Summary

Postharvest treatments of organic strawberries are necessary to maintain high quality of the product for longer periods, to reduce post-harvest losses and to add value. The present study appraised the use of a coating process using 2.5% cassava starch in combination with 1% copaiba oil in the post-harvest period. In addition, it aimed to evaluate the physical, chemical and microbiological characteristics of ‘Camarosa’ strawberries produced by an organic system and stored at 11 ± 0.7 °C and 80-90% relative humidity. The physical analyses of the stored fruit were carried out every three days. The sensory analysis of the fruit appearance was carried out on day 12 of storage, that is, when the fruit were appropriate for sale. The fruit coated with a combination of cassava starch and copaiba oil did not last any longer, but showed a lower weight loss if compared with the control fruit. There were no differences in the development of color, rottenness, pH and soluble solids during storage. The mean values for titratable acidity of the fruit increased slightly during storage, and the fruit coated with cassava starch showed higher values for acidity after six days. The addition of 1% copaiba oil to the 2.5% cassava starch reduced the acceptability of the fruit, due to its darker colour, and no anti-microbial action was observed.

Key words: Fragaria × ananassa Duch.; Postharvest; Modified atmosphere; Copaiba oil; Cassava starch.

Resumo

Tratamentos pós-colheita em morango orgânico são necessários para manter a alta qualidade dos frutos, reduzir perdas pós-colheita e agregar valor. O presente estudo avaliou o revestimento utilizando 2,5% de fécula de mandioca e este em combinação com 1% de óleo de copaiba em morango orgânico ‘Camarosa’, no período pós-colheita, por meio de avaliações das características físicas, químicas e microbiológicas durante o armazenamento a 11 °C e 80-90% de umidade relativa. A análise física dos frutos foi realizada de três em três dias e a análise sensorial do atributo aparência foi feita aos doze dias de armazenamento, enquanto os frutos estavam adequados para a venda. Frutos com revestimento de fécula de mandioca e em combinação com óleo de copaiba apresentaram menor perda de massa do que o grupo controle. Não houve diferenças na evolução da cor, podridões, pH e sólidos solúveis durante o armazenamento. Os valores médios de acidez titulável aumentaram ligeiramente durante o armazenamento dos frutos, por outro lado, frutos revestidos de fécula de mandioca tinham valores mais elevados após seis dias. A adição de 1% de óleo de copaiba reduziu a aceitabilidade das frutas, devido ao revestimento mais escuro, e não foi verificada ação antimicrobiana.

Palavras-chave: Fragaria x ananassa Duch.; Pós-colheita; Atmosfera modificada; Óleo de copaiba; Fécula de mandioca.
1 Introduction

The production of conventional strawberry is highly dependent on agrochemicals. However, if cultivated under an organic management system, the process favours a balanced nutrition of the plants, producing healthier fruit and eliminating the risk of contaminating the food, rural workers and the environment. It is possible to produce high quality strawberries without pesticides and to maintain a high commercial standard (SCHERER et al., 2003).

Strawberry is internationally appreciated for its attractive and nutritious aspects as well as for its good flavour. However its postharvest conservation is difficult because of its high rate of metabolic activity and great susceptibility to the attack of pathogens.

Besides using refrigerated cooling, many authors have tested biodegradable coatings to prolong life of the fruit and maintain quality (PARK et al., 2005; TANADA-PALMU and GROSSO, 2006). The application of 1, 2 and 3% cassava (Manihot esculenta Crantz.) starch coatings to strawberries decreased weight loss and improved texture, thus prolonging fruit quality for 10 days, with no difference in the sensory analysis and no loss of visual fruit quality (HENRIQUE and CEREDA, 1999). Cassava starch has positive attributes - it is not sticky or poisonous, it is shiny and transparent, it can be ingested together with the protected product or it can be removed by water, and it is also a low cost commercial product.

