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# Quality attributes of fresh pineapple-mango juice blend during storage

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*juice blends, pineapple, mango, quality attributes*

**Abstract**

Blending or mixing two or more of fruit juices is able to improve the quality of juices as compared to single flavour. Pineapple and mango are among the popular tropical fruits in Malaysia. Despite the massive production of pineapple in Malaysia, utilisation of pineapple as a juice remains unpopular due to its exotic and strong flavour. Blending of pineapple with mango is believed to overcome this issue. Nevertheless, suitable blending ratios play important role in the end product quality. The present work aims to determine the physicochemical and nutritional quality of fresh blended pineapple-mango juice at different blending ratios for 25 days of refrigerated storage (4 ± 2°C). Physicochemical (colour, pH, titratable acidity, and total soluble solid) and nutritional (vitamin C, total phenolic content, and total antioxidant content) properties of fresh pineapple-mango juice blends of ratio 80% pineapple with 20% mango (R80:20) and 50% pineapple with 50% mango (50:50) were determined throughout 25 days of storage. Pineapple-mango juice blends at blending ratio of R80:20 exhibited better qualities in term of colour (lightness, chroma, hue, and browning index), chemical composition, and nutritional content.



## Introduction

Fruit juices are naturally obtained from the extraction of fruits, and consumed as beverage or as natural flavouring and colorant in foods (Chung, 2015). Fruit juice can be described as an unfermented product, but still can be fermented from mature, fresh, and good quality fruits (Bates *et al.,* 2001). Juice blends are produced from blending two or more fruit juices to obtain a new flavour. Recently, fruit juice blends have been extensively marketed due to its unique and palatable flavour (Handwerk and Allen, 1969). Moreover, increasing demand for healthy and fresh products, and increasing health awareness among consumers renders juice blend market to bloom. Blending different fruit juices enhances the overall nutritional quality of juice blends. Jothi *et al.* (2014) added that vitamin and mineral contents of juice blends are improved depending on the type and grade of fruits or vegetables used as the blending ingredients. Besides taste, flavour and aroma of single fruit juice can also be improved through juice blending.

Pineapple (*Ananas comosus* L.) is among the most important sources of tropical fruit juices apart from banana, passion fruit, and mango. Pineapple is a type of tropical plant indigenous to South America and said to have originated from the area between southern Brazil and Paraguay (Morton, 1987). In Malaysia, there are several varieties of pineapple including Josapine, Moris, Gandul, and Sarawak Pineapple. Pineapple is usually turned into jams, chips, and canned products (MOA, 2016); thus showing that, as juice, pineapple is quite unpopular locally. This could be due to its strong acid flavour (Jan and Masih, 2012; Shamsudin *et al.,* 2014) despite the massive production of pineapple in Malaysia (MOA, 2016). In the past, there have been several studies that blended pineapple juice with that of carrot and orange (Jan and Masih, 2012), with guava (Tripathi *et al.,* 1992), and with grapefruit (Handwerk and Allen, 1969).

Meanwhile, mango (*Mangifera indica* L.) is one of the most favoured fruits, known as “king of tropical fruits”, due to its succulence, sweet taste, and exotic flavour with good source of ascorbic acid, phenolic compounds, and other dietary antioxidants (Naresh *et al.,* 2015). Mango is also among the famous fruits grown in Malaysia for many years. Mango is a popular evergreen fruit tree indigenous to South-Eastern Asia. There are more than five mango varieties planted in Malaysia such as Chokanan (MA224), Harumanis (MA128), and Sala (Anem, 2013). The sweet taste and excellent colour of mango makes it suitable to be blended with other fruits. In the past, there have been several studies that blended

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mango juice with that of roselle (Mygaya-Kilima *et al.,* 2015), and with orange and papaya (El-Mansy *et al.,* 2005).

Previous study by Kamarul Zaman *et al.* (2016) showed that fresh pineapple-mango juice blend with higher pineapple ratio resulted in greater quality. However, its quality attributes during storage were not emphasised. Therefore, the present work aimed to evaluate the quality attributes of pineapple-mango juice blend at blending ratio of 80% pineapple and 20% mango (v/v) and 50% pineapple and 50% mango (v/v) throughout 25 days of refrigerated storage at 4 ± 2°C.

