Determination of Concentrations of Camellia Sinensis Oil on Preservation of Cool Stored Strawberry

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Abstract: *Camellia Sinensis oil was synthesized from the seeds of Japanese-grown tea trees (CSO). Emulsion solutions were prepared by mixing 1.0% (w/v) chitosan, 1% (w/v) citric acid, and varying concentrations of CSO ranging from 0.05%, 0.25%, and 0.5% (w/v). The study investigated the impact of the emulsion on the physicochemical characteristics of Amaou strawberries under specific conditions of 5 °C, 85 ± 5 % humidity level (RH). The finding suggested that concentrations of CSO had an impact on fruit metabolism, leading to notable variations in some biochemical characteristics such as firmness, TSS, and pH. The emulsion solutions effectively preserved the fruit with greater efficacy observed when CSO was included in the solution at a concentration of 0.25%.*

Keywords: Tea seed oil, chitosan, strawberry, preservation

1. INTRODUCTION

Strawberries (Fragaria × ananassa), often referred to as the "queen of fruits," are renowned globally for their distinctive taste and aroma, making them one of the most sought-after fruits. The high nutritional value of strawberries is attributed to their content of vitamin C, carotene, vitamin E, and various bioactive compounds, which are beneficial for consumer health. However, strawberries possess a notably brief postharvest longevity and exhibit high perishability owing to various factors such as moisture loss, mechanical damage, and physical and microbial decay.

Camellia Sinensis oil (CSO), extracted from the seeds of Japanese tea plant, which have an oil content of 19.88% [1], is a versatile natural oil utilized in various applications, including cooking oil [2], antioxidant agents [3], medicine [4], and biodiesel [5]. CSO is rich in unsaturated fats, comprising oleic acid (approximately 70%) and linoleic acid (around 10%), and is rich in antioxidants, including phenolic compounds, as well as a variety of minerals and vitamins [3] [6]. A unique compound in CSO, identified by Lee et al. [7] as 2,5-bis-benzo [1,3] dioxol-5-yl-tetrahydro-furo[3,4-d][1,3] dioxide, is a major lignan constituent that demonstrated the effect on antioxidant activities which was higher than 16 times sesamin. Research by Sahari et al. [1] indicated that at 63°C, CSO has a longer shelf life compared to sunflower oil. Additionally, Joshi et al. [8] documented that glycosides extracted from the seeds of tea tree possess comprehensive antifungal activities. CSO also demonstrated to extend the stored time of other oils due to its oxidation inhibitor properties [1] [4]. Thus, this study advocates for the future use of CSO to reduce waste and protect the environment. This study aims for determining the effect of the CSO concentration in preservation of strawberries, especially the change of strawberry quality during stored time as a natural way of replacing of plastic bags [9].

2. MATERIALS AND METHODS

2.1. Preparation of solutions

The emulsion solution was prepared following as methods from Tran et al. [10], 1% (w/v) citric acid was utilized in purified water to dilute 1% (w/v) chitosan powder (CH) at 80.0 mol% deacetylation. The composite was heated and stirred in 3 hours at 85°C and 750 rpm. After heating, the solution was divided into four portions. One portion was kept as base CH, and the other three were mixed at 0.05%, 0.25%, and 0.5% (w/v) CSO (labeled CSO5, CSO25, and CSO50) along with 20% Tween 80 and 30% glycerol as emulsifiers and plasticizers. These CSO emulsions were combined with the initial CH compound, adjusted to a final volume with distilled water, then homogeneity at 22,000 rpm for 3 minutes. The final solutions named CH, C.CSO5, C.CSO25, and C.CSO50.

