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Development of polysaccharide-lipid based composite wax formulation to enhance the storage quality of orange

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Abstract Comparative effects of different concentrations of coatings bee wax, cassava starch, corn oil, coconut oil and sodium bicarbonate on improving the keeping quality of orange and its storage performance was evaluated. Orange after harvesting were washed with 200ppm chlorine solution and kept for air drying in shade at room temperature (25-30^{0}C). The fruits were coated with different coating solutions ; Bee wax 0.5%,cassava starch 2%, corn oil 1% and sodium bicarbonate 1% (T_1); Bee wax 0.5%,cassava starch 2%, coconut oil 1% and sodium bicarbonate 1% (T_2) ; Bee wax 0.5%,cassava starch 2% and sodium bicarbonate 1% (T_3); Control(without coating) stored under ambient condition (29-32^{0}C and 65%- 70%RH).The physicochemical and physiological characters (physiological weight loss, Total soluble solids contents (TSS), fruit juice content, ascorbic acid content and the respiration rate) of fruits were evaluated for 10 days storage and the coating formulations consist Bee wax 0.5%,cassava starch 2%, corn oil 1% and sodium bicarbonate 1% (T_1) showed a remarkable effects significantly ($P<0.05$) to protect the physiological and biochemical characteristics of citrus. It extends storage life up to 10 days with appreciable retention of most of quality characteristics tested.

Key words: citrus, coating, cassawa starch, corn oil, storage

Introduction

Sweet orange cultivation in Sri Lanka is distributed majority confined to rain fed areas. In other areas of the country scattered trees are found in the home gardens. Present global production of sweet orange is about 50 million tons and according to FAO (2001) world production of sweet orange has increased by 36-54% from 1975 to 2000.Postharvest loss of horticultural crops may still reach high levels for some commodities, up to 30-40%.Incompetent handling of fruits result in injury to the surface layer making them more susceptible to attack by spoilage organisms with consequent reduction in consumer appeal in the market. The cultivars grown in Sri Lanka send to local

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market without giving any treatment for shelf life extension leads to wilting and shriveling due to higher moisture losses. That's leads to higher economic loss and demand for local produce also decreased.

Films and coatings may be heterogeneous in nature, consisting of a blend of polysaccharides, protein and lipids. This approach enables one to utilize the distant functional characteristics of each class of film former. The main objective of producing composite film is to improve the permeability or mechanical properties as dictated by the need of a specific application (Kamper and Fennema, 1984). Examples of these studies are using lipid and hydroxyprophyl cellulose (Hagenmaier and Shaw, 1990), fatty acid (Park *et al.*, 1996), gelatin and soluble starch (Arvanitoyannis *et al.*, 1997), soy protein isolate and gelatin (Cao *et al*., 2007).

Materials and methods

Material and sampling

The study was carried out using ripe fruits of citrus cv. Bibila Sweet Samples were harvested in June 2010 from farmer field in North Western part of Sri Lanka. The fruits were individually washed with 200ppm chlorine solution for disinfection and allowed to remove surface water at room temperature (30^0C). Bee wax, corn oil, coconut oil and sodium bicarbonate were purchased from the market and for preparation of cassava starch roots were crushed, peeled and rasped followed by strained the pulp with addition of water. The mash obtained was allowed to settle and the resulted starch was washed and dewatered in a clean bag by pressing. The extracted starch was dried and sieved to get fine particles using sieve (100 μ).The coating solutions were prepared on the percentage weight basis using bee wax ,cassava starch, corn oil, sodium bicarbonate and coconut oil in different concentrations.

