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Submission date: 03-Aug-2021 12:31PM (UTC+0800)

Submission ID: 1627222926

File name: ioxidant_on_Jackfruit_Straw_Artocarpus_heterophyllus,_L._Jam.pdf (778.62K)

Word count: 4861

Character count: 23273

The Addition of “senduduk” Fruit (*Melastoma malabathricum*, L.) Extract as Colorants and Antioxidant on Jackfruit Straw (*Artocarpus heterophyllus*, L.) Jam.

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Abstract— Straw of jackfruit is part of a jackfruit which has not been used optimally. Jackfruit straw is rich in fiber so it can be processed into jam, but this product has a weakness in color. The addition “senduduk” fruit extract, has a lot of anthocyanin expected improving the color and antioxidant activity of the jam. In this study, it has been done the addition of some level of concentration of “senduduk” fruit extract, were: 2%, 4%, 6%, 8% and 10%. The result shows, the more “senduduk” fruit extract was added, the stronger the color and the higher antioxidant activity of the Jam. Addition 8% of “senduduk” fruit extract was the best product.

Keywords— antioxidant activity; anthocyanin; color; straw of jackfruit jam and “senduduk” fruit

I. INTRODUCTION

Plant jackfruit (*Artocarpus heterophyllus*, L.) is a tropical plant that growth in Indonesia, both in lowland and highland and can also be grown on all soil types. These plants can bear fruit throughout the year, although most production in October to December. West Sumatra is one of the jackfruit producing areas, with production reaching 7624 tons in 2013 [8]. Jackfruit consists of fruit pulp, seeds, straw and leather. Meat ripe jackfruit has a sweet taste and the specific flavor and usually consumed directly. Jackfruit seeds and straw are part of jackfruit are still underutilized. The processing of Jackfruit straw into food has not been used optimally, even though it has been carried out at research level that had been processed into flour for making cookies rich in fibre [7], processed into Nata [2] and processed into animal feed and a raw material into bioethanol.

Reference [5] shown that the fibre content of jackfruit straw two times greater than the fruit, that is equal 36.58%. Based on the component, Jackfruit straw can be processed into Jam. Reference [9] has conducted research on making jam using straw of Jackfruit with “Belimbing wuluh”.

Jam is a product that is made by cooking fruit puree with sugar (45:55) until thick [6]. From the preliminary research, it found that the colour was yellow pale. It was assumed that addition the colorant, can be improve the quality of the Jam.

“Senduduk” fruit (*Melastoma malabathricum*, L.) is one of the purple fruit because of the fitochemical content that

was anthocyanin. Reference [3] predicted anthocyanin in “senduduk” fruit is pelargonin. They is stable between pH 1-3 (red) pH 5-9 (light purple to chocolate) and stable at temperature change 30 – 100 °C [3]. Anthocyanin is natural colorants which have raised a growing interest due to their extensive range of colours innocuous and beneficial health effects. Anthocyanin is one of the antioxidant compounds.

Antioxidant compounds in food play an important role as a health protecting factor. Scientific evidence suggests that antioxidants reduce the risk of chronic diseases including cancer and heart disease. Antioxidant compounds like phenolic acids, polyphenols and flavonoids scavenge free radicals such as peroxide, hydroperoxide or lipid peroxyl and thus inhibit the oxidative mechanisms that lead to degenerative diseases [1].

The major problem of anthocyanin use as natural food colorants are in their stability, either in simple or in complex food formulation. Anthocyanin are stable under acidic condition (pH < 2.0), under normal processing they transform to colourless. A number of factors influence the stability of anthocyanin, such as temperature, pH, light [4], oxygen, enzyme, presence of ascorbic acid, sugar, sulphite salts, metal ions and co pigment.

It had been reported that anthocyanin extracts of *Musa acuminata* bract were highly or moderately resistant to the pH, temperature and light factors tested. *Musa acuminata* bract anthocyanin extract was more stable at pH 5.1 and 6.0, temperature at 20° C and 30° C both in the presence and

absence of light. Increase in environmental factors like pH, temperature and light accelerates destruction of anthocyanins [4]. Sorghum is rich in 3-deoxyanthocyanidins that give yellow to orange colour in acidic media. The red sorghum bran contain anthocyanins were more stable to temperature, light and pH-induced [23].