## Materials and methods

*Fruit juice preparation*

Ripe Josapine pineapple and Chokanan mango were purchased from a local market in Selangor, Malaysia. Then, the fruits were washed under running tap water; peeled and cut into smaller pieces prior to separate extraction using a juice extractor (Power Juice, Smart ShopTM, USA). No water was added during the extraction process. Then, both pineapple juice and mango juices were mixed according to their pineapple:mango blending ratios as shown in Table 1.

Table 1. Blending ratios and percentages of pineapple to mango.

| Blending ratios | R100:0 | R80:20 | R50:50 | R0:100 |
|---|---|---|---|---|
| Pineapple (%) | 100 | 80 | 50 | 0 |
| Mango (%) | 0 | 20 | 50 | 100 |

The blended juices were then refrigerated (4 ± 2°C) for 25 d in tightly closed glass bottle. The bottle was covered in aluminium foil to minimise the effect of light on the juice quality as some nutrients such as vitamin C is light-sensitive. The quality attribute analysis was done at five-day intervals for 25 days.

*Colour measurement*

*Colour*

Appearance and colour of foods are the first quality parameters that will be perceived by consumers. Even though there are dissimilar colour spaces, the most used method in measuring the food colour is the L* a* b* colour space since it is very close to human colour perception and has consistent colour distribution (Leon *et al.,* 2006). The colour measurement (L*, a* and b*) of samples was measured using a colour spectrophotometer (D65 HunterLabUltraScan Pro, USA). Hue angle and Chroma were calculated using Eq. 1 and 2:

Hue angle, H° = tan-1(b* / a*) (Eq. 1)

Chroma, C = (a*2 + b*2)1/2 (Eq. 2)

*Browning index*

Enzymatic browning is one of the largest causes of the loss of quality in fruits which can lead to fruit degradation (Ioannou and Ghoul, 2013). CIE L* a* b* coordinates were measured for colour measurement and in this way it was possible to calculate the browning index (BI), using Eq. 3 (Lunadei *et al.,* 2010):

$$BI = ((x - 0.31) / 0.172) \times 100 \quad \text{(Eq. 3)}$$

where, $x$ = chromaticity coordinates, calculated from the L* a* b* values using Eq. 4:

$$x = (a^* + 1.75 L^*) / (5.64 L^* + a^* - 3.012 b^*) \quad \text{(Eq. 4)}$$

*Determination of physicochemical properties*

*pH*

Generally, fruit juices are acidic with pH < 4.6 in which bacteria cannot grow, thus avoiding fruit juice spoilage. In previous study by Aronsson and Rönner (2001), the changes in fruit juices' pH influenced the type of microorganisms that might grow in the juice. In the present work, pH was directly measured from 100 mL of sample by using a digital pH meter (785 DMP Titrino, Metrohm, Switzerland).

*Total titratable acidity*

Total titratable acidity is measured by titration to a pH endpoint by using a strong base (Boulton, 1980). Fruit juices with high level of acidity may be harmful for human consumption as it stimulates salivary flow. In the present work, a digital autotitrator (785 DMP Titrino, Metrohm, Switzerland) was used to measure the acidity of sample. Briefly, 10 mL of sample was mixed with 40 mL of distilled water. The electrode was pushed into the mixture and measured under continuous stirring. Each sample was titrated with 0.1 mol/L NaOH to end point of 8.2 (pH) and the amount (mL) of NaOH used was recorded. Titratable acidity was expressed in percentage of citric acid, and calculated using Eq. 5:

Titratable acidity % = ([mL NaOH used] × 0.064 × molarity of NaOH × 100) / (volume of sample) (Eq. 5)

*Total soluble solid*

Refractometer is broadly used in the food industry to carry out analysis on quality of food. According to Cavalcanti *et al.* (2013), refractive index can be used to calculate the concentration of a product or the percentage of dissolved solids of a substance. In the present work, the total soluble solid (TSS) of samples was measured using a digital refractometer (Model AR-2008, Kruss, Germany).

