low yield, due to the pressing stage. The proximal composition of the tofus didn’t show a statistical difference. When evaluating the color of the tofus, there was a statistical difference in all the parameters evaluated (L*, a*, b*). The application of smoke to the tofu caused a better acceptance of the attributes aroma, texture, flavor and global acceptance, the smoked tofu’s texture was the attribute with the best acceptance among evaluators.

KEYWORDS: soymilk, coagulation, yield, color, acceptance.

1. INTRODUCTION

Traditional tofu consists of a gel obtained from soymilk, formed from the denaturation of the proteins by heating. Depending on the preparation method, type of coagulant and moisture content, it is possible to classify the tofu as firm tofu, soft tofu and silken tofu. In addition, the yield and quality of the product may be influenced by the type of soy cultivar, quality of the grain (which depends on the plant’s growth and storage conditions) and processing conditions (Li et al. 2013).

The processing of the tofu may vary according to the manufacturer, but the basic stages are grain maceration; water milling; filtration; addition of one or more coagulants to the soymilk, followed by heating, to facilitate the coagulation (Cui et al., 2004). If the desired result is a firmer texture, cutting and whey removal of the coagulant are optional steps (Prabhakaran et al. 2006).

Soy products, such as tofu, are traditionally oriental. Despite their high nutritional and functional properties, they are not typically consumed in the basic Brazilian diet, due to their unpleasant flavor and odor (off flavor), attributed to the presence of lipoxygenase enzymes, which form the hydrogen peroxide, and the aggravation of flatulence caused by oligosaccharides and their anti-nutritional compounds. The genetic advancement and other processing measures, such as grain blanching, are being used as a solution to improve the consumer acceptability (Da Silva et al. 2009).

The acceptability level of foods depends mostly on cultural habits, therefore, when a food is created or modified, it is extremely important to evaluate it with consumers or potential consumers. It is highly known that some attributes, such as flavor and texture, are extremely relevant for the global acceptance of products. One alternative to modify the tofu’s particular flavor is the smoking process,
previously used only as a conservation procedure, but applied nowadays to alter sensory characteristics. In addition to the changes in flavor, the color is relevant in smoked products because the first consumer evaluation is primarily visual.

The purpose of this study is to prepare traditional tofu and apply smoking to evaluate the products’ physical-chemical and sensory characteristics and the effects of processing.

2. MATERIAL AND METHODS

In order to prepare the tofus, the cultivar used was the BRS 284 (2011/2012 crop), cultivated in the city of Mauá da Serra, state of Paraná. At the coagulation phase, the coagulant used was the calcium sulfate P.A.. Two types of tofu were produced, the standard tofu and the smoked tofu. The grains were submitted to the blanching process (five minutes of ebullition, followed by five minutes of cooling with water and ice). The processing conditions followed the procedures described at Benassi et al. (2011), with a few alterations. The maceration process was done overnight in the proportion of 1:3 (grain:water); the milling used water at 90°C in an industrial blender model Metvisa LQ 15 for 10 minutes in the proportion of 1:10, subtracting the quantity of water absorbed by the grains in the maceration phase. The resulting extract was separated from the okara through centrifugation; the coagulant was used in the proportion of 1:13, with the time of coagulation of 10 minutes at 75-76°C. The resulting clots were transferred to plastic molds and lined with fine nylon meshes and, next, kept under pressure of 64g/cm² for one hour to conclude the whey removal. After the whey removal, the tofu was submitted to the smoking process, based on Laguna and Egito (2008); the smoking chamber (Monibrás model Meg50) was heated up to 42°C, using the eucalyptus chip to create smoke, where the tofu remained for 2 hours.

The yield of tofu in relation to the soymilk was calculated by dividing the tofu’s weight by the soymilk’s weight. And the yield of tofu in relation to the grain was calculated by dividing the weight of the tofu by the weight of the grain. These values were expressed in percentage.

The determination of moisture was performed at 105°C with air circulation, ashes were quantified for carbonization in muffle at 550°C, The lipids were determined by Soxhlet extraction with petroleum ether. The proteins were determined by Micro-kjeldahl, using correction factor of 6.25, according to the methodologies described at AOAC (2000). The carbohydrates were calculated by difference.

The color of the samples was evaluated in colorimeter Konica Minolta CR-400 and the results obtained were expressed in L* values, which indicates luminosity varying from 0 (black) to 100 (white), a* which varies from green(-) to red (+) and b*, which varies from blue (-) to yellow (+).

The sensory analysis was applied with individual samples to allow the assessment of the product’s acceptance and the consumer’s purchase intention. The attributes evaluated were color, aroma, texture, flavor and global acceptance, using the hedonic structured scale of 10 points, anchored on both extremes and in the middle, where 10: Liked extremely, 5: Did not like nor disliked, and 0: Disliked extremely (Villanueva et al. 2005). For each formulation, a purchase intention test of 5 points was performed, where 5: Would certainly buy it, and 1: Would certainly not buy it. The tofu was tasted by consumers and non-consumers of tofu, totaling 100 judges from both genders. This analysis was approved by the Research Bioethics and Ethics Committee from the Santa Casa de Londrina Fraternity – BIOISCAL, at project no. 355/10 = CAAE: 0015.0.083.000 – 10.