2.2. Materials and methods

2.2.1. Material: Strawberries, uniform in color, shape, and size, were procured from Japanese Agriculture society in Itoshima, Fukuoka, Japan, and directly provided for experiment in the laboratory. Prior to the required experiments, strawberries were immersed into a 0.01% disinfectant bleach in 30 secs, after that they were dehydrated at normal condition. The treatments were conducted as steps below:

Control: The fruit was soaked into the solution of citric acid (1% (w/v)) in 1 min, then dehydrated at normal condition, and then stored in polyethylene terephthalate (PET) packages setting 5 °C, 85 ± 5% RH in 15 days.

Treatments: Fruits were immersed into emulsion solutions of CH, C.CSO5, C.CSO25, and C.CSO50 for 1 min, dehydrated at normal condition, storage in PET packs at 5 °C, and 85 ± 5% RH in 15 days.

2.2.2. Quality assessment

2.2.2.1. Respiration Rate

A volume of gas (0.5 mL) was taken out by the autosampler and transferred to the GC system (GL Science Inc., Japan). The headspace was determined by sealing a single intact strawberry in a 240G2 desiccator (inside of 245 mm, ASOEN Co., Ltd.) for 2 hours. The Helium gas served as the carrier gas at 33 mL/min of flow rate. The temperature settings included the oven (50 °C), injector (80 °C), and TCD detector (100 °C). Quantitative analysis utilized an absolute calibration method to establish a calibration curve.

2.2.2.2. Weight loss rate:

Fruits from groups were scaled before stored and after 5, 10, and 15 days. Weight loss rate (%) was calculated using the following the method from Van et al. [11] as below:

Weight loss rate = (the weight before storage – the weight at stored time) ×100 /the weight before storage

2.2.2.3. Firmness, TSS content, and pH measurements

The firmness of strawberry slices was assessed using a firmness meter (RE-3305, Yamaden Co., Ltd.), where slices were put on the holder of samples and penetrated to 7 mm of depth, 10 mm/s of speed with 6-mm probe in the shoulder region of the fruit. For the pH and TSS measurements, fruit pieces after that were homogenized, then the composition was analyzed. pH was determined with LAQUATWIN-pH-22 (HORIBA, Ltd., Japan) and TSS with MASTER-T test (Atago Co., Ltd., Japan), with results reported in terms of pH and °Brix.

2.2.2.4. Sensory evaluation

A 5-point Hedonic taste assessment was used to evaluate strawberry quality during storage. Samples were color-coded, and participants scored them from 1 (strongly disliked) to 5 (most favorable). Sensory parameters include color, odor, texture, and acceptability were evaluated at the day of 0, 5, 10, and 15.

2.3. Statistical analyses

The experimental data were analyzed using R version 3.6.3. Treatment effects were evaluated through analysis of variance (ANOVA), and Tukey tests were employed to identify significant differences between groups. A significance of $P < 0.05$ was officially recognized for statistical significance.

3. RESULT AND DISCUSSION

3.1. Respiration rate and weight loss

Strawberries exhibit a climacteric respiratory pattern, characterized by a sharp increase in respiration rate until it peaks, followed by a gradual decline [12]. Fig. 1 illustrates the respiration rates of all strawberry samples. The results indicated an increase in respiration rate by the third day of stored time, which then gradually decreased by the fifth day in all samples, with control fruits showing higher respiration rates than treatment ones. The emulsion solution likely forms a partially permeable layer on the surface of fruit, limiting the exchange of gas and thus delaying metabolomic progresses compared to control fruits [13].

Fruit weight loss steadily increased during storage, with not significantly differ among the control and treatments. The measurements of firmness exhibited a fluctuated line across samples. At the end of storage, fruits treated with CSO showed slightly higher firmness compared to the first day, but this difference was not statistically significant ($P > 0.05$). The natural water and weight loss in agricultural products during storage is attributed to transpiration, respiration, and the reduction of components. The thin layers on the surface of fruits which formed from emulsion reduced moisture loss, protected the peel from mechanical damage. They contributed to heal small damage holes, which might reduce the moisture loss process [14]. Additionally, the firmness values changes related to the enzyme activity of cell wall or the transformation of protopectin into pectin [15].