An outer layer or coating on strawberries regulates the loss of water in the form of vapour, which results in weight loss, and fruit gas-exchanges provoked by the external environment, which can include the loss of volatiles responsible for the fruit flavour and odour (CHITARRA and CHITARRA, 2005). Fruit coatings have numerous advantages - they are biodegradable and show good barrier and physical protection properties, contributing to an improved appearance of the foods and providing protection during storage and handling (VILLADIEGO et al., 2005). Combined polysaccharide and lipid films show the mechanical and gas barrier properties of polysaccharides, combined with the water vapour barrier properties of lipids. The addition of sunflower oil to a starch base has significantly diminished water vapour permeability to (GARCIA et al., 2000).

Besides providing semi-permeable barriers, the coating can also transport nutritious ingredients, such as antioxidants, anti-microbial agents and flavourings (KROCHTA and MULDEN-JOHNSTON, 1997). Innovations in edible films and coverings aim to reduce, inhibit or delay the growth of microorganisms in foods, and have been developed by adding components with anti-microbial properties (APPENDINI and HOTCHKISS, 2002). Copaiba oil ( Copaifera spp.) is a natural product, considered to be an efficient anti-microbial agent (MACIEL et al., 2005), but there is a lack of research on its application to fruits.

The use of different post-harvest treatments is necessary to reduce the losses associated with organic production, and to maintain product quality for longer. The present investigation appraised the use of a 2.5% cassava starch coating and its combination with 1% copaiba oil, in prolonging the life of strawberry fruits (Fragaria × ananassa Duch.). In addition, the physiochemical characteristics of cv. Camarosa produced by organic systems were studied, when stored in a cooled system.

2 Material and methods

2.1 Fruit material

In September 2006, 1000 strawberry fruits (Fragaria × ananassa Duch.) cv. Camarosa were picked when 75% of the fruit surface was red. The fruit came from an organic producer, located in Warta, in the municipal district of Londrina (Paraná State, Brazil), certified by the Foundation Mokiti Okada. The fruits were received at the laboratory of Food Biochemistry of the State University of Maringá, Paraná State, two hours after being picked, and were selected according to size, colour, and lack of physical damage and fungal infection.

2.2 Procedures

The 2.5% cassava starch coating was made by heating a suspension of 50 g of dry starch in 2 L of distilled water with constant stirring. The starch jellification process occurred in approximately 30 min at 70 °C and the mixtures were then left at rest to cool to room temperature. The fruit were immersed in the cooled mixtures for 1 min and then placed on a nylon drainer to remove excess liquid. The copaiba oil coating was made by adding 20 g of the oil to 2 L of 2.5% cassava starch suspension, and mechanically agitating/rotating for 2 min at room temperature. These fruit were then immersed in these suspensions for 1 min all together, and then removed using a plastic skimmer and placed on a nylon drainer to remove excess coating.

The fruit were stored in a Biological Oxygen Demand unit at 11 ± 0.7 °C and 80-90% relative humidity (RH) for 12 days, aiming to reproduce the environment of the chilled display units used in supermarkets. The fruits have were stored for as long as they were appropriate for sale.

2.3 Physical analysis

The fruits were distributed into 10 fruit portions and conditioned in transparent plastic boxes with polyethylene terephthalate lids, preparing five replications for each sample. The fruits were analyzed at the beginning of the experiment and every three days during storage.
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2.3.1 Weight loss

The portions were weighed on a semi-analytical scale (BG 4.400, Gehaka, São Paulo, Brazil) to calculate the weight loss during storage i.e. Weight loss (g.100 g–1) = [(Initial Weight – Final Weight)/Initial Weight] ×100, expressed in % of fresh mass loss.

2.3.2 Colouration

Subjective scales of from 1-3 were used to classify fruit colour: score 1 was 75% of epidermis with a red colour, score 2 was 75-95% red epidermis, and score 3 was >95%. The average for each portion was calculated from the sum of the scores for all the fruits in the portion.

2.3.3 Rottenness

Rottenness was classified according to the number of rotten areas of the following sizes: 1-3; 4-6; 7-9 and >10 mm. Fruits with a rotten area >10 mm were discarded, and expressed as a percentage of waste.

