EFFECTS OF VEGETABLE COAGULANTS IN THE PRODUCTION AND STORAGE OF TOFU

Jéssica Tamiozzo Schmidt¹, Keli Cantelli¹, Clarice Steffens¹, Juliana Steffens¹*, Jamile Zeni¹

ABSTRACT: The aim of this study was to develop and characterize tofu with vegetable coagulant kiwi, ginger and lemon. Soybeans used for tofu processing was from conventional cultivar. Soybeans were analyzed in relation to moisture, protein, ash and pH. In soybean soluble extract (SSE) beyond analyzes of soybeans, were also analyzed acidity. In tofu I and II were carried out the analysis of yield, syneresis index, moisture, ash, pH, protein, acidity, color, total count of psychrophilic and coliforms bacteria, at 1st and 7th day of storage. The tofu I and II showed no significant differences for acidity, pH and protein on the 1st and 7th days of storage. Yield and syneresis of the tofu I with kiwi and ginger were higher than the others. Microbiological analyzes are within the standards established by legislation. The results of this work show that the coagulants of kiwi, ginger and lemon can be used for the preparation of tofu and the best conditions for its obtaining were pH 2.0 and coagulation temperature of 80°C, obtaining tofu with more firm mass for the three analyzed coagulants.

Key-words: Soluble extract of soybean, coagulation, yield.

EFEITOS DE COAGULANTES VEGETAIS NA PRODUÇÃO E ESTOCAGEM DO TOFU

RESUMO: O objetivo deste trabalho foi desenvolver e caracterizar tofu com diferentes coagulantes vegetais de kiwi, gengibre e limão. A soja utilizada para o processamento do tofu foi proveniente de cultivar convencional. Os grãos de soja foram analisados em relação a umidade, proteína bruta, cinzas e pH. No EHS, além das análises realizadas nos grãos de soja, foi realizada a análise de acidez. Nos tofus I e II foram realizadas as análises de rendimento, índice de sinérese, umidade, cinzas, pH, proteína, acidez titulável, cor, contagem total de bactérias psicrófilas, coliformes totais e termo tolerantes, no 1º e 7º dias de armazenamento. Os tofus I e II não apresentaram diferenças significativas para a acidez, pH e proteína do 1º para o 7º dia de armazenamento. Os rendimentos e as sinéreses do tofu I de kiwi e gengibre foram maiores do que os demais. As análises microbiológicas ficaram dentro dos padrões estabelecidos pela legislação. Os resultados deste trabalho mostram que os coagulantes de kiwi, gengibre e limão podem ser utilizados para a elaboração de tofus e as melhores condições para a obtenção foram de pH 2,0 e temperatura de coagulação de 80°C, obtendo-se um tofu com massa mais firme para os três coagulantes analisados.

Palavras-chave: Extrato hidrossolúvel de soja, coagulação, rendimento.

¹ Universidade Regional do Alto Uruguai e das Missões - URI - Erechim, Av. Sete de Setembro, 1621, CEP 99709-910, Erechim - RS, Brasil. *E-mail: julisteffens@unicer.edu.br. Autor para correspondência.

INTRODUCTION

Throughout history, vegetarianism blended with the culture around the world, its spread was slow, but growing. Race, emotional and health factors are some reasons for the adoption of this kind of diet (COUCEIRO et al., 2008). From the vegetarian way of life, veganism arises. A lifestyle that rejects the use of animals and products derived from them, and avoid the consumption of products that generate death or mistreatment of animals (ABONIZIO, 2013).

In this context of standard diets for human consumption, soy can be used because of its nutritional and functional values through a modern system of food production (BOATTO et al., 2010).

A product derived from soybean produced in the food industry is the soluble soy extract (SSE) or soy milk. From this extract it is possible to produce tofu, and other products (CIABOTTI et al., 2007).

The tofu, originally from China, is becoming increasingly popular worldwide. Considered to be a valuable source of protein compared to meat, fish and cheese, it is important for vegans (LI et al., 2015). It has a mild flavor and porous texture, is cholesterol free, and is a source of protein, minerals and polyunsaturated fatty acids (SERRAZANETTI et al., 2013).

