COST FP1405 STSM REPORT

Researching the antimicrobial effects and application areas of biobased active coatings for paper-based packaging applications of various fresh products

KCPK
KENNISCENTRUM PAPIER EN KARTON

COLOPHON

COST ACTION	FP1405 ActInPak (Financial Support)
STSM TITLE	Researching the antimicrobial effects and application areas of biobased active coatings for paper-based packaging applications of various fresh products
STSM PERIOD	06/03/2016 to 18/03/2016
COST STSM REFERENCE NUMBER	COST-STSM-ECOST-STSM-FP1405-060316-072222
STSM TYPE	Regular (from Netherlands to Portugal)
APPLICANT	Anouk Dantuma Kenniscentrum Papier & Karton Arnhem, The Netherlands a.dantuma@kcpk.nl
HOST	Maria Dulce Antunes University of Algarve Faro, Portugal mantunes@ualg.pt

IJsselburcht 3, NL-6825 BS Arnhem | +31 26 365 3515 | www.kcpk.nl | info@kcpk.nl

1 INTRODUCTION

Due to different aspects, maintaining the quality of fresh products such as fruits and vegetables is difficult, resulting in losses of over 30% (CE Delft, 2007). In order to improve this, various active coatings have been developed that have been proven (on lab-scale) to be able to reduce the growth of fungi and/or bacteria. When these coatings are applied to paper-based packaging materials, they may be able to prolong the shelf life of the aforementioned fresh products. KCPK and the University of Algarve aim to start collaboration on the further development and market implementation of such active packaging for one or more specific fresh (food) products, among which strawberries.

Gaining a better understanding of the factors that cause post-harvest quality loss in strawberries through performing more realistic microbiological tests (i.e. testing directly on strawberries and by mimicking the value chain) and learning more about whether or not and how active coatings can influence the organoleptic properties of the strawberries will be very important for a successful market implementation of active strawberry packaging.

The main purpose of the STSM is therefore to test the efficacy of the various available active coatings and papers on extending the shelf life of strawberries, and to evaluate whether or not their effect on the organoleptic properties such as smell, taste and structure is acceptable to consumers. The results of these tests will provide a good basis for the further development and market implementation of active strawberry packaging. To gain maximum benefit from the stay at the host institution, the secondary goal of the STSM is to learn more about the University of Algarve and its facilities.

2 PERFORMED ACTIVITIES

Before the start of the STSM, various types of active papers were produced and/or collected:

1. A release-coating based on cinnamon essential oil. Cinnamon oil has been proven effective against various types of bacteria. This coating was applied by means of rod-coating to two different papers (paper A and paper B) in four different layer thicknesses: 4, 8, 12 and 24 µm.
2. A sizing agent consisting of a mixture of cinnamon essential oil and starch. Cinnamon oil has been proven effective against various types of bacteria. The sizing agent was applied by means of a size-press to a 90 g/m^2 and a 300 g/m^2 paper.
3. A commercially-available active paper based on herbs. This paper is marketed to be effective at elongating the shelf life of fruits and vegetables.
4. An active packaging consisting of folding box board treated with a coating based on TiO_2. TiO_2 has been proven effective against various types of both fungi and bacteria.
5. Corrugated board treated with a coating based on nanosilver. Nanosilver has been proven effective against various types of both fungi and bacteria.

During the STSM, several tests were performed to test the efficacy of each of these active papers on the post-harvest quality of fresh strawberries, using both objective and subjective evaluation techniques. To ensure that the results of the tests are a good indication of the reallife post-harvest quality of the fruits, the current value chain was mimicked as much as possible, starting with the purchasing of fresh strawberries directly at the grower. The strawberries were then placed in conventional plastic strawberry containers, in which a piece of each active paper was placed on the bottom so that the bottom of the containers was completely covered with the active paper (Figure 1 left). The safebox was an exception here; these were simply erected and had some holes punched in the lid to allow for an air flow similar to that in the other containers. Five strawberries were placed in each of the containers and eight containers were prepared for each type of active paper; three to be used for each of the measuring moments and two for the taste panel. The same amount of boxes was prepared as a control sample to represent the current situation; these simply consisted of a plastic container with strawberries, but without any active paper. All containers were placed in crates in two layers of 9. One might argue that stacking of the containers might increase the chances of cross-contamination between two consecutive layers of strawberry boxes, but this way of packing is common in the strawberry value chain and was therefore used during the tests as well, to provide the most accurate test results. The strawberries were placed in a cooled storage room that was set at 4 °C (Figure 1 right). This temperature was chosen as storage and transport in the value chain is done at an average of this temperature. Since the humidity in the cooled storage room is lower than the 95% relative humidity that is common in the value chain of strawberries (this is to prevent them from drying out), buckets of water were placed in the cold storage room to increase the humidity.

