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# The effect of packaging methods (paper, active paper, and edible coating) on the characteristic of papaya MJ9 in ambient temperature storage

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**Abstract**. Papaya is one of the export commodities that contain high vitamin C but having short shelf-life. One method that use to extend the shelf-life and maintain the quality of papaya is packaging. The aim of this study was to investigate the effect of the packaging methods (paper, active paper and edible coating) on the characteristics of papaya MJ9 (weight loss, firmness, total soluble solid (TSS), Total Titratable Acid (TTA), pH, vitamin C and total mold and yeast). The packaging methods were control (F1), wrapping paper (F2), wrapping active paper (F3), combination of edible coating and wrapping paper (F4), and combination of edible coating and wrapping active paper (F5). The result showed that paper packaging, edible coating and active paper packaging significantly affected the weight loss, firmness, total soluble solid, total titratable acids, pH, vitamin C, and total mold and yeast of papaya. The weight loss, total soluble solid and pH of packaged papaya was lower than that of control sample, however, the value of firmness and total titratable acid was higher than that of the control sample. Packaging can inhibit the increase of weight loss, total soluble solids and pH, and the decrease of firmness, total titratable acid, vitamin C and total mold and yeast. Based on the papaya characteristics, the selected packaging method was the combination of edible coating and wrapping active paper.

***Keywords:*** *papaya, coating, active paper, lemongrass*

## 1. Introduction

Papaya (*Carica papaya L*) is one of the tropical fruits commonly consumed in the form of fresh mature papaya due to vitamin C and vitamin A content [1]. According to FAO (2013), Indonesia is the 3rd largest papaya producing country after India and Brazil. One of papaya varieties cultivated in Boyolali is MJ9 papaya. The MJ9 papaya is the more sweet taste, more chewy flesh, and thicker than other varieties [2].

Fruits are perishable commodities. This is due to the high water content of fruit (70-95%). Microorganisms such as molds, bacteria, and viruses could contaminate the fruits that cause damage of papaya. Poor post-harvest handling can cause bruised and soft wounds that trigger papaya damage [3].

Food packaging can prevent and reduce damage, protect food from contamination or mechanical damage such as friction and collision. Packaging that is commonly on papaya is using baskets or paper to avoid wound on the fruit [4]. One of the food packaging being developed is an active paper packaging. Active paper packaging is the incorporation of certain additive compounds into paper packaging for the purpose of maintaining the shelf life of the product [5]. Active paper packaging with the addition of active ingredients can inhibit the growth some fungi such as *C. albicans*, *A. flavus*, *P. nalgiovense*, *P. roqueforti*, and *E. repens* [5] and prevent the damage of fresh fruit such as tomatoes [6] strawberries [7] and dragon fruit [8].

Another packaging that can be used is edible packaging, which is one type of packaging that environmentally friendly [9] and proven to inhibit oxidation [10]. The addition of an antimicrobial active component to edible coatings can increase the shelf life because the barrier properties of the coating will be reinforced with antimicrobial active components that can inhibit bacterial spoilage. Lemongrass (*Cymbopogon citratus*) is one of the natural herbal ingredients that have antimicrobial activity caused by the components of α-citral (geranial) and β-citral (neral) [11]. Edible coatings of food products have been widely practiced such as on paprika [12], tomatoes [13], melons [14].

However, the application of edible coating packaging can not protect food from mechanical hazards. Paper packaging can protect food from mechanical hazards. Paper can act as a vibration damper during distribution and simultaneously give a permeable effect on gas [15]. Therefore, this study investigated the effect of the combination of packaging methods on the characteristic of MJ9 papaya at ambient temperature storage and to determine the best treatment for preservation of papaya MJ9.

## 2. Materials and Methods

### *2.1. Materials*
In this study, papaya obtained from farmer's group in Mojosongo, Boyolali (Indonesia) and lemongrass obtained from the local market in Surakarta (Indonesia). The materials used to produce edible coatings were citrus pectin from Cargill-Germany, glycerol, tween 80 and lemongrass essential oil. The ingredients of active paper packaging were filter paper, tapioca (Rose Brand), acetic acid, tween 80, distillation waste lemongrass oleoresin and chitosan.