Sample treatments

The treatments used for coating of fruits were; T_1: Bee wax 0.5%, Cassawa starch 2%, corn oil 1%, Sodium bicarbonate 1%; T_2: Bee wax 0.5%, Cassawa starch 2%, coconut oil 1%, Sodium bicarbonate 1%; T_3: Bee wax 0.5%, Cassawa starch 2%, Sodium bicarbonate 1%; T_4: control (without any coating).The washed fruits after drying were subjected to treatments consisting different coating solutions. Coated fruits were kept for air drying in shade at room temperature 28-30^0C and stored under ambient condition at 28-30^0C. The quality of treated fruits were monitored in 2 day intervals for 10 days.

Percentage weight loss

Fruit weight was taken after each storage interval and loss in weight during storage was expressed as % of initial weight. Pre-weigh fruit samples weighed on top lording balance (OHAUS, model ARA 520, New Jersey, 07058, USA) after each storage interval. The loss in weight on each sample date was observed.

Fruit juice content

Juice was extracted manually and the juice content (%) was calculated according to the total fruit weight.

Total soluble solids

The content of total soluble solids (TSS) is defined as the sugar content expressed in grams for 100g of juice. This parameter has been determined by direct reading on a refractometer {ATAGO, Model: HR-5 (9-90%), Japan}Reading was reported as ^{0}Brix.

Titratable acidity (TA)

Titratable acidity was determined by the following volumetric method. The juice was neutralized by a NaOH solution (0.1 mol L^{-1}) added by some drops of phenolphthalein as indicator solution. Indeed, under neutral conditions, the NaOH solution turns the juice pink.

Respiration rate

Respiration rate was measured by the closed method described by Kader *et al*., (1989), where gas tight glass box of 1L volume were filled with approximately 1 kg of oranges per box. The accumulation of CO_2 inside the box was measured after a period of 30 min. Sample of ml of head space gas were taken from each box with a calibrated syringe and CO_2 production monitored in gas analyzer (Varian cp-3800,po box 8033,43330 EA, MIDDELBURG, The Netherlands).

Surface colour change

Colour changes during postharvest storage were observed by an increase in the a/b ratio with an increase in yellowness (b) and decrease in greenness (a)

orange external colour was evaluated with colour difference meter (Konica Minolta TR 400) which provided L*, a* and b* values . L* is lightness and a* (-greenness to + redness) and b* (- blueness to + yellowness) are the chromaticity coordinates measurements were done in triplicate.

Statistical analysis: All analysis were done in triplicate and the statistical comparison of data was performed by ANOVA to reveal significant differences for each parameters. A probability value of $p<0.05$ was adopted as the criteria for significant differences.

Citrus cultivars were harvested at commercial maturity level TA: 0.3%; TSS: 12^0 from farmer field. The fruits were individually washed with 200ppm chlorine solution for disinfection and allowed to dry at 30^0C. Fruits were weighed after each storage interval and loss in weight during storage was expressed as % of initial weight. The fruit juice was extracted manually using juice extractor and juice content was calculated. The total soluble solids (TSS) content in fruit juice was recorded with Erma hand refractometer (ATAGO, model; HR-5) by squeezing the juice with cotton wool on to the clean sensor and reading was reported as ^{0}Brix. The pH of a known amount of fresh fruit juice in a 100ml beaker was recorded with a digital pH meter (Thermoorin, Model, 230A+). After standardizing the pH meter with buffer solutions of pH 4 and 7 (Ranganna, 1986) .The titratable acidity was determined as a known weight of fruit sample was crushed and taken in 250 ml volumetric flask and the volume was made up. After filtration 10 ml of filtrate using phenolphthalein as indicator to the end point of faint pink colour (AOAC, 1995). The peel colour was measured by colour difference meter (Konica Minolta, TR-400) and the results expressed as L,a,b values.

Statistical analysis

Three replicates were used in each treatments and the results were assessed by completely randomized design .Each replicate consist of 20 fruits and mean separation was done by using Least Significant Difference (LSD) at $\alpha= 0.05$.