*Antioxidant properties*

*Vitamin C*

Excessive vitamin C in foods may cause inhibition of natural processes in food. It also inhibits oxidation process which may affect the quality of food. Therefore, its level must be monitored during storage (Pisochi *et al.,* 2008). Vitamin C was measured by manual titration method, and 0.1% 2,6-dicholorephenol indophenol (DCPIP) was used as the titrant. A standard solution of 0.1% ascorbic acid was prepared. Next, 1 mL of DCPIP was placed into specimen tube and titrated with sample drop by drop until DCPIP discoloured. The result was expressed as mg/100 g. The concentration of vitamin C of sample was calculated using Eq. 6 (Rekha *et al.,* 2012):

Concentration of vitamin C (mg / 100g) = (volume of 0.1% vitamin C solution) / (volume of fruit juice) × 100 (Eq. 6)

*Total phenolic content*

Phenolic compounds are one of the crucial quality parameters since they contribute to the fruit's colour and organoleptic characteristics (bitterness, flavour, and astringency) (Burin *et al.,* 2010). The total phenolic content of the juice blend in the present work was determined using the Folin-Ciocalteu method reported by Lukanin *et al.* (2003) with slight modifications. The juice blends were centrifuged at 5,000 rpm for 5 min at 5°C. Then, 1 mL of clarified juice blend was mixed with 1 mL of Folin-Ciocalteu reagent and 10 mL of 20% sodium carbonate solution. Next, the mixture was diluted to 100 mL with distilled water and mixed thoroughly. The absorbance of the mixture was measured using a UV-VIS spectrophotometer (Ultrospec 3100 pro, Amersham Bioscience, UK) at 765 nm following 1 h incubation at room temperature in the dark. The results were expressed as gallic acid equivalents (mg GAE/L).

*Total antioxidant activity*

Different fruits contain different kinds of antioxidants. Some flavonoids that are normally components of the human diet have strong antioxidant activities (Hanasaki *et al.,* 1994); therefore, it is crucial to measure total antioxidant activity of a fruit. The total antioxidant activity of the juice blends in the present work was determined using the DPPH free radial scavenging assay method. Briefly, 12.5 µ L to 100 µL/mL of samples in 0.002% methanol was prepared. Next, 2 mL of 2,2-diphenyl-1-picrylhydrazyl (DPPH) solution was mixed with 2 mL of samples. Then, the mixture was incubated at room temperature for 30 min. The optical density was then measured at 517 nm, and the scavenging activity was calculated using Eq. 7 (Madhu, 2013):

Scavenging activity (%) = [(A-B) / A ] × 100 (Eq. 7)

where, A = absorbance of DPPH, B = absorbance of fruit juice and DPPH combination.

*Statistical analysis*

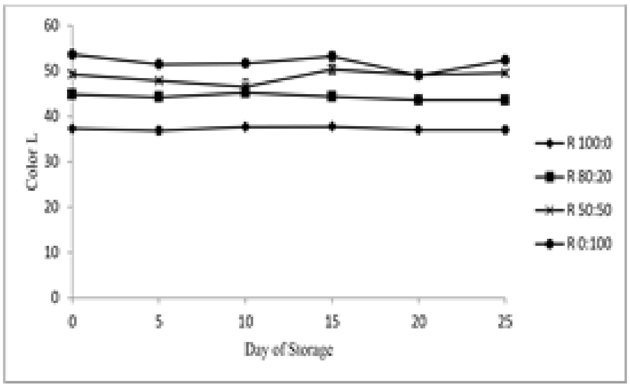
All data were presented as means ± standard deviations (SD) of triplicate measurements. Statistical analyses were performed using Design-Expert 6.0.8 (Stat-Ease, Inc.).