### *2.2. Preparation of edible coating*
The edible coating was prepared by dissolving 50 g of pectin in 1000 ml distilled water at 75 ° C for 30 minutes. Glycerol (2% w/v) was added and the solution was then allowed to cool. The essential oil (1% v/v) was added and stirred using a magnetic stirrer [16].

### *2.3. Preparation of active paper packaging*
The active paper was prepared by immersion filter paper (2mmx2mm) for 24 hours. The paper was crushed, then chitosan solution in 1% acetic acid, tapioca suspension (4.5 g/50 ml of distilled water), and 2% (b/b) oleoresin emulsion were added to the pulp. The pulp was pressed and dried for 48 hours [17].

### *2.4. Packaging application*
Whole papayas were dipped into the pectin-based edible coating solution then dried using a dryer. Coated papayas were repackaged with paper (F4) or active paper (F5). Uncoated papayas were packed with paper (F2) or active paper (F3). Uncoated papayas which were unpacked use as a control (F1). Each sample was prepared in duplicate and stored in baskets at ambient temperature for 18 days.

### *2.5. Determined of weight loss, firmness, total soluble solids, total titratable acid, vitamin C, pH and total mold and yeast*
Weight loss was obtained by calculating the weight every 3 days. The results were shown in weight loss percentage [18]. Firmness values were measured using a fruit hardness tester (FR5105) expressed in N [19]. Total soluble solids were obtained by dripping the pulp of papayas on refractometer (Master Refractometer Manual Atago) [19]. 10 grams of papaya's pulp was dissolved in 250 ml of aquades and taken as 25 ml to be titrated with 0.1 N NaOH. Phenolphthalein was used as an indicator to determine the total percentage of titrated acids [18]. The pH measurements were performed using pH

meter (pH tester 20) [20]. Vitamin C levels were analyzed by an iodometric titration method with starch indicator [21]. The growth of mold and yeast was analyzed by microbiological test using total plate count (TPC) technique [22]. All samples were analyzed on days 0, 3, 6, 9, 12, 15 and 18 during storage .

## 3. Result and Discussion

### 3.1. Weight loss

The results showed significantly increased ($p<0.05$) in weight loss percentage of packed papaya and unpacked (control) during storage at room temperature. The control samples had the greatest losses than packed samples (Table 1). The edible coating was a good barrier for water and oxygen so as to control the rate of respiration [23] and the paper was able to absorb the vibrations during distribution and simultaneously affected the permeability of the gas [16]. The combination packaging methods could be a good barrier so that papaya on the treatment F4 and F5 had a lower weight loss than that of the control, F2, and F3 samples. Coating of papaya MJ9 by cassava-starch based edible coating solution enriched with lemongrass oil also decreased the weight loss of fruit [24].

**Table 1.** Weight loss percentage of papaya MJ9 during storage

| Formula | Storage (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 |
| F1 | 0.000$^{Aa}$ ±0.000 | 4.367$^{Db}$ ±0.053 | 8.464$^{Ec}$ ±0.009 | 18.111$^{Ed}$ ±0.059 | 26.86$^{Ee}$ ±0.073 | 31.404$^{Ef}$ ±0.006 | 38.800$^{Eg}$ ±0.034 |
| F2 | 0.000$^{Aa}$ ±0.000 | 4.114$^{Cb}$ ±0.041 | 7.299$^{Cc}$ ±0.018 | 16.089$^{Dd}$ ±0.029 | 20.053$^{Ce}$ ±0.015 | 28.962$^{Df}$ ±0.114 | 35.134$^{Dg}$ ±0.039 |
| F3 | 0.000$^{Aa}$ ±0.000 | 4.322$^{Db}$ ±0.071 | 7.623$^{Dc}$ ±0.030 | 14.523$^{Cd}$ ±0.069 | 20.885$^{De}$ ±0.002 | 27.924$^{Cf}$ ±0.053 | 34.799$^{Cg}$ ±0.023 |
| F4 | 0.000$^{Aa}$ ±0.000 | 3.458$^{Bb}$ ±0.006 | 6.542$^{Bc}$ ±0.049 | 13.856$^{Bd}$ ±0.083 | 19.061$^{Be}$ ±0.119 | 27.091$^{Bf}$ ±0.056 | 34.143$^{Bg}$ ±0.073 |
| F5 | 0.000$^{Aa}$ ±0.000 | 3.180$^{Ab}$ ±0.083 | 5.882$^{Ac}$ ±0.028 | 12.158$^{Ad}$ ±0.078 | 17.445$^{Ae}$ ±0.037 | 25.441$^{Af}$ ±0.082 | 30.801$^{Ag}$ ±0.045 |