The tofu manufacturing process involves two main steps. The first is to obtain soluble soybean extract by maceration and grinding the soybean and heating of the extract of soybeans, where the thermal inactivation of lipoygenase enzymes will be performed. The second is the coagulation of soybean soluble extract, which is an important step in obtaining one adequate texture and yield of tofu (KAMIZAKE et al., 2016). Coagulation of the soluble soybean extract can be performed from animal, microbial or vegetable coagulants. If in the case of vegans individuals, the use of coagulants of plant origin becomes an option.

This work aimed to evaluate the influence of pH of vegetable coagulants (kiwi, ginger and lemon) and coagulation temperature in tofu processing, which was characterized physicochemically (ash, acidity, pH and protein ), physically (yield, and color syneresis), and microbiologically (psychrophilic and coliforms bacteria).

MATERIAL AND METHODS

Soy beans

Soy beans (Glycine max (L.)) used in this study were provided by the company Precisão Agro Comércio e Representações Ltda of Augusto Pestana city – RS/Brazil, from conventional cultivars, category S1, of the season 2013/2014.

Soluble soy extract (SSE)

SSE was obtained by processing of soybeans according to methodology adapted of Benassi et al. (2011). First, 150g of soybean grains were selected, sorted, weighed and washed, and then was left macerating (immersed) in 500 mL of distilled water at room temperature (±25°C) for 16 h. Subsequently the grains were drained and weighed to evaluate the amount of water absorbed, measured by the difference in mass of grains macerated by the initial mass of grains (g of water/100g of grain). Then, it was added to soybean, distilled water (90 °C), considering water absorbed by the grain so that they complete a volume of 1200 ml, with a final ratio of 1: 8 (beans: water). The mixture was triturated in processor (M. Vitry, 1/2 HP model) for 3 min. He was separated EHS okara (residue) by vacuum filtration (Tecnal, TE-058 model). (M. Vitry, modelo HP 1/2), per 3 min. Then it separates the SSE of the okara (residue) by filtration vacuum (Tecnal, TE-058 model). Were performed analyzes of moisture, protein, ash and pH on soybeans and SSE, according to the methodology described by Instituto Adolfo Lutz (IAL, 1985), on a dry basis.
Vegetable coagulants

The vegetable coagulants used in this work were kiwi, ginger and lemon, which were purchased in local shops (Erechim-RS-Brazil). Coagulants extracts of kiwi and ginger were obtained according to the methodology described by Mazorra-Manzano et al. (2013) and lemon according to the methodology of Adetunji et al. (2008). The Kiwi and ginger were washed, peeled, cut and crushed into processor (M. Vithory, 1/2 HP model) with 20 mM of sodium phosphate buffer (pH 7.2) (1:1 w/v). After, were performed a centrifugation (MPW® Centrifuge, Model 351R) at 5000 g for 30 min at 4 °C with subsequent vacuum filtration (Tecnal, TE-058 model), and storage at 4 °C. The lemons were washed, cut and extracted the juice, to obtain 1L of juice.

Influence of pH of coagulants

To evaluate the influence of pH on the coagulation of SSE with vegetables coagulants (lemon, kiwi and ginger) tests were conducted at different pHs (2.0, 4.0 and 6.0), where they were adjusted with citric acid (1M), for all coagulants. Temperature of 80 °C was used for lemon coagulant (ADETUNJI et al., 2008), and 40 and 65 °C were used for kiwi and ginger coagulant (MAZORRA-MANZANO et al., 2013), respectively.

Subsequently 1 mL of each coagulant at each pH, was added to 10 mL of the SSE, followed by stirring and coagulated for 40 min. After checking the best pH condition, a new test was conducted by fixing the pH at 2.0 for all coagulants, changing the coagulation temperatures (40, 65 and 80 °C).