In this study, it has been carried out the addition of extract of "senduduk" fruit as colorant and antioxidant on Jackfruit straw jam.

II. MATERIAL AND METHODS

A. Raw Material

The raw material had been used in this study were Straw of Jackfruit (*Artocarpus heterophyllus*, L.), "senduduk" fruit (*Melastoma malabathricum*, L.), sugar, pectin and citric acid.

B. Pulping Straw of Jackfruit

Jackfruit straw sorted and washed with clean water, then was blanched for 5 minutes at 75°C to reduce the sap contained in the jackfruit and also can inhibit browning reaction. Then it was crushed in a blender with the addition of water is 2: 1.

C. Making of "senduduk" Fruit Extract

Chopped "senduduk" fruit that have purplish black colour was sorted and washed with clean water, then crushed using a blender by adding water 1: 3, then filtered using gauze.

D. Making of Jackfruit Jam

Forty-five g of Jackfruit straw pulp mixed with 55 g sugar, 0.5 g citric acid and pectin (1 g per the total weight of raw materials). Then boiled and stirred to be homogeneous. Then the temperature is lowered to 40°C. Then put "senduduk" fruit extracts such as the treatment (2%, 4%, 6%, 8% and 10%). Continue the cooking at temperature of 50°C for 15 minutes, while stirring slowly so as not to form air bubbles. Cooking is considered completed after testing with a "spoon test" to see the establishment of jam. Spoon test is done by taking a bit of the dough with the tip of a spoon, let it cool slightly, then spoon tilted, if not immediately fall, means cooking is stopped. Then put in glass jar that has been sterilized before.

Formulation of making jam is based on a formula created as in [10] with modifications and based on pre-study that has been done.

E. Observation

Data were collected consist of: analysis of vitamin C, using spectrophotometer UV-Vis; analysis of total acid, using titrimetri method; analysis pH, using pH meter; analysis of beta-carotene, using spectrophotometer; analysis of anthocyanin, using pH differential method; analysis of color, using hunter colorimeter (chromameter CR 300 Minolta); analysis of total phenol using Folin-ciocalteu; and analysis of antioxidant activity, using DPPH Method.

F. Statistical Analysis

This research use completely randomized design (CRD) with 5 treatment and 3 replication. The observation of each variable was statistically analyzed by F test and continued

with Duncan's New Multiple Range Test (DNMRT) at the 5% significance level.

The treatment in this study was the concentration of fruit extracts of "senduduk" added in making of jam, which is 2%, 4%, 6%, 8% and 10%.

III. RESULTS AND DISCUSSION

A. Analysis of Raw Material

Table I shows that jackfruit straw pulp contain $607.7 \pm 6.01 \mu\text{g}/100 \text{ mL}$ of beta-carotene. Total acid in pulp of jackfruit straw was $0.52 \pm 0.14 \%$, this value is lower than total acid in "senduduk" fruit extract, that was $1.04 \pm 0.00 \%$. Although total acids in "senduduk" fruit extract was higher than the total acid in jackfruit straw, but it seems to have no influence on the pH value, where the pH of the "senduduk" fruit extract was 5.9 ± 0.00 while the pH of the straw of jackfruit was 4.6 ± 0.00 . Vitamin C in jackfruit straw pulp was $3.2 \pm 0.07 \text{ ppm}$, while vitamin C in "senduduk" fruit extracts was $1.73 \pm 0.00 \text{ ppm}$.

The value of each variable observed was lower in "senduduk" fruit extracts, allegedly caused by the use of water is much more to get the extract of "senduduk" fruit. The addition of more water in making of "senduduk" fruit extract is aim in order to easier filter the extract. The addition of smaller water showed that the solution can not be filtered. Filtering should be done in order to mixing of the extract with pulp of jackfruit straw produced a homogeneous mixture.