The results obtained were analyzed with the use of the Statistica 10.0 software, applying variance analysis (ANOVA), and the averages were compared with the Tukey test at the significance level of 5% (Statsoft, 2011).
3. RESULTS AND DISCUSSION

The tofu showed a low yield (13.51% in relationship to the soymilk and 118.77% in relationship to grain), when compared to the study of Prabhakaran et al. (2006), whose authors obtained 45% of tofu in relationship to the soymilk, using the same coagulant used in this study, the calcium sulfate. This low yield registered is probably due to the manufacturing process. In this study, the mechanical pressing was applied, with strength of 64g/cm², superior to the pressure of 28g/cm² used by the authors. It is important to point out that during this phase, the gel is broken and the water previously retained is released, decreasing the product yield.

The tofu yield is also influenced by the variety and quality of the soy, the grow place and the grain storage conditions, besides the processing conditions (Li et al., 2013; Yang and James, 2013). Kong et al. (2008) have studied the alterations in the quality of soy grains during storage in relationship to the production of soymilk and tofu, and observed that the tofu’s yield depends on its protein content. The proper extraction during the processing also influences the tofu’s yield, as the concentration of solids during extraction increase the product yield. The coagulation phase and its variants (time, agitation speed and the coagulant’s concentration) are also relevant in the extraction and yield of proteins.

The proximal composition of the standard and smoked tofu did not show a statistical difference (Table 1). The standard and smoked tofu were produced simultaneously, therefore, in the pressing phase, the loss of moisture was similar for both products. Cold smoking was immediately applied after the pressing for a short period of time (2h), therefore, there was no alteration due to the forced air circulation in the moisture percentage, and consequently, in the solid compounds. This may be a consequence of the short-term smoking, which was insufficient to cause superficial dehydration.

Table 1: Proximal composition of standard and smoked tofus (g/100g).

<table>
<thead>
<tr>
<th>Type</th>
<th>Moisture</th>
<th>Ashes</th>
<th>Lipids</th>
<th>Proteins</th>
<th>Carbohydrates*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>77.66±0.41a</td>
<td>2.79±0.11a</td>
<td>5.85±0.50a</td>
<td>10.37±0.44a</td>
<td>4.34</td>
</tr>
<tr>
<td>Smoked</td>
<td>78.09±0.08a</td>
<td>2.22±0.71a</td>
<td>6.73±0.49a</td>
<td>10.15±0.44a</td>
<td>2.81</td>
</tr>
</tbody>
</table>

Triplicate average ± standard deviation; Averages followed by the same letter in the same column, don’t show significant difference in Tukey Test (p≤0.05). *Carbohydrates calculated by difference.

The major solid components of the tofu are proteins, followed by lipids and ashes, that is, a reflection of the grain’s composition, determined by Gonçalves et al. (2014), where authors quantify 33.24% of proteins, 22.54% of lipids and 4.60% of ashes. The soy proteins have a high nutritional value especially because they have essential amino acids, lysine and leucine. In addition, according to the Food and Drug Administration - FDA (1999), the daily consumption of 25g of soy proteins, as part of a diet with low consumption of saturated fat, may reduce the risk of cardiovascular diseases. Therefore, the tofu is a product that could contribute to this daily consumption, besides being a possible replacement for other sources of proteins, such as meat, for vegetarians, and cheese for those who are lactose-intolerant. The tofu’s lipids have great health benefits because they have polyunsaturated fatty acids (PUFA), particularly the linoleic acid, and they are cholesterol free. This product is also rich in minerals, as 50% of all the minerals present in the grains stay in the tofu.

When evaluating the color of the standard and the smoked tofu, there was a 5% difference in the parameters evaluated (L*, a*, b*). The a* parameter indicated that all the samples tend to red (positive values) and the parameter b* indicated the yellow color (positive values) (Table 2). The luminosity L* indicated more clarity for the standard sample and more darkening for the smoked sample. In the smoked tofu, there was an intensification of color, leaning towards the red (higher values for a*) and yellow (higher values for b*). These differences observed in the color evaluation
are a consequence of the smoking effect, as during this process, the smoke particles are deposited over
the food’s surface, causing color alteration and darkening.

Table 2: Standard and smoked tofus color

<table>
<thead>
<tr>
<th>Tofus</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>86.27±0.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.94±0.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>15.35±0.12&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Smoked</td>
<td>85.35±0.22&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.10±0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.12±0.32&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Ten sample average ± standard deviation; Averages followed by the same letter in the same column,
don’t show significant difference in Tukey Test (p≤0.05).