Figure 1: Preparation of samples (left) and storage of samples in cold storage room (right)

2.1 Objective evaluation of active papers

The quality of strawberries can be determined objectively based on four quality indicators, namely weight loss, color (darkening), firmness and sugar content. To test the effects on the post-harvest quality of strawberries, these four quality indicators were measured at the start of the experiments, after 6 days and after 9 days of storage.

2.1.1 Weight loss

Weight loss generally means loss of moisture, and causes the strawberries to lose their smoothness and start wrinkling. The lower the amount of weight loss therefore means the strawberry has better maintained its quality.

The weight of each box containing 5 strawberries was determined at the start of the experiments and after 6 and 9 days of storage. The percentage of weight loss was calculated by means of the following formula:

$$WL = \frac{W_0 - W_T}{W_0} \cdot 100\%$$ In which:

WL = weight loss and W_T = weight at the time of measurement

2.1.2 Color

Strawberries tend to slightly change color when their quality decreases. Since strawberries do not ripen after harvest, the color at the moment of harvest is a good means for comparison; the closer the color of the strawberry at any given moment is to the color at the moment of harvest, the better the quality of the strawberry.

The color of the strawberries was measured non-destructively, and for each of the 5 individual strawberries in each box. This was done by using a color sensor (Figure 2), which determines the exact color of the strawberry within the Lab color scale, based on three measurements at different spots of the strawberry. In the Lab color scale, L indicates lightness, with high and low values indicating lighter and darker colors respectively. The a-value indicates the color on the scale from red to green, ranging from -1 (green) to +1 (red). The b-value represents the color on a scale from yellow to blue, ranging from -1 (blue) to +1 (yellow). This is also visualized in Figure 3. These values were then used to calculate hue and chroma.

Since strawberries darken once they lose their quality, it is especially the lightness (or chroma) that is important in color measurements. The brightness of the red color may also change due to darkening of the fruit, which is why also the a-value and/or the hue are important in evaluating the color of the strawberries.

Figure 3: Color measurements

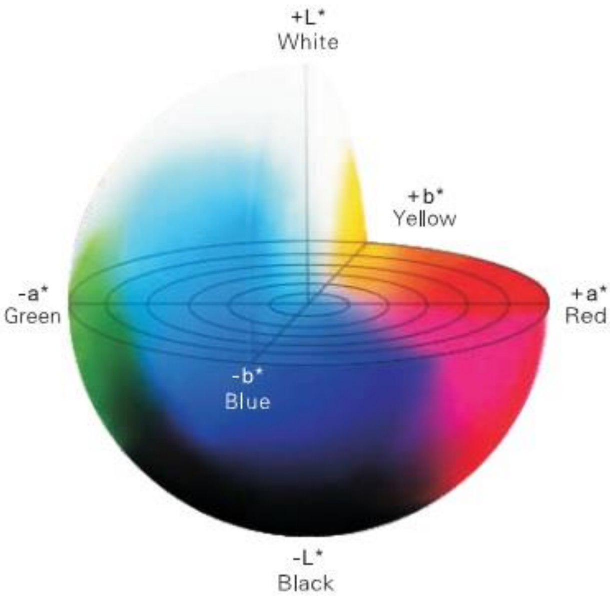

Figure 3. Lab color spectrum

2.1.3 FIRMNESS

Decrease of firmness makes strawberries more susceptible to mechanical damage and thereby, indirectly, also to microbial spoilage. Hence, the more strawberries are able to maintain their firmness, the better they are able to maintain their overall quality.