**Results and discussion**

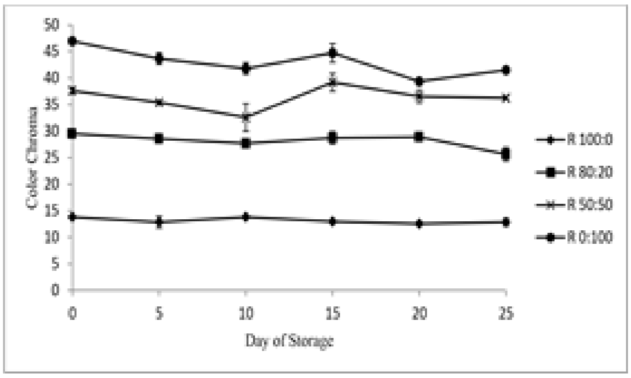
*Colour changes during storage*

The changes in lightness (L*), chroma, and hue of pineapple-mango juice blends during 25 days storage are illustrated in Figures 1a, 1b and 1c, respectively. Initially, single pineapple juice (R100:0) had lower value of L* than mango juice (R0:100), which were 37.29 and 53.65, respectively. While, L* of pineapple-mango juice blend was 44.83 for blending ratio of R80:20 and 49.27 for R50:50. Higher amount of mango in the blend juice (R50:50) resulted in lighter juice colour. All juice blending ratios were not significantly different ($p < 0.05$) throughout the storage time. The results deviate from prior study on roselle-mango juice blend in which the lightness decreased with increasing storage time due to the enzymatic browning in mango juice (Mygaya-Kilima *et al.,* 2015). Mango juice is also high in carotenoids that are highly susceptible to degradation by heat, pH, and light exposure. The present work demonstrated that the blending of pineapple and mango was able to reduce the degradation of L* values in juices as the L* value was stable throughout the storage time, with juice blending ratio at R50:50 was lighter in colour with highest L* values after 25 days.

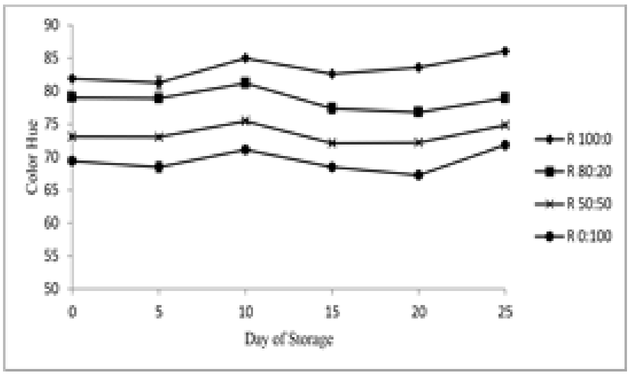
Chroma determines the difference of hue in comparison of grey colour with the same lightness, while hue defines colour appearance parameter. Both chroma and hue are used as qualitative attributes of colour (Fernandez-Vazquez *et al.,* 2011). At week 0, pineapple juice (R100:0) yielded the lowest value of chroma (13.82) as compared to mango juice (R0:100) (46.93) as shown in Figure 1b. This could be due to the yellow colour of mango juice which was more concentrated and lighter than pineapple juice as observed in Figure 1a. Chroma of pineapple-mango juice blends at R80:20 was more stable ($p$ > 0.05) throughout the 25 days of storage, while R50:50 fluctuated at day 15.



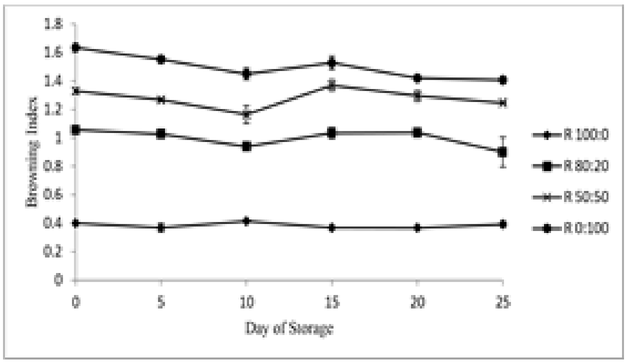

(a) Change in L




(b) Change in colour chroma




(c) Change in colour hue




(d) Change in browning index

Figure 1. Colour changes of pineapple-mango juice blend during 25 days storage at 4 ± 2°C (R 100:0, R 80:20, R 50:50, and R 0:100 are 100% pineapple, 80% pineapple and 20% mango, 50% pineapple and 50% mango, and 100% mango, respectively).

