Improving quality of dragon fruit (Hylocereus costaricensis) syrup by processing with double jacket vacuum evaporator

B Susilo*, S M Sutan, Y Hendrawan and R Damayanti

Department of Agricultural Engineering, Faculty of Agricultural Technology, Universitas Brawijaya, Malang – East Java, Indonesia

Email: bmsusilo@gmail.com; susilo@ub.ac.id

Abstract. Red dragon fruit (Hylocereus costaricensis) is a famous fruit because of its high nutritional content. Although the product diversification of red dragon fruit is quite a lot, however, this product has limited information as a syrup product. The evaporation process for making syrup at the traditional level is usually carried out at high temperatures which results in the high destruction of nutritional content and reduces the quality of syrup. The study of the evaporation process at low temperature and low pressure using a double jacket vacuum evaporator for manufacturing red dragon fruit syrup was conducted in this research in order to improve product quality. The aims of this study are to evaluate the effect of temperature process and vacuum pressure on the quality of red dragon fruit (H. costaricensis) syrup using a double jacket vacuum evaporator and to know the optimum temperature process and vacuum pressure to producing red dragon fruit syrup with higher content of vitamin C. The double jacket evaporator operates at a pressure lower than atmospheric pressure so that there were 9 treatment combinations. The result showed the temperature gave a highly significant effect, especially on vitamin C. It also gave on moisture content and reducing sugar. The temperature gave no significant effect on total sugar content. Whereas, the pressure gave a significant on moisture content, but not gave a significant on vitamin C, reducing sugar content and total sugar content. However, the best treatment for optimum vitamin C is 50 °C/-60 cmHg with 8.75 mg/100 ml.

1. Introduction

Pitayias, commonly known as dragon fruit, belong to the genus Hylocereus of the order Caryophyllales. Hylocereus species originate from Latin America and are cultivated in tropical and subtropical regions worldwide. H. costaricensis are the most widely cultivated and have the same red fruit skin color but different flesh colors, white and red, respectively. Two betalain pigments, namely, the red-violet betacyanins and yellow-orange betaxanthins, contribute to the red flesh color [31]. Fruits of Hylocereus species or “pitahayas” or “dragon fruit” can range from small (100–250 g) to large (200–800 g) depending on the species [2]. Dragon fruit has various types of them white, red and fleshy dragon fruit yellow. Red fleshy dragon fruit is the fruit the most preferred compared to others because of the sweet taste and color of the fruit flesh which is interesting [19]. Red dragon fruit (Hylocereus polyrizhus) is a kind of fruit plant that has beautiful colours, as well as unique shapes. Dragon fruit needs in Indonesia to date recorded 200-400 tons per year. The need is not only for consumption in the fresh form but also for health products [28]. It has red flesh and also the red skin
of dragon fruit [5]. This fruit is a rich source of nutrients and minerals like vitamin C, soluble fiber (vitamin B1), riboflavin (vitamin B2), niacin, vitamin B3, lycopene, carotene, calcium, proteins, lipids, calcium, zinc, flavanoid, pyridoxine, pholifenol, phosphor and sodium [4,8,13,17,20]. On the other hand, it has also rich in phytoalbumin which serves as an antioxidant to prevent the formation of cancer caused by free radicals [32]. However, this fruit has a weakness in the short shelf life of 14 days at 10 °C or 5 days at room temperature [18]. The processing of red dragon fruit (H.costaricensis) into syrup is one way to extend shelf life, maintain quality, and increase the economic value of red dragon fruit.

Syrup is a traditional viscous liquid product obtained from heating fruit porridge. Syrup is one of the drinks that are quite liked by many people, because it is practical, tastes good and refreshing, as well as beneficial for bodily health [1]. Syrup is a beverage product made from a mixture of water and sugar with a sugar content of at least 65% with or without other foodstuffs and / food ingredients permitted in accordance with applicable provisions [24]. Traditionally, the production of red dragon fruit (H.costaricensis) syrup is by heating the raw material in an open pan until certain viscosity without being equipped with temperature control so that the heating process cannot be controlled. The uncontrolled temperature during the process can lead to overheating and impact the quality of the syrup product. To overcome the problem, the technology for the production of red dragon fruit syrup using vacuum technology is developed. The principle of vacuum processing is to condition the heating under atmospheric pressure (1 atm), so the heating temperature can be lowered. As a result, the damage caused by the influence of temperature can be reduced and able to maintain the quality contained in the syrup. This study aims to evaluate the effect of the temperature process and vacuum pressure on the quality of red dragon fruit (H.costaricensis) syrup using a double jacket vacuum evaporator and to know the optimum temperature process and vacuum pressure to produce red dragon fruit sirup with higher content of vitamin C.

