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Effect of Packaging Materials of Aloe VeraLime Juice Container on Physicochemical Properties during Storage

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Abstract: Aloe vera-lime juice (ALJ) is processed drink product which is provide nutrients for consumer but nowadays fruit juice tend to become easily spoiled after storage. This study aims to investigating the effect of packaging materials of aloe veralime juice container on physicochemical properties during storage. Therefore, the aloe vera-lime juices were produced and pasteurized at 95℃ for 1 min. The juices were packaged in different packaging materials - PET bottle, brown glass bottle and colorless glass bottle in 250ml batches and stored for six weeks at room (28℃) and refrigeration (4℃) temperature. During the study, brown glass bottle has a significantly higher pH value than other packaging material at 28℃ and 4℃ which is 2.83 and 3.21, respectively. Following with the titratable acidity (TA) which is inversely proportional with pH, brown glass bottle was the lowest TA value. While for total soluble solid (TSS), aloe vera-lime juice stored in PET bottle shows the lowest decrement of sucrose from 6.77°Brix to 7.23°Brix for both temperatures with percentage reduction was 6.79% after 6 weeks. After 6 weeks, aloe vera-lime juice become darker, greener and yellower in colour. While, brown glass bottle has significantly higher value of total phenolic content with 64.17% reduction for 28℃ and 63.55% reduction for 4℃. Sensory evaluation of aloe vera-lime juice, shows that the most acceptance is juice stored in brown glass bottle. All data from analysis involved shows the best packaging material to preserve aloe vera-lime juice was brown glass bottle.

Keywords: Packaging Materials, Temperature, Time, Physiochemical, Juice

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1. Introduction

Juices are one of the processed drink products which conveniently consume to provide nutrients in diet from the ingredients used and also provide better taste and give freshness after drink. The main source of beverage juice is from the flesh of fruit and vegetables. *Aloe barbadensis Miller* or Aloe vera is a native plant species of South Africa that has spread throughout the continent of Europe, where it has reached nearly every country on the world [1]. In recent years, the food and beverages industry is facing problems related to the degree of deterioration and the changes in taste, texture and color due to the factors of ingredients used, packaging consumption, temperature, storage time and others. Therefore, to overcome the problem citrus such as limes (*Citrus aurantifolia*) were added which can act as antibacterial in mixture have been affected against the bacteria (*S.aureus and S.pyogenes*) that cause of cough and prolonged the shelf life of juice or food.

Consumers normally purchase a product based on their first perception of the appearance such as design of packaging, color, labelling and price. Colour changes are influenced by environmental and management factors such as manufacturing process and storage. To limit these changes in fruit juice during storage, temperature, humidity, and insect management, as well as inventory control, are required [2]. Packaging is one of the most critical considerations to control the quality and shelf life of the juices. Fruit juices are typically packaged in a variety of materials such as polyethylene terephthalate (PET), polypropylene (PP), paper, metal and glasses. Juices are packaged in these materials as a technological approach to promote preservation of quality and nutrients. Therefore, many packaging materials were used today to pack beverage products. Because of their benefits, each of these materials has found a demand (e.g., light-weighting, oxygen or light projection, inertness, etc.) [3]. The main objective of this study is to investigate the effect on physiochemical properties, color, phenolic content and sensory characteristics of aloe vera-lime juice in three different packaging materials during storage at room (28°C) and refrigeration (4°C) temperatures in six weeks. Results from this study will allow us to make recommendations on which container is the best for preserving, store and package ALJ.

2. Materials and Methods

2.1 Materials

Aloe vera leaves were collected from botanical garden of Merlimau, Melaka while lime fruits were procured from local farm of Merlimau. Packaging materials - polyethylene terephthalate (PET) bottle, colorless glass and brown glass were used and all others materials will be provided from Universiti Tun Hussein Onn Malaysia (UTHM) Pagoh Campus.