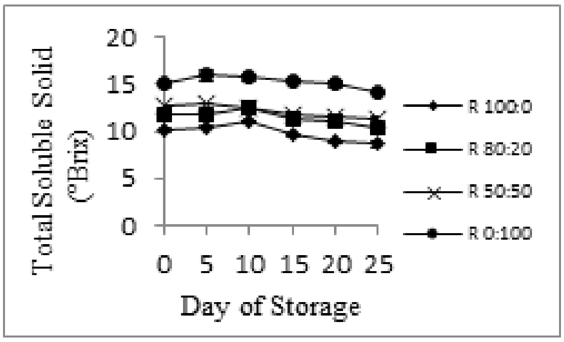
Initially, the hue of R100:0 and R0:100 were 81.89 and 69.39, respectively. Blending of pineapple juice with 20 and 50% mango juice decreased the hue values to 78.99 (R80:20) and 73.08 (R50:50), respectively. The results agree with Kamarul Zaman *et al.* (2016) who showed that hue angle increased as the pineapple juice ratio increased in the blends of fresh pineapple and mango juice. According to Esteve and Frigola (2007), juices become redder and less yellow when the hue decreases. In addition, the colour of juice may change due to heating, air, and light, which cause carotenoids to undergo oxidation, *cis/trans* change and alteration in epoxide rings as a function of storage. Similar results have been reported by Chia *et al.* (2012) in which the angle hue of untreated pineapple juice significantly decreased throughout the storage time. In the present work, all juice blending ratios exhibited similar trend of hue changes during storage.

Other parameter to evaluate colour is browning index (BI) as shown in Figure 1d. BI represents the purity of brown colour in juice (Ndiave *et al.,* 2011). The initial colour of juice blends was significantly different among blending ratios. BI initial value for blending ratios of R80:20 and R50:50 were 1.06 and 1.33, respectively. It was shown that ratio of R50:50 yielded higher value of BI throughout the storage as compared to R80:20, which indicated a higher degree of browning (Siler and Morris, 1993) in mango juice than pineapple juice. The results support earlier results of hue (Figure 1c). Similarly, higher amount of persimmon in blend juice of pineapple, orange and persimmon juice caused the intensity of red colour to increase and promote browning which affected the consumer acceptability on the product (Curi *et al.,* 2017). However, there was no significant difference (p > 0.05) in BI found among the individual juices ratio during the storage period. Based on all colour parameters (L*, hue, chroma, and BI), pineapple-mango juice at blending ratio R80:20 yielded more acceptable colour appearance throughout the storage time.

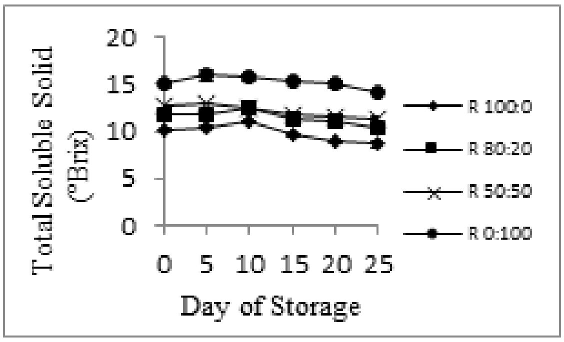
*Physicochemical properties of pineapple mango juice blends during storage*