2.4 Chemical analysis

The samples were homogenized for 2 min in a Britânia Mixer (Brazil), six fruits per test, according to Carvalho et al. (1990). Three replicates were used for each treatment and the analysis performed in duplicate. The fruits were analyzed at the beginning of the experiment and every three days during storage.

2.4.1 Soluble solids

Soluble solids (SS), expressed in °Brix, were measured with a pocket refractometer (PAL-1, Atago, Washington, U.S.A.), as described by Carvalho et al. (1990).

2.4.2 Titratable acidity

The titratable acidity (TA) was determined by titration with standardised NaOH 0.1 mol.L–1, homogenising 10 g of sample in 100 mL of water and titrating to pH 8.1. The TA was expressed in g citric acid .100 g –1 pulp (CARVALHO et al., 1990).

2.4.3 pH

The pH was determined by direct reading on a potentiometer (pH300, Hanna Instruments Brazil, São Paulo, Brazil), using the same homogenate prepared for AT before titration.

2.4.4 Ascorbic acid

Ascorbic acid was determined by titration using the sodium 2,6-dichlorophenolindophenol method, standardized using ascorbic acid and expressed in mg ascorbic acid.100 g –1 pulp (CARVALHO et al., 1990).

2.5 Sensory analysis – fruit appearance

Thirty-eight judges evaluated fruit appearance using a hedonic scale varying from ‘disliked immensely’ (value 1) to ‘liked immensely’ (value 9) (MONTEIRO, 2005). Fruits coated with 2.5% cassava starch + 1% copaiba oil were first evaluated with the coatings and subsequently after removal of the coating under running water. The fruits were analyzed after 12 days at low temperature.

2.6 Microbiological assays

The fresh fruits were analyzed for total and heat tolerant coliforms, mesophilic and psychrotrophic microorganisms and for yeasts and moulds. The controls and coated samples were analyzed after 12 days of storage at 11 °C. For each determination, 25 g samples were homogenized for 60 s according to APHA (2001). The viable counts were expressed as log colony forming units (CFU) g –1 fruit.

2.7 Statistical analyses

Analyses of the chemical characteristics were performed with the software SAS (2000), using the programme PROC GLM and PROC REG to choose and adjust the models.

The physical and sensory analyses were evaluated by ANOVA. For each variable a Scott-Knot test was carried out (RAMALHO et al., 2000), with p < 0.05 being considered significant, using the 4.2 Sisvar program, developed in the Pure Science Department of the Federal University of Lavras, Minas Gerais State, Brazil.

3 Results and discussion

3.1 Shelf life, weight loss and colour development

The cv. Camarosa strawberries produced in an organic system, had a 12 day shelf life when stored under cooled conditions (11 ± 0.7 °C and 80-90% RH), all fruits being appropriate for sale. Similarly, Malil and Grossmann (2003) achieved a 14 day shelf life for cv. Dover when coated with yam starch and glycerol and cooled to 4 °C. The cvs. Selva and Diamante showed a 9-day shelf life when stored at 5 °C for 11 days, in an atmosphere with 20 kPa CO 2 (PELAYO et al., 2003). Such a storage life was similar to that of the cooled cv. Camarosa in the present study. However, the cassava starch coating did not increase the storage period, as reported by Henrique and Cereda (1999).

According to Terrazzan et al. (2006), regardless of the crop system adopted (organic or conventional)
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strawberries cv. Oso Grande showed a maximum shelf life of 6 days, with subsequent losses of fresh mass above 10%, during storage at 1 or 11 °C and 70% RH.

The weight loss and colour development of the strawberries increased with storage time under the cooled conditions, for both the control and coated fruits (Table 1). However, the fruits with cassava starch or cassava starch plus copaiba oil coatings showed lower weight losses than the controls, reaching 9.80% after 12 days of storage.