2.2 Preparation of aloe vera-lime juice

Healthy and mature *Aloe barbadensis Miller* leaves are harvested from Merlimau, Melaka and placed at suitable temperature. Whereas the fresh lime fruits will be bought from a local farm. Aloe vera plants and lime must be at the same level of maturity. The aloe vera leaves will be harvested and leave under running tap water to properly washed. Each of the leaves were cut vertically into half and the inner mucilaginous pulp was scooped out. Washed 2-3 times the pulp to reduce the aloin content. The aloe vera gel was homogenised using blender and filtered using muslin cloth. While, lime is washed and cut into two halves then squeezed and filtering to obtain juice. Formulated ALJ with mixed ratio 70% of aloe vera gel, 5% of lime juice, 5% of sugar and 20% of water. Then, pasteurized the formulation at 95°C for 1 min and filled into 250 ml sterile PET bottles, 250 ml sterile brown glass bottle and 250ml sterile colorless glass bottle before being stored at 4°C and 28°C for six weeks.

2.3 Physicochemical analysis pH

Physicochemical analysis pH was determined using pH- meter (EUTECH Instruments pH 700, US) according to the AOAC, 2000 [4]. Although the total soluble solid (TSS) measured by hand refractometer (ATAGO hand refractometer, ATAGO CO., LTD, Japan) and were showed as °Brix

(AOAC, 2016) [5]. Titratable acidity was measured by the 0.1N sodium hydroxide (NaOH) and phenolphthalein indicator. All the analysis will be analysed for every week until six week of storage. Percentage acid citric (%) in the sample was calculated using below equations 1 [6].

$$\%\ citric\ acid = \frac{v(ml) \times N(N) \times citric\ acid\ MV\ (\frac{g}{mol})}{s(ml) \times 10} \quad Eq.1$$

2.4 Colour analysis

Aloe vera-lime juices were filled in a petri dish until fully covered for measure of colour. The color of aloe vera-lime juice stored at room and refrigeration temperature were measured after preparation of aloe vera-lime juice then after every 7 days intervals up to 2 months of storage using Hunterlab colorimeter (MiniScan EZ 4000L Spectrophotometer, Hunter Associates Laboratory, Inc., United States) in accordance to color scale. It was expressed in L*, a* and b* units. L* is the luminosity or brightness, a* is the greenness (-) or redness (+) and b* is the blueness (-) or yellowness (+) [7]. Samples were determined in triplicate in each case, and the mean values were recorded to reflect a certain months.

2.5 Total phenolic content

Spectrophotometer was used to determine the total phenolic content by the Folin-reagent Ciocalteu method [8]. The Folin-reagent Ciocalteu (0.1 mL) was mixed with drink (0.5 mL) and let to stand for 6 minutes. Then, 0.5 mL distilled water and 1 mL sodium carbonate (7%) were added and finally let it another stay time for 90 minutes. The absorbance was measured via UV-Vis spectrophotometer against a control sample at 765 nm. Gallic acid and equivalent was calculated from the absorbance value.

2.6 Sensory evaluation

The stored samples at different temperatures of aloe vera-lime juice samples were evaluated on appearance, flavour, smell, texture and overall acceptability by a group of 30 untrained panelists among students of Universiti Tun Hussein Onn Malaysia (UTHM). A 9-point hedonic scale with ranges from 9 means "like extremely" to 1 means "dislike extremely" were used [9]. The evaluation was done on week 3 and week 6.

2.7 Statistical Anlysis

All the results were expressed as mean ± standard deviation. The mean, standard deviation and significant difference ($p<0.05$) were determined using the one – way analysis (ANOVA) by IBM SPSS Statistics version 20

3. Results and Discussion

3.1 Physicochemical analysis

The storage stability can be observed through physicochemical and sensory evaluation for all types of packaging materials in different storage temperature. Physiochemical parameters involves such as pH, titratable acidity (TA), total soluble solid (TSS), colour analysis and total phenolic content (TPC).

3.2 pH

The pH value of the ALJ shows a decreasing pattern as the storage day increase (Table 1). Brown glass bottle has a significantly higher pH value than other packaging material at room temperature (28℃) and refrigeration temperature (4℃) which is 2.83 and 3.21, respectively with percentage of reduction pH is 18.44% and 7.49% from week 0 to week 6. The drop was most likely caused by microbial metabolic activity that converted the carbohydrates in the samples to organic acids, resulting in pH lowering, spoiling, and shorter shelf life.

