

Physical-chemical and Microbiological Characteristics of Organic Strawberries Conserved with Biofilms and Refrigeration

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Abstract

Biodegradable and edible coatings were applied on fresh strawberries (*Fragaria x ananassa Duch*), 'Camarosa cultivar', produced in organic system and stored at 10°C for nine days. Color, mass loss, incidence of rottenness and chemical analyses contents was evaluated. Suspension of cassava starch and grains of kefir milk reduced evolution of fruit coloration when compared uncoated fruits. Treatment associated cassava starch and kefir liquid resulted in a lower rottenness incidence and less mass loss of the fruits, is therefore recommended for postharvest organic strawberries. Anthocyanin and titrable acidity contents increased during storage, regardless of the treatments in general.

Keywords: *Fragaria x ananassa* duch, 'Camarosa' cultivar, organic system, postharvest, coatings

1. Introduction

Strawberry (*Fragaria x ananassa Duch*) is appreciated in the whole world because of its nutritional qualities, flavor and peculiar appearance, being consumed 'in natura' or industrially processed (Reichert & Madail, 2003). 'Camarosa' is one of the most cultivated cultivars in Brazil (Emater, 2001). It has precocious cycle and high production capacity. The strawberry is classified as a non-climacteric fruit; however, it presents respiratory activity, which leads to fast deterioration when maintained at room temperature (Santos et al., 2007).

Strawberry production in organic system favors a balanced nutrition for plants, consequently resulting in healthier fruit, and eliminating the risk of contaminating the food, the rural worker and the environment with the use of pesticides. Scherer et al. (2003) states that it is possible to produce high quality strawberries with high commercial standards without making use of pesticides, although there is an amount of losses around 15%, due to insect attacks/pests and diseases. The use of different postharvest treatments that may be associated with the organic production is necessary so as to reduce losses and to keep the product quality for longer periods, enhancing the technological, economical, environmental and social development that are embedded in the productive chain of organic vegetables. Low temperatures and application of eatable films can aid in the increase of postharvest conservation of fruits (Santos et al., 2007; Oliveira et al., 2007; Tanada-Palmu & Grosso, 2005; Park et al., 2005). Eatable coatings regulate the gaseous exchanges of the product with the external environment and the water loss that results in strawberry mass loss, and also control the loss of the volatiles responsible for fruit 'flavor' (taste and aroma) (Chitarra & Chitarra, 2005).

Postharvest coatings may transport nutritional ingredients such as antioxidants, antimicrobials and flavorings, and may improve the mechanical integrity and the food handling characteristics (Krochta & Mulder-Johnston, 1997). The main limiting factors for shelf life of strawberry are the development of fungi (Siro et al., 2006). In the control of postharvest diseases has been effective method of biological control through use of microorganisms such as bacteria and fungi, which act through various mechanisms such as antibiosis, production of lytic enzymes, parasitism, induced resistance and competition for nutrients and space (Janisciewicz & Korsten, 2002). A yeast with potential for controlling diseases of plants is *Saccharomyces cerevisiae*, it presents the ability to synthesize antibiotic compounds, ability to compete for space and nutrients on the phylloplane of many plant species, and have the cell wall elicitors (Piccinin et al., 2005). In strawberries' Camarosa', treatment with preparations of *S. cerevisiae*, reduced the incidence of decay caused by *B. cinerea*, comparable to treatment with fungicides (Gouvêia, 2007). The application of microbial antagonists should be part of an integrated

management of postharvest diseases, checking compatibility with other postharvest practices commercial (Baños, 2006).

The postharvest phytopathogen control, through the induction of resistance by using natural processes, is being studied with promising results (Benato et al., 2001). The incorporation of innocuous bioactive compounds, by aspersion or biofilms, has been showing promising perspectives to the use of yeasts in the biocontrol of mycotoxigenic and deteriorating fungi (Coelho et al., 2003). There were 10 species of yeasts identified in kefir, as reported by Latorre-Garcia et al. (2007), and the main species were *Isaatchenkia orientalis*, *Saccharomyces unisporus*, *S. exiguus* and *S. humaticus*. The species found in most types of kefir grains of milk collected in Argentina were *Lactococcus lactis* subsp. *lactis*, *Lactobacillus kefir* and *L. plantarum*, *Acetobacter* and *Saccharomyces*, and the *Lactobacillus species* and *L. kefirianofaciens kefirgranum*, usually described in the kefir grains in milk, were not detected (Garrote et al., 2001). Coating made with cassava starch presents positive aspects, once it is not sticky or poisonous, it is brilliant and transparent, it may be ingested together with the protected fruit or may be removed with water, besides being a commercial product of low cost (Cereda et al., 1995). The present investigation had as main objective to evaluate biodegradable coatings in organic strawberries, 'Camarosa' cultivar, aiming at maintaining the quality and the lengthening of the fruit useful life through the evaluation of aspects such as, coloration, mass loss, incidence of rottenness and total anthocyanin contents during the storage period under refrigeration.