$^{A-E}$ Mean different letter within each column are significantly different ($p<0.05$)
$^{a-g}$ Mean different letter within each line are significantly different ($p<0.05$)

### 3.2. Firmness

The firmness of all samples decreased significantly ($p <0.05$) during storage. Papaya with packaging treatment could inhibit the decrease of the firmness than the control (Table 2). Papaya without packaging indicates a faster maturity rate that causes by an increased of ethylene production [18] so that caused a partial change of water-insoluble protopectin into water-soluble resulting in soft fruit [25]. Other study also stated that the firmness of papaya MJ9 treated with cassava starch-based coating could maintain the firmness better than the control [24]. The combination of edible coating and wrapping active paper (F5) can protect the fruit both mechanically and microbiologically damages so could maintain the firmness of the fruit.

**Table 2.** Firmness of papaya MJ9 during storage (N)

| Formula | Storage (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 |
| F1 | 11.655$^{Ag}$ ±0.025 | 5.381$^{Af}$ ±0.026 | 3.661$^{Ae}$ ±0.052 | 2.694$^{Ad}$ ±0.018 | 1.921$^{Ac}$ ±0.087 | 1.293$^{Ab}$ ±0.101 | 0.616$^{Aa}$ ±0.048 |
| F2 | 11.573$^{Ag}$ ±0.099 | 5.484$^{Bf}$ ±0.011 | 4.425$^{Be}$ ±0.075 | 2.661$^{Ad}$ ±0.030 | 2.107$^{Bc}$ ±0.078 | 1.810$^{Bb}$ ±0.018 | 1.250$^{Ba}$ ±0.014 |
| F3 | 11.510$^{Af}$ ±0.064 | 6.600$^{Ce}$ ±0.024 | 4.553$^{BCd}$ ±0.076 | 3.027$^{Bc}$ ±0.060 | 3.047$^{Dc}$ ±0.006 | 2.070$^{Cb}$ ±0.053 | 1.444$^{Ca}$ ±0.038 |
| F4 | 11.532$^{Ag}$ ±0.091 | 7.560$^{Ef}$ ±0.042 | 4.607$^{Ce}$ ±0.003 | 3.087$^{Bd}$ ±0.042 | 2.330$^{Cc}$ ±0.075 | 2.017$^{Cb}$ ±0.021 | 1.608$^{Da}$ ±0.068 |
| F5 | 11.541$^{Ag}$ ±0.076 | 7.445$^{Df}$ ±0.060 | 5.359$^{De}$ ±0.034 | 4.432$^{Cd}$ ±0,074 | 3.484$^{Ec}$ ±0.034 | 3.031$^{Db}$ ±0.030 | 2.858$^{Ea}$ ±0.026 |

$^{A-E}$ Mean different letter within each column are significantly different ($p<0.05$)
$^{a-g}$ Mean different letter within each line are significantly different ($p<0.05$)

### *3.3. Total soluble solids*

Table 3 showed the significant increase of total soluble solids of papaya due to the breakdown of starch into simple sugars. The packaging treatment prevents oxygen contact, which inhibits respiration and transpiration [26]. The addition of the active component of lemongrass to the packaging of F3, F4, and F5 caused an inhibition of increase the total soluble solids MJ9 papaya. Other study about coating papaya MJ9 by cassava starch-based coating also state that total soluble solids were increase during storage [24].