Table 1: Physicochemical properties of aloe vera-lime juice in three different packaging materials at 28℃

Physiochemical properties	Packaging materials	Storage time (weeks)						
		0	1	2	3	4	5	6
pH	PET	3.47 ± 0.005	3.43 ± 0.008	3.35 ± 0.005	3.20 ± 0.005	3.15 ± 0.012	3.11 ± 0.005	2.73 ± 0.008
	Brown	3.47 ± 0.005	3.45 ± 0.008	3.34 ± 0.008	3.27 ± 0.008	3.23 ± 0.005	3.18 ± 0.005	2.83 ± 0.017
	Colorless	3.47 ± 0.005	3.45 ± 0.005	3.33 ± 0.005	3.24 ± 0.008	3.21 ± 0.005	3.18 ± 0.012	2.82 ± 0.005
Titratable acidity (TA) (%)	PET	0.78 ± 0.03	0.77 ± 0.02	0.85 ± 0.02	0.88 ± 0.02	0.93 ± 0.03	0.98 ± 0.05	1.04 ± 0.03
	Brown	0.78 ± 0.03	0.79 ± 0.02	0.82 ± 0.02	0.89 ± 0.02	0.95 ± 0.04	0.97 ± 0.05	0.99 ± 0.05
	Colorless	0.78 ± 0.03	0.77 ± 0.03	0.84 ± 0.02	0.87 ± 0.02	0.93 ± 0.02	0.98 ± 0.01	1.01 ± 0.03
Total soluble solid (TSS) (°Brix)	PET	6.77 ± 0.05	6.81 ± 0.05	6.89 ± 0.28	6.92 ± 0.12	6.96 ± 0.05	7.10 ± 0.05	7.23 ± 0.05
	Brown	6.77 ± 0.05	6.86 ± 0.09	6.90 ± 0.16	7.00 ± 0.12	7.11 ± 0.05	7.30 ± 0.05	7.49 ± 0.08
	Colorless	6.77 ± 0.05	6.83 ± 0.05	6.88 ± 0.29	6.97 ± 0.22	7.09 ± 0.09	7.27 ± 0.05	7.42 ± 0.09

Key: PET = PET bottle, Brown = brown glass bottle, Colorless = colorless glass bottle.

Both temperature did not significant ($p>0.05$) on this study. While, similar study also found that the pH of freshly manufactured orange-Aloe vera RTS samples did not change significantly ($p>0.05$) between treatments or during storage (90 days) [10]. The pH value was observed at the end of storage time with mean values of 3.16 for PET bottle, 3.21 for brown glass bottle and 3.19 for colorless glass bottle when stored at refrigeration temperature (Table 2). The percentage degradation of pH juice from week 0 until week 6 of storage was 7.49% when stored at brown glass bottle. Mean that brown glass bottle are more effective to preserve the acidity of juice.

Table 2: Physicochemical properties of aloe vera-lime juice in three different packaging materials at 4℃

Physiochemical properties	Packaging materials	Storage time (weeks)						
		0	1	2	3	4	5	6
pH	PET	3.47 ± 0.005	3.46 ± 0.008	3.45 ± 0.005	3.41 ± 0.005	3.32 ± 0.012	3.30 ± 0.005	3.16 ± 0.000
	Brown	3.47 ± 0.005	3.47 ± 0.008	3.44 ± 0.008	3.39 ± 0.008	3.33 ± 0.0050	3.29 ± 0.005	3.21 ± 0.005
	Colorless	3.47 ± 0.005	3.47 ± 0.008	3.45 ± 0.008	3.44 ± 0.008	3.34 ± 0.005	3.29 ± 0.012	3.19 ± 0.005