2. Material and Methods

In this experiment, Strawberries belonging to 'Camarosa' cultivar were used (*Fragaria x ananassa Duch*) and they were picked in $\frac{3}{4}$ ripe conditions (75% of the surface with red coloration) by visual observation. Fruits were produced in the municipality of Maringá, state of Paraná, Brazil, in an organic system certified by the Institute of Biodynamics (IBD). The strawberries were picked at 7 o'clock a.m. and received the first selection in the agricultural property, in a large packing tent, without being exposed to sunrays. Afterwards, strawberries samples were taken to the Laboratory of Food Biochemistry of the State University of Maringá (UEM), where strawberries were selected according to their size, color, shape, ripening level and sanity. 190 fruits samples were selected at random for each treatment: strawberries without coating (control, CF); samples with coating of cassava starch 2.0% (CSF); kefir liquid 15% (KL); kefir grains 15% (KG); association of CSF to KL resulting in CSKL (in a proportion of 50% each), kefiraride (whey of kefir-milk) 15% (KRD) and association of grains and milk kefir 15% (GKL).

CSF coating was obtained by heating the cassava starch suspension in distilled water under rotation/shaking. Kefir grains were cultivated with 30g of brown sugar and 30g of grains in 1.0L distilled water, which was changed every 12 hours, and maintained at room temperature. One day before its use, the proportion was duplicated. For performing KL treatment, 300 mL of kefir liquid was used, and then the solution was sieved and filled with distilled water to reach the concentration of 15%. KG was obtained from 300 g of kefir grains, added to 1.5L distilled water and maintained under heating at 50°C, and under light rotation for 30 minutes. A mixer was used for two minutes to disintegrate the grains. After reaching room temperature, a solution with concentration of 15% was obtained. CSKL coating was obtained by associating CSF to KL (in a proportion of 50% each) in a mixer, and maintained under rotation for two minutes. Strawberries were immersed in CSF, KL, KG and CSKL suspensions, and kept for one minute under light movement. They were removed and placed apart on a 'nylon' screen, so as to drain the coating excess liquid. Fruit natural drying occurred in about 3 hours. Following, strawberry samples were divided into portions of 10 fruits each, and conditioned into transparent plastic boxes type PET (tereftalato of polyethylene) with a lid without perforations (17 cm x 9.5 cm x 4.5 cm), and each packing constituted an experimental unit. The experimental outlining was totally at random with 5 treatments and six replications in each treatment. Samples were stored in a refrigerated chamber at 10°C ± 2, with relative humidity (RH) between 60 and 80%. Evaluations were carried out periodically in the 1st, 3rd, 6th and 9th day of storage under refrigeration; then mass loss and color were analyzed. The incidence of rottenness and the anthocyanin content were checked just on the 9th day of storage.

2.1 Mass Loss

Portions were weighed in a semi-analytical scale (Bel, M500), and then the loss of accumulated mass during every storage period was verified.

2.2 Color

A color subjective scale with levels from 1 to 4 was used visually, thus fruits were classified as: level 1 - presented 75% of the epidermis with red color; Level 2 - from 75 to 95% red color; Level 3- more than 95% red color and; Level 4 - attributed to fruits with 100% of intense red color. The average of each portion was

calculated by multiplying the number of strawberries by its respective mark and then dividing that value by the total number contained in the portion.

2.3 Microbiological Analyses

2.3.1 Incidence of Rottenness

Strawberries that presented rottenness were discarded along the storage period. The incidence of rottenness was separated visually by disease after the 9th day of storage.

2.3.2 Bacteriological Evaluation

Mesophilic and psychrotrophic plate counts using 25 g of strawberry disintegrated for each analysis, with serial dilution (10^{-1} , 10^{-2} and 10^{-3}) and in duplicate, following methodology of the FDA/AOAC (1995).

2.3.3 Yeasts and Molds Evaluation

Yeasts and molds were counts used method of plating in agar surface in Dichloran Rose Bengal Chloramphenicol and 25 °C/5 days of incubation.

2.4 Chemical Analyses

Each treatment was separated six fruits, in triplicate, which formed the sampling unit for the chemical analyzes. Each sample unit was homogenized in mixer for 2 minutes to perform the determination of pH, soluble solids, titratable acidity, ascorbic acid and anthocyanins. These analyzes were performed in duplicate, every three days up to nine days, during which time the fruits were looking for commercialization.

2.4.1 pH

The pH values were evaluation for digital potentiometer (Hanna Instruments, Portugal).

2.4.2 Total Soluble Solids

Determination using a portable refractometer (Atago, pocket PAL-1, Japão), and expressed in °Brix, with the necessary corrections on the environmental temperature exceeds 20°C content and acidity of fruit more than 1%, according to the methodology described by Carvalho et al. (1990).

2.4.3 Total Titratable Acidity

Determination by titration with standardized NaOH 100 mM, by using 10 g of sample diluted in 100 ml of water, using pot at pH of 8.1 and expressed in grams of acid citric 100 g⁻¹ of pulp of accordance with the methodology of AOAC (1975).

2.4.4 Ascorbic Acid Content

Ascorbic acid content was determined by titration, the reduction of 2,6-dichlorophenolindophenol sodium, standardized with ascorbic acid and expressed in mg of ascorbic acid 100 g⁻¹ of sample, according to Carvalho et al. (1990).

2.4.5 Content of Total Anthocyanins

The total anthocyanin content was determined according to Nunes et al. (2005). In order to extract anthocyanin, 2.0 g of strawberry pulp and 18 mL of a solution of methanol was acidified with 0.5% hydrochloric acid, and kept for one hour under refrigeration at 4°C. Afterwards, a dilution 1:10 was carried out and a reading was made in a spectrophotometer (Jenway, Genova, UK) at 520 nm. Results were expressed in mg 100g⁻¹ of pelargonidin-3-glycoside (PGN). The analysis was made with three replications.

