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# EFFECTS OF ACTIVE PAPER SHEETS ON THE QUALITY OF CHERRY TOMATOES DURING COLD STORAGE

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**Abstract:** *Plant essential oils (EOs) have several technological properties such as antimicrobial, antioxidant, enzyme inhibitors, etc., which are then highly valued in the food sector as a sustainable conservation alternative to controversial chemical additives. Active packaging with EOs is a technique with great potential to extend the shelf life of fruit and vegetables. For it, we studied the application of active paper (kraft) sheets (including β-cyclodextrin inclusion complexes with a thymol:eugenol mix (50:50)) to preserve cherry tomatoes (also known as grape tomatoes) for up to 14 days at 10 ºC. The tomato quality was assayed through physicochemical (pH), colour and microbial analyses. The microbial growth of psychrophilic was highly controlled, with ≈1 log unit lower counts compared to control after 14 days of refrigerated storage, in tomatoes when the active sheets were used. Furthermore, active sheets did not affect (p>0.05) the physicochemical quality (pH) or colour of tomatoes. Conclusively, EOs active sheets packaging controlled microbial growth during refrigerated storage of tomatoes.*

**Keywords:** *essential oils, β-cyclodextrin, inclusion complex, food safety, quality*

## 1. INTRODUCTION

Tomatoes, specifically the uvalina cherry tomato (*Solanum pimpinellifolium*), are plant products of high economic interest [1]. From the United States to Europe, this plant product is consumed at a high rate all year round, either as a processed product (sauces, purees, etc.) or in fresh form in salads and other preparations. It is also considered a healthy product of high interest in diets [2].

Vitamin C (ascorbic acid), phenolic compounds and carotenoids are abundant in tomatoes and their byproducts. Vitamin E, potassium and folic acid are also present in tomatoes [3]. The pre and postharvest variables can influence the fruit and vegetable content of bioactive and nutritious components. These chemicals may be impacted by pre-harvest variables like as irrigation, soil, climate, cultivars, cultural techniques, etc. [4]. These substances have an impact on the product's postharvest quality features, such as soluble solids, pH, titratable acidity, firmness, colour, and overall sensory perception, in addition to its nutritional content. Similarly, the fruit quality, which establishes its safety for consumption, is correlated with the physiological reaction to stress (such as salt stress) caused by these elements.

Essential oils (EOs) are a substitute for chemical-based antimicrobials in the control of microbial growth as extensively documented [5]. The high levels of antibacterial and antioxidant compounds of these plant extracts are specifically attributed to some major components, including terpenes, terpenoids, and low molecular weight aromatic and aliphatic chemicals. Furthermore, combining pure EOs with their major components (carvacrol and oregano oil, for instance) may improve the antibacterial activity by 10–30% [6]. On the other

hand, EOs deteriorate (oxidations, etc.) and evaporate readily in atmospheric conditions. Thus, a controlled release of EOs is made possible by the formation of inclusion complexes of EOs with β-cyclodextrins. Hence, adding these EO inclusion complexes into active packaging may increase the shelf life of plant products like tomatoes [7].
The aim of this study was to analyze the quality changes of tomatoes packaged with active paper sheets during refrigerated storage at 10 ºC up to 15 days.

## 2. MATERIALS AND METHODS

### 2.1. Materials

Uvalina cherry tomatoes (*Solanum pimpinellifolium*) were supplied by the biosystem centre Jorge Tadeo Lozano University (Bogotá, Colombia) in November 2023. The fruits were then stored in a cold room at the Jorge Tadeo Lozano University, where they were kept until the next day when packaging treatments were done. Active packaging were prepared by the companies bio-iPack (Murcia, Spain) and Hinojosa Packaging (Valencia, Spain) by a coating of paper (Kraft) sheets with 1 g/m$^2$ of an inclusion complex of an EOs mix (thymol: eugenol 50:50 *weight* (*w):w*) with β-cyclodextrin, as previously described [8]. Subsequently, one active sheet was introduced in a plastic bag (15×15 cm), which was then filled with 150 g of tomatoes. Bags without active sheets were used as control packaging. Packaged tomatoes were then stored at 10 ºC up to 15 days. Three replicates (3 bags) were made for each sampling time and packaging treatment (control or active).