Titratable acidity (TA) (%)	PET	0.78 ± 0.03	0.80 ± 0.02	0.83 ± 0.03	0.87 ± 0.07	0.90 ± 0.02	0.84 ± 0.00	0.99 ± 0.03
	Brown	0.78 ± 0.03	0.79 ± 0.03	0.83 ± 0.03	0.88 ± 0.02	0.93 ± 0.05	0.96 ± 0.02	0.99 ± 0.02
	Colorless	0.78 ± 0.03	0.78 ± 0.02	0.85 ± 0.02	0.90 ± 0.02	0.94 ± 0.03	0.95 ± 0.03	0.98 ± 0.02
Total soluble solid (TSS) (°Brix)	PET	6.77 ± 0.05	6.85 ± 0.05	6.89 ± 0.08	6.92 ± 0.12	6.96 ± 0.28	7.10 ± 0.05	7.23 ± 0.05
	Brown	6.77 ± 0.05	6.86 ± 0.14	6.96 ± 0.05	7.14 ± 0.19	7.22 ± 0.09	7.44 ± 0.09	7.59 ± 0.19
	Colorless	6.77 ± 0.05	6.83 ± 0.08	6.88 ± 0.08	6.97 ± 0.21	7.09 ± 0.05	7.27 ± 0.00	7.30 ± 0.05

Key: PET = PET bottle, Brown = brown glass bottle, Colorless = colorless glass bottle.

3.3 Titratable acidity (TA)

Titratable acidity concentration decreased significantly when stored for longer period of time. The decrease in TA value was most likely caused by an excess of organic acids from sugars generated by the metabolic activities of microbes [11]. Mean value of TA when stored at PET bottle is higher with 1.04% compared at brown glass bottle and colorless glass bottle with data 0.99% and 1.01%, respectively (Table 1). Similar study stated that the titratable acidity (%) of *C.parchycarpa* juice held at room temperature rose from 0.21 to 0.75 which is higher than stored in the fridge and the changes in *C.lepidota* juice values followed the same trend [12].

While, the titratable acidity of ALJ was found decrease even though stored at refrigeration temperature (4°C) tabulated in Table 2. Compared with other study, the TA of several of the rosellefruit juice blends was shown to drop considerably ($P<0.05$) at 28°C as well as at 4°C, which might be attributable to acidic hydrolysis of polysaccharides [13]. Colorless glass bottle show the lowest value which is 0.98 compared to others packaging materials and that means colorless glass bottle highly can preserve ALJ to less acidic when store for 6 weeks.

3.4 Total soluble solids (TSS)

Based on Table 1, total soluble solids (TSS) content increased during the storage period. The result shows that ALJ have the highest total soluble solids with range 6.77 to 7.49 °Brix during 6 weeks of storage. While PET bottle shows the TSS after 6 week of storage at room temperature with (28°C) with 7.23 °Brix. According to other study found that TSS of roselle-mango blended stored in glass and plastic bottles ranged from 8.0 to 13.7 °Brix at room temperature (28°C) and 8.0 to 14.1 °Brix at refrigeration temperature (4°C) [14].

The significantly highest TSS of brown glass bottle were observed at 6 week of storage at 4°C followed by 6 week of storage at 28°C with mean values of 7.59 and 7.49, respectively (Table 2). The significantly lowest total soluble were found at the zero day of storage period with mean value of 6.77. TSS increased during 6 weeks of refrigerated storage. An increase in TSS might be due to the conversion of polysaccharides and other juice ingredients into sugar.

3.5 Colour analysis

L* value decreasing from week 0 of storage until week 6 (Figure 1). This means the ALJ become darker in colour as the storage period continue. There no significant differences in L* value were observed between all packaging materials at 28°C during storage. Samples white, green, and brown bottle, there was a progressive rise in colour values as storage time proceeded, but there was no significant ($p>0.05$) influence on the colour of the juice at room temperature [15]. Then, colorless glass

bottle have lowest L* value than others packaging materials and this can be described as juice are darker due to nonenzymatic browning events occur.

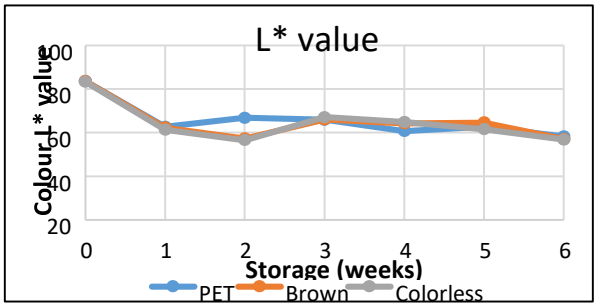

Figure 1: L* value of aloe vera-lime juice in three different packaging materials at 28℃

While, L* value of aloe vera-lime juice (ALJ) stored in three packaging materials at 4℃ drop slightly from week 0 to week 1 (Figure 2). L* value of ALJ slightly constant in data from week 1 to week 5 when package in PET bottle, brown glass bottle and colorless glass bottle. But L* value drop in week 6 at all packaging materials. Colorless glass bottle was contain the highest L* value mean that juice lightness colour compared to others.