Production of tofu

Tofu was prepared from the adapted methodology of Benassi et al. (2011), were three formulations are performing from vegetable coagulants (kiwi, ginger and lemon). SSE (2 L) for each formulation was heated to 90 °C in a water bath (Marconi®, MA126 model). For tofu I, the heated SSE, was transferred to a glass vessel and left cooling to the coagulation temperature 80 °C, 65 °C and 40 °C for lemon, ginger and kiwi, respectively, where these temperatures were fixed according to Adetunji et al. (2008) for lemon and Mazorra-Manzano et al. (2013) for kiwi and ginger coagulant. After reaching the temperature, was added to the SSE 600 µL of CaCl₂ (40%) and the vegetables coagulants at a concentration of 10%, according to methodology of Fasoyiro (2014), with a natural pH of each coagulant: kiwi (4.0), ginger (6.0) and lemon (2.0), homogenized and coagulated for 40 min.

For tofu II, the best conditions obtained from the evaluation of the influence of pH and temperature of the vegetable coagulants was used (pH 2.0 and 80 °C temperature), for all coagulants. After heating, the SSE was cooled to 80 °C and added coagulant (lemon, ginger and kiwi) at a concentration of 10% and 600 µL CaCl₂ (40%), homogenized and coagulated for 25 min.

After coagulation of tofu I e II, the mass was cut by lire, and inserted into cheese molds (500 mL), which remained for 30 min to syneresis. After the tofu was removed of the mold, and packed in plastic packages without adding water and without vacuum, and stored under refrigeration (4 °C) for 7 days.

Analysis

In the soy beans was carried out analysis of: moisture, protein, ash, pH. In the SSE and tofu (1st and 7th days of storage), it was carried out analysis of: moisture, protein, lipids, ash, pH and acidity according to the methodology of Institute Adolfo Lutz (IAL, 1985).

Moisture was determined by the gravimetric method, in a drying chamber (Fanem®, a Model 320) at 105°C for about 4 h to constant weight. Proteins were determined by Kjeldahl method. Lipids were determined by the Soxhlet method, and ashes were obtained by gravimetric method, after calcination in a muffle oven (Quimis), at 550°C for 6 h. The pH was determined by potentiometry (Digimed, modelo DM-22),
while the acidity was analyzed by titrimetric method.

The color analysis of tofu I and II was determined by reflectance with handheld colorimeter (Minolta Chroma-meter model CR400 Minolta Camera Co., Japan). The parameters analyzed were L* (lightness), a* (grade of greenness/redness) and b* (grade of blueness/yellowness) (BOLLIN; HUXOLL, 1991).

The tofu yield was obtained according to Benassi et al. (2011). The syneresis of tofu was determined by the method of drainage according to Hassan et al. (1996). The results of yield and syneresis were expressed in wet basis.

Total coliforms were detected by MPN procedure according to standard method (APHA, 1985). Presence of faecal coliforms was determined using FAO (1979) and total psicrophilic bacteria by American Public Health Association (APHA, 2001).

All analyzes of tofu were performed on the 1st and 7th day of storage, except the yield.

Statistical treatment

The results of analyses were analysed according to the methodology of design of experiments and analysis of variance (ANOVA) followed by Tukey's run to compare the differences between the means, with the aid of STATISTICA software (Statsoft, v.8.0 for Windows), with a significance level of 90 and 95% confidence.

RESULTS AND DISCUSSION

Analysis of soybeans and EHS

The soybeans presented a mean moisture content of 7.81 g.100g⁻¹ and ash content of 4.89 g.100g⁻¹. Similar values of ash were observed by Gonçalves et al. (2014) in soybean on the BRS 284 cultivars (4.60 g.100g⁻¹) and BMX Power RR (4.79 g.100g⁻¹) and by Brunelli and Venturini Filho (2012) on the cultivar BRS 213 (4.57 g.100g⁻¹). The protein content was of 33.97 g.100g⁻¹, approaching to the values reported by Gonçalves et al. (2014) on the cultivar BRS 284 (33.24 g.100g⁻¹) and the BMX Power RR (34.74 g.100g⁻¹). Ciabotti et al. (2006) obtained values of 32.67 g.100g⁻¹ for the common cultivar. The pH value found for the soybean was 6.6, while Boatto et al. (2010) obtained pHs of 4.3 and 4.4 for Embrapa 48 (common cultivar) and BRS 213 (soybean without lipoxygenase), respectively.