2. Material and methods

The experiment was conducted in the Postharvest and Food Process Engineering Laboratory, Department of Agricultural Engineering, Testing Laboratory of Food Quality and Food Safety, Departement of Agricultural Product Technology, Universitas Brawijaya, and Biochemistry Laboratory, Department of Chemistry, Universitas Brawijaya. Red dragon fruit (H.costaricensis) was collected from the local market. The major ingredients for the preparation of products were sugar, and other chemicals were used from the laboratory store.

2.1. Extraction of red dragon fruit juice

The method used is a modified method from Islam et al. [12] and Susanti [29]. The fully ripe, healthy, and fresh dragon fruit (H.costaricensis) was sorted and washed thoroughly with water. Then the skin was removed with a knife. The pulps of red dragon fruit (H.costaricensis) were crushed by blender with the addition of water. The fruit ratio and water are 2: 1 (b/v). Then, the juice thus obtained was sieving using a sieve and preserved by freezing for further experiment.

2.2. Productions of red dragon fruit syrup

The method used is a modified method from Nisa [25]. The red dragon fruit (H.costaricensis) syrup prepared from 0.5 liter of red dragon fruit (H.costaricensis) juice and 375 grams of sugar. The temperature used in this study were 30, 40 and 50 °C and the vacuum pressure was -40, -50, and -60 cmHg. Hence, the combination of treatments were 30 °C/-40 cmHg, 30 °C/-50 cmHg, 30 °C/-60 cmHg, 40 °C/-40 cmHg, 40 °C/-50 cmHg, 40 °C/-60 cmHg, 50 °C/-40 cmHg, 50 °C/-50 cmHg, and 50 °C/-60 cmHg. Then, all the raw materials are put into the chamber of the vacuum evaporator and processed according to the treatment combinations until the Total Suspended Solid (TSS) is equal to 68 °Brix. During evaporating, stirring was applied by turning on the agitator at the speed of 150 rpm. In this case, in each treatment combination, the evaporator was opened and a TSS sample of red dragon fruit (H.costaricensis) syrup was determined by hand refractometer. The total time of the
process was counted from the beginning. Red dragon fruit \textit{(H.costa- ricensis)} syrup was bottled for further analysis.

\subsection*{2.3. Determination of the quality of red dragon fruit syrup}

The method described by Islam \textit{et al.} \cite{12} for determining several parameters such as vitamin C measured by titration with a 2,6-dichlorophenolindophenol sodium salt solution and chloroform was used for intensely colored extracts, sugar content, moisture content of the sample was determined by the oven methods at 105 °C and also Total Soluble Solids (TSS) using refractometer.

\subsection*{2.4. Statistical analysis}

Data were analyzed by ANOVA (Analysis of Variance) based on Randomized Complete Block Design (RCBD). If any significant effect was continued by Duncan’s Multiple Range Test (DMRT).

\section*{3. Results and discussion}

\subsection*{3.1. Characteristics of raw materials}

The raw material used in this study is red dragon fruit \textit{(H.costa- ricensis)} which was obtained from a local market in Malang. The parameters of raw materials analyzed were vitamin C content, reducing sugar content, total sugar content, moisture content and TSS. Data analysis is shown in Table 1.

\begin{table}[h]
\centering
\caption{Characteristics of raw materials red dragon fruit \textit{(H.costa- ricensis)} pulp.}
\begin{tabular}{|l|c|c|}
\hline
Parameter & Data Analysis & Literature \\
\hline
Vitamin C content (g/100 mg) & 14.25 & 9.9 ± 0.04* \\
Reducing Sugar Content (%) & 8.3 & 4.5 ± 0.04* \\
Total Sugar Content (%) & 8.51 & 8.00 ± 0.01* \\
Moisture Content (%) & 86.42 & 85.05 – 89.98** \\
TSS (°Brix) & 8.0 & 11.00 ± 0.03* \\
\hline
\end{tabular}
\end{table}

Sources : *[12] **[26]

Based on Table 1, vitamin C content of red dragon fruit \textit{(H.costa- ricensis)} has a higher value (14.25 g / 100 mg) than literature (9.9 ± 0.04 g/100 mg). This is due to the different maturity levels of red dragon fruit \textit{(H.costa- ricensis)} which are used. According to Ezeh \textit{et al.} \cite{6}, maturity stage may influence the concentration of vitamin C in the fresh fruit. Vitamin C content will decrease as the maturity level increase. Different vitamin C content may also be due to the biosynthesis of vitamin C which is affected by the activity of ascorbic acid oxidase during storage \cite{9}. Table 1 also showed the reducing sugar content and total sugar contained in red dragon fruit \textit{(H.costa- ricensis)} are 8.3% and 8.51%, respectively.

