Quality Jackfruit Syrup using Different Jackfruit Varieties

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บทคัดย่อ

ขนุนเป็นผลไม้พื้นเมืองที่พบในแถบภูมิภาคเอเชียที่มีสารสำคัญหลากหลายประเภท นอกจากนี้ยังพบว่าขนุนมีปริมาณของแข็งทั้งหมดที่ละลายและมีกลิ่นรสเฉพาะที่เหมาะสมที่น่าจะนำมาใช้เป็นวัตถุดิบในการผลิตกลูโคสไซรัป อย่างไรก็ตามขนุนในแต่ละสายพันธุ์ประกอบไปด้วยสารสำคัญที่มีปริมาณและชนิดที่แตกต่างกันไปซึ่งน่าจะส่งผลต่อคุณลักษณะของไซรัปได้ ดังนั้นในงาวิจัยนี้จึงศึกษาคุณภาพของไซรัปจากขนุนจำนวนสามสายพันธุ์ คือ พันธุ์ทองประเสริฐ พันธุ์มาเลเซีย และพันธุ์พื้นเมืองของจังหวัดอุบลราชธานี และผลิตไซรัปโดยใช้วิธีการย่อยด้วยเอนไซม์ ซึ่งในการทดลองใช้เอมไซม์แบบผสมเชิงการค้า ที่ประกอบไปด้วย เพคติเนส เซลลูเลส กลูโคสอะไมเลส อัลฟาอะไมเลส และโปรตีเอส จากการทดลองพบว่า ไซรัปที่ผลิตได้จากขนุนทั้งสามสายพันธุ์มีค่าสมมูลเด็กซ์โทรส (DE) ระหว่าง 69-73 และมีน้ำตาลรีดิวซ์เพิ่มขึ้นร้อยละ 23 โดยไซรัปที่ผลิตจากขนุนพันธุ์มาเลเซียมีปริมาณน้ำตาลรีดิวซ์สูงที่สุดอย่างมีนัยสำคัญทางสถิติ แต่ไซรัปที่ผลิตจากขนุนพันธุ์พื้นเมืองจะมีร้อยละค่าการส่องผ่านแสงสูงที่สุดที่ระดับความเชื่อมั่นร้อยละ 95 ซึ่งสอดคล้องกับปริมาณสารประกอบฟีโนลิกทั้งหมดที่ต่ำในขนุนสายพันธุ์นี้ และพบว่า หลังจากการผลิตไซรัปจากขนุนทุกสายพันธุ์มีปริมาณแคโรทีนอยด์ สารประกอบฟีโนลิกทั้งหมด กรดแอสคอบิค และกิจกรรมการเป็นสารต้านอนุมูลอิสระลดลง จากการศึกษานี้พบว่า ไซรัปที่ผลิตจากขนุนสายพันธุ์ทองประเสริฐมีปริมาณสารสำคัญสูงที่สุดเมื่อเทียบกับไซรัปที่ผลิตจากขนุนสายพันธุ์อื่นๆ ที่ระดับความเชื่อมั่น ร้อยละ 95

คำสำคัญ: ขนุน ไซรัป สารสำคัญ

Abstract

Jackfruit is an indigenous fruit of Asian countries containing different bioactive compounds. Due to its high total soluble solid and unique flavor, using jackfruit as a source for glucose syrup is potentially interesting. Also, different varieties of jackfruit may contain different bioactive compounds, thus it is possible to obtain jackfruit syrups with different characteristics. Three varieties of jackfruit were studied, Thong Prasert var., the Malaysian var., and the Indigenous var. of Ubon Ratchathani province. Enzymatic digestion was conducted using a commercial complex enzyme, for example pectinase, cellulase, glucose amylase, α-amylase, and protease. Different varieties of jackfruit syrup were obtained at DE values between 69 and 73. The reducing sugar content increased up to 23% of the initial content after syrup processing. It was found that the syrup using the Malaysian var. provided a higher amount of reducing sugar than the others ($p\leq0.05$). However, the syrup obtained from the Indigenous var. provided the highest % transmittance compared to the others (($p\leq0.05$). This result agreed with the low total phenolic content of the jackfruit. Carotenoids, total phenolic compounds, ascorbic acid, and its antioxidation activities decreased after the syrup process. Jackfruit syrup using Thong Prasert var. provided the highest value of bioactive compounds compared to the others.