The firmness of the strawberries was measured in a destructive manner, and also for each of the 5 individual strawberries in each box. This was done using a penetrometer, equipped with a tip for measuring firmness in soft fruits such as strawberries. The tip of the device would slowly move down onto the strawberry, until it has punctured the strawberries to a depth of 5 mm (see Figure 4). The pressure required to create this puncture indicates the firmness of the fruits, and is measured in kilograms.

Figure 4: Firmness measurements

2.1.4 SUGAR CONTENT

The taste of strawberries is another crucial factor in determining the quality of the fruits, whereby especially the sweetness, or sugar content, of the strawberry is important. The sugar content of strawberries is highest once strawberries are properly ripened and tends to decrease when decay processes proceed. Sugar content is often expressed as Soluble Solids Content (SSC), expressed in % Brix. In general, strawberries with an SSC-value of 8% Brix or higher are considered to be of good quality.

Since strawberries do not ripen after harvest, the sugar content at the moment of harvest is a good means for comparison; the closer the sugar content of the strawberry at any given moment is to the sugar content at the moment of harvest, the better the quality of the strawberry.

Figure 5: Soluble Solids Content measurements

The Soluble Solids Content of the strawberries was determined using a refractometer (Figure 5). Using a garlic press, some juice from each of the individual strawberries from each container was applied onto the refractometer, which would then calculate the soluble solids content. After each series of three containers with 5 strawberries of the same coating, the refractometer and the garlic press were cleaned to provide accurate calculations.

2.2 SUBJECTIVE EVALUATION

To also evaluate the effect of the active papers in a subjective way, a taste panel was held at the 8th day after the start of the experiments. For each active paper, two containers, each of which holding 5 strawberries, were used. One of the containers was placed on a table without lid. The strawberries in the other container were cut into smaller pieces and served on a plate that was placed next to the open box. The plates and the containers were numbered to facilitate the experiment, yet not explain to the participants of the taste panel which active paper was in the packaging (see Figure 6).

The participants of the taste panel, who were both students and employees at the university, were asked to evaluate the appearance, aroma, texture, sweetness and the acidity of the strawberries packed using each of the different active coatings on a scale from 1 to 7, in which 1 representing a strong disliking and 7 representing a strong liking. They were also asked to give a general appreciation, using the same scale.

Figure 6: Taste panel

3 RESULTS

3.1 WEIGHT LOSS

The weight loss of the strawberries after 6 and 9 days of storage is visualized in Figure 7. As is clearly visible, all active papers but paper with an herb-based active coating and the folding boxboard treated with TiO_2 were able to cause a significant reduction in weight loss when compared to the control sample.