Results and discussion

The quality parameters including Weight loss percentage (Fig 1), juice yield, TSS, TA (Titratable Acidity), are shown in Table 1, the values varied greatly among different coating treatments, where the coating formulations with corn oil (1%) achieved the highest juice yield (38.4%) and the lowest value 23.3% was recorded by control (without coating).Initial increase in TSS was observed in all treatments thereafter decreasing was observed.

Table 1. Changes in titratable acidity, total soluble solids (TSS in ^{0}B) and juice yield (%) in coated oranges

Parameter	Treatments	Storage intervals in days			
		Day 2	Day 4	Day 6	Day 8
Titratable acidity	T_1	2.1_{bc}	2.0_{d}	1.7_{bef}	1.5_{fg}
Initial value:2.4	T_2	2.2_{abc}	1.5_{fg}	1.4_{gh}	1.2_{h}
	T_3	1.8_{de}	1.7_{cd}	1.4_{gh}	1.2_{h}
	T_4	2.3_{ab}	1.2_{h}	1.2_{i}	0.9_{i}
TSS	T_1	9.6_{de}	10.0_{cd}	11.0_{a}	10.0_{cd}
Initial value:9^{0}B	T_2	8.0_{f}	11.3_{a}	10.0_{bc}	9.7_{de}
	T_3	10.0_{cd}	10.5_{b}	10.2_{c}	9.5_{e}
	T_4	11.0_{a}	10.5_{b}	10.2_{bc}	9.7_{de}
Juice yield	T_1	41.7_{b}	44.2_{a}	41.4_{b}	38.4_{d}
Initial value:	T_2	26.1_{j}	36.0_{e}	32.3_{g}	30.1_{h}
31.69%	T_3	39.0_{cd}	40.5_{bc}	40.7_{bc}	33.7_{fg}
	T_4	32.6_{g}	35.6_{ef}	28.4_{h}	23.5_{j}

Means within same raw and same column with different superscripts are significantly different ($p<0.05$) in each parameter, n=3

T_1: Bee wax 0.5%, Cassawa starch 2%, corn oil 1%, Sodium bicarbonate 1%; T_2: Bee wax 0.5%, Cassawa starch 2%, coconut oil 1%, Sodium bicarbonate 1%; T_3: Bee wax 0.5%, Cassawa starch 2%, Sodium bicarbonate 1%; T_4: control (without any coating)

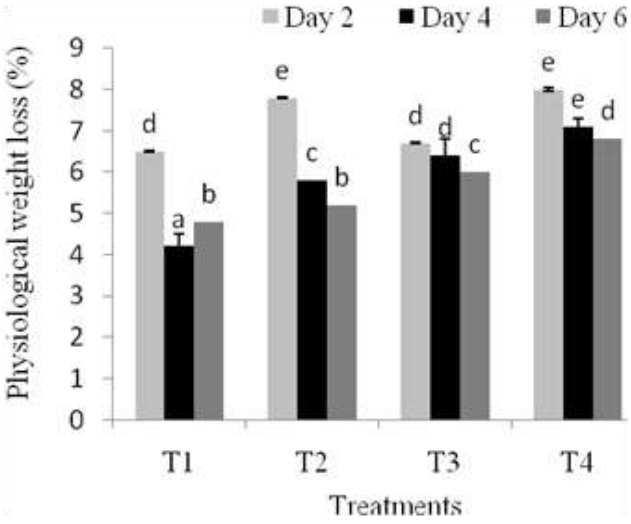


Fig. 1. Physiological weight loss % during storage, T_1: Bee wax 0.5%, Cassawa starch 2%, corn oil 1%, Sodium bicarbonate 1%; T_2: Bee wax 0.5%, Cassawa starch 2%, coconut oil 1%, Sodium bicarbonate 1%; T_3: Bee wax 0.5%, Cassawa starch 2%, Sodium bicarbonate 1%; T_4: control (without any coating); Results are expressed of three measurements. Means followed by a different letter are significantly different at α= 0.05