In general, the difference between the values of moisture, ash, protein and pH found in this study in relation to literature, can be attributed to genetic differences between soybean cultivars, the stage of development in which the grains were harvested and also time and temperature conditions (SILVA, 2009).

For SSE the average ash content was 0.17 g.100g⁻¹, values close to those reported by Marin et al. (2014) that obtained 0.13 g.100g⁻¹. Values above this study were reported by Carvalho et al. (2011) with 0.84 g.100g⁻¹. The protein content was 3.45 g.100g⁻¹, value within the standards established by Resolution RDC No. 268 of September 22, 2005 (BRAZIL, 2005), where the minimum content must be at least 3 g.100g⁻¹. Ciabotti et al. (2006) found a value of 3.56 g.100g⁻¹ in SSE obtained from conventional soybean. Values below of this work were obtained by Marin et al. (2014) (1.7 g.100g⁻¹), Carvalho et al. (2011) (2.51 g.100g⁻¹) and on the Brazilian Food Composition Table (UNICAMP, 2011) (2.4 g.100g⁻¹). The pH value of SSE was 6.3, while Carvalho et al. (2011) found 6.7 and Marin et al. (2014) obtained 4.4. According to Lambrech et al. (1996), the optimal range of pH for the extraction of proteins for the tofu production is between 6.4 and 6.6, value close to the obtained in this work. The acidity was 0.136% lactic acid, next found by Martins et al. (2013), that was 0.1 and 0.2%.

Effects of vegetables coagulants in the tofu processing

Figure 1 shows the visual aspect of the tofu I obtained by coagulants of kiwi, ginger and lemon, respectively. It is observed that tofu Kiwi and ginger presented visual
appearance more liquid when compared with lemon.

**Figure 1.** Visual aspect of tofu I obtained with kiwi, ginger and lemon coagulants, respectively.

This visual difference between the tofu can be justified by the difference in pH (2.0) and temperature (80 °C) of the tofu I obtained with lemon, which presented firm aspect. Based on this, studies have been conducted evaluating conditions of pH and temperature for the different coagulants on the tofu production.

**Evaluation of conditions of pH and temperature in the tofu processing**

To evaluate the influence of pH on tofu processing, tests was performed adjusting the pH of all coagulants (kiwi, ginger and lemon) at 2.0, 4.0 and 6.0. The coagulation temperature of 40 °C was used for coagulants adjusted at pH 4.0, while the temperature of 65 °C for coagulants adjusted at pH 6.0 and temperature of 80 °C for coagulants adjusted at pH 2.0.

On the tofu obtained at pH 2.0 with all the vegetable coagulants was observed a firm curd. At pH 4.0 was obtained a firm curd for coagulants of kiwi and lemon and there was no coagulation when used ginger. In the pH 6.0 was observed soft mass for all the vegetables coagulants.

Thus, it was found that more acid is the vegetable coagulant, better is the coagulation of SSE. From this result, new tofu production tests were carried out by adjusting the pH of all coagulants (kiwi, lemon and ginger) in 2.0 using the temperatures of 40, 65 and 80 °C.

The results showed that using temperature of 80 °C, at pH 2.0 for the three coagulants, the curds presented firm mass (tofu II), as shown in Figure 2.

**Figure 2.** Visual aspect of tofu II obtained with kiwi, ginger and lemon coagulants with pH adjusted at 2.0 and temperature of 80°C.

In terms of processing, to perform the coagulation at 80 °C is advantageous because is no necessary to reduce the temperature for to make the coagulation of the SSE, as SSE is...
at the same temperature of the water bath outlet (step of SSE obtainment), besides reducing coagulation time.