TABLE I
THE CONTENT OF JACKFRUIT STRAW PULP AND "SENDUDUK" FRUIT EXTRACT

	Jackfruit Straw Pulp	"senduduk" Fruit Extract
Vitamin C (ppm)	3.2 ± 0.07	1.73 ± 0.00
Total Acid (%)	0.52 ± 0.14	1.04 ± 0.00
pH	4.6 ± 0.00	5.9 ± 0.05
Beta-carotene (%)	607.7 ± 6.01	-
Anthocyanin (mg/L)	-	13.71 ± 0.43
Total Phenol (%)	-	0.90 ± 0.19
Antioxidant Activity (IC ₅₀ /ppm)	101 ± 0.00	83 ± 0.00

- ; not tested

Total phenol of "senduduk" fruit extract was $0.90 \pm 0.19\%$. The content of total phenols of "senduduk" leaves dissolved in water (1:20) recorded $3344.2 \pm 19.1 \text{ mg}/100 \text{ g}$ [24], the number is much higher when compared with the total content of phenols in the "senduduk" fruit dissolve in water (1:3) is $0.90 \pm 0.19 \%$ (mg/100 mg) as is shown in Table I. The anthocyanin was $13.71 \pm 0.43 \text{ mg} / \text{L}$. The antioxidant activity of the extracts of the fruit is higher than in straw pulp jackfruit that was $83 \pm 0.00 \text{ ppm}$ in the extract, while in pulp of jackfruit straw was $101 \pm 0.00 \text{ ppm}$. The lower the IC₅₀ value shows the higher the antioxidant activity. At a concentration of 101 ppm jackfruit straw pulp, and of 83 ppm "senduduk" fruit extracts can inhibit the oxidation of 50%.

B. Jam of "senduduk" fruit extract

The addition of "senduduk" fruit extracts have affected on the color, the aroma and the taste of Jackfruit straw jam. The

higher the percentage of “senduduk” fruit extracts is added, the darker the color of the jam. Aroma of the jam is caused of aroma of jackfruit, the higher the addition of the extract of “senduduk” fruit, the more decrease jackfruit aroma of the jam, similarly with the taste. The higher the addition of the extract, the more decrease jackfruit taste on the jam.

The addition of the extract into the raw materials reduces the aroma and taste of jackfruit in a jam. The aroma and the taste of Jackfruit are still there up to 8%. The addition of 10% extract is going to produce jam with a slightly bitter taste.

C. Analysis of Vitamin C

The addition of “senduduk” extract had significant effect at $\alpha = 5\%$ on vitamin C ($p=0,009$). Table II shows that the value of vitamin C in the jam are 2.81 ± 0.02 ppm until 3.02 ± 0.01 ppm. The highest value is in treatment A(2% extract) that is 3.02 ± 0.01 ppm and the lowest value is in treatment

E (10% extract) that is 2.81 ± 0.02 ppm. Getting higher the addition of the extract, getting lower the value of vitamin C. It assumed that was related with 2 reason: (1) The content of vitamin C in the extract of “senduduk” fruit is lower (1.73 ± 0.00 ppm) than vitamin C in jackfruit straw pulp (3.2 ± 0.07 ppm), so the higher the addition of the extract, the lower vitamin C content in the jam; (2) the lower the addition of the extract, the longer cooking of the jam. Cooking time of treatment A (2%), B (4%), C (6%), D (8%) and E (10%) were 5 minutes and 7 seconds, 5 minutes and 36 seconds, 6 minutes and 7 seconds, 7 minutes and 23 seconds and 8 minutes and 6 seconds respectively.

Reference [12], showed that vitamin C easy to break because of environment changing such as temperature, concentration of salt and sugar, pH, oxygen, enzyme, catalyst, metal ion, ratio concentration of ascorbic acid and dehydro ascorbic acid.

TABLE II
VITAMIN C, TOTAL ACID AND PH OF JACKFRUIT STRAW JAM

“senduduk” added	Vitamin C (ppm)	Total Acid (%)	pH
2 %	3.02 ± 0.01 a	$3.02 \pm 0,15$	3.4 ± 0.04 a
4%	2.99 ± 0.04 ab	$3.22 \pm 0,15$	3.4 ± 0.03 a
6%	2.96 ± 0.05 bc	$3.33 \pm 0,00$	3.5 ± 0.01 ab
8%	2.89 ± 0.00 c	$4.26 \pm 0,15$	3.6 ± 0.00 bc
10%	2.81 ± 0.02 c	$2.49 \pm 0,88$	3.7 ± 0.12 c
p	0.009	0.056	0.000

D. Total Acid

The addition of the extract had no significant effect at $\alpha = 5\%$ on the total acid ($p=0,056$). But there is significant difference on the total acid at $\alpha = 6\%$. The lowest value is in treatment E (10% extract) that is 2.49 ± 0.88 %, and the highest value is in treatment D (8%) that is 4.26 ± 0.15 %.