The color evaluation of foods is extremely important because the general appearance of the
products has proved to be crucial to the consumer’s acceptance or rejection because it
the first criterion to be considered. However, the human eye is often unable to detect differences in food color,
the smoking caused alterations in the tofu, which was measured by the colorimeter, but not
differentiated by the sensory judges (Table 3).

Table 3 – Sensory analysis of standard and smoked tofu.

<table>
<thead>
<tr>
<th>Tofus</th>
<th>Color</th>
<th>Aroma</th>
<th>Texture</th>
<th>Flavor</th>
<th>Global Acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>6.92±2.46&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.72±2.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.47±2.85&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.05±2.59&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.61±2.60&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Smoked</td>
<td>6.81±1.88&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.59±2.24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.88±2.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.83±2.70&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.69±2.29&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

One hundred samples average ± standard deviation; Averages followed by the same letter in the same
column, don’t show significant difference in Tukey Test (p≤0.05).

At the sensory analysis, the acceptance level of the attributes aroma, texture, flavor and
global acceptance showed a significant difference favoring the smoked tofu. The acceptance of the
attribute color did not show a statistical difference, and got a grade equivalent to “liked moderately”
and “disliked slightly”. Based on the scale used. Therefore, the effects of the smoking process (intensification of the red
and yellow colors and decrease in luminosity), verified at the instrumental evaluation, were not detected or
did not interfere in the acceptance of this attribute by the sensory judges.

The standard tofu’s aroma had a level of acceptance near ‘liked slightly’, but the smoked
tofu had a higher value for this attribute, equivalent to ‘liked moderately’. For this attribute, some
judges mentioned, in the evaluation record, that the smoked tofu was very pleasant because is a
product that is different from the traditional tofu.

The smoked tofu’s texture was the attribute with the best acceptance with a grade equivalent
to the attribute color, as the standard tofu’s texture had a grade next to indifference. The flavor was the
attribute with the lowest level of acceptance for both kinds of tofu, nevertheless the smoked sample
had the higher grade, next to ‘did not like, nor disliked’; the evaluation of flavor for the traditional
tofu, however, was rejected, because it showed an average equivalent to ‘disliked slightly’.

According to Rekha and Vijayalakshmi (2013), the tofu has a mild flavor and a porous
texture and, due to its neutral sensory characteristics, the tofu’s texture has an important role in the
quality of the product, as well as the consumer acceptance. This was exactly what happened in the
sensory evaluation of the different kinds of tofu in this study; both showed the highest averages for the
attribute texture, and the lowest for the flavor.
The global acceptance of the standard tofu was near indifference, based on the scale used, but for the smoked tofu, the acceptance improved and was near the value for ‘liked slightly’. The judges can concentrate themselves in different aspects of the samples during the global acceptance evaluation in order to form their opinion, positive or negative, and then it is believed that the attribute flavor had a strong influence in the global acceptance grade. It is important to consider that most judges were non-consumers of tofu. In addition, there were comments in the evaluation records indicating that the product needed spices, salt or soy sauce to improve its flavor.

Separating the judges’ grades in two groups, consumers and non-consumers, and analyzing only the values that corresponded to the products approval (from 5.1 to 10) in the scale used, the results showed that the color was not relevant in relationship to the fact of being a consumer or not because both groups has a similar distribution of acceptance (Figure 1). For the attribute aroma, the regular consumers did not report a difference between the traditional and the smoked tofu, however, this attribute showed a remarkable difference among non-consumers, for whom the smoked tofu had a greater acceptance when compared with the standard tofu.

Figure 1: Distribution of the acceptance attributes of standard and smoked tofus by consumers (A) and non-consumers (B) judges.

The smoking process was extremely relevant for the attributes texture, flavor and global acceptance according to both groups of judges, as the smoked tofu showed higher values in comparison with the standard tofu. It is also visible the impact of knowing or not knowing the product under evaluation, because the averages of the products evaluated by consumers were always higher than the evaluations of non-consumers.

4. CONCLUSION

Due to the processing used to prepare the tofu, with the application of press extraction, the yield was low. The cold smoking did not altered the proximal composition of the standard and the smoked tofu, but it did change the color in parameters a* and b*, and luminosity as well, representing the darkening of the product. In regards to the sensory analysis performed by all the judges, the acceptance of the attributes aroma, texture, flavor and global acceptance showed a significant difference favoring the smoked tofu. The texture of the tofu was the attribute with the highest acceptance by the evaluators, and flavor was the attribute with the lowest acceptance for both kinds of tofu. Separating the grades of the judges in two groups, consumer and non-consumer, we can clearly see the influence of previously knowing the product under evaluation, and the relevance of smoking.
as the smoked tofu showed the highest values in comparison with the standard tofu, including taste and global acceptance.

5. ACKNOWLEDGMENTS

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6. REFERENCES