**Analysis of tofu**

Table 1 presents the results of physicochemical analyses for tofu I and II at 1st and 7th days of storage. In relation to the ash content, it was observed that there was a significant difference (p < 0.05) between the 1st and 7th day of storage for tofu I with kiwi, ginger, and lemon, whereas in the tofu II this behavior was not observed, presenting no significant difference (p > 0.05). These results are similar to those reported by Kamizake et al. (2016) that obtained values of 0.74 g.100g1 and 0.84 g.100g1 for tofu (coagulated with MgSO4.7H2O) produced by Coodetec 214 and BRS 267 cultivars, respectively. Li et al. (2015) observed higher values of ash (1.85 g.100g1) than the present study, which used organic soybean to prepare tofu, coagulated with MgCl2.

With the storage time, it was possible to see that the ash values decrease, this fact can be explained by the release of whey during storage, causing salt migration of the tofu to the whey.

**Table 1.** Results of physicochemical analysis of tofu I and II obtained with kiwi, ginger, and lemon, on the 1st and 7th days of storage.

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Tofu I Storage Days</th>
<th>Tofu II Storage Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>7th</td>
</tr>
<tr>
<td></td>
<td>0.66 (±0.09)a</td>
<td>0.39 (±0.02)b</td>
</tr>
<tr>
<td>Ash (g.100g−1)</td>
<td>Kiwi</td>
<td>Ginger</td>
</tr>
<tr>
<td></td>
<td>0.63 (±0.12)a</td>
<td>0.36 (±0.03)b</td>
</tr>
<tr>
<td></td>
<td>0.94 (±0.26)a</td>
<td>0.56 (±0.09)b</td>
</tr>
<tr>
<td></td>
<td>Kiwi</td>
<td>Ginger</td>
</tr>
<tr>
<td></td>
<td>0.17 (±0.03)a</td>
<td>0.20 (±0.01)a</td>
</tr>
<tr>
<td>Acidity (% lactic acid)</td>
<td>Ginger</td>
<td>0.07 (±0.03)a</td>
</tr>
<tr>
<td></td>
<td>0.10 (±0.05)a</td>
<td>0.19 (±0.03)a</td>
</tr>
<tr>
<td>pH</td>
<td>Kiwi</td>
<td>Ginger</td>
</tr>
<tr>
<td></td>
<td>5.7 (±0.03)a</td>
<td>5.7 (±0.03)a</td>
</tr>
<tr>
<td></td>
<td>6.5 (±0.01)a</td>
<td>6.4 (±0.05)a</td>
</tr>
<tr>
<td></td>
<td>5.1 (±0.02)a</td>
<td>5.0 (±0.06)a</td>
</tr>
<tr>
<td>Protein (g.100g−1)</td>
<td>Kiwi</td>
<td>Ginger</td>
</tr>
<tr>
<td></td>
<td>5.48 (±0.09)a</td>
<td>5.55 (±0.07)a</td>
</tr>
<tr>
<td></td>
<td>4.72 (±0.10)a</td>
<td>4.82 (±0.08)a</td>
</tr>
<tr>
<td></td>
<td>10.05 (±0.04)a</td>
<td>10.00 (±0.05)a</td>
</tr>
</tbody>
</table>

Mean ± standard deviation followed by same letters in the lines for each storage time of each tofu indicate no significant difference at the 5% level (Tukey test).

The acidity values for tofu I and II coagulated with kiwi, ginger, and lemon showed no significant differences (p < 0.05) between the 1st and 7th day of storage. Similar results of this work were obtained by Fasoyiro (2014), with tofu produced with...
soybean of the cultivar TGX-1448-IE (coagulated with different concentrations of dried Roselle flowers), with acidity values of 0.16% to 0.42%. According to Fasoyiro (2014), the tofu acidity values are dependent on the coagulant used.

The pH values for tofu I and II coagulated with kiwi, ginger and lemon presented no significant difference (p < 0.05) between the 1st and 7th day of storage. Values close to this work for pH were found by Fasoyiro (2014), between 5.3 and 6.2, for tofu obtained by soybean of the cultivar TGX-1448-IE, coagulated with different concentrations of dried Roselle flowers.