Keywords: Jackfruit: Syrup: Bioactive compounds

Introduction

Jackfruit is an important tropical fruit in Thailand and other Asian countries, and contains different bioactive compounds, such as carotenoids, flavonoids, total phenolics compounds, and ascorbic acid [1], [2]. It is popular with local and foreign consumers and is industrially processed into various products. The golden yellow color of jackfruit provides more color in glucose syrup, and its unique flavor and high total soluble solid may produce glucose syrup with special attributes compared to general glucose syrup for consumers in the market. Due to several bioactive compounds, jackfruit gives a high nutritive value to glucose syrup, providing a product at a low market price.

In general, production of glucose syrup is done in two stages, juice extraction and concentration. The enzymatic extraction and digestion are normally done at low temperatures. Chidchai [3] found that high consumer acceptance for banana syrup was obtained by using multi-component enzymes (pectinase, α-amylase, glucosidase amylase, and protease), and it was also found that a high yield of glucose syrup was achieved compared to other methods. However, different varieties of jackfruit with different amounts of bioactive compounds may produce glucose syrups with different characteristics.

The purpose of this study was to compare the glucose syrups produced from different jackfruit varieties.

Materials and Methods

Raw material

Two varieties of jackfruit, Thong Prasert var. and Malaysia var., were purchased from Talaad Thai market. The Indigenous var. was obtained from a local farm in Amphor Warinchumrab, Ubon Ratchathani Province. The fruit was kept at room temperature until a ripening stage was reached before the glucose syrup process.

Jackfruit syrup process

The three varieties of jackfruit were prepared after fully ripening. Only flesh jackfruit was used by hand-picking before washing with tap water and mincing using a blender. The products were kept in zip-lock bags and stored at -18°C before further processing. Jackfruit purees were obtained by mixing with water at the ratio of 1:1 (w/w) before heating at a temperature of 98°C for 5 minutes and cooling down to 50ºC [3]. 0.5% (v /v, E/S) of a commercial complex enzyme such as pectinase, cellulase, glucose amylase, α-amylase, and protease (Lunazyme complex AK-1, supplied by DKSH Thailand) was mixed with the jackfruit purees before incubation in a water bath at 55ºC for 300 minutes. The enzyme activity was terminated by heating at 80ºC for 2 minutes and then filtrated by the use of a white cloth. The filtrate was then concentrated using rotary evaporator evaporation at 50°C [4] until a total soluble solid at 72°Brix was obtained. The syrups were packed in closed jars and stored at room temperature for further analysis.

Total phenol content (TPC)

TPC was determined using the Folin-Ciocalteu's reagent [5]. The absorbance at 765 nm was measured. Total phenol contents were expressed in Gallic acid equivalents.

DPPH assay

The free radical scavenging activity of the fruit extracts were measured by assessing the decrease in absorbance of methanolic DPPH solution at 517 nm in the presence of the extract [6]. The initial concentration of DPPH was 0.1 mM and the reading was taken after allowing the solution to stand for 30 min. The antioxidant activity was expressed as follows:

$$\% \text{ disappearance} = ((A_{control}-A_{sample})/A_{control}) \times 100\%$$

IC_{50}, the amount of sample extracted into 1 ml solution necessary to decrease by 50% the initial DPPH concentration, was derived from the % disappearance vs. concentration plot (concentration here meant mg of fruit extracted into 1 ml solution).

Ferric reducing power

The FRAP assay was carried out according to the procedure described in Benzie and Szeto [7]. Briefly, the FRAP reagent was prepared from sodium acetate buffer (300 mM, pH 3.6), 10 mM TPTZ solution (40 mM HCl as solvent), and 20 mM iron (III) chloride solution in a volume ratio of 10:1:1 respectively. The absorbance of the mixture was measured at 593 nm after 4 min. The standard curve was constructed using $FeSO_4$ solution.

Carotenoids content

Flesh samples were ground to a fine pulp with the addition of 20 ml of 80% acetone. The extract was centrifuged (5000 rpm for 5 min) and supernatant was obtained. The final volume was made up to 100 ml with 80% acetone and the absorbance were read at 480 (for β-carotene) and 510 nm (for lycopene) against the solvent (80% acetone) as blank [8]. The carotenoids were determined and expressed in mg per 100 g of pulp.

Ascorbic acid

The ascorbic acid of jackfruit was determined at different steps of the glucose syrup process using Iodine Titration method [9].

Chemical Properties

Total sugar and reducing sugar content of the jackfruit were monitored at different steps of the glucose syrup process starting with fresh material and puree (before digestion process) and after digestion process. The Lane and Eynon Volumetric Method was used for reducing sugar content analysis [9]. Also, total acidity, pH, total solid, and total soluble solid were monitored by using the AOAC method [9]. DE value of syrup was obtained from the ratio of reducing sugar formed compared with the glucose of total sugar content [10]. The viscosity of syrup was measured using a Brookfield viscometer.