Corrections: Indicate X and Y axis scale and its label in figure 1

Average weight loss percentage of orange fruits significantly increased during storage (29-32^{0}C, 65-70% RH) up to 8 days and the fruits without coating had a significant increase 7.3% at the end of storage. Use of corn oil (1%) combined with cassava starch showed lower loss in fruit weight ranged between (6.5-4.8%) related to other treatments. An initial increase and then decrease in weight loss were recorded in all treatments and final decrease in weight loss might be due to the movement of water vapors from the saturated atmosphere in to the fruits. Dorria (2007) reported that the use of jojoba oil as a coating significantly affect the reduction of weight loss percentage with its concentration increased. The TA value of orange coated with Bee wax 0.5%, Cassawa starch 2%, corn oil 1%, Sodium bicarbonate 1% was the highest TA content (1.5%) followed by the fruits coated with Bee wax 0.5%,Cassawa starch 2%, coconut oil 1% and Sodium bicarbonate 1% (1.2%).

In present study, after 2 days of storage, orange had similar Respiration Rate (RR) independent of the uncoated treatments Table 2, .Maximum level of rate of respiration was found in control among all the treatments under ambient condition at the end of storage. Data illustrated in Table 2 related that there was noticeable significant increases thereafter decrease in respiration rate of oranges. In general all coating showed significant lower rate of CO_2 production than control (4.21 $mlCO_2/Kg^{-1}/hr^{-1}$). Moreover, the fruits caused by the least respiration rate (3.1$mlCO_2/Kg^{-1}/hr^{-1}$) was observed in fruits treated with Bee wax 0.5%, Cassawa starch 2%, corn oil 1%, Sodium bicarbonate 1% followed by the Bee wax 0.5%,Cassawa starch 2%, coconut oil 1% and Sodium bicarbonate 1% (3.2 $mlCO_2\,Kg^{-1}\,hr^{-1}$) respectively.

Table 2. Changes of respiration rate ((3.2 $mlCO_2\,Kg^{-1}\,hr^{-1}$) in coated oranges

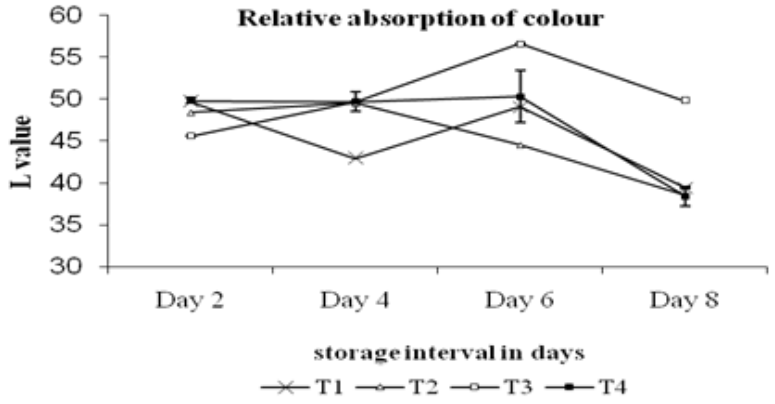
Treatments	Storage intervals in days			
	Day 2	Day 4	Day 6	Day 8
T_1	4.1_c	4.3_{ab}	4.4_{abc}	3.1_{ef}
T_2	4.1_c	4.2_{ab}	4.0_d	3.2_e
T_3	4.2_{ab}	4.4_{abc}	4.3_{ab}	2.9_{gh}
T_4	4.6_a	4.4_{abc}	4.3_{ab}	4.2_{ab}

Means within same raw and same column with different superscripts are significantly different ($p<0.05$) , n=3