**Table 3.** Total soluble solids (TSS) of papaya MJ9 during storage (°Brix)

| Formula | Storage (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 |
| F1 | 7.950$^{Aa}$ ±0.071 | 8.800$^{Bb}$ ±0.000 | 9.650$^{Cc}$ ±0.071 | 10.050$^{Dd}$ ±0.071 | 11.050$^{De}$ ±0.071 | 11.350$^{Bf}$ ±0.071 | 11.750$^{Cg}$ ±0.071 |
| F2 | 8.350$^{Ba}$ ±0.071 | 8.450$^{Aa}$ ±0.071 | 9.100$^{Bb}$ ±0.141 | 9.650$^{Cc}$ ±0.071 | 10.800$^{Cd}$ ±0.000 | 11.000$^{Bd}$ ±0.000 | 11.300$^{Be}$ ±0.141 |
| F3 | 8.050$^{Aa}$ ±0.071 | 8.450$^{Ab}$ ±0.071 | 8.850$^{Ac}$ ±0.071 | 9.150$^{Ad}$ ±0.071 | 9.850$^{Be}$ ±0.071 | 10.100$^{Af}$ ±0.141 | 10.350$^{Ag}$ ±0.071 |
| F4 | 8.100$^{Aa}$ ±0.000 | 8.500$^{Ab}$ ±0.141 | 9.050$^{ABc}$ ±0.071 | 9.750$^{Cd}$ ±0.071 | 9.850$^{Bde}$ ±0.071 | 10.100$^{Aef}$ ±0.283 | 10.400$^{Ag}$ ±0.000 |
| F5 | 8.100$^{Aa}$ ±0.141 | 8.400$^{Ab}$ ±0.000 | 8.850$^{Ac}$ ±0.071 | 9.400$^{Bd}$ ±0.141 | 9.650$^{Ae}$ ±0.071 | 10.050$^{Af}$ ±0.071 | 10.300$^{Ag}$ ±0.000 |

$^{A-E}$ Mean different letter within each column are significantly different ($p<0.05$)
$^{a-g}$ Mean different letter within each line are significantly different ($p<0.05$)

### *3.4. Total titratable acid*

Table 4 showed the significant decrease of papayas total titrated acids ($p < 0.05$) on all treatments during storage caused by the use of acids by the respiratory process. The active compound of the lemongrass that added to the packaging of F3, F4, and F5 can protect the papaya from mechanical and microbiological damage thus inhibiting respiration rate [27]. The controls showed the greatest decrease whereas F2 showed no significant difference compared to control on the total titratable acids parameters.

**Table 4.** Total titratable acid (TTA) of papaya MJ9 during storage (%)

| Formula | Storage (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 |
| F1 | $0.600^{Af}$ ±0.056 | $0.480^{Ae}$ ±0.000 | $0.400^{Ad}$ ±0.000 | $0.320^{Ac}$ ±0.000 | $0.240^{Ab}$ ±0.000 | $0.260^{Ab}$ ±0.028 | $0.160^{Aa}$ ±0.000 |
| F2 | $0.640^{Ae}$ ±0.000 | $0.520^{ABd}$ ±0.056 | $0.440^{ABc}$ ±0.056 | $0.380^{ABbc}$ ±0.028 | $0.320^{Ab}$ ±0.000 | $0.300^{ABb}$ ±0.028 | $0.160^{Aa}$ ±0.000 |
| F3 | $0.640^{Af}$ ±0.000 | $0.560^{ABe}$ ±0.000 | $0.480^{ABd}$ ±0.000 | $0.440^{BCcd}$ ±0.056 | $0.400^{Ac}$ ±0.000 | $0.320^{Bb}$ ±0.000 | $0.240^{Ba}$ ±0.000 |
| F4 | $0.600^{Ac}$ ±0.056 | $0.560^{ABc}$ ±0.000 | $0.480^{ABb}$ ±0.000 | $0.480^{Cb}$ ±0.000 | $0.480^{Db}$ ±0.000 | $0.340^{Ba}$ ±0.028 | $0.300^{Ca}$ ±0.028 |
| F5 | $0.640^{Ad}$ ±0.000 | $0.600^{Bd}$ ±0.056 | $0.520^{Bc}$ ±0.056 | $0.480^{Cc}$ ±0.000 | $0.460^{Dbc}$ ±0.028 | $0.400^{Cb}$ ±0.000 | $0.320^{Ca}$ ±0.000 |

$^{A-E}$ Mean different letter within each column are significantly different ($p<0.05$)
$^{a-g}$ Mean different letter within each line are significantly different ($p<0.05$)

### 3.5. *Vitamin C*

Vitamin C of papaya in all treatments increased until reach the peak maturity. It is in line with other study that stated the value of vitamin C papaya increased with ripening [28]. The fruits then decayed and vitamin C decreased (Table 5). Vitamin C of papaya control decreased after 6 days storage, while papaya packed without the addition of active compounds of lemongrass decreased after 9 days storage. Papaya packed with incorporation active component of lemongrass can inhibit the maturity rate so the vitamin C decreased after 12 days storage. The decrease of vitamin C is due to the oxidation of ascorbic acid [29].