The moisture content of raw materials used in this study amounted to 86.46%. This is supported by Nurul and Asmah \cite{26} which states that the moisture content of red dragon fruit \textit{(H.costa- ricensis)} ranged from 85.05 - 89.98%. While the value of TSS (total dissolved solids) of raw materials amounted at 8 °Brix lower than literature which stated the value of TSS on red dragon fruit \textit{(H.costa- ricensis)} ranged from 11 °Brix. However, TSS refers to the sugar content and other small amounts of dissolved components such as vitamins, proteins, free amino acids, pigments, phenolic and also minerals. TSS content in red dragon fruit \textit{(H.costa- ricensis)} syrup may also be influenced by fruit maturity.

\subsection*{3.2. Effect of temperature process and vacuum pressure on the processing time}

The production of red dragon fruit \textit{(H.costa- ricensis)} syrup expected to get TSS 68 °Brix by using Double Jacket Vacuum Evaporator with temperature 30 - 50 °C and pressure (-40 cmHg) - (-60
cmHg). Table 2 showed the time of process to obtain red dragon fruit (H. costaricensis) syrup with TSS 68 °Brix. Based on Table 2, the longer processing time was 165 minutes at the treatment of 30 °C/-40 cmHg, while the treatment of 50 °C/-60 cmHg is the fastest processing time with 68 minutes (1 hour 8 minutes). In general, with the increasing temperature process, the time processing will be decreased. The same condition also happens to the pressure, the higher vacuum pressure was used will also cause the processing time production of red dragon fruit (H. costaricensis) syrup to decrease. This result is supported by Nisa [25] which states the increasing of temperature and vacuum pressure tend to reduce the processing time of tea syrup.

### Table 2. Processing time to produce red dragon fruit (H. costaricensis) syrup.

| Temperature (°C) | Pressure (cmHg) | Time (minutes) |
|-----------------|-----------------|----------------|
| 30              | -40             | 165            |
| 30              | -50             | 128            |
| 30              | -60             | 107            |
| 40              | -40             | 94             |
| 40              | -50             | 86             |
| 40              | -60             | 85             |
| 50              | -40             | 84             |
| 50              | -50             | 77             |
| 50              | -60             | 68             |

3.3. Vitamin C

Vitamin C is a compound that is very soluble in water, has acidic and strong reducing properties. Vitamin C in the red dragon fruit (H. costaricensis) syrup ranged between 0.19 and 8.75 mg/100 g. The results of ANOVA showed the temperature process gave a significant effect (P<0.05) on vitamin C content of red dragon fruit (H. costaricensis) syrup, but the pressure gave no significant effect. Vitamin C of red dragon fruit (H. costaricensis) syrup showed in Figure 1.

![Figure 1. Vitamin C of red dragon fruit (H. costaricensis) syrup.](image)

As can be seen in Figure 1, the treatments of 50 °C/-60 cmHg had the highest vitamin C content was 8.75 mg/100 gram, while the lowest vitamin C value obtained at the treatment 50 °C/-40 cmHg with vitamin C content was 3.15 mg/100 gram. The varied results on vitamin C content of red dragon
fruit (*H. costaricensis*) syrup are affected by the processing time. The longer of processing time caused more vitamin C damage. Igwemmar *et al.* [10] reported that the vitamin C in fruit and vegetables decreased with increasing heating time at constant temperature. Bello and Fowoyo [3] also reported the longer heating process caused increasing damage to vitamin C in green vegetables and citrus fruit. Figure 1 also explained the red dragon (*H. costaricensis*) fruit syrup processed using vacuum technology has higher levels of vitamin C than control. This is due to low temperatures of processing and pressures that are able to reduce the extent of food damage and maintain the nutrient content such as vitamin C in processed foods. It is supported with the previous studies, in which processing by using vacuum process for food will be produced a product with the maintained nutrients content as protein, fats, and vitamins [27].