Figure 2 shows the effect of storage period for 25 days on physicochemical properties of TSS (°Brix) (Figure 2a), pH (Figure 2b) and titratable acidity (TA) (Figure 2c) on pineapple-mango juice blend with different blending ratios. Total soluble solid (TSS) is an important indicator of juice quality. These soluble solids are primarily sugar; sucrose, fructose, and glucose. Initially, TSS of fresh pineapple (R100:0) and mango (R0:100) juice were 10.21 and 15.10°Brix, respectively. Whereas, TSS of juices with blending ratios of R50:50 and R80:20 were 12.64 and 11.78°Brix, respectively. Juice with higher mango percentage resulted with higher TTS value which might due to hydrolysis of polysaccharides like pectin, cellulose, and starch and its conversion into simple sugar (glucose and fructose) (Mohd Hanif *et al.,* 2016). Reduction of TSS content in blend juice during storage was due to the growth of yeasts and moulds where the microorganisms utilise the sugar for growth, thus, reducing the °Brix value (Shamsudin *et al.,* 2014). During the storage period (15th - 25th days), strong fermented smell was noted upon opening the glass bottle of juices of R50:50 and R0:100. Therefore, blending ratio with higher amount of mango juice (R50:50) could increase the TSS (12.64°Brix) of juice blend thus resulting in sweeter taste as compared with juice blend with lower mango juice in the blending ratio (R80:20) (11.78°Brix). However, higher TTS had shorter storage time due to the higher sugar content and tendency for spoilage. All in all, pineapple-mango juice blend with ratio of R80:20 yielded the best result for TTS.

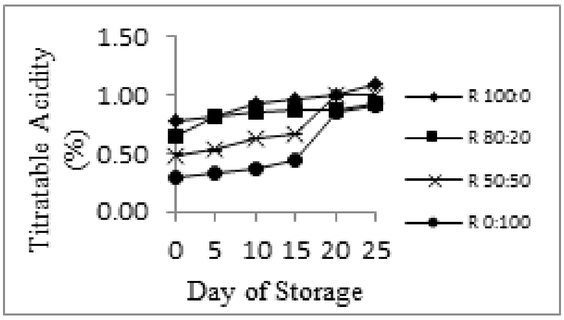
The changes in pH of pineapple-mango juice blends during storage of 25 days are shown in Figure 2b. The initial pH of pineapple (R100:0) and mango juice (R0:100) were 3.71 and 4.89, respectively, showing that pineapple juice was more acidic as compared to mango juice. As the concentration of pineapple juice volume decreased from 80% (R80:20) to 50% (R50:50), the pH also decreased. More acidic juice could alter the overall pH of juice blends to become more acidic, as supported by Jan and Masih (2012), where the initial pH of pineapple juice was 4.21, and decreased to 4.14, 4.03, and 3.98 when pineapple juice was mixed with carrot and orange juices at ratios of 80:10:10, 60:10:30, and 50:20:30, respectively. The pH of all juice ratios decreased throughout the storage. Similarly, pH of mango juice, papaya-pineapple juice blend and bael-guava juice blend (Nidhi *et al.,* 2008) also decreased during storage. The decrease in pH throughout the storage for pineapple-mango juice blend indicated the spoilage of juice as the juice did not undergo any treatments. This is supported by Begum *et al.* (2018), where the decrease in pH of mango-pineapple-orange juice blend during storage of 30 days might be due to the carbohydrate degradation present in the juice blend as affected by microbial activities.




(a) Change in TSS




(b) Change in pH



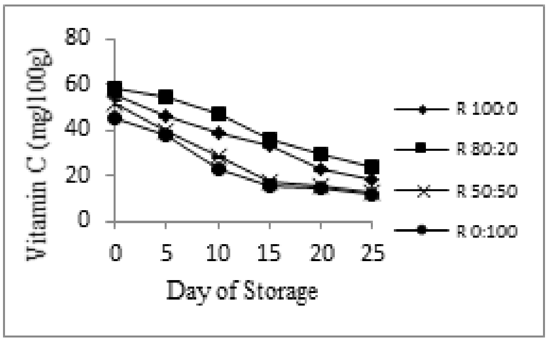

(c) Change in TA

Figure 2. Effect of storage period for 25 days on (a) TSS (°Brix); (b) pH, and (c) titratable acidity (TA) on pineapple-mango juice blend with different concentrations.