**Table 5.** Vitamin C of papaya MJ9 during storage (%)

| Formula | Storage (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 |
| F1 | $0.090^{Ab}$ ±0.003 | $0.125^{Bc}$ ±0.003 | $0.161^{Ce}$ ±0.003 | $0.136^{Ad}$ ±0.006 | $0.116^{Ac}$ ±0.003 | $0.099^{Ab}$ ±0.003 | $0.071^{Aa}$ ±0.006 |
| F2 | $0.092^{Aa}$ ±0.000 | $0.108^{Ab}$ ±0.003 | $0.130^{Bc}$ ±0.003 | $0.152^{ABd}$ ±0.003 | $0.134^{Ac}$ ±0.003 | $0.127^{Bc}$ ±0.006 | $0.088^{Ba}$ ±0.007 |
| F3 | $0.092^{Aa}$ ±0.000 | $0.114^{Ab}$ ±0.000 | $0.132^{Bc}$ ±0.006 | $0.136^{Ac}$ ±0.006 | $0.158^{Bd}$ ±0.000 | $0.130^{Bc}$ ±0.003 | $0.112^{Cb}$ ±0.003 |
| F4 | $0.094^{Aa}$ ±0.003 | $0.110^{Ab}$ ±0.006 | $0.116^{Ab}$ ±0.003 | $0.169^{Cc}$ ±0.009 | $0.213^{Cd}$ ±0.009 | $0.161^{Cc}$ ±0.003 | $0.112^{Cb}$ ±0.003 |
| F5 | $0.090^{Aa}$ ±0.003 | $0.110^{Ab}$ ±0.006 | $0.132^{Bc}$ ±0.006 | $0.162^{BCd}$ ±0.006 | $0.281^{De}$ ±0.012 | $0.154^{Cd}$ ±0.006 | $0.119^{Cbc}$ ±0.000 |

$^{A-E}$ Mean different letter within each column are significantly different ($p<0.05$)
$^{a-g}$ Mean different letter within each line are significantly different ($p<0.05$)

### 3.6. *pH*

Table 6 showed an increase of all papayas pH ($p <0.05$) during storage. An increase in pH papaya during storage was due to the conversion process of carbohydrate to sugar and the use of acids for metabolism [30]. Papaya control showed the highest pH value compared to other treatments. The packing combination (F4) and (F5) showed significantly different results compared to the control. Papaya with edible coating packaging and active paper can suppress the presence of air exchange in fruit and environmental contacts that allow the occurrence of metabolic processes due to microbial contamination. The active component in essential oils and oleoresins can interact with the cell membrane thus affecting the metabolic cycle and fruit aging [31].

**Table 6.** pH of papaya MJ9 during storage

| Formula | Storage (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 |
| F1 | 4,775$^{Aa}$ ±0,035 | 5,250$^{Bb}$ ±0,000 | 5,600$^{Cc}$ ±0,000 | 5,800$^{Dd}$ ±0,000 | 6,250$^{Ce}$ ±0,071 | 6,575$^{Cf}$ ±0,035 | 6,850$^{Dg}$ ±0,071 |
| F2 | 4,775$^{Aa}$ ±0,035 | 5,250$^{Bb}$ ±0,000 | 5,250$^{Bb}$ ±0,071 | 5,600$^{Cc}$ ±0,000 | 5,775$^{Bd}$ ±0,035 | 6,175$^{Be}$ ±0,035 | 6,625$^{Cfa}$ ±0,035 |
| F3 | 4,750$^{Aa}$ ±0,071 | 4,975$^{Ab}$ ±0,035 | 5,025$^{Ab}$ ±0,035 | 5,200$^{Ac}$ ±0,000 | 5,425$^{Ad}$ ±0,035 | 5,850$^{Ae}$ ±0,071 | 6,375$^{Bf}$ ±0,035 |
| F4 | 4,850$^{Aa}$ ±0,000 | 5,225$^{Bb}$ ±0,035 | 5,300$^{Bb}$ ±0,000 | 5,400$^{Bc}$ ±0,000 | 5,550$^{Ad}$ ±0,071 | 5,825$^{Ae}$ ±0,035 | 6,350$^{Bf}$ ±0,071 |
| F5 | 4,800$^{Aa}$ ±0,000 | 5,150$^{Bb}$ ±0,071 | 5,225$^{Bb}$ ±0,035 | 5,375$^{Bc}$ ±0,035 | 5,525$^{Ad}$ ±0,035 | 5,750$^{Ae}$ ±0,071 | 6,150$^{Af}$ ±0,071 |