3.4. Reducing sugar content

The reducing sugar content of red dragon fruit (*H. costaricensis*) syrup ranged between 46.76 and 54.41% as can be seen in Figure 2. The results of ANOVA showed the temperature process gave a significant effect (P< 0.05) on reducing the sugar content of red dragon fruit (*H. costaricensis*) syrup, but the pressure gave no significant effect.

![Figure 2. Reducing sugar of red dragon fruit syrup.](image)

Figure 2 demonstrated the increase of temperature and vacuum pressure causes the reducing sugar content of red dragon fruit (*H. costaricensis*) syrup to be lower. For vacuum processing, the treatment of 30 °C/-50 cmHg had the highest of reducing sugar content with 51.12%, while the lower treatment was obtained in the treatment of 50 °C/-60 cmHg with 49.10%. The decreasing trend of reducing sugar content is influenced by the processing time. The different lengths of red dragon fruit (*H. costaricensis*) syrup production causes the difference of sucrose breakdown to glucose and fructose, so the reducing sugar is also different. The longer the processing time, the more sucrose will be inverted to glucose and fructose. This research is supporting the previous studies, in which the reducing sugar was increased with the duration of heating [30]. Gaewchingduan and Pengthemkeerat [7] also reported that the increase of heating time has a positive correlation on reducing sugar. The length of the heating time was increased the hydrolysis process, so it will increase the levels of reducing sugar content.

Moreover, Figure 2 also explained red dragon fruit (*H. costaricensis*) syrup processed using vacuum technology has lower reducing sugar content than control. It is presumed that the use of low temperature and vacuum pressure inhibits the inversion of sucrose into glucose and fructose which resulted in lower reducing sugar. This is supported by Naknaen *et al.* [21,22], which state that the
process of using low temperature and short time can minimize the occurrence of the sucrose inversion which causes low reducing sugar in palm sugar syrup.

3.5. Moisture content
The moisture content of red dragon fruit (*H. costaricensis*) syrup ranged between 50.86 and 54.21%. The result of ANOVA showed the temperature and pressure gave a significant effect (P < 0.05) to the moisture content of red dragon fruit (*H. costaricensis*) syrup. The water content of red dragon fruit (*H. costaricensis*) syrup can be seen in Figure 3. Figure 3 showed the increasing temperature and vacuum pressure causes the lower moisture content in the red dragon fruit (*H. costaricensis*) syrup. The treatment with the highest water content was 30 °C/-40 cmHg with a moisture content of 54.21%, while the lowest moisture content was obtained at the treatment of 50 °C/-60 cmHg with a moisture content of 50.86%. This is due to the higher the temperature and the lower the pressure, water evaporation be the faster rate. The same opinion has also been expressed by Jamaluddin et al. [14,15], which states that the higher temperature and vacuum pressure caused a tendency rapid rate of water evaporation. This is due to differences in pressure inside and outside the solids, as well as the pressure difference between frying chamber and atmospheric pressure, solids will lose water faster in the form of water vapor through the pores.

![Figure 3. Moisture content of red dragon fruit syrup.](image)

3.6. Total sugar content
The total sugar content of red dragon fruit (*H. costaricensis*) syrup ranged between 50.86 and 54.21%. The result of ANOVA showed the temperature and pressure gave not significant effect on the total sugar content of red dragon fruit (*H. costaricensis*) syrup (α = 0.05). The total sugar content of red dragon fruit (*H. costaricensis*) syrup showed in Figure 4.
Figure 4. Total sugar content of red dragon fruit syrup.

As can be seen in Figure 4, the increase of temperature and vacuum pressure causes the total value of red dragon fruit (H. costaricensis) syrup sugar content to decrease, except at combination treatment of 40 °C/-40 cmHg and 50 °C/-60 cmHg. For vacuum processing, the highest total sugar content was recorded at the treatment of 40 °C/-40 cmHg with 52.11%, while the lowest value was obtained at the treatment of 30 °C/-40 cmHg with 48.19%. Decreasing total sugar content is expected by the different processing times. Figure 4 also explained that the red dragon fruit (H. costaricensis) syrup processed using vacuum technology has a lower total sugar content than control. This is thought to be due to the use of different temperatures. Generally, in the conventional method of syrup processing temperatures are used to reach 100 °C, whereas in the syrup processing by using vacuum technology uses lower temperatures between 30 -50 °C, which causes a lower value in the total sugar content in the syrup. This result is supported by Jaya et al. [16], who explained an increase in temperature can increase the total sugar in palm juice.