2.5 Statistical Analyses

Variance analysis (ANOVA) was carried out, and for each variable a Scott-Knott test was performed, according to Ramalho et al. (2000), at 5% of probability, with aid of SISVAR software statistical program, developed by the Department of Exact Sciences of the University of Lavras- MG, Brazil.

3. Results

3.1 Physical Analyses

Strawberries belonging to 'Camarosa' cultivar, produced in organic system and coated, showed useful life of nine days if maintained under refrigerated storage. Results obtained when assaying mass loss and color evolution of strawberries without coating (CF), or coated with different films, produced in organic system and stored under refrigeration, are shown in Table 1. It may be observed that were statistical differences in mass loss (%), between the treatments and the control ($p < 0.05$), as KA and CSKL treatments had lower weight loss for the nine days of

storage, and there was a significant difference in the averages of storage time ($p < 0.05$). The reduction of fruit mass in all treatments presented increasing values, depending on the storage period. The average of the fruit initial coloration was close to 3.0 (around 95% or plus, with red color), thus showing the fast evolution of the red coloration during the application of treatments and the assembling of the parcels, since the fruits were picked with level of maturation 1 (75% of red color) (Table 1). At three days of storage, all of the fruits presented more than 95% of the epidermis with red color (level 3). These fruits presented significant differences ($p < 0.05$), through Scott-Knott test, a test for grouping averages.

Table 1. Evolution of mass loss and color in organic strawberries, belonging to ‘camarosa cultivar’, without and with coatings, stored at $10^{\circ}\text{C} \pm 2$ and 60-80% UR, for 9 days ($n=6$)

T*	Mass/Pulp Loss (%)			Coloration (levels 1-4)			
	3 days	6 days	9 days	0 days	3 days	6 days	9 days
CF	2.10 aA**	4.36 aB	8.45 aC	3.00 aD	3.18 bC	3.35 aB	3.60 aA
CS	2.81 aA	5.27 aB	9.14 aC	2.88 aC	3.10 bB	3.23 aA	3.36 bA
CSKL	1.56 bA	3.98 bB	6.86 bC	2.95 aA	3.35 aB	3.40 aB	3.51 aB
KL	3.21 aA	5.04 aB	9.25 aC	2.90 aD	3.08 bC	3.26 aB	3.47 aA
KG	2.56 aA	4.68 aB	8.97 aC	2.95 aB	3.38 aA	3.43 aA	3.57 aA
KA	2.46 aA	4.80 aB	7.35 bC	2.95 aA	3.25bB	3.37aB	3.51aC
GKA	2,88 aA	5.28 aB	8.70 aC	2.93 aA	3.25bB	3.36aB	3.37bB

*T = Treatment, n = number of replications, CF = control fruit, CS = cassava starch, CSKL = association of cassava starch 2.0% and kefir liquid 15%, KL = kefir liquid 15%, KG = kefir grains 15%; KA = kefiraride; GKA = association grains kefir and kefiraride.

**Averages with the same letters do not differ significantly among themselves by Scott-Knott test ($P < 0.05$). Small letters, in the column, stand for treatments; capital letters, in the line, stands for days, in ascending order.

3.2 Microbiological Analyses

The evolution in the incidence of rottenness in ‘Camarosa’ organic strawberries is shown in Table 2. At three days of storage, the treatment with KL was the treatment that presented the lowest losses due to rottenness in the strawberries (3.33%). The highest incidence values, at nine days of refrigerated storage, were observed in the fruits coated with CSF and with KL, an index over 70%. The lowest total rottenness incidence found was 36.18%, which occurred in CSKL fruits. In Figure 1 it may be observed the incidence of anthracnose, soft and peduncle rottenness in organic strawberries, ‘Camarosa’ cultivar, without coating (CF) and in the ones coated with CSF, KL, KG and CSKL, stored under refrigeration (10°C and RH60 -8%).

Table 2. Evolution of rottenness incidence of in ‘camarosa’ organic strawberries, without and with coatings, stored at $10^{\circ}\text{C} \pm 2$ and 60-70% UR, for 9 days ($n = 6$)

Treatments *	Incidence of rottenness (%)			
	3 days	6 days	9 days	Total
CT	0.00	10.00	48.21	58.21
CS	0.00	5.00	65.09	70.09
CSKL	0.00	3.33	32.85	36.18
KL	3.33	10.56	63.39	73.95
KG	0.00	8.33	50.66	58.99
KA	0.00	5.00	59.52	64.72
GKA	0.00	13.50	57.76	71.26

* CT = control; CSF = cassava starch 2.0%; CSKL = association of cassava starch 2.0%, and liquid of kefir water 15%; KL = liquid of kefir water 15%; KG = grains of kefir water; KA = kefiraride; GKA = association grains kefir and kefiraride. n = number of replications.