The higher the addition of the extract, the higher the total acid, but the increase in total acid in the jam is only up to addition of 8%, while the addition of 10% extract, the total acid decreased. It maybe related with cooking time, the addition 10% of extract require a longer time for cooking, so more acid was damaged in the cooking process. The taste of the jam that was added 10% of extract was going to produce the more astringent, this may be associated with the decreasing of total acids and increasing of total phenol.

This research use jackfruit straw as the raw material, that color of the jackfruit is pale yellow. Reference [5] shows that the physical and chemical characteristic of jackfruit straw and pulp of jackfruit fruit is almost the same.

Beta-carotene is a provitamin A and is included in the group of carotenoids are abundant in fruits colored [11].

E. pH

The addition of the extract had significant effect at $\alpha = 5\%$ on the pH ($p=0,000$). The lowest pH is treatment A (2% extract) that is 3.4 ± 0.04 , and the highest pH is treatment E (10% extract) that is 3.7 ± 0.12 . The higher the addition of the extract, the higher the pH of the jam. The pH of extract of “senduduk” fruit is higher than pH of jackfruit straw pulp, so the higher the addition of the extract, the higher the pH of

the jam. An increasing in the pH value is in line with a decreasing in the value of the vitamin C, but not in line with the changing of the total acid value. The increase total acid is not accompanied by a decrease in the pH value.

F. Analysis of Beta-Carotene

The addition of the extract had no significant effect at $\alpha = 5\%$ on beta-carotene of the jam ($p=0,957$). Table III shows that the highest beta-carotene is in treatment A (2% extract) that is 314 ± 38.95 $\mu\text{g}/100$ mL and the lowest is in treatment E (10% extract) that is 300 ± 4.90 $\mu\text{g}/100$ mL.

G. Analysis of Anthocyanin

The addition of the extract had no significant effect at $\alpha = 5\%$ on the anthocyanin ($p=0,729$). Table III shows that the value of anthocyanin are 6.86 ± 1.42 mg/L until 9.43 mg/L. Although there is not significant difference, but from the number, we can see there is difference. The highest value is in treatment E (10% extract) that is 9.43 ± 2.31 mg/L and the lowest value is in treatment A (2% extract) that is 6.86 ± 1.42 mg/L. The higher extract was added the higher anthocyanin in the jam.

Anthocyanin is a group Anthocyanins is a group flavonoid pigment that are generally soluble in water. The color of anthocyanin pigments is red, blue, violet, and are usually found on flowers, fruits and vegetables. At low pH (acid) is a red pigment and at high pH turns violet and then to blue [13].

It has been reported that sugar stabilizes the red colour of strawberry anthocyanin with 40% sucrose concentration or at temperatures below 55°C due to reduced water activity,

hyperchromic effect, enzymes inhibition or steric interference [22]. It was reported that at 50 °C all investigated sugars improved anthocyanin stability, while at higher temperatures (70 and 90°C) stabilisation effect was only observed when glucose and trehalose were added to blackberry juice [23].

Reference [3], reported that anthocyanin in “senduduk” fruit is pelargonidin, which absorb color on λ vis max 510 nm. At pH 1-3 the color is red, at pH 5-9 the color is violet

until blue and stable at temperature (30-100)°C. Extract of “senduduk” fruit have antioxidant activity and the inhibition maximal at 0.2%.

Reference [14] said that the maturity of the fruit has an effect on the color and levels of anthocyanins on strawberry jam produced. Appropriate level of maturity is the most important to produce the best jam. The fully ripe strawberries as the raw material will produce the more red jam with a high anthocyanin.