4. Conclusions
Effect of temperature process and vacuum pressure on the quality of red dragon fruit (H. costaricensis) syrup using double jacket vacuum evaporator were investigated. The temperature gave a significant effect on Vitamin C, moisture content, and reducing sugar, but gave no significant effect on total sugar content. Whereas, the pressure gave a significant on moisture content, but not gave a significant on vitamin C, reducing sugar content and total sugar content. The best treatment for optimum vitamin C is 50 °C/-60 cmHg with 8,75 mg/100 ml.

References
[1] Asrawaty, Noer H and Wahyudin 2019 Physical chemical and organoleptic characteristics of mango fruit syrup on different addition of sugar (Karaktiristik fisik kimia dan organoleptic sirup buah manga pada penambahan gula yang berbeda) AGRISAINTIFIKA Jurnal Ilmu-Ilmu Pertanian 3 (3) [In Indonesian]
[2] Balendres M A and Bengoa J C Diseases of dragon fruit (Hylocereus species): Etiology and current management options. Crop protection 126 104920.
[3] Bello A A and Fowoyo P T 2014 Effect of heat on the ascorbic acid content of dark green leafy vegetables and citrus fruits African Journal of Food Sciencesand Technology 5 (4) 114-118
[4] Choo W S and Young W K 2011 Antioxidant properties of two species of Hylocereus fruits Advances in Applied Science Research 2 (3) 418-425
[5] De Mello F R, Bernardo C, Dias C O, Bosmuler L C, Silveira J L, Amante E R et al. 2014 Evaluation of the chemical characteristics and rheological behaviour of pitaya hylocereus undatus peel Fruits (69) 381-390

[6] Ezeh E, Okee O, Ozuah A C and Onwobiku R O 2017 Comparative assessment of the effect of ripening stage on the vitamin C content of selected fruits grown within nsukka axis of enugu state International Journal of Environment, Agriculture and Biotechnology 2

[7] Gaewchingduang S and Pengthemenkeerati P 2010 Enhancing efficiency for reducing sugar from cassava bagasse by pretreatment International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering 4 (10) 477-480

[8] Halimoon N and Hasan M H A 2010 Determination and evaluation of antioxidative activity in red dragon fruit (hyllocereus undatus) and green kiwi fruit (actinidia delicosa) American Journal of Applied Sciences 7 (11) 1432-1438

[9] Harnowo I and Yunianta 2015 The effect of addition of betel nut seed extract and citric acid to the characteristic properties of star fruit juice (Penambahan ekstrak biji buah pinang dan asam sitrat terhadap sifat fisik, kimia dan organoleptik sari buah belimbing manis) Journal of Food and Agroindustry 3 (3) 1241-1251 [In Indonesian]

[10] Igwemmar N C, Kolawole S A and Imran I A 2013 Effect of heating on vitamin C content of some selected vegetables International Journal Of Scientific & Technology Research 2 (11) 209-212

[11] Igwemmar N C, Kolawole S A and Imran I A 2013 Effect of heating on vitamin C content of some selected vegetables International Journal of Scientific & Technology Research 2 (11) 209-212

[12] Islam M Z, Khan M T H, Hoque M M and Rahman M M 2012 Studies on the processing and preservation of dragon fruit (hyllocereus undatus) jelly The Agriculturits 10 (2) 29-35

[13] Jaafar R A, Rahman A R B A, Mahmood N Z C and Vasudevan R 2009 Proximate analysis of dragon fruit (hyllocereuspolyhyzus) American Journal of Applied Sciences 6 (7) 1341-1346

[14] Jamaluddin, Rahardjo B, Hastuti P and Rochmadi 2011 Mathematical model optimization to improve the process of vacuum frying on the texture of fruit chips (Model matematika optimasi untuk perbaikan proses penggorengan vakum terhadap tekstur keripik buah) Journal of Industrial Engineering, 12(1) 82-89 [In Indonesian]

[15] Jamaluddin, Suardy, Siswantor and Laga S 2011 The influence of temperature and vacuum pressure on water vaporization, volume changes and density ratio of fruit chips during vacuum frying (Pengaruh suhu dan tekanan vakum terhadap penguapan air, perubahan volume dan rasio densitas keripik buah selama dalam penggorengan vakum) Jurnal Teknologi Pertanian 12 (2) 100-108 [In Indonesian]