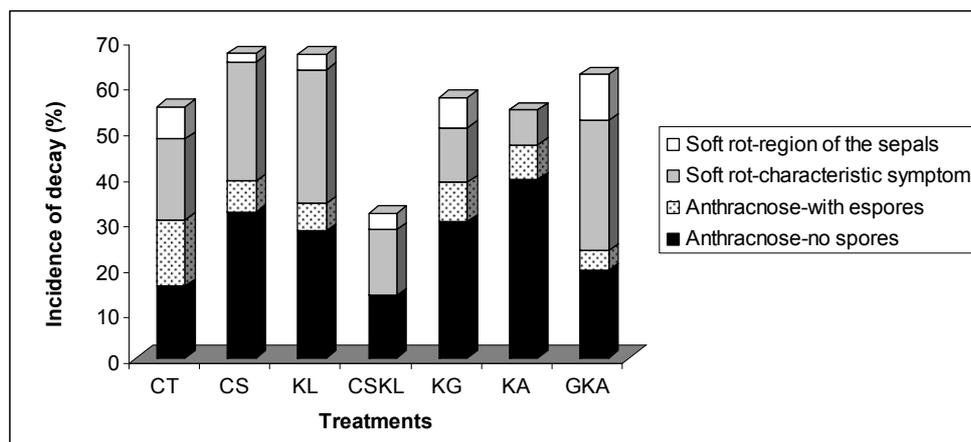


Figure 1. Incidence of fungi symptoms in the strawberry without and with coatings, stored at $10^{\circ}\text{C} \pm 2$ and 60-80% UR, for 9 days

*CT = control fruit, CS = cassava starch, CSKL = association of cassava starch 2.0% and kefir liquid 15%, KL = kefir liquid 15%, KG = kefir grains 15%; KA = kefiraride; GKA = association grains kefir and kefiraride.

3.3 Chemical Analyses

Table 3 shows the mean of values chemical analyses for treatments carried out with organic strawberries - 'Camarosa' cv, kept under refrigeration ($10^{\circ}\text{C} \pm 2$ and RH 60 - 80%).

Table 3. Values of chemical characteristics in organic strawberries, 'camarosa' cv, to fresh fruit and fruits stored ($10^{\circ}\text{C} \pm 2$ and UR 60 - 80%), for nine days (n=3)

T	pH	Total soluble solids ($^{\circ}\text{Brix}$)	Total titratable acidity (g citric acid 100g^{-1} pulp)	Ascorbic acid ($\text{mg } 100\text{g}^{-1}$ pulp)	Anthocyanins ($\text{mg } 100\text{g}^{-1}$ pulp)*
FF	3.46 a	7.16 a	1.06 a	45.17 b	13.30 a
CT	3.46 a	6.85 a	1.22 b	39.55 a	21.02 b
CS	3.46 a	7.53 a	1.27 c	44.00 b	20.74 b
KL	3.42 a	7.27 a	1.24 b	41.96 a	20.34 b
KG	3.40 a	7.81 a	1.24 b	44.87 b	21.19 b
CSKL	3.44 a	7.47 a	1.22 b	41.37 a	20.94 b
KA	3.43 a	7.86 a	1.24 b	39.30 a	21.19 b
GKA	3.50 b	8.51 b	1.27 c	41.60 a	24.50 c

T = Treatments, FF = fresh fruit; CT = control fruit; CF = cassava starch; CSKL = association of cassava starch 2.0% and kefir liquid 15%; KL = kefir liquid 15%; KG = kefir grains 15%; ; KA = kefiraride; GKA = association grains kefir and kefiraride; PGN = pelargonidin-3-glycoside. n = number of replications.

4. Discussions

4.1 Physical Analyses

The shelf life of organic strawberries for nine days, a better result was obtained by Mali and Grossmann (2003) for strawberries from Dover cultivar, coated with yam cassava starch and glycerol, refrigerated at 4°C , once their quality was preserved for 14 days. The latter cultivar has shown characteristics of longer useful life, and was submitted to lower storage temperature if compared to the temperature used in the present study. Mass loss, in strawberries preserved with coatings, at the end of the storage time (nine days), varied from 6.86% (CSKL) to

9.25% (KL). Such values were superior to the advisable maximum value for strawberries, maximum of 6% of water loss to avoid depreciation of fruit appearance (Cantillano, 2003). In an experiment carried out by Tanada-Palmu and Grosso (2005), with organic strawberries belonging to 'Osso Grande' cultivar, the mass loss was lower than 10% in fruits coated with association of gluten, bee wax, stearic and palmitic acids, and also in the treatment with PVC films, on the 16th day of storage under refrigeration (7- 10°C and 60-80% RH), whereas the fruits of the control group and the ones coated only with gluten presented over 50% of mass loss. Such a great difference between fruit mass losses with and without coatings was not observed in the current study, and that may be attributed to the use of plastic packing in the fruits belonging to the control group, thus providing a modified atmosphere in its interior, and consequently avoiding the mass loss that occurs mainly due to the water steam loss, that occurs from fruits to the environment.

Strawberry cultivars known as 'Selva' and 'Diamante' were studied by Pelayo et al. (2003) and showed useful life of nine days when stored at 5°C, and a useful life of 11 days when 20 kPa CO₂ was added, at the same temperature. The applications of KG and CSKL were the products that presented the greatest evolution of red color. On the 6th day of conservation, were statistical differences between the treatments applied ($p < 0.05$). However, on the 9th day, it was observed that the application of CS was the treatment that less evidenced the red coloration. Color values varied from 3.36 (CS) to 3.60% (CF). Divergent results for color were verified by Ribeiro et al. (2007), who have not found any significant difference in fruits coated with different starch, carrageen or chitosan compounds. Del-Valle et al. (2005) also observed that the color of strawberries was not affected by the edible coating made from cactus mucilage. Henrique and Cereda (1999) used cassava starch for strawberry conservation 'IAC Campinas' and verified that the application at 3.0% was the one that resulted in better appearance and red color.