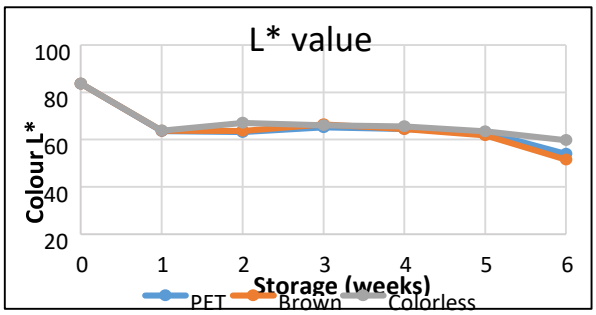

Figure 2: L* value of aloe vera-lime juice in three different packaging materials at 4℃

Based on figure 3, the graph shows that PET bottle has the highest negative value of a* on week 6. This means that ALJ package in PET bottle has the greenest colour then others. All of the sample contain same among of aloe vera gel, lime juice, sugar and water. Therefore, the factor of changes a* value for aloe vera-lime juice might be type of packaging materials and temperature. Furthermore, during storage degradation of red colour also occur for all the samples.

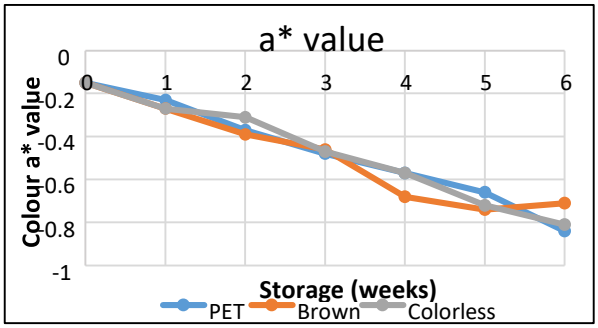

Figure 3: a* value of aloe vera-lime juice in three different packaging materials at 28℃

Figure 4 shown that a* value sharply decrease from week 0 to week 3. The decreasing in a* value (redness) in storage time indicate that the juice are more to green than red. Refrigerated mandarin juice was a sharp decrease in a value even after only 18 days of storage (17.72±0.01) which there were no significant differences in the value of a* during the storage of juice [16]. Based on the graph, PET bottle

and colorless glass bottle get the highest negative value of a* on week 6 which -0.75 and it is mean that aloe vera-lime juice more greenish in colour.

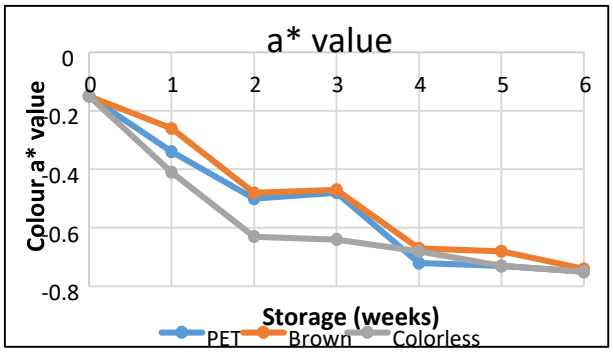

Figure 4: a* value of aloe vera-lime juice in three different packaging materials at 4℃

Aloe vera-lime juice stored in PET bottle when stored at 28℃ has highest b* value, this indicates that juice has the most yellowish colour of juice (Figure 5). The b* value of ALJ stored in colorless glass bottle continually increase starting from week 1 until week 6 of storage. Overall seen, all juices stored at all types of packaging materials has increasing value of b* from week 0 until week 6 and means that colour of juice slowly changes to yellowish colour.