### 2.2. Color and pH analyses

A colorimeter (Chroma Metre CR-400, Konica Minolta, Tokyo, Japan) was used to test the samples' colour using an 8 mm viewing aperture, 2° observer and D65 illuminant. For every tomato, three surface colour measurements were taken, and the equipment automatically averaged them. The CIELab system was used to represent colour measurements in terms of the spatial coordinates *L** (brightness), *a** (green-red) and *b** (blue-yellow). The Chroma index was calculated according to the equations previously described [9].
The pH of tomatoes (juice was previously extracted) was measured with a pH metre (Crison Basic20; Alella, Spain).

### 2.3. Microbiological determinations

Tomatoes' surface microbial burdens were as previously described [10]. Briefly, three tomatoes were combined with 1:1 (*w:volume*) buffered peptone water and incubated at 4 °C for one hour. Then, appropriate dilutions were prepared using buffered peptone. Aliquots of the dilutions were plated in PCA (plate count agar) for psychrophiles, which were incubated at 4 ºC for 7 days. Results were expressed in log colony-forming units (CFU) per cm$^2$. Two analyses of each of the three replicates were conducted.

### 2.3. Statistic analysis

Statistical analysis was performed using the SPSS software program (v.19 IBM, New York, USA) using multivariate analysis of variance (ANOVA) (treatment × storage time) with Tukey's test (p=0.05).

## 3. RESULTS

### 3.1. pH

Regarding pH values, no differences (p>0.05) were recorded between the different packaging treatments during conservation at 10 ºC (Figure 1). pH values are different to those previously reported [11]. It can be explained by the variety of tomatoes used, as well as the degree of ripening linked with a higher content of organic acids, which are transformed into sugars as the ripening of the fruit progresses.

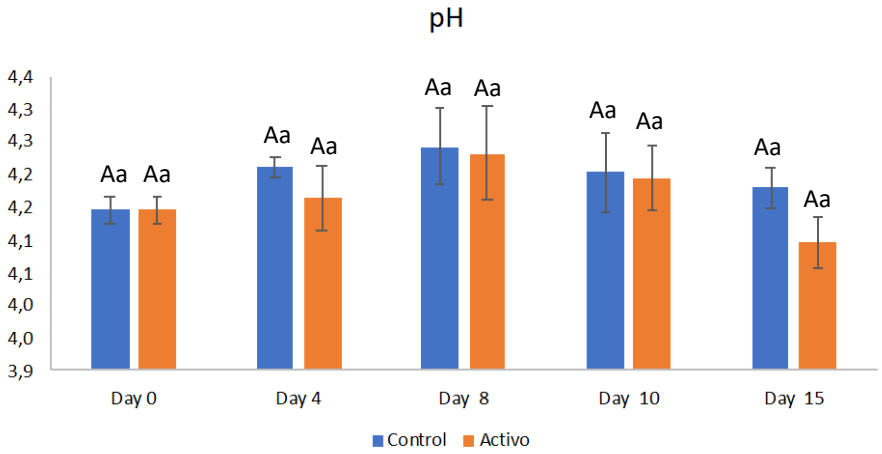


Figure 1. pH of tomatoes preserved in active or control bags for 15 days at 10 ºC (mean (n=3) ± SD). Different uppercase letters indicate significant differences ($p<0.05$) between packaging treatments for the same storage time. Different lowercase letters denote significant differences ($p<0.05$) between sampling times for the same packaging treatment.

### 3.2. Colour

The *Hue* and *Chroma* indexes showed no differences ($p>0.05$) between treatments and during storage (Figure 2). Hence, active packaging did not alter the colour of tomatoes, which may occur in other plant products due to oxidation processes caused by specific EOs. Different colour indexes have been previously reported [12], which may be explained by the different varieties, preharvest conditions, etc.