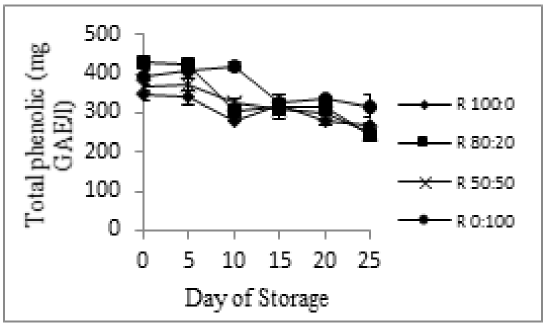
Initially, fresh pineapple juice (R100:0) had higher TA value as compared to mango juice (R0:100), which were 0.77 and 0.29% of citric acid, respectively. At higher pineapple ratio (R80:20), the TA value was higher at 0.64% of citric acid as compared to R50:50 (0.49% of citric acid). The devaluation of acid value in juice blend leads to less acidic taste and makes the juice sweeter. Similar trend was reported by Leahu *et al.* (2013), where acidity of orange-kiwi juice blends (3.78 g/L) followed orange juice (3.92 g/L) properties at higher ratio of orange in the blend juice (70 orange:30 kiwi). Kamarul Zaman *et al.* (2016) also reported similar finding of higher TA value of higher pineapple in the pineapple-mango juice blend. During storage, TA of R80:20 and R50:50 juices significantly increased ($p < 0.05$). The change of TA in fruit juice is due to the addition of citric acid and release of acids from juice particles. The increase in acidity during storage also might be due to conversion of acids into salts and sugars by enzymes particularly invertase as reported by Hashem *et al.* (2014). Similar results were found by Byanna and Doreyappa Gowda (2012) in sweet orange and pomegranate blend RTS, and Jan and Masih (2012) in pineapple juice blends with carrot and orange juice. Microbial activity may also contribute to the increase in TA value during storage of pineapple-mango juice blend. Action of microorganisms, especially acid-producing microorganisms, is believed to be one of the factors increasing TA during storage (Begum *et al.,* 2018).

*Antioxidant properties of pineapple-mango juice blends during storage*

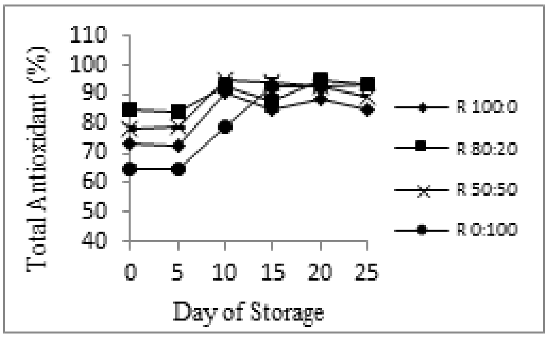
According to El-Ishaq and Obirinakem (2015), chemical reactions in fruits affect storage life and also chemical deterioration of fruits in term of their colour, flavour, and odour changes. Figure 3a shows that the pineapple-mango juice blends of R80:20 (59.51 mg ascorbic acid/100 g) contained significantly higher vitamin C as compared to R50:50 (51.73 mg ascorbic acid/100 g). The initial ascorbic acid content of pineapple-mango juice blend for both blending ratios (R80:20 and R50:50) were lower than single pineapple juice (55.59 mg ascorbic acid/100 g) but higher than single mango juice (44.78 mg ascorbic acid/100 g). Mixing two or more fruit products may combine the nutritional characteristic of the end product, which leads to the increase or decrease in the bioactive compound. Also, antioxidant activity is correlated with the chemical reaction occurring during blending or mixing (Curi *et al.,* 2017). A similar result was found by Leahu *et al.* (2013), where orange-kiwi juice blend at higher




(a) Change in vitamin C




(b) Change in total phenolic content




(c) Change in total antioxidant

Figure 3. Nutrient and antioxidant content changes of pineapple-mango juice blend during 25 days storage at 4 ± 2°C (R 100:0, R 80:20, R 50:50, and R 0:100 are 100% pineapple, 80% pineapple and 20% mango, 50% pineapple and 50% mango, and 100% mango, respectively).