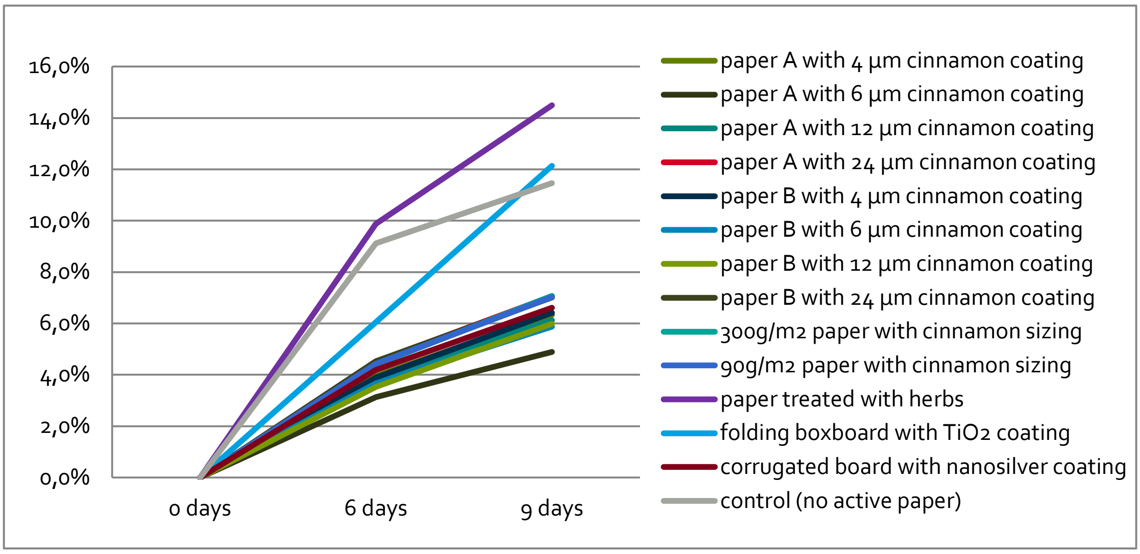

Figure 7: Weight loss in strawberries after 6 and 9 days of storage

3.2 COLOR (LIGHTNESS)

The lightness of the strawberries after 0, 6 and 9 days of storage is visualized in Figure 8. The graph shows a darkening in all strawberries, with very little difference between the different samples.

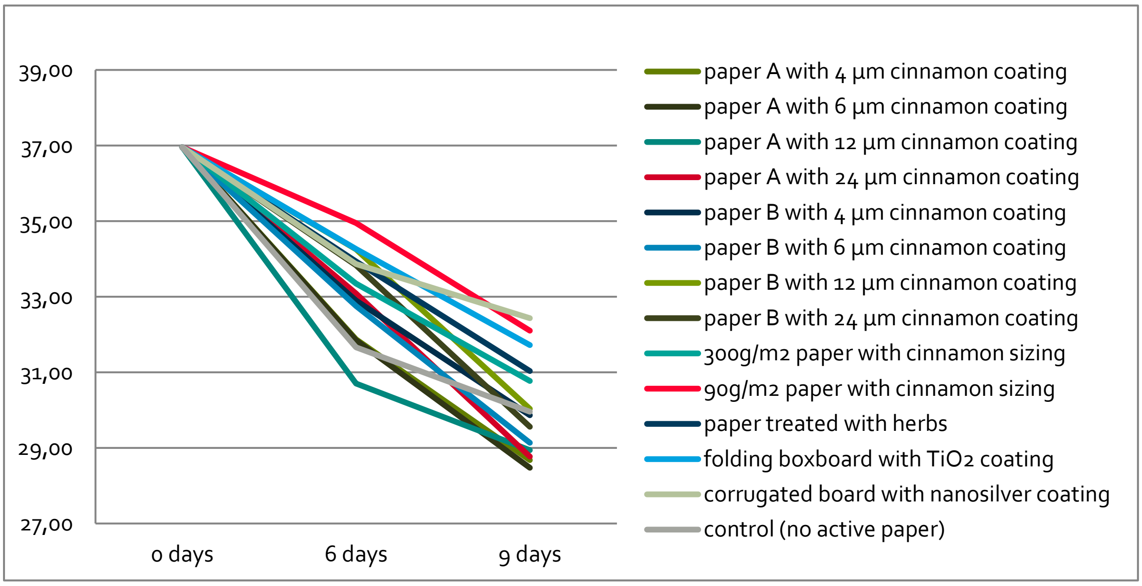

Figure 8: Lightness of color of strawberries after 0, 6 and 9 days of storage

3.3 Firmness

The firmness of the strawberries, expressed in kilograms, is visualized in Figure 9. The graph clearly depicts a significant drop in firmness between 0 and 6 days of storage, for all strawberries. Zooming in further on the data for days 6 and 9 shows a distinction between two groups of active papers (Figure 10), but since the order of differences is so small, these are hardly significant results.