4.2 Microbiological Analyses

Lower values of rotteness incidences, an average of 20%, were found by Malgarim et al. (2006) and Zaicovski et al. (2006), in 'Camarosa' strawberries, with a modified temperature or environment, stored under refrigeration, after 9 days at 0°C, and, for other 3 days at 8°C. According to Baldwin et al. (2006), a significant reduction of diseases was observed in stored strawberry immersed in pectin oligomers, with polymerization degree between 8 and 24, for 10 seconds. That removed the ethylene production, thus favoring the fruit defense response. Lower values were also reported by Tanada-Palmu and Grosso (2005), who found 40% of rotteness in strawberries coated with gluten after 16 days of storage under refrigeration; and 30% in fruits coated with compounds such as, gluten, bee wax and stearic and palmitic acids. Fruits doubly coated (first in gluten and soon afterwards in the formulation of bee wax and acids). Brackmann et al. (1999) found high incidence of rotteness in 'Tangi' cultivar strawberry (values over 40%), stored for 5 days at 20°C, with more than 40% rotteness, even with 20 kPa of CO₂. It may be observed that the coatings applied on organic strawberries have reduced the incidence of peduncle rotteness at nine days of storage under refrigeration. Fruits coated with KG showed a reduction in the incidence of soft rotteness if compared to the control fruits. According to Dias et al. (2007), temperatures inferior to 8-10°C, inhibit the development of fungi and sporangia production. However, according to Fortes (2003), one of the most efficient controls of postharvest soft rotteness is to maintain the fruits under a temperature below 6°C. The temperature of 10°C, used in the present experiment, was not enough to inhibit the development of soft rotteness in the fruits, consequently having 10% of discards in the control group at nine days of storage.

Soft rotteness has fungi such as *Rhizopus stolonifer* Ehr. (Fortes, 2003) and *R. nigricans* Ehr, as causal agent. It is observed that, fruits carry fungi structures on their surface, and that constitute its inoculum. Thus the infection occurs after harvest, and fungi may be quickly disseminated when in contact with the juice that drips from infected fruit to healthy fruits conditioned in packing. Therefore it is really important to avoid fungi dissemination (Dias et al., 2005). Fresh fruit (FF) had low content of all types of microorganisms, with strong development during storage, mainly in yeast, which reached the highest values (10⁵), and values were reduced with application of coatings tested (Figure 2). In coatings based on water kefir and milk, although lower than the control, the values were higher than other treatments, possibly by the presence of yeast in these coatings. Reis et al. (2008) found 1.08x10³ values of the count of fungi and yeasts in strawberries. Oso Grande cv., newly harvested, along with evolution of the storage period, reaching 4.25x10³ the nine days of storage and intensive reduction in the use of chlorates products. Psychrotrophics were reduced by coating with starch and this combined with chitosan and the water kefir on the control and other treatments.

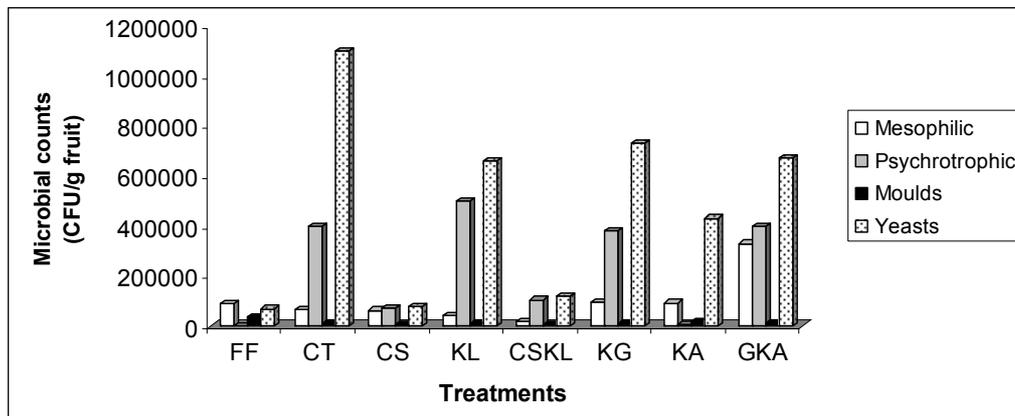


Figure 2. Incidence of microorganism in organic strawberry without and with coatings, stored at $10^{\circ}\text{C} \pm 2$ and 60-80% UR, for 9 days

*FF = Fresh fruit, CT = control fruit, CS = cassava starch, CSKL = association of cassava starch 2.0% and kefir liquid 15%, KL = kefir liquid 15%, KG = kefir grains 15%; KA = kefiraride; GKA = association grains kefir and kefiraride.

The incidence of mold was quite low in relation to other microorganisms. These results agree with Mali and Grossmann (2003) found that the reduction of mesophilic microorganisms, and psychrotrophics mold / yeast strawberries in 'Dover' covered with films based on starch from yam, throughout the storage period. According Siro et al. (2006) extending the useful life of strawberry 'Camarosa' by means of passive modified atmosphere rich in oxygen and atmosphere did not favor the increase of acid-resistentes pathogens: *Escherichia coli*, *Listeria monocytogenes* and *Salmonella* sp, but the restricted development and survival these are available in the fruit stored at 7°C . Ribeiro et al. (2007) studied coatings based on polysaccharides such as starch (2.0%), carrageenan (0.3%) and chitosan (1%) and observed that the lower rate of development of micro-organisms occurred in strawberries coated with chitosan. The chitosan, as reported by Park et al. (2005), controlled the development of *Rhizopus* sp and *Cladosporium* sp, when combined with potassium sorbate, and control the aerobic microorganisms and coliforms during storage of strawberries coated with polysaccharide.