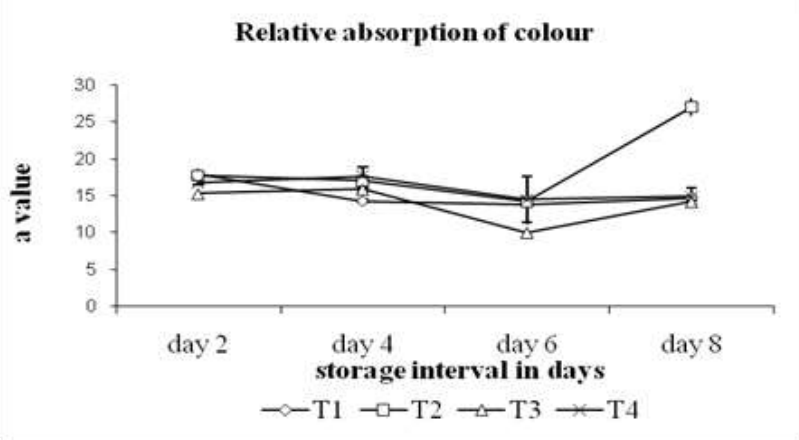
T_1: Bee wax 0.5%, Cassawa starch 2%, corn oil 1%, Sodium bicarbonate 1%; T_2: Bee wax 0.5%, Cassawa starch 2%, coconut oil 1%, Sodium bicarbonate 1%; T_3: Bee wax 0.5%, Cassawa starch 2%, Sodium bicarbonate 1%; T_4: control (without any coating)

In early storage the presence of a high concentration of chlorophyll in the orange peel tissues is significantly related the higher intensity of green colour

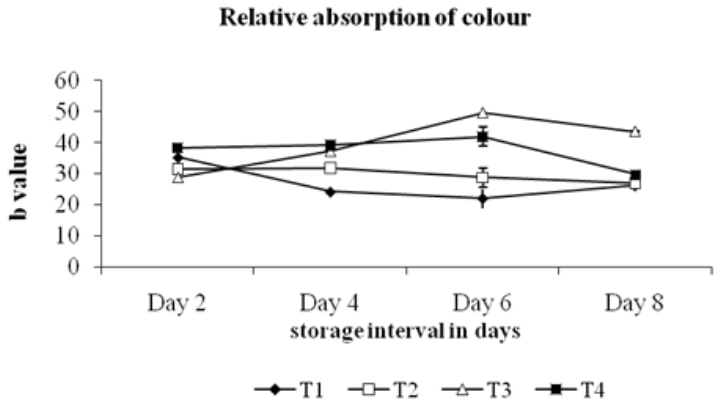
observed. So, as advancement of storage, chlorophyll degradation (Hernandez *et al*., 2008) and the predominance of xanthophylls and other carotenoids pigments are the reason for the variation in colour turning from green to yellow. In control (without coating) the higher amount of yellowing can be identified significantly >0.05 than coated fruits (Fig 2). Yellowing of the fruit peel was characterized at the decaying period, by a constant increase in the value a* (less green) and a maximum magnitude of b* (more yellow).



a



b



c

Fig. 2. Changes of peel colour in the L* (Fig.2.a) a*(Fig.2.b) b*(Fig.2.c) parameters. Vertical bars ± SD of three measurements

Corrections: Indicate X and Y axis scale and its label in figure 1

Specially correct the Y axis label (Fig.2.a) as L value (Fig.2.b) as a value (Fig.2.c) as b value

Note: All the correction already I have been made above

Conclusion

The results of present work indicated that quality parameters weight loss %, TSS, TA, juice yield, Respiration Rate, fruit peel colour varied with different coating formulations. The fruits coated with Bee wax 0.5%, Cassawa starch 2%, corn oil 1%, Sodium bicarbonate 1% showed the higher TA content, juice content and the lower physiological weight loss and the respiration rate followed by Bee wax 0.5%, Cassawa starch 2%, coconut oil 1%, Sodium bicarbonate 1% coating applications significantly.TSS in general showed an initial increase then a decreasing trend in all treatments. Therefore, the said coating formulations may be considered as the better performing application for citrus.

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