[16] Jaya R S, Ginting S and Ridwansyah 2016 Effect of temperature heating and storage on quality change of sugar palm (Arenga pinnata) (Pengaruh suhu pemanganan dan lama penyimpanan terhadap perubahan kualitas nira aren (Arenga pinnata)) Journal of Food and Agriculture Engineering 4 (1) 49 -57 [In Indonesia]

[17] Jeronimo M C, Orsine J V C, Borgesand K K and Novaes M R C G 2015 Chemical and physical-chemical properties, antioxidant activity and fattyacid profile of red pitaya [hyllocereus undatus (haw.) britton & rose] grown in brazil J Drug Metab. Toxicol 6 (4) 1-6

[18] Le Bellec F and Vaillant F 2011 Pitahaya (pitaya) (Hyllocereus spp.) in Postharvest biology and technology of tropical and subtropical fruit ed. E.M Yahia (Foreword: Woodhead Publishing) 4

[19] Lutfia U, Rugayah, Hendarto K and Andalasari T D 2017 Growth response of stem cuttings of red-fleshed dragon fruit (hyllocereus costaricensis) on the application of coconut water (Respon pertumbuhan setek batang buah naga merah (hyllocereus costaricensis) terhadap pemberian air kelapa) Jurnal Penelitian Pertanian Terapan 17 (3): 149-156 [In Indonesian]

[20] Minh N P 2014 Various factors influencing to red dragon fruit (hyllocereus polyhyzus) wine fermentation International Journal of Multidiciplinary Research and Development 1 (5) 94-98
[21] Naknaen P and Meenune M. 2016. Quality Profiles of Pasteurized Palm Sap (Borassus flabellifer Linn.) Collected from Different Regions in Thailand. Walailak J Sci & Tech 13(3): 165-176.

[22] Naknean P, Meenune M and Roudat G 2009 Changes in physical and chemical properties during the production of palm sugar syrup by open pan and vacuum evaporator As. J. Food Ag-Ind 2 (04) 448-456

[23] Naknean P, Meenune M and Roudth G 2013 changes in properties of palm sugar syrup produced by an open pan and a vacuum evaporator during storage International Food Research Journal 20 (5) 2323 – 2334

[24] National Standardization Agency (NSA) 2013 Syrup SNI 3544: 2013 National Standardization Agency (NSA) [In Indonesian]

[25] Nisa J A 2014 Development of a process for producing red tea syrup using vacuum evaporator evap-50 owner food machinery Thesis (Bogor: Institut Pertanian Bogor) [In Indonesian]

[26] Nurul S R and Asmah R 2014 Variability in nutritional composition and phytochemical properties of red pitaya (hylocereus polyrhizus) from Malaysia and Australia International Food Research Journal 21(4) 1689-1697

[27] Pantan S R 2012 Study effect of temperature on the quality of frying vacuum dried chili () Thesis (Makassar: Universitas Hasanuddin) [In Indonesian]

[28] Sanjaya W, Indratmi D and Sufianto S 2019 Applications various extracts of plant on stem growth response of red dragon fruit (Hylocereus polyrhizus) Journal of Tropical Crop Science and Technology 1 (1) [In Indonesian]

[29] Susanti C 2016 The effect of rasio of red dragon fruit (hylocereuspolyrhizus) with bongkok salak juice (salaccaedulisreinw) and type of stabilizer on the characteristics of fruit syrup Thesis (Bandung: Pasundan University) [In Indonesian]

[30] Trissanthi C M and Susanto W H 2016 Effect of citric acid concentration and heating time on chemical and sensory characteristics of syrup “alang-alang” (imperata cylindrica) (Pengaruh konsentrasi asam sitrat dan lama pemanasan terhadap karakteristik kimia dan organoleptik sirup alang-alang) Journal of Food and Agro-Industry 4 (1) 180-189 [In Indonesian]

[31] Xi X, Zong Y, Li S, Cao D, Sun X and Liu B. 2019. Transcriptome Analysis Clarified Genes Involved in Betalain Biosynthesis in the Fruit of Red Pitayas (Hylocereus costaricensis) Molecules 24(3) 445

[32] Zainoldin K H and Baba A S 2009 The effect of hylocereus polyrhizus and hylocereus undatus on physicochemical, proteolysis, and antioxidant activity in yogurt World Academy of Science, Engineering and Technology 60 361-366