The protein for tofu I and II coagulated with kiwi, ginger and lemon showed no significant difference (p < 0.05) between the 1st and 7th day of storage. More protein was observed in tofu I coagulated with lemon and in tofu (coagulated with kiwi, ginger and lemon). Kamizake et al. (2016) found similar values to this work for tofu I (with kiwi and ginger) using tofu made from soybean of cultivars Coodetec 214 and BRS 267, coagulated with MgSO₄·7H₂O, obtaining values of 6.56 g.100g⁻¹ and 7.86 g.100g⁻¹, respectively. Li et al. (2015), with tofu of organic soybean, coagulated with MgCl₂ observed value of 13.72 g.100g⁻¹. Higher values were found by Benassi et al. (2011), using different soybean cultivars, coagulated with CaSO₄ obtained mean values of 52.75 g.100g⁻¹.

Table 2 show the yield results and syneresis index of tofu I and II obtained with kiwi, ginger and lemon.

In relation to tofu I, was observed that the coagulant of kiwi and ginger showed higher yield compared to lemon coagulant, and this can be justified due to the differences in the coagulation conditions (80 °C and pH 2.0 to lemon, 65 °C and pH 6.0 to ginger, 40 °C and pH 4.0 to kiwi) and because not have occurred whey release, and they showed less firm aspect and not complete syneresis, what caused higher yield.

However, tofu I with lemon coagulant showed firm aspect, losing more whey, and therefore, with less yield. Tofu II presented similar yields for the different coagulants, possibly due to the coagulants pH adjustment. Fasoyiro (2014) found higher values than this work, with values of 87.3 g.100g⁻¹ for tofu produced with soybean of cultivar TGX-1448-IE, coagulated with different concentrations of dried Roselle flowers. According to Kong et al. (2008), the coagulation step, stirring speed, pH and concentration of coagulant are factors that interfere on the tofu yield.

**Table 2.** Results of yield and syneresis index for tofu I and II obtained with kiwi, ginger and lemon.

<table>
<thead>
<tr>
<th>Process</th>
<th>yield (g tofu.100g⁻¹ grain)</th>
<th>Syneresis index (%)</th>
<th>Storage Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1st</td>
</tr>
<tr>
<td>Tofu I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kiwi</td>
<td>23.82</td>
<td>44.33 (±0.16)</td>
<td>7.96 (±1.41) b</td>
</tr>
<tr>
<td>Ginger</td>
<td>33.29</td>
<td>39.51 (±0.12)</td>
<td>4.68 (±1.19) b</td>
</tr>
<tr>
<td>Lemon</td>
<td>11.82</td>
<td>10.99 (±0.08)</td>
<td>1.46 (±0.19) b</td>
</tr>
<tr>
<td>Tofu II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kiwi</td>
<td>10.94</td>
<td>9.70 (±1.74)</td>
<td>4.87 (±0.18) b</td>
</tr>
<tr>
<td>Ginger</td>
<td>10.66</td>
<td>7.86 (±1.21)</td>
<td>2.47 (±1.39) b</td>
</tr>
<tr>
<td>Lemon</td>
<td>10.65</td>
<td>8.21 (±1.43)</td>
<td>4.30 (±0.92) b</td>
</tr>
</tbody>
</table>

Mean ± standard deviation followed by same letters in the lines for each storage time of each tofu, indicate no significant difference at the 5% level (Tukey test).
The syneresis index values (Table 2) shows that there was a significant difference (p <0.05) between the 1st and 7th day of storage in the tofu I and II for the three coagulants. Tofu I of kiwi and ginger released more whey than lemon, being higher on 1st day of storage. This is due during whey released, the tofu of kiwi and ginger presented aqueous consistency, not releasing the whey. Already syneresis of tofu II was lower than the tofu I, regardless of the coagulant, being lower on the 7th day of storage. This behavior is due to increase of protein precipitation during the tofu processing, causing increased of whey, consequently, there is less whey to be released during storage.