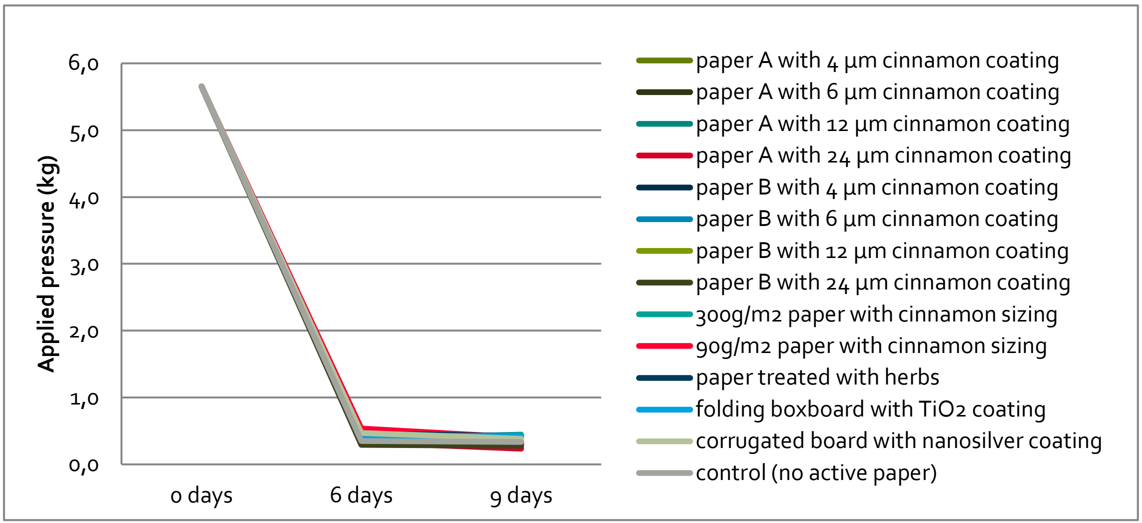

Figure 9: Firmness of strawberries after 0, 6 and 9 days of storage

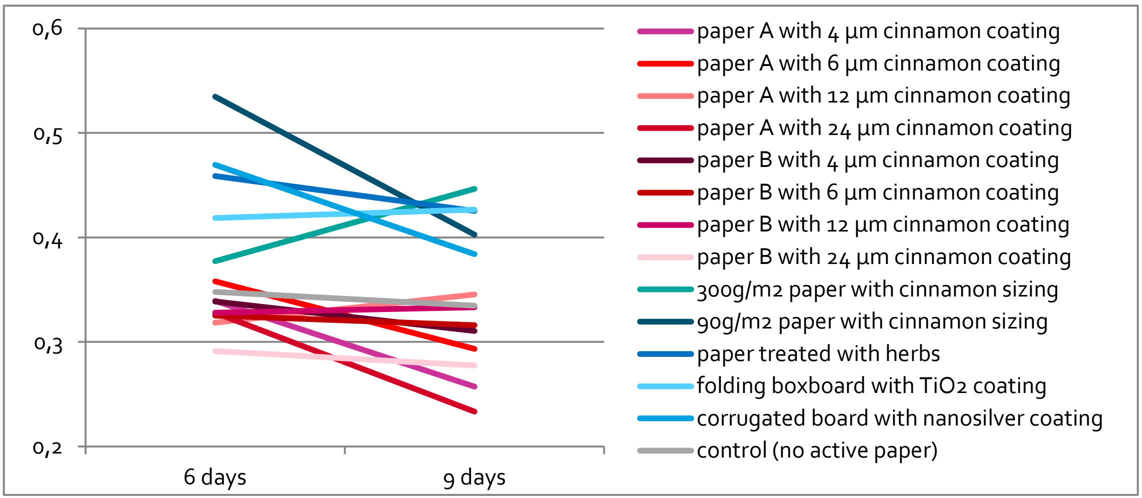

Figure 10: Firmness of strawberries after 6 and 9 days of storage

3.4 SUGAR CONTENT

Figure 11 shows the Soluble Solids Content (SSC) for the strawberries after 0, 6 and 9 days of storage. As is clearly visible, there is a high variability in results between the samples, even within the measurements for the same type of active paper.