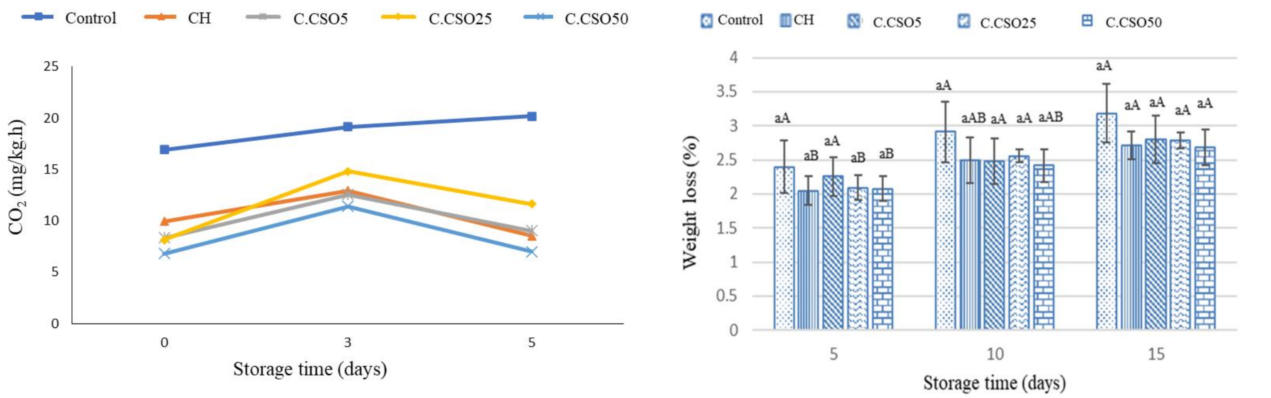

Fig. 1. Respiration rate (mg/kg.h) and weight loss of strawberry at 5 °C, 85 ± 5% RH

3.2. Quality change

Table 1. Firmness, TSS, pH and color of strawberry at 5 °C, 85 ± 5% RH

Parameters	Days	Treatments				
		Control	CH	C.CSO5	C.CSO25	C.CSO50
Firmness (N)	0	0.73 (0.14)^{aA}	0.66 (0.07)^{aA}	0.61 (0.10)^{aB}	0.73 (0.03)^{aA}	0.67 (0.04)^{aB}
	5	0.74 (0.08)^{aA}	0.90 (0.06) ^{aA}	0.96 (0.16) ^{aA}	0.78 (0.01) ^{aA}	0.92 (0.05) ^{aA}
	10	0.77 (0.01) ^{cA}	0.83 (0.05) ^{bcA}	0.96 (0.00) ^{aA}	0.92 (0.00) ^{abA}	0.90 (0.00)^{abcA}
	15	0.71 (0.53) ^{aA}	0.68 (0.11) ^{aA}	0.85 (0.07) ^{aAB}	0.87 (0.09) ^{aA}	0.82 (0.09)^{aA}
TSS (^{0}Brix)	0	8.17 (0.09)^{cB}	9.43 (0.17) ^{bA}	7.97 (0.05)^{cD}	9.17 (0.05)^{bA}	9.97 (0.05) ^{aA}
	5	9.47 (0.05)^{aA}	9.20 (0.08) ^{bAB}	9.40 (0.08)^{abB}	9.17 (0.05) ^{bA}	8.17 (0.09)^{cB}
	10	8.30 (0.28)^{cB}	9.10 (0.19) ^{bB}	10.17 (0.25)^{aA}	9.17 (0.16)^{bA}	10.00 (0.16)^{aA}
	15	8.17 (0.05)^{bB}	8.20 (0.05) ^{bC}	8.23 (0.05)^{bC}	9.07 (0.05)^{aA}	7.30 (0.00)^{cC}
pH	0	4.07 (0.02)^{aA}	4.02 (0.00)^{bAB}	4.05 (0.01)^{abA}	4.01 (0.01)^{bB}	3.95 (0.02)^{cB}
	5	4.05 (0.00)^{bA}	4.06 (0.00)^{bAB}	4.08 (0.01)^{bAB}	4.05 (0.01)^{bA}	4.14 (0.02)^{aA}
	10	4.04 (0.02)^{bcA}	3.98 (0.04)^{cB}	4.12 (0.02)^{aA}	4.08 (0.01)^{abA}	4.08 (0.01)^{abA}
	15	4.05 (0.01)^{bcA}	4.02 (0.02)^{cAB}	4.09 (0.01)^{abAB}	4.06 (0.01)^{bcA}	4.14 (0.02)^{aA}