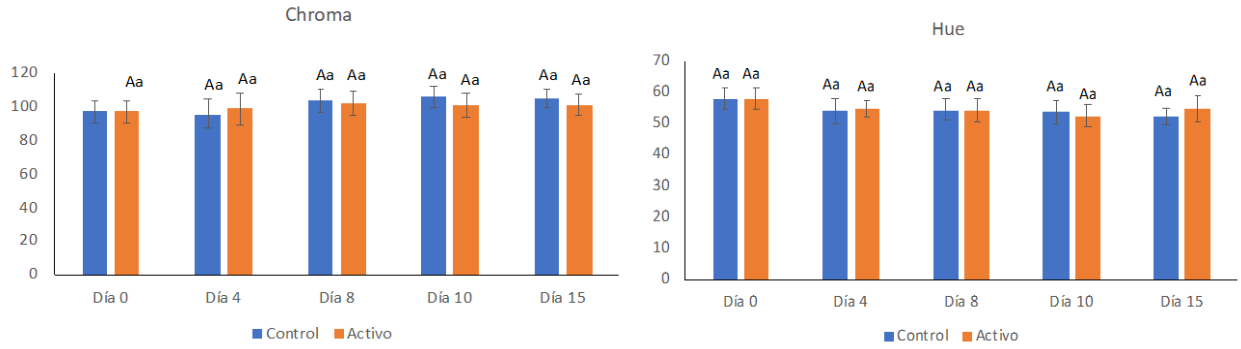


Figure 2. Chroma and Hue indexes of tomatoes stored in active and control packages for 15 days at 10 ºC (mean (n=3) ± SD). Different uppercase letters indicate significant differences ($p < 0.05$) between packaging treatments for the same storage time. Different lowercase letters denote significant differences ($p < 0.05$) between sampling times for the same packaging treatment.

### 3.3. Microbiological analysis

The psychrophilic counts were lower within active packages compared to control samples on days 4, 8 and 10 (Figure 3). Such better microbial quality was also observed in the previous days. This indicates that the preservation of vegetables with EOs active packaging may control microbial growth. The microbial loads obtained were lower than those previously reported [6].

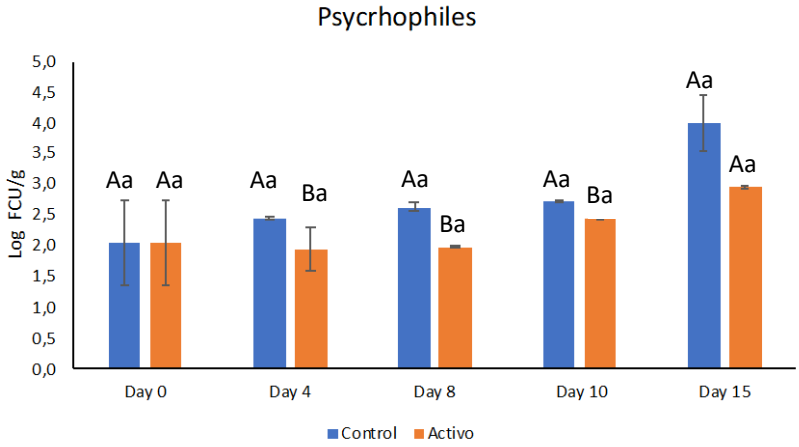


Figure 3. Count of total mesophilic psychrophiles (CFU/cm$^2$) of tomatoes preserved in active or control bags for 15 days at 10 ºC (mean (n=3) ± SD). Different uppercase letters indicate significant differences ($p < 0.05$) between packaging treatments for the same storage time. Different lowercase letters denote significant differences ($p < 0.05$) between sampling times for the same packaging treatment.

## 4. CONCLUSIONS

The conservation of cherry tomatoes with EOs did not negatively affect the pH or colour of the tomatoes. The microbial growth was controlled during storage using the active packaging, with psychrophilic loads ≈1 log unit lower than control samples. Therefore, it can be concluded that preserving cherry tomatoes with EOs is a good alternative since it preserves their quality in refrigeration.

## ACKNOWLEDGMENT

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