4.3 Chemical Analyses

The variation between the average pH of the fruit was very small for most treatments, between 3.40 and 3.46, similar to the pH values obtained in fresh fruit. Fruits GKA had average pH of 3.50, significantly superior to other fruits. These values were slightly lower than those found by Cordenunsi et al. (2003) for cultivars 'Oso Grande', 'Dover', 'Campineiro' and 'Mazi', which have variation of pH between 3.5 and 3.8, even after refrigerated storage. For the content of total soluble solids (TSS) the fruits coated GKA had the highest value, above 8.51°Brix , differing significantly from other treatments, which ranged between 6.85 and 7.86°Brix , values close to the fresh fruit of 7.16°Brix . Similar initial average, 7.35°Brix , was found in strawberry 'Camarosa' (Margarim et al., 2006). Fresh fruit, in this work, showed values of total acidity of 1.06 g of citric acid 100g^{-1} of pulp, fruit stored differed statistically, with increases in all treatments and control groups, differing significantly between them to nine days. Lower values were obtained by Margarim et al. (2006), on strawberries 'Camarosa' fresh 0.6 g citric acid 100g^{-1} pulp, due, probably, according to the authors, the conditions of cultivation and edafoclimáticas different. The average titratable acidity of fruits coated GKA and CS was 1.27 g citric acid 100g^{-1} of pulp, statistically superior to other treatments in the fruits of the ninth day of storage, which showed between 1.22 and 1.24 100g^{-1} citric acid pulp. It was found that the association with starch did not favor increasing the acidity in fruits coated. Changes were observed in levels of acidity unaccompanied by pH, which can be explained by the buffer capacity of the pulp of the strawberry, due to the high content of citric acid, and through the release of ions to the water, acting as a buffer and opposing to changes in pH (Lehninger, 1976).

The average content of ascorbic acid original was 45.17 mg 100g^{-1} pulp. Most of the fruits showed significant reduction in the contents of the storage period, except the fruits coated with CS and that KG did not differ significantly from the fresh fruit. Calegari et al. (2002) also found a reduction in content of ascorbic acid during storage of strawberry 'Oso Grande' cv. Most fruits reached around 40 mg ascorbic acid 100g^{-1} for 9 days. However, the fruit receiving resveratrol sprinkled to 4000 ppm, had significant reduction in levels of ascorbic

acid. Anthocyanin contents in 'Camarosa' organic strawberries, after 9 days storage under refrigeration, varied from 13.30 (fresh fruit) to 21.19 mg of pelargonidin-3-glycoside (PGN) 100g⁻¹ of pulp (KG), in the different treatments made. Severo et al. (2007) found a content around 12.52 mg of PGN 100g⁻¹ of fresh 'Camarosa' strawberry pulp, in commercial maturation condition, similar to results found in this investigation for freshly-picked fruits (Table 3). An increase in anthocyanin contents was reported by Gil et al. (1997) during refrigerated storage. Anthocyanin initial values were around 12.02 ± 2 mg 100g⁻¹ for 'Selva' strawberry, reaching 15.3 ± 1.2 and 14.2 ± 3.9 mg 100g⁻¹ in a period between five - ten days, respectively. However, they found lower values in fruits treated with concentrations of CO₂ in 10, 20 and 40%. Silva et al. (2007) determined the total anthocyanin content in five different strawberry cultivars and found a variation between 20 and 60 mg 100g⁻¹, in which PGN (77 - 90%) and cyanidin-3-glycoside (3 - 10%) prevailed. The author has also mentioned aspects such as, the influence of the different cultivars, the degree of maturity or ripeness, edaphic-climatic factors and the postharvest storage in their reports.

5. Conclusions

The application of postharvest coating CSKL, as a result of the association of cassava starch at 2.0% (CSF) to the liquid of kefir water at 15% (KL), which presented the best results regarding the preservation of the physical characteristics and the reduction in the incidence of rottenness in organic strawberries belonging to 'Camarosa' cultivar.