The changes in the fruit's physicochemical properties are summarized in Table 1. Firmness showed fluctuations in all samples. In CSO treatment, fruits showed slightly higher firmness on the final storage day compared to the first ($P > 0.05$). Control samples peaked in firmness on day 10, while others peaked on day 5, except for C.CSO50. Firmness changes were due to metabolism or weight loss. Membranes reduced moisture loss and protected the peel from damage, delaying dehydration [14]. Weight loss was also linked to the water vapor permeability (WVP) of the film [16]. Variations in firmness were due to enzyme activity changes or fungal growth [17].

TSS values for control and CH treatment increased slightly from day 5 and then decreased by day 15. C.CSO5, C.CSO25, and C.CSO50 samples increased TSS by day 10, decreasing by day 15. Treatment samples had higher TSS than controls at day 15 ($P < 0.05$) except for C.CSO50. TSS changes were due to metabolic processes affecting starch and sugar. Treatments slowed metabolism, limiting TSS decrease compared to controlling fruits.

The pH values of the emulsion solution significantly impacted strawberries, but this effect was not consistent throughout storage. pH values for most samples remained stable at the final day, excepted for C.CSO50. The results suggest that the treatment might postpone biochemical processes, resulting in better effects on preservation.

3.3. Sensory evaluation

Sensory determination of control and treatment strawberries during stored time are depicted in **Fig.2**. Fruits initially indicated an increase in color and overall preference during the stored period, along with a gradual reduction at the end of storage. Odor increased until day 10 and then decreased. Conversely, texture declined throughout storage. There were significant differences in color, texture, and odor at the day 15 compared to the initial stored time ($P < 0.05$), but no crucial changes through treatments on the same day of storage. The acceptance scores were higher for treatment fruits compared to control. Previous studies have cautioned about sensory limitations when using CH and essential oils (EOs). For instance, acetic acid used to dissolve CH can impart a bitter and astringent flavor due to the increase of amine groups at 1 g per 100 mL solution [16] [18]. Additionally, EOs like lemon oils have been reported to negatively affect on sensory of strawberries compared to control and CH treatment [19]. Otherwise, the smell of treatment fruits was perceived more favorably than control fruits, indicating that the emulsion solutions did not adversely alter fruit smell over stored time in this study. These findings suggest promising consumer acceptance of such coatings in the future.