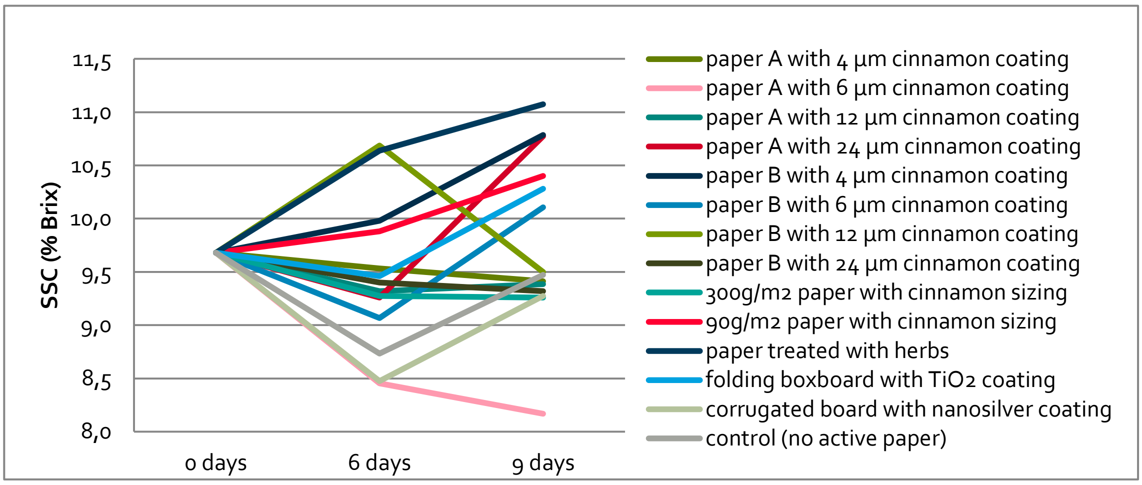

Figure 11: Soluble Solids Content after 0, 6 and 9 days of storage

This variability is likely caused by the combination of a high variability in sugar content between different strawberry fruits and the fact that the sugar content is measured using destructive techniques (i.e. the strawberries are destroyed during the tests). The destructiveness of the tests means that different strawberries have to be used for each single measurement, thus making it impossible to track the sugar content of the exact same strawberry over time and resulting in a high variability in the test results.

3.5 SUBJECTIVE EVALUATION (TASTE PANEL)

The results of the taste panel are shown in Figure 12. As can be read from the graphs, the control sample was among the highest scores on all of the evaluated aspects but appearance; on this aspect, almost all of the active papers managed to contribute to a higher perceived quality. On most aspects, the papers sized with cinnamon essential oils scored among the highest as well, often similarly to or exceeding the scores received by the control sample. Other samples with high taste panel scores were the active papers containing up to 12 µm of cinnamon essential oil.