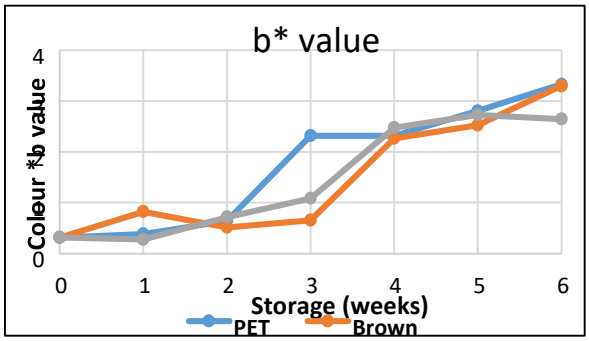

Figure 5: b* value of aloe vera-lime juice in three different packaging materials at 28℃

Furthermore, the b* value of ALJ when stored at refrigeration temperature (4℃) shows in figure 6. PET bottle and brown glass bottle increase in b* value from week 1 to week 6. ALJ stored in brown glass bottle more yellow in colour due to highest in b* value (2.83). The yellowness in ALJ also due to the presence of carotene in limes (*Citrus aurantifolia*). These carotenoids, however, are very sensitive to deterioration due to heat, low pH, oxygen and light exposure [17]

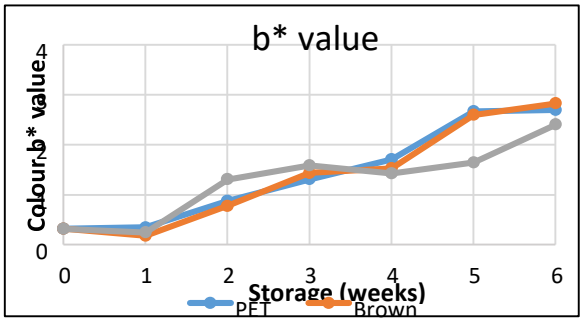

Figure 6: b* value of aloe vera-lime juice in three different packaging materials at 4℃

3.4 Total phenolic content (TPC)

Total phenolic content is likely to decrease with increasing storage time. ALJ stored in PET bottle exhibit the lowest total phenolic content with 0.15 ± 0.033 at the end of storage which is week 6 (Table 3). ALJ stored in colorless glass bottle exhibit the highest decrement of TPC loss with 0.571% 0.234% from week 2 to week 5. The aloe vera drink or juice contains a lot of antioxidants, total phenols and ascorbic acids however, after two months of storage at 28°C, these compounds were gone [18].

Table 3: Total phenolic content value of aloe vera-lime juice in three different packaging materials at 28°C

Packaging materials	Total phenolic content (mg GAE/g)						
	0	1	2	3	4	5	6
PET	0.653 ± 0.004	0.510 ± 0.010	0.521 ± 0.049	0.446 ± 0.091	0.419 ± 0.033	0.258 ± 0.033	0.158 ± 0.033
Brown	0.653 ± 0.004	0.410 ± 0.004	0.410 ± 0.008	0.385 ± 0.009	0.354 ± 0.047	0.261 ± 0.007	0.234 ± 0.010
Colorless	0.653 ± 0.004	0.630 ± 0.008	0.571 ± 0.042	0.357 ± 0.014	0.328 ± 0.243	0.234 ± 0.020	0.173 ± 0.033

Key: PET = PET bottle, Brown = brown glass bottle, Colorless = colorless glass bottle.

The highest mean value of TPC was brown glass bottle with 0.238% after 6 week of storage at refrigeration temperature (4°C) (Table 4). Brown glass bottle and colorless glass bottle declined in TPC from 0.653 to 0.238 and 0.653 to 0.190, respectively from week 0 until week 6 of storage. Folin-reagent is nonspecific because it is affected by the presence of reducing sugars, organic acids, aromatic amines, ascorbic acid, sulphur dioxide and other natural compounds present in fruit juices, making the results frequently unstable.