orange ratio 70:30 (orange:kiwi) resulted in higher value of ascorbic acid than juice blend at ratio of 30:70 (orange:kiwi) with ascorbic acid value of 52.8 mg/100 g and 96.8 mg/100 g, respectively. During storage, the ascorbic acid content of all juice ratios significantly decreased ($p < 0.05$) which might be due to oxidation by trapped oxygen in glass bottles and formation of dehydro-ascorbic acid, processing, and storage temperature (Byanna and Doreyappa Gowda, 2012) as ascorbic acid is sensitive to oxygen, light, and heat. Ascorbic acid content remained high throughout the storage time as compared to single pineapple (R100:0) and mango (R0:100) juices which proved that blend of fruit juices improved the juice nutritional content. Ascorbic acid is often used as one of the parameters to determine product shelf-life, which is the time taken for 50% of ascorbic acid concentration to degrade (Torregrosa *et al.,* 2005). Based on the obtained results, pineapple-mango juice blend of R80:20 had longer shelf-life as the ascorbic acid exceeded its half-life at day 20 of storage, whereas at blending ratio of R50:50, the half-life of ascorbic acid was reached at day 15 of storage.

Phenolic compounds provide antioxidant potential and health-promoting properties, and contribute to the flavour and colour attributes of fruits and vegetables. Initially (week 0), juice blend ratio of R80:20 had higher phenolic content (430.56 mg GAE/L) than R50:50 (365.34 mg GAE/L) with both blends ratio showed increment as compared to single juice of pineapple (347.39 mg GAE/L) and mango (395 mg GAE/L) (Figure 3b). The results show different trend than ascorbic acid where the content decreased after blending. However, there were no significant changes ($p > 0.05$) of phenolic content during storage for R80:20 and R50:50, but increased slightly at day 5 of storage and constantly decreased thereafter. This might be due to some compounds that were formed during storage and reacted with the Folin-Ciocalteu reagent to change the phenolic content as reported by Klimczak *et al.* (2007) as the phenols in kiwifruits remained stable during first two months at 0°C storage, and increased significantly after six months of storage. Another finding was reported by Chia *et al.* (2012) who found that the phenolic content of pineapple juice decreased sharply during the first week, and remained stable from week 3 to 9.

Total antioxidant capacity may include vitamin C, vitamin E, beta carotene, and flavonoids. Figure 3c shows that initially pineapple juice had higher antioxidant (73.26%) than mango juice (64.85%), and juice blend at R80:20 had higher value of antioxidant (84.76%) followed by R50:50 (78.39%). This agreed with ascorbic acid and total phenolic results in which juice ratio of R80:20 had higher amount as compared to R50:50. There was an increase in antioxidant capacity starting at day 5 before the reading became stable starting from day 10. This deviates from previous study by Del Caro *et al.* (2004) which could be due to the biochemical reaction that occurred during storage. According to Ibrahim (2016), juice with high organic acids will be possible to undergo biochemical reaction which will later result in lower pH and an increase in microbial activity. In the present work, the pH of pineapple-mango juice blend did decrease throughout the storage time (Figure 2b). However, the results agreed with Hashem *et al.* (2014) for orange-carrot juice blend. All in all, R80:20 yielded better juice quality in terms of nutritional content (including vitamin C), phenolic content, and antioxidant capacity, and thus could be beneficial for health.

## Conclusion

As a conclusion, it is possible to improve the quality of single juice by blending with various fruits like pineapple and mango. The 25 d storage showed that the fresh pineapple-mango juice blend became more stable chemically and nutritionally as compared to its single juice. Blending ratio of 80% pineapple and 20% mango exhibited better quality in terms of physicochemical and nutritional properties. By taking vitamin C as an indicator of juice spoilage, pineapple-mango juices blend of R80:20 showed longer shelf-life as compared to R50:50. However, further study on the effect of juice blending on chemical reaction and microbial activities of the juice blend is warranted. The present work can provide a useful data on blended juice for commercial production of juice blend.

## Acknowledgement

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