TABLE III
BETA-CAROTENE, ANTHOCYANIN, TOTAL PHENOL AND ANTIOXIDANT ACTIVITY OF JACKFRUIT STRAW JAM

“senduduk” added	Beta-carotenee ($\mu\text{g}/100 \text{ mL}$)	Anthocyan in (mg/L)	Total Phenol (mg/mL)	Antioxidant Activity/IC ₅₀ (ppm)
2 %	300 ± 4.90	6.86 ± 1.42	0.99 ± 0.25	102.01± 0.046
4%	303 ± 4.90	7.20 ± 3.70	1.08 ± 0.20	101.51± 0.020
6%	306 ± 8.50	833 ± 3.71	1.11 ± 0.10	101.07± 0.269
8%	308 ± 35.38	9.15 ± 1.84	1.31 ± 0.07	92.29± 1.87
10%	314 ± 38.95	9.43 ± 2.31	1.34 ± 0.03	83.89± 0.01
P	0.957	0.729	0.253	0.06

Results are expressed as mean ± standard deviation.

H. Total Phenol:

The addition of the extract had no significant effect at $\alpha = 5\%$ on the total phenol ($p=0,253$). Table III shows that the total phenol of the jam is range $0.99 \pm 0.25 \text{ mg/ml}$ until $1.34 \pm 0.03 \text{ mg/ml}$. The highest value is in treatment E (10% extract) that is $1.34 \pm 0.03 \text{ mg/ml}$ and the lowest is in treatment A (2% extract) that is $0.99 \pm 0.25 \text{ mg/ml}$. The lower the extract was added, the higher the total phenol in the jam. Anthocyanin is a compound that includes a group of flavonoid compounds. Flavonoids and tannins were included into the group of polyphenol compounds [15]. As in [24], leaf extract of “senduduk” possess antiproliferative activity against various types of cancer cells, which can be associated with antioxidant properties and high polyphenol contents.

I. Antioxidant Activity

The addition of the extract had no significant effect at $\alpha = 5\%$ on the antioxidant activity ($p=0,06$). But at $\alpha = 6\%$, shown that there is significant difference on antioxidant activity between different treatment. Determinant of antioxidant activity used DPPH method. This method is appropriate method to analyze antioxidant activity that was polar, because of DPPH crystals dissolve and only give a maximum absorbance in polar solvents such as water, methanol and etha[3].

Reference [16] reported that a compound is considered to have antioxidant activity if it has IC₅₀ less than 200 ppm. In this study we have found the IC₅₀ value of less than 200 ppm ($83.89 \pm 0.01 \text{ ppm}$ until $102.01 \pm 0.046 \text{ ppm}$). Reference [21], suggest that a compound can be characterized as very strong antioxidant (IC₅₀ < 50 ppm), strong antioxidant (IC₅₀: 50 – 100 ppm), middle (IC₅₀: 100 – 150 ppm), weak (IC₅₀: 150 – 200 ppm), and very weak (IC₅₀: > 200 ppm). Based on the research, antioxidant activity in our research can be said strong.

The more addition of the extract the higher the antioxidant activity in the jam. it was related to the flavonoid content in

the form of anthocyanin and phenolic compound in fruit of “senduduk”. Reference [17] showed that “senduduk” fruit (*Melastoma malabathricum*, L.) has reddish purple color and it was predicted contain antioxidant compound that was antosianin.

Reference [18] reported that the presence of antioxidants in strawberry jam is caused by the presence of anthocyanin compounds in strawberries.

In this jam, as antioxidant compounds not only from fruit extract of “senduduk”, but also from straw jackfruit. Jackfruit straw contains beta-carotene as much as $607.7 \pm 6.01 \text{ mg}/100 \text{ mL}$. Beta-carotene is a compound a group of carotenoids, is a precursor of vitamin A, as antioxidant, increased the immune system, and anti-cancer. In addition, so[13] classes of carotenoids are also used as food coloring.

Antioxidants are compounds that can inhibit oxidation reactions by binding free radicals or highly reactive molecules that damage cells can be inhibited [19].

J. Analysis of Color

Color is one of the characteristics that affect the acceptance by consumers. Colors that appear on foods such as orange or red or purple is derived from the components contained in the food. Orange color is usually produced from beta-carotene, whereas red or purple color resulting from anthocyanin.