Fruits coated with cassava starch lost 6.67% of weight during refrigerated storage; and when combined with copaiba oil, they lost 6.93%, a value not significantly different. According to Cantillano (2003), a maximum weight loss of 6% is recommended for strawberries to avoid depreciation of the fruit appearance.

Fruit coated with only cassava starch lost 6.67% of weight during refrigerated storage; and 6.93% when combined with copaiba oil, a value not significantly different. According to Cantillano (2003), the maximum weight loss recommended for strawberry is 6% to avoid depreciation in fruit appearance.

The loss in weight of organic cv. Oso Grande strawberries coated with gluten combined with a solution of beeswax and stearic and palmitic acids was < 10%, when stored wrapped in PVC film for 16 days at 7-10 °C and 60-80% RH (TANADA-PALMU and GROSSO, 2005). The control group and those only coated with gluten showed a weight loss > 50%. Nevertheless, the small difference in weight loss between coated and non-coated fruits obtained in the present investigation, can be attributed to the relatively high storage humidity and to the plastic packing used.

A mean value of about 2.7 was obtained for the fruit colour at the beginning of the experiment, showing a rapid development of red colour during installation of the experiment, and therefore the fruits were harvested with 75% of red epidermis. Considering both the concentrations used and the combination with copaiba oil, the cassava starch coating did not interfere with the fruit colour (total red colour) after nine days of storage. Ribeiro et al. (2007) made a similar finding of no significant difference in strawberries coated with different compounds, such as starch, carrageenan and chitosan. Del-Valle et al. (2005) also found that the strawberry colour was not affected by using an edible coating of cactus mucilage.

3.2 Rottenness

Small lesions began to develop on day 3 of storage, and the first discards were made on day 6 (Table 2).

**Anthracnose (Colletotrichum sp.) and Rhizopus sp.** lesions were observed on the strawberries. Generally the coated fruits showed a smaller number of injuries of all sizes. However the number and size of the lesions intensified on days 9 and 12, with the results that a total of 22% of the control fruits, 28% of the cassava starch coated fruits and 34% of the starch and copaiba oil coated fruits were discarded.

A high incidence of decay was also verified by Tanada-Palmu and Grosso (2005), who reported 40% rottenness in gluten coated strawberries after 16 days of cold storage and 30% in fruits coated with a compound made from gluten with beeswax and stearic and palmitic acids and also in double-coated fruits, coated first with the gluten and then with the beeswax and acids formulation. Brackmann et al. (1999) found >40% of rottenness in cv. Tangi stored for five days at 20 °C, even with a supply of 20 kPa CO$_2$.

The fruit coated with starch and copaiba oil reached the highest rate of discarding, in disagreement with the trials of Baldwin et al. (2006), who found a significant reduction in disease in strawberries stored after immersion in pectin oligomers with a polymerization degree of 8–24, for 10s, which favoured ethylene production and probably allowed for the induction of systemic resistance in the fruits.

3.3 pH, soluble solids, titratable acidity and ascorbic acid

The mean fruit pH varied from 2.98 to 3.28 (Figure 1) and mean SS (Figure 2) from 5.93 to 7.53 °Brix, showing no trends, either during storage or between treatments.

### Table 1. Weight loss and colouration of cv Camarosa strawberries produced in an organic system and submitted to coating with 2.5% cassava starch (Starch), and starch + 1% copaiba oil (Cop.Oil), stored at 11 ± 0.7 °C and 80-90% RH.