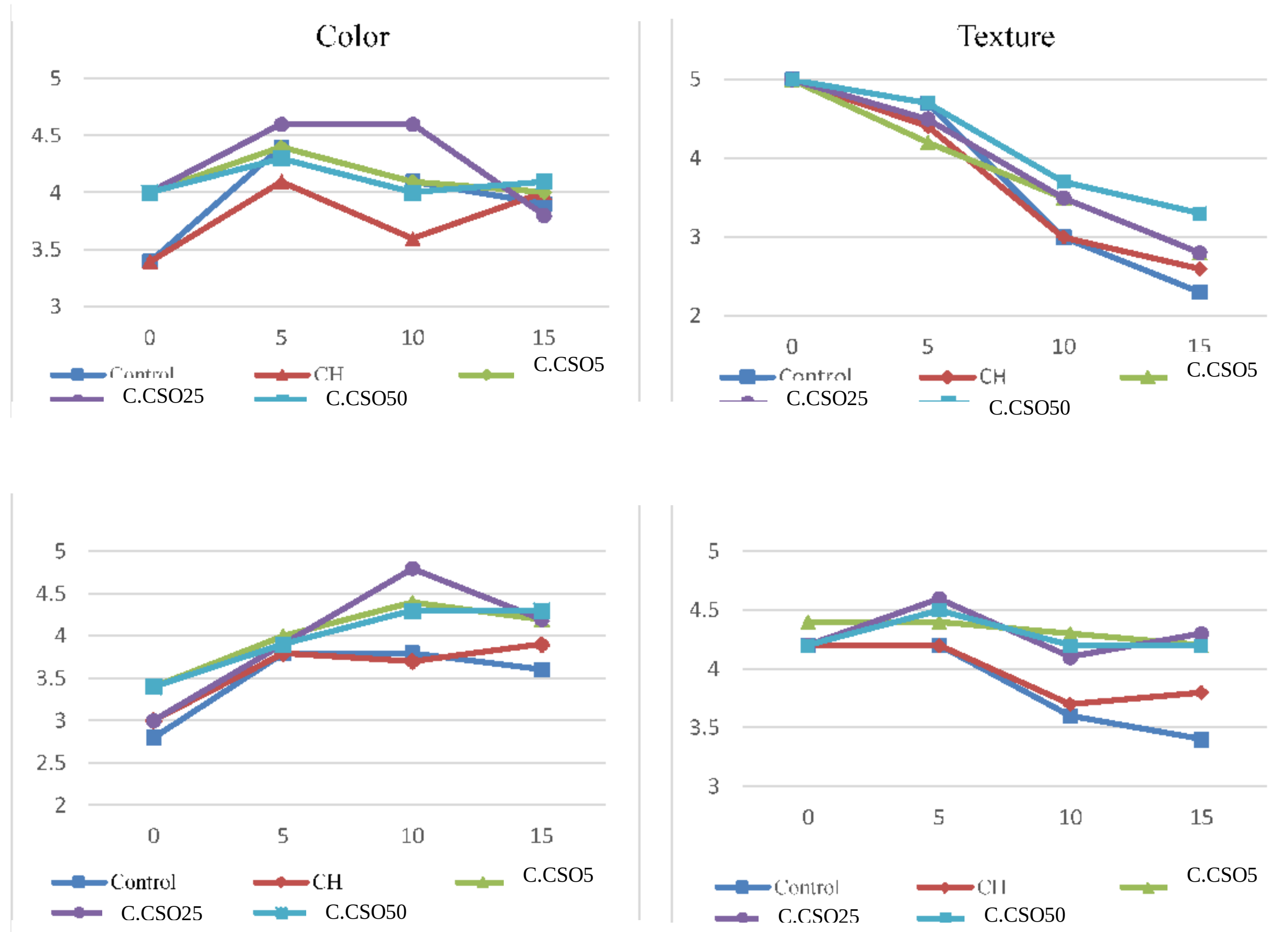

Fig.2. Sensory values of control and treatment strawberry storage at 5 °C and 85 ± 5% RH

4. CONCLUSION

In this study, emulsion solutions contained CH 1% and CSO (0.05%, 0.25%, and 0.50% (*w/v*)) have been evaluated on strawberry. These solutions, particularly those containing CSO, affected fruit metabolism, as evidenced by totally differences about certain properties including respiration rate, firmness, TSS, and pH. Specifically, the respiration rate of strawberries treated with emulsions totally decreased in comparison to other samples. In addition, C.CSO25 and C.CSO50 showed a higher effect in keeping the firmness of fruits compared to control, CH, and C.CSO5 group. In addition, the results demonstrated that CSO played a crucial role in maintaining the sensory of strawberry, particularly in C.CSO25 and C.CSO50. The results suggest that CSO incorporation with CH can contribute to extending the lifespan of strawberries by friendly environmental preservation method.

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