Table 4: Total phenolic content value of aloe vera-lime juice in three different packaging materials at 4°C

Packaging	Total phenolic content (mg GAE/g)						
	0	1	2	3	4	5	6
Colorless materials	±	0.681 ± 0.0078	0.580 ± 0.010	0.337 ± 0.014	0.370 ± 0.117	0.251 ± 0.012	0.174 ± 0.006
PET	±	0.650 ± 0.006	0.533 ± 0.007	0.355 ± 0.070	0.328 ± 0.057	0.266 ± 0.021	0.238 ± 0.010
Brown	±	0.522 ± 0.003	0.471 ± 0.038	0.323 ± 0.017	0.324 ± 0.017	0.233 ± 0.025	0.190 ± 0.014
	0.653 ± 0.004						
	0.653 ± 0.004						
	0.653 ± 0.004						

Key: PET = PET bottle, Brown = brown glass bottle, Colorless = colorless glass bottle.

3.5 Sensory evaluation

Based on figure 7, it is exhibited that ALJ stored in colorless glass bottle is liked the most based on the overall acceptability of the panellists. But for the smell or odour that panellists preferred was stored in brown glass bottle with means 6.53 which is 0.13 higher than stored in colorless glass bottle. According to the statistical study, there is no significant preference between the ALJ stored in PET bottle, brown glass bottle and colorless glass bottle ($p>0.05$).

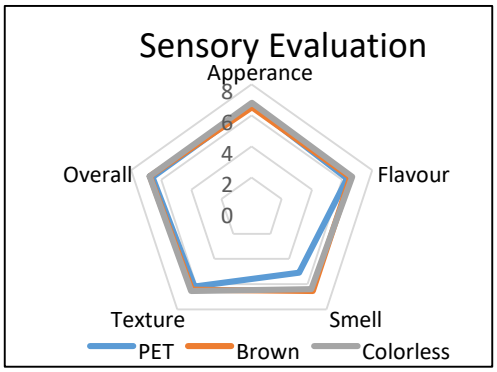

Figure 7: Sensory evaluation of aloe vera-lime juice during 3 week at 4℃

After 6 week of storage, data for every attributes drop due to degradation of flavour, colour and odour of the juice. Figure 8 shows, brown glass bottle get the highest score of flavour, smell, texture and overall acceptance among other two packaging bottle. The entry of light into these packing materials may have resulted in the breakdown of some of the juice's chemical components [19]. Then cause the degradation in volatile aroma and flavour components of juice

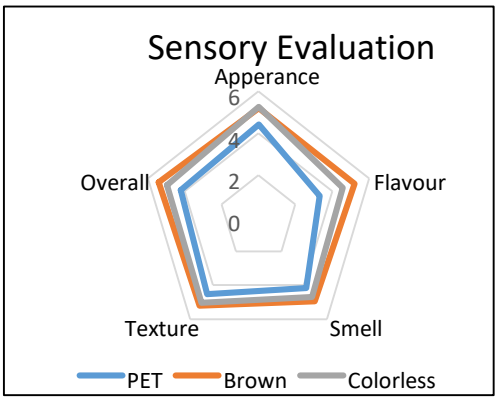

Figure 8: Sensory evaluation of aloe vera-lime juice during 6 week at 4℃

4. Conclusion

Brown glass bottle has a significantly higher pH value than other packaging material at room temperature (28℃) and refrigeration temperature (4℃) which is 2.83 and 3.21, respectively with percentage of reduction pH is 18.44% and 7.49% from week 0 to week 6. But the highest titratable acidity (TA) value when stored at 4℃ was colorless bottles with 25.64% of reduction acidity from week zero of storage. While for total soluble solid (TSS), aloe vera-lime juice stored in PET bottle shows the lowest decrement of sucrose which is 7.23°Brix in 28℃ and 4℃ with percentage reduction was 6.79% after 6 week of storage. Furthermore, for colour of L*, a* and b* value are experience changes for all packaging materials. L* and a* value was decreasing as the storage time increase, meanwhile value of a* increasing until the end of storage. After 6 week of storage ALJ become darker, greener and yellower in colour. Brown glass bottle has significantly higher value of total phenolic content which 64.17%

reduction for 28℃ and 63.55 reduction for 4℃. Sensory evaluation of ALJ after 6 week of storage shown that the most accepted among panellist are juice stored in brown glass bottle and all data from analysis involved shows the best packaging material to preserve aloe vera-lime juice was brown glass bottle.

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