<table>
<thead>
<tr>
<th>Storage (days)</th>
<th>Weight loss (%)</th>
<th>Colouration (score 1-3)**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control Starch</td>
<td>Cop.Oil</td>
</tr>
<tr>
<td></td>
<td>Control Starch</td>
<td>Cop.Oil</td>
</tr>
<tr>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>1.92*</td>
<td>2.14*</td>
</tr>
<tr>
<td>6</td>
<td>3.53*</td>
<td>3.43*</td>
</tr>
<tr>
<td>9</td>
<td>7.49*</td>
<td>4.97*</td>
</tr>
<tr>
<td>12</td>
<td>9.80*</td>
<td>6.67*</td>
</tr>
<tr>
<td></td>
<td>Control Starch</td>
<td>Cop.Oil</td>
</tr>
<tr>
<td></td>
<td>2.74*</td>
<td>2.68*</td>
</tr>
<tr>
<td></td>
<td>2.96*</td>
<td>2.92*</td>
</tr>
<tr>
<td></td>
<td>2.98*</td>
<td>2.98*</td>
</tr>
<tr>
<td></td>
<td>3.00*</td>
<td>3.00*</td>
</tr>
<tr>
<td></td>
<td>3.00*</td>
<td>3.00*</td>
</tr>
</tbody>
</table>

* Values with different letters in the same line are statistically different (p ≤ 0.05); ** score 1 indicated 75% red fruit epidermis, score 2 indicated 75-95% red epidermis, and score 3 > 95% red epidermis.
After the sixth day of storage, the fruits coated only with cassava starch showed significantly higher TA than uncoated fruits and those coated with starch and copaiba oil. These significant changes in the TA contents, not accompanied by changes in the pH, can be explained by the buffering capacity of the strawberry pulp due to the high citric acid content, and to the liberation of ions into the aqueous environment, acting as a buffer and moderating the pH changes (LEHNINGER, 1976).

The initial mean vitamin C content was 49.35 mg ascorbic acid/100 g pulp, and was not significantly different from those of the starch and starch with copaiba oil coated fruits (49.71 and 49.38 mg ascorbic acid/100 g–1, respectively) after cold storage for 3 days (Figure 4).

Cordenunsi et al. (2003) found higher pH values from 3.5 to 3.8 for the cvs. Oso Grande, Dover, Campineiro and Mazi, even under cold storage.

Similarly, Terrazzan et al. (2006) and Malgarim et al. (2006a) found variations in the levels of soluble solids, but with no significant differences between the treatments or storage periods. The packing of cv. Sequoia in PVC did not interfere with the pH, SS or TA values during storage for 14 days at 4 °C (SCALON et al., 1996).

The fruits showed initial total TA values of 0.98 g citric acid.100 g–1 pulp, with small increases for all treatments during low temperature storage (Figure 3).

Terrazzan et al. (2006) also found a small increase in TA during cold storage at 1 or 11 °C for organic ‘Oso Grande’ strawberries, with an initial value of 0.84 g citric acid.100 g–1 pulp.

After the sixth day of storage, the fruits coated only with cassava starch showed significantly higher TA than uncoated fruits and those coated with starch and copaiba oil. These significant changes in the TA contents, not accompanied by changes in the pH, can be explained by the buffering capacity of the strawberry pulp due to the high citric acid content, and to the liberation of ions into the aqueous environment, acting as a buffer and moderating the pH changes (LEHNINGER, 1976).

The initial mean vitamin C content was 49.35 mg ascorbic acid/100 g pulp, and was not significantly different from those of the starch and starch with copaiba oil coated fruits (49.71 and 49.38 mg ascorbic acid.100 g–1, respectively) after cold storage for 3 days (Figure 4).

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**Table 2.** Evolution of the average number of injuries and discarding of organic strawberries, cv. Camarosa, submitted to coating with 2.5% cassava starch (Starch), and starch + 1% copaiba oil (Cop.Oil), stored at a temperature of 11 ± 0.7 °C and 80-90% RH.