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References

- AOAC. (1975). *Association of Official Agricultural Chemistry. Methods of Analysis*. (12 ed.) Washington, D. C.: AOAC.
- Baldwin, E., Narciso, J., Cameron, R., & Plotto, A. (2006). Effect of pectin oligomers on strawberry fruit decay and ethylene production. *Hort Science*, 41, 1044.
- Baños, S. B. (2006). El control biológico en la reducción de enfermedades postcosecha em productos hortofrutícolas: uso de microorganismos antagonicos. *Revista Iberoamericana Tecnologia Postcosecha*, 8, 1-6.
- Benato, E. A., Cia, P., & Souza, N. L. (2001). Manejo de doenças de frutos pós-colheita. *Rev. An. Patol. Plant*, 9, 403-440.
- Brackmann, A., Hunsche, M., & Balem, T. A. (1999). Efeito de filmes de PVC esticável e polietileno no acúmulo de CO₂ e na manutenção da qualidade pós-colheita de morango cultivar Tangi. *Revista Brasileira de Agrociência*, 5, 89-92.
- Calegari, J. M., Pezzi, E., & Bender, R. J. (2002). Utilização de atmosfera modificada na conservação de morangos em pós-colheita. *Pesquisa Agropecuária Brasileira*, 37, 1-6.
- Cantillano, R. F. (2003). *Colheita e pós-colheita*. In: Santos, A. M., Medeiros, A. R., Morango. Produção. Embrapa Clima Temperado (Pelotas, RS) Brasília: Embrapa Informação Tecnológica. pp. 1-81.
- Carvalho, C. R. L., Mantovan, D. M. B., Carvalho, P. R. N., & Moraes, R. M. (1990). *Análises químicas de alimentos*. Campinas, SP: Instituto de Tecnologia de Alimentos (Manual técnico).
- Cereda, M. P., Bertollini, A. C., Silva, A. P., Oliveira, M. A., & Evangelista, R. M. (1995). Películas de Almidón para la preservación de frutas. In: *Anais do Congresso de Polímeros Biodegradáveis*. Avances y perspectivas, Buenos Aires.
- Chitarra, M. I. F., & Chitarra, A. B. (2005). *Pós-colheita de frutos e hortaliças: Fisiologia e manuseio*. 2ed. Lavras: UFLA, pp. 1-785.
- Coelho, A. R., Hoffmann, F. L., & Hirooka, E. Y. (2003). Biocontrole de doenças pós-colheita de frutas por leveduras: perspectivas de aplicação e segurança alimentar. *Semina: Ciências Agrárias*, 24, 337-358.
- Cordenunsi, B. R., Nascimento, J. R. O., & Lajolo, F. M. (2003). Physicochemical changes related to quality of five strawberry fruit cultivars during coolstorage. *Food Chemistry*, 83, 167-173. [http://dx.doi.org/10.1016/S0308-8146\(03\)00059-1](http://dx.doi.org/10.1016/S0308-8146(03)00059-1)
- Del-Valle, V., Hernández-Munoz, P., Guarda, A., & Galotto, M. J. (2005). Development of a cactus-mucilage edible coating (*Opuntia ficus Indica*) and its application to extend strawberry (*Fragaria ananassa*) shelf-life.

- Food Chemistry*, 91, 751-756. <http://dx.doi.org/10.1016/j.foodchem.2004.07.002>
- Dias, M. S. C., Canuto, R. S., Santos, L. O., & Martins, R. N. (2005). *Doenças do morango. Informe Agropecuário*, 26, 40-43.
- Dias, M. S. C., Costa, H., & Canuto, R. S. (2007). Manejo de doenças do morangueiro. *Informe Agropecuário*, 28, 64-77.
- Emater, Empresa de Assistência Técnica e Extensão Rural. (2001). *Produção orgânica aumentou 60%*. [Online] Available: <http://www.emater.tche.br/agroecologia/artigos/producao.htm>
- FDA/AOAC. (1995). *Food and Drug Administration Bacteriological Analytical Manual*. Gaithersburg, USA. 8ed.
- Fortes, J. F. (2003). *Doenças*. In: Santos A M, Medeiros A R. Morango. Produção. Embrapa Clima Temperado (Pelotas, RS) Brasília: Embrapa Informação Tecnológica, p. 81.
- Garrote, G. L., Abraham, A. G., & Antoni, G. L. (2001). Chemical and microbiological characterization of kefir grains. *Journal Dairy Research*, 68, 639-652. <http://dx.doi.org/10.1017/S0022029901005210>
- Gil, M. I., Holcroft, D. M., & Kader, A. A. (1997). Changes in strawberry anthocyanins and other polyphenols in response to carbon dioxide treatments. *Journal of Agricultura and Food Chemistry*, 45, 1662-1667. <http://dx.doi.org/10.1021/jf960675e>
- Gouvêa, A. (2007). *Controle em campo e pós-colheita de doenças e metabolismo do morangueiro após tratamento com Saccharomyces cerevisiae*. 85p. Tese (Doutorado) - Departamento de Fitotecnia e Fitossanitarismo, Setor de Ciências Agrárias, Universidade Federal do Paraná, Curitiba.
- Henrique, C. M., & Cereda, M. P. (1999). Utilização de biofilmes na conservação pós-colheita de morango (*Fragaria ananassa* Duch) cv. IAC Campinas. *Ciência e Tecnologia de Alimentos*, 19, 231-233. <http://dx.doi.org/10.1590/S0101-20611999000200014>
- Janisciewicz, W. J., & Korsten, L. (2002). Biological control of postharvest diseases of fruits. *Ann Rev. Phytopathology*, 40, 411-441.
- Krochta, J. M., & Mulder-Johnston, C. (1997). Edible and biodegradable polymer films: challengers and opportunities. *Food Technology*, 51, 61-74.
- Latorre-García L., Castillo-Agudo L., & Polaina J. (2007). Taxonomical classification of yeasts isolated from kefir based on the sequence of their ribosomal RNA genes. *World Journal Microbiology Biotechnology*, 23, 785-791. <http://dx.doi.org/10.1007/s11274-006-9298-y>
- Lehninger, A. L. (1976). *Bioquímica: componentes moleculares das células* (2ed.). São Paulo: Edgar Blucher.
- Malgarim, M. B., Tibola, C. S., Zaicovski, C. B., Ferri, V. C., & Silva, P. R. (2006). Modificação da atmosfera e resveratrol na qualidade pós-colheita de morangos 'Camarosa'. *Revista Brasileira de Agrociência*, 12, 67-70.
- Mali, S., & Grossmann, M. V. E. (2003). Effects of yam starch films on storability and quality of fresh strawberries (*Fragaria ananassa*). *Journal of Agricultural of Food Chemistry*, 51, 7005-7011. <http://dx.doi.org/10.1021/jf034241c>
- Nunes, M. C. N., Brecht, J. K., Morais, A. M. M. B., & Sargent, S. A. (2005). Possible influences of water loss and polyphenol oxidase activity on anthocyanin content and discoloration in fresh ripe strawberry (cv. Oso Grande) during storage at 1°C. *Journal of Food Science*, 70, 79-84. <http://dx.doi.org/10.1111/j.1365-2621.2005.tb09069.x>
- Oliveira, C. S., Grden, L., & Ribeiro, C. O. M. (2007). Utilização de filmes comestíveis em alimentos. *Série em Ciência e Tecnologia de Alimentos: Desenvolvimentos em Tecnologia de Alimentos*, 1, 52-57.
- Park, S., Stan, S. D., Daeschel, M. A., & Zhao, Y. (2005). Antifungal coatings on fresh strawberry (*Fragaria x ananassa*) to control mold growth during cold storage. *Journal of Food Science*, 70, 202-207. <http://dx.doi.org/10.1111/j.1365-2621.2005.tb07189.x>
- Pelayo, C., Ebeler, S. E., & Kader, A. A. (2003). Postharvest life and flavor quality of three strawberry cultivars kept at 5°C in air or air + 20 kPa CO₂. *Postharvest Biology and Technology*, 27, 71-183.
- Piccinin, E., Di Piero, R. M., & Pascholati, S. F. (2005). Efeito de *Saccharomyces cerevisiae* na produtividade de sorgo e na severidade de doenças foliares no campo. *Fitopatologia Brasileira*, 30, 5-9. <http://dx.doi.org/10.1590/S0100-41582005000100001>