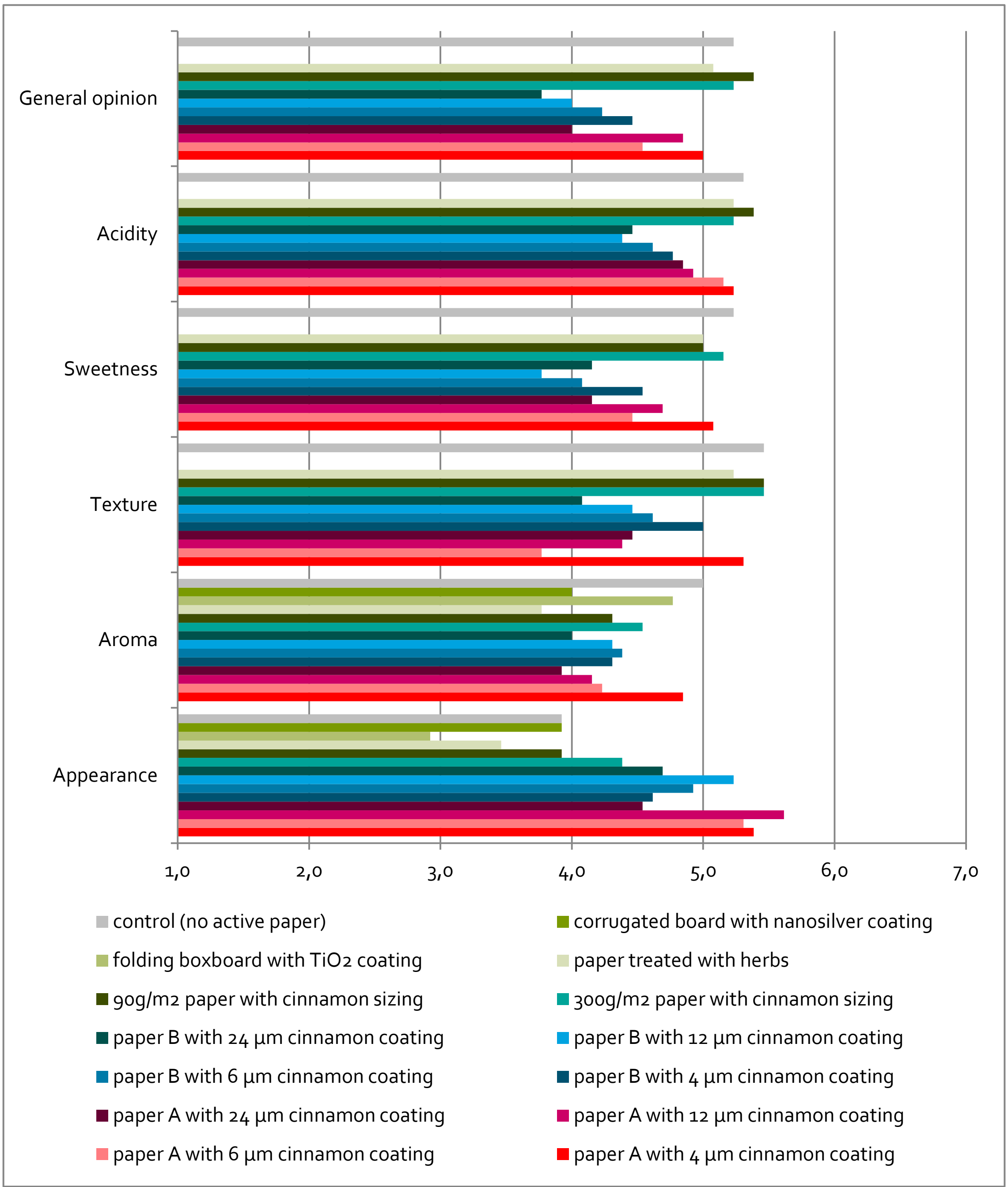

Figure 12: Taste panel results

4 CONCLUSIONS

The tests have proven that all active papers are able to - to some extent - maintain the quality of fresh strawberries longer, especially when it comes to weight loss. What also has become clear, however, is that the inclusion of active substances in the packaging material negatively impacts the organoleptic properties (taste, smell and structure) of the strawberries, especially when the active substances are applied in higher concentrations or amounts. Therefore it can be concluded that in general, one should be very careful in applying active packaging materials to strawberries. More specifically for the different active papers that were tested during the experiments described in this report, it can be concluded that the active papers containing the lower quantities of the cinnamon essential oil active coating as well as the papers treated with the sizing agent based on cinnamon essential oil are the best options for packing strawberries. Both of these papers have a positive effect on the quality of strawberries (especially weight loss), but at the same time do not affect the smell and taste of the strawberries negatively.

5 DISCUSSION

The combination of having to use different strawberries during each moment of testing due to the destructiveness of the tests and a naturally high variability in strawberry quality, there was no possibility to track the decay progress of an individual strawberry. Because of this, the results of the tests, and especially the conclusions that were drawn based on them, may or may not be completely accurate. However, since three boxes that each contained 5 strawberries were used for each of the active paper samples and at each of the testing moments (this equals 15 strawberries per sample), and average results were taken for the general evaluation of the efficacy of the active paper samples, it is believed that the high variability in strawberry fruits is balanced out as much as possible.

6 FOLLOW-UP

Testing the efficacy of the various available active coatings and papers on extending the shelf life of strawberries and evaluating the effect of these coatings on the organoleptic properties of the food has led to new insights regarding the possibilities for applying these active coatings in strawberry packaging. The obtained results therefore form a good basis for further development and market implementation of active packaging for strawberries, which will be carried out in collaboration with material and coating producers as well as launching customers in the coming months. The aim is to have performed the first in-store trials with active strawberry packaging by the end of 2016.

In addition thereto, the STSM has been a great opportunity to get to know the Post-Harvest group at the University of Algarve, its facilities and its people better. KCPK and the University of Algarve already had plans to collaborate on the topic of active packaging before the start of the STSM, to which the STSM has been a great start.