<table>
<thead>
<tr>
<th>Days</th>
<th>Treatment</th>
<th>1-3 mm</th>
<th>4-6 mm</th>
<th>7-9 mm</th>
<th>&gt;10 mm</th>
<th>Discarding (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Control</td>
<td>6.4</td>
<td>6.4</td>
<td>1.0</td>
<td>0.6</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Starch</td>
<td>5.4</td>
<td>5.8</td>
<td>1.6</td>
<td>0.6</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Cop.Oil</td>
<td>5.8</td>
<td>2.8</td>
<td>0.6</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Control</td>
<td>10.0</td>
<td>9.7</td>
<td>1.0</td>
<td>0.8</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Starch</td>
<td>7.2</td>
<td>7.2</td>
<td>0.6</td>
<td>0.4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Cop.Oil</td>
<td>8.0</td>
<td>7.2</td>
<td>0.4</td>
<td>0.0</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>Control</td>
<td>11.4</td>
<td>7.6</td>
<td>1.8</td>
<td>1.2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Starch</td>
<td>8.0</td>
<td>4.4</td>
<td>0.8</td>
<td>0.8</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Cop.Oil</td>
<td>12.4</td>
<td>6.4</td>
<td>0.8</td>
<td>1.4</td>
<td>10</td>
</tr>
<tr>
<td>12</td>
<td>Control</td>
<td>10.2</td>
<td>7.6</td>
<td>1.6</td>
<td>1.4</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Starch</td>
<td>5.2</td>
<td>7.0</td>
<td>1.2</td>
<td>1.2</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Cop.Oil</td>
<td>2.0</td>
<td>7.4</td>
<td>1.4</td>
<td>1.4</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>38.0</td>
<td>31.3</td>
<td>5.4</td>
<td>4.0</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Starch</td>
<td>25.8</td>
<td>24.4</td>
<td>4.2</td>
<td>3.0</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Cop.Oil</td>
<td>28.2</td>
<td>23.8</td>
<td>3.2</td>
<td>2.8</td>
<td>34</td>
</tr>
</tbody>
</table>

---

**Figure 1.** pH values for organic strawberries, cv Camarosa, submitted to coating with 2.5% cassava starch (Starch) and starch + 1% copaiba oil (Cop.Oil), stored for twelve days at 11 ± 0.7 °C and 80-90% RH.

**Figure 2.** Soluble Solids of organic strawberries, cv Camarosa, submitted to coating with 2.5% cassava starch (Starch), and starch + 1% copaiba (Cop.Oil), stored for twelve days at 11 ± 0.7 °C and 80-90% RH.
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The starch and starch plus copaiba oil coated fruits maintained their initial vitamin C contents up to the third day of cold storage. After this period, there was a decrease, with the lowest values reaching 34.78, 33.88 and 33.61 mg ascorbic acid.100 g⁻¹ pulp for the control, starch and copaiba oil groups, respectively. The mean values for the treatments decreased with continued storage. There were significant differences amongst the groups, being higher for the controls on day 9, and for the copaiba oil samples on day 12. Similar results were obtained by Malgarim et al. (2006b) and Zaicovski et al. (2006), with decreasing vitamin C during the storage of ‘Camarosa’ strawberry, and by Calegaro et al. (2002) for ‘Oso Grande’ strawberries. Malgarim et al. (2006b) wrapped the strawberries in polyethylene film, and found values of 32.20 mg.100 mL⁻³ of juice after 9 days at 0 °C and after 3 days at 8 °C.

According to Chitarra and Chitarra (2005), the reduction in the level of ascorbic acid is due to the direct action of the enzyme ascorbic acid oxidase or to the action of oxidases such as peroxidase.

3.4 Fruit appearance

Appearance is one of the main quality attributes of fruits and interferes with consumer decisions to purchase. After 12 days of storage, the control fruits did not differ from the cassava starch coated fruits, showing similar values of seven ‘I quite liked it’ (Figure 5).

Although the cassava starch coating improved the fruit appearance by making it more shiny, due to the lower weight loss, it was liked less than the control group, because of the twisted sepals.

The fruits coated with cassava starch and copaiba oil received a mean score of 2.4 ‘disliked considerably’; and those eaten after being washed of 4.3 ‘disliked a bit’. The addition of copaiba oil, as an anti-microbial agent, reduced the acceptability of the fruit due to the dark appearance of the coating, and when washed the rejection decreased. A different result was obtained by Fakhouri et al. (2007) for the sensory evaluation of grapes coated with 3% starch and 1% gelatine, in which the fruit acceptability was the same or higher than that of the control group, when considering overall appearance, shine, colour and intention to purchase.