- Ramalho, M. A. P., Furtado, D., & Oliveira, A. C. (2000). *Experimentação em genética e melhoramento de plantas*. UFLA, pp. 1-324.
- Reichert, L. J., & Madail, J. C. M. (2003). Aspectos econômicos. In: Santos, A. M., Medeiros, A. R. M. *Morango. Produção*. Embrapa Clima Temperado (Pelotas, RS) Brasília: Embrapa Informação Tecnológica, 1-81.
- Reis, K. C., Siqueira, H. H., Alves, A. P., Silva, J. D., & Lima, L. C. O. (2008). Efeito de diferentes sanificantes sobre a qualidade de morango cv. Oso Grande. *Ciência e Agrotecnologia*, 32, 196-202. <http://dx.doi.org/10.1590/S1413-70542008000100029>
- Ribeiro, C., Vicente, A. A., Teixeira, J. A., & Miranda, C. (2007). Optimization of edible coating composition to retard strawberry fruit senescence. *Postharvest Biology and Technology*, 44, 63-70. <http://dx.doi.org/10.1016/j.postharvbio.2006.11.015>
- Santos, L. O., Martins, R. N., Durigan, J. F., & Mattiuz, B. (2007). Técnicas de conservação pós-colheita do morango. *Informe Agropecuário*, 28, 84-87.
- Scherer, E. E., Verona, L. A., & Signor, G. (2003). Produção agroecológica de morango no Oeste Catarinense. *Agropecuária Catarinense*, 16, 20-24.
- Severo, J., Azevedo, M. L., Chim, J., Schreinert, R. S., Silva, J. A., & Rombaldi, C. V. (2007). Avaliação de compostos fenólicos, antocianinas e poder antioxidante em morangos cv. Aromas e Camarosa. In: IX ENPOS. *Pesquisa e responsabilidade ambiental*. Faculdade de Agronomia Eliseu Maciel, Pelotas.
- Silva, F. L., Escribano-Bailón, M. T., Alonso, J. J. P., Rivas-Gonzalo, J. C., & Santos-Buelga, C. (2007). Anthocyanin pigments in strawberry. *Food Science and Technology*, 40, 374-382.
- Siro, I., Devlieghere, F., Jacxsens, L., Uyttendaele, M., & Debevere, J. (2006). The microbial safety of strawberry and raspberry fruits packaged in high-oxygen and equilibrium-modified atmospheres compared to air storage. *International Journal of Food Science and Technology*, 41, 93-103. <http://dx.doi.org/10.1111/j.1365-2621.2005.01046.x>
- Tanada-Palmu, P. S., & Grosso, C. R. F. (2005). Effect of edible wheat gluten-based films and coatings on refrigerated strawberry (*Fragaria ananassa*) quality. *Postharvest Biology and Technology*, 36, 199-208. <http://dx.doi.org/10.1016/j.postharvbio.2004.12.003>
- Zaicovski, C. B., Tibola, C. S., Malgarim, M. B., Ferri, V. C., Pegolaro, C., Dal Cero, J., & Silva, P. R. (2006). Resveratrol na qualidade pós-colheita de morangos 'Camarosa'. *Revista Brasileira de Agrociência*, 12, 443-446.