Table 3 presents the mean values of color of tofu I and II obtained with kiwi, ginger and lemon, on the 1st and 7th day of storage. There is no significant difference (p <0.05) in the brightness (L) for tofu I and II between the 1st and 7th day of storage. However, the intensity of yellow (b) for tofu I and II presented significant difference (p >0.05) during the storage.

Ciabotti et al. (2007) reported that the color characteristic of tofu, commonly express the quality of product, ranging from the white and the light yellow. Therefore, according to this information, it is observed that the tofu I and II of this work losing yellow intensity (b), that is, losing quality during the storage. Kamizake et al. (2016) found similar results to this study, in tofu from soybean of cultivar Coodetec 214 and BRS 267, coagulated with MgSO₄·7H₂O obtaining brightness values (L) of 86.20 and 84.82, respectively. Ciabotti et al. (2007), for tofu with normal soybean (coagulated with Glucono-δ-lactone (GDL)), obtaining results of brightness (L) of 84.81 and yellow intensity value (b) of 11.08.

**Table 3.** Results of instrumental color of tofu I and II obtained with kiwi, ginger and lemon at 1st and 7th days storage.

<table>
<thead>
<tr>
<th>Process</th>
<th>Storage Days</th>
<th>1st</th>
<th>7th</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L*</td>
<td>b*</td>
<td>L*</td>
</tr>
<tr>
<td>Tofu I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kiwi</td>
<td>89.64 (±0.07)a</td>
<td>13.65 (±0.04)a</td>
<td>82.40 (±0.10)a</td>
</tr>
<tr>
<td>Ginger</td>
<td>86.67 (±0.18)a</td>
<td>11.35 (±0.03)a</td>
<td>84.03 (±1.00)a</td>
</tr>
<tr>
<td>Lemon</td>
<td>89.13 (±3.60)a</td>
<td>12.79 (±0.26)a</td>
<td>83.59 (±0.55)a</td>
</tr>
<tr>
<td>Tofu II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kiwi</td>
<td>85.21 (±0.48)a</td>
<td>15.62 (±0.49)a</td>
<td>84.67 (±0.15)a</td>
</tr>
<tr>
<td>Ginger</td>
<td>85.58 (±0.66)a</td>
<td>13.52 (±0.10)a</td>
<td>84.92 (±0.02)a</td>
</tr>
<tr>
<td>Lemon</td>
<td>86.14 (±0.44)a</td>
<td>13.84 (±0.52)a</td>
<td>85.79 (±0.14)a</td>
</tr>
</tbody>
</table>

Mean ± standard deviation followed by same letters in the lines for each storage time of each tofu indicate no significant difference at the 5% level (Tukey test). Where: L = brightness, ranging from black (0) to white (100); b = blue range (-60) to yellow (60).

Microbiological results for tofu I and II on the 1st and 7th day of storage for total coliforms, thermo tolerant coliforms and psychrophilic bacteria, remained within the standards established by Brazilian low (BRASIL, 2001), where is established to tofus that coliforms at 45°C, must have values less than 10² MPN·g⁻¹ and the total count of psychrophilic bacteria has not counting standard for tofu. These results indicate that in the analyzed period, the tofu I and II are in adequate sanitary conditions for the consumption.
CONCLUSIONS

From a technological point of view, it can be concluded that using coagulants of kiwi, lemon and ginger, with pH 2.0 and coagulation temperature of 80°C is possible to obtain the better coagulation, that is, tofu with firm mass. Thus, tofu prepared with vegetable coagulants is one alternative of product for vegan’s consumers.

ACKNOWLEDGMENTS

The authors would like to thank URI Erechim, CNPq, CAPES and FAPERGS for the infra-structure and financial support for this research.

REFERENCES


Effects of vegetable...


MAZORRA-MANZANO, M.A.; MORENO-HERNÁNDEZ, J.M.; RAMÍREZ-SUAREZ, J.; TORRES-LLANEZ, M.J.; GONZÁLEZ-...