3.5 Microbial counts

Table 3 shows that the total and heat tolerant coliform counts were inferior to 1 x 10¹ CFUs.g⁻¹ of fruit for all the treatments studied. After 12 days of storage the non coated fruits showed the highest mesophilic and psychrotrophic microbial counts and yeast and mould counts, with 5.6 x 10⁴, 1.10 x 10⁵ and 7.14 x 10⁵ CFU.g⁻¹, respectively.
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Table 3. Microbial counts in fresh cv. Camarosa strawberries produced in an organic system, and submitted to coating with 2.5% cassava starch (Starch) and starch + 1% copaiba oil (Cop.Oil), and stored for twelve days at 11 ± 0.7 °C and 80-90% RH.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Total coliforms (CFU.g⁻¹ fruit)</th>
<th>Heat tolerant coliforms (CFU.g⁻¹ fruit)</th>
<th>Mesophilic (CFU.g⁻¹ fruit)</th>
<th>Psychrotrophic (CFU.g⁻¹ fruit)</th>
<th>Yeasts and moulds (CFU.g⁻¹ fruit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh</td>
<td>&lt;1.00 x 10¹</td>
<td>&lt;1.00 x 10¹</td>
<td>1.91 x 10³</td>
<td>1.70 x 10³</td>
<td>1.18 x 10⁶</td>
</tr>
<tr>
<td>12 days:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>&lt;1.00 x 10¹</td>
<td>&lt;1.00 x 10¹</td>
<td>5.60 x 10⁴</td>
<td>1.10 x 10⁴</td>
<td>7.14 x 10⁵</td>
</tr>
<tr>
<td>Starch</td>
<td>&lt;1.00 x 10¹</td>
<td>&lt;1.00 x 10¹</td>
<td>1.80 x 10³</td>
<td>2.00 x 10⁴</td>
<td>9.00 x 10⁴</td>
</tr>
<tr>
<td>Cop. Oil</td>
<td>&lt;1.00 x 10¹</td>
<td>&lt;1.00 x 10¹</td>
<td>1.00 x 10³</td>
<td>2.30 x 10²</td>
<td>7.80 x 10⁴</td>
</tr>
</tbody>
</table>

The cassava starch and cassava starch plus copaiba oil coated fruits showed the lowest values.

These results were in agreement with those of Mali and Grossmann (2003), who found a reduction in mesophilic and psychrotrophic microorganisms, yeasts and moulds in cv. Dover coated with/inhame starch based films.

According to Siro et al. (2006), prolonging the shelf life of strawberry cv. Camarosa by storage in a modified passive atmosphere and an oxygen-rich atmosphere did not favour an increase in the acid-resistant pathogens: *Escherichia coli*, *Listeria monocytogenes* and *Salmonella* spp., that had been artificially inoculated into the packaged fruits. However, the restricted development and survival of these microorganisms is possible in fruit stored at 7 °C. Ribeiro et al. (2007) found that polysaccharides such as 2% starch, 0.3% carrageenan and 1% chitosan resulted in less microbial development than in strawberries coated with chitosan combined with calcium chloride. Chitosan coating controlled the development of Rhizopus sp. and Cladosporium sp., when combined with potassium sorbate, and controlled aerobic coliforms and microorganisms during cold storage (PARK et al., 2005).

## 4 Conclusion
The cassava starch and cassava starch plus copaiba oil coatings did not increase the shelf life of organic 'Camarosa' strawberries, but resulted in reduced weight loss as compared to the control and lower counts of mesophilic and psychrotrophic microorganisms and of yeasts and moulds.

The coatings did not interfere with fruit colouring, pH or soluble solids contents during cold storage. They did not increase the scores for the appearance of the fruits, and the addition of copaiba oil reduced the acceptability of the fruit.

## References
Coating on ‘Camarosa’ organic strawberries stored at low temperature

CAMPOS, R. P. et al.