$^{A-E}$ Mean different letter within each column are significantly different ($p<0.05$)
$^{a-g}$ Mean different letter within each line are significantly different ($p<0.05$)

### *3.7. Total mold and yeast*

The increase of total molds and yeast of papaya occurred in all treatments (Table 7). The controls showed a large mold and yeast growth (6,199 log CFU/g). The packaging treatment showed a significant difference compared to the control. Incorporation of essential oil and oleoresin lemongrass into treatments F3, F4 and F5 can inhibit the growth of mold and yeast of papaya. Total mold and yeast of papaya on treatment F3, F4, F5 were 3,908 log CFU/g, 5,310 log CFU/g, 3,484 log CFU/g. This is because the active component of lemongrass there are α-citral (geranial) and β-citral (neral) can be an antimicrobial agent against mold and yeast growth [32]. Other study showed that the total mold and yeast of papaya MJ9 treated with coating incorporated with 1% lemongrass oil was smaller than that of the control sample [24].

**Table 7**. Total mold and yeast of papaya MJ9 during storage (log CFU/g)

| Formula | Storage (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 12 | 15 | 18 |
| F1 | 1.544$^{Ba}$ ±0.000 | 2.435$^{Db}$ ±0.078 | 3.108$^{Ec}$ ±0.016 | 3.416$^{Ed}$ ±0.037 | 4.454$^{De}$ ±0.001 | 5.174$^{Df}$ ±0.008 | 6.199$^{Eg}$ ±0.016 |
| F2 | 1.719$^{Ca}$ ±0.029 | 2.112$^{Cb}$ ±0.047 | 2.953$^{Dc}$ ±0.016 | 3.047$^{Dd}$ ±0.008 | 4.391$^{De}$ ±0.016 | 5.203$^{Df}$ ±0.043 | 5.990$^{Dg}$ ±0.054 |
| F3 | 1.238$^{Aa}$ ±0.088 | 1.627$^{Bb}$ ±0.036 | 2.657$^{Bc}$ ±0.021 | 2.741$^{Bc}$ ±0.030 | 3.219$^{Bd}$ ±0.042 | 3.518$^{Be}$ ±0.121 | 3.908$^{Bf}$ ±0.047 |
| F4 | 1.813$^{Cb}$ ±0.000 | 1.349$^{Aa}$ ±0.068 | 2.763$^{Cc}$ ±0.011 | 2.901$^{Cc}$ ±0.105 | 3.388$^{Cd}$ ±0.015 | 4.414$^{Ce}$ ±0.110 | 5.310$^{Cf}$ ±0.109 |
| F5 | 1.477$^{Bb}$ ±0.000 | 1.398$^{Aa}$ ±0.000 | 2.514$^{Ac}$ ±0,033 | 2.498$^{Ac}$ ±0.020 | 2.596$^{Ad}$ ±0.031 | 2.956$^{Ae}$ ±0.011 | 3.484$^{Af}$ ±0.010 |

$^{A-E}$ Mean different letter within each column are significantly different ($p<0.05$)
$^{a-g}$ Mean different letter within each line are significantly different ($p<0.05$)

## 4. Conclusion

Packaging methods significantly affected the weight loss, firmness, total soluble solid, total titratable acids, pH, vitamin C, and total mold and yeast of papaya. The weight loss, total soluble solid and pH of packaged papaya was lower than that of the control sample, however, the value of firmness and total titratable acid was higher than that of the control sample. Addition of active components of lemongrass on the edible and paper packaging can inhibit the increase of weight loss, total soluble solids and pH, and the decrease of firmness, total titratable acid, vitamin C and total mold and yeast. Based on the papaya characteristics, the selected packaging method was the combination of edible coating and wrapping active paper with the incorporation of essential oils (1%) and oleoresin (2%).

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