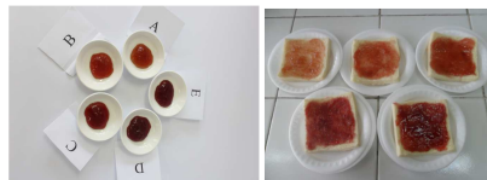


Fig.1 Jackfruit straw jam of treatment A (2%), B (4%), C (6%), D (8%) and E (10%)

Fig. 1 Jackfruit straw jam of treatment A (2%), B (4%), C (6%), D (8%) and E (10%)

Table IV show that there are difference significant between the addition of the extract on the value of L*, b*, C* and H* (p = 0.000), otherwise there is no difference significant between the addition of the extract on the value

of a* (p = 0.301), but from the figure can be seen there is a difference, with the tendency of increasing the addition of the extracts resulting decreases the value of a*. There is no significant statistical difference maybe it is caused of there is higher standard deviation in one treatment (addition of 6% the extract).

TABLE IV
COLORIMETER PARAMETER OF DIFFERENT TREATMENT OF JACKFRUIT STRAW JAM

“senduduk” added	L*	a*	b*	C*	H*
2 %	37.00±0.78 a	20.32±0.03	17.81±0.06 a	27.01±0.06 a	41.17±0.12 a
4%	31.42±0.03 b	17.98±0.01	10.38±0.03 b	20.76±0.02 b	29.93±0.06 b
6%	31.44±0.32 b	16.22±5.70	7.20±0.15 c	20.83±0.25 b	20.13±0.21 c
8%	28.99±0.08 c	16.60±0.08	4.17±0.02 d	17.11±0.08 c	14.00±0.00 d
10%	28.30±0.16 d	16.24±0.10	3.86±0.05 e	16.69±0.12 d	13.27±0.12 e
p	0.00	0.301	0.00	0.00	0.00

Results are expressed as mean ± standard deviation.
Values with different letters are statistically different at p ≤ 0.05.

All of the colorimeter parameter value (L*, a*, b*, C* and H*) have the same tendency. The higher the addition of extract, the lower the colorimeter variable value, and the higher the addition of the extract, the darker color of the jam, the higher anthocyanin level on the jam. It can be seen in table III. L* is the value that describes the brightness of the product, the value ranges from 0 (black) to 100 (white). Table IV show that the more addition of the extract, the lower of L* value, it means the addition of the extract can decrease the brightness of the jam.

The value of a* shows the red color. The range of the value is 20.32±0.03 until 16.24±0.10. The higher the addition of the extract, the more decrease intensity of red color. The value of b* shows the yellow color. The range of the value is 17.81±0.06 until 3.86±0.05. It shows that the more added of the extract, the more decrease intensity of the yellow color. The yellow color is produced from the color of jackfruit straw, so the higher the addition of the extract, it means the lower the jackfruit straw in the jam. The value of C* and H*, declined sharply by the higher the addition of the extract

Similarly as in [14], color test conducted using Hunter Lab color system (LabScan XE, Reston, Virginia, USA). the resulting chroma on strawberry jam made from various levels of maturity, that were 29.4 (nearly ripe) , 27.6 (ripe) and 26.9 (fully ripe) and the anthocyanin content were 13.0 mg / 100g ; 25.2 mg / 100g and 33.1 mg / 100g respectively. They concluded that the ripe fruit is used in the manufacture of jam, the lower the colorimeter value and the higher the content of anthocyanin.

IV. CONCLUSIONS

Results from this study clearly showed that the addition of the extract had effect on the color and anthocyanin of the jam. The higher the addition of the extract, resulting the darker the color of the jam and the higher the anthocyanin of the jam. The colorimeter parameter (L*, a*, b*, c*, H*, C*) is strongly related with anthocyanin content. The color of the

jam is affected pH, and the pH is affected by vitamin C, but the mal acid is not affecting the pH.

The addition of the extract had effect on the antioxidant activity of the jam. In the jam contain beta-carotene, anthocyanin, total phenol, vitamin C that have antioxidant character. But our findings confirm that antioxidant activity in the jam is affected by anthocyanin and total phenol.

The increase the antioxidant activity of the extract occurs until the addition of 10%, but the addition of 10% extract produce jam with a slightly bitter taste.

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