Results and Discussion

Three jackfruit varieties, Thong Prasert, Malaysia, and Indigenous, were kept at room temperature until completely ripened by controlling total soluble solids (TSS, ^{o}Brix) to be unchanged. After fully ripening, TSS of Tong Prasert var. was 19.4 ± 0.06 ºBrix, and 26.6 ± 0.01 ºBrix for Malaysia var., and 26.0 ± 0.02 ºBrix for Indigenous var. after 7 days storage. It was found that TSS and pH value of the Thong Prasert var. were lower than the Malaysia and Indigenous var. ($p \leq 0.05$) as shown in Table 1. Compatible with low pH value, the total acidity was found high in Thong Prasert var. compared with the Malaysia and Indigenous var. ($p \leq 0.05$). These results agreed with the high ascorbic acid obtained ($p \leq 0.05$). On the other hand, the Malaysia var. contained higher total sugar and reducing sugar content than the others ($p \leq 0.05$). Also, carotenoids content for Indigenous and Thong Prasert var. were high compared to the Malaysia var. ($p \leq 0.05$). Total phenolic compounds and ascorbic acid of the Thong Prasert var. were high ($p \leq 0.05$) which expressed in a high ability of antioxidants for electrons transferring to free radicals as a reducing agent (the percentage of inhibition, IC50) was lower than the other varieties ($p \leq 0.05$). However, the ferric reducing antioxidant power (FRAP) of jackfruit was not compatible with bioactive compounds while the Malaysia var. was found higher in reducing power than the others ($p \leq 0.05$). It was observed that the Malaysia var. contained a high value of total sugar and reducing sugar compared to the other varieties ($p \leq 0.05$). Reducing sugar of jackfruit flesh were 85.20%, 71.16% and 84.72% for Thong Prasert var., Malaysia var., and Indigenous var. respectively. These characteristics of jackfruit flesh can be a potential source of high nutritional value for the syrup product.

During the syrup process, bioactive compounds were monitored before and after digestion (Table 2 and Table 3). It was clearly observed that carotenoids, total phenolic compounds, and ascorbic acid decreased after enzyme hydrolysis ($p \leq 0.05$) for all varieties. There was a decrease in the ability of electron transfer (measured by DPPH method) and ferric reducing antioxidant power (FRAP) was also observed after digestion ($p \leq 0.05$).

Table 1 Properties of three jackfruit varieties

Flesh characteristics	Thong Prasert var.	Malaysia var.	Indigenous var.
Total soluble solid (Brix)	19.4± 0.06^{b}	26.56± 0.01^{a}	26.03± 0.02^{a}
pH	5.63±0.00^{b}	6.77±0.00^{a}	6.6±0.00^{a}
Total acidity (%, as citric acid)	0.12 ± 0.00^{a}	0.07 ± 0.00^{b}	0.07 ± 0.00^{b}
Reducing sugar (%)	85.2	71.2	84.7
Carotenoid content (μg/g)	0.478 ± 0.02^{a}	0.377 ± 0.02^{b}	0.485 ± 0.01^{a}
Total phenolic content (μg GAE/g)	154.65 ± 10.98^{a}	145.57 ± 21.50^{b}	95.05 ± 2.33^{c}
Ascorbic acid (mg/g)	0.87 ± 0.13^{a}	0.76 ± 0.10^{b}	0.56 ± 0.05^{c}
IC50 (μg/ml)	25 ± 0.09^{a}	28 ± 0.04^{b}	50 ± 0.00^{b}
FRAP value (μmol Trolox/ml)	0.21 ± 0.005^{b}	0.034 ± 0.028^{a}	0.0059 ± 0.002^{a}

Note: a, b, c mean significantly different between jackfruit varieties ($p \leq 0.05$)

Table 2 Bioactive compounds of jackfruit puree during syrup process

Syrup process	Jackfruit varieties	Carotenoid (µg/ml)	Ascorbic acid (mg/ml)
Before digestion	Thong Prasert	$4.10 \pm 0.56^{A,b}$	$0.27 \pm 0.06^{A,a}$
	Malaysia	$7.13 \pm 2.96^{A,a}$	$0.23 \pm 0.01^{A,b}$
	Indigenous	$2.23 \pm 0.50^{A,c}$	$0.15 \pm 0.03^{A,c}$
After digestion	Thong Prasert	$0.82 \pm 0.17^{B,b}$	$0.25 \pm 0.02^{B,a}$
	Malaysia	$1.55 \pm 0.03^{B,a}$	$0.20 \pm 0.02^{B,b}$
	Indigenous	$0.56 \pm 0.03^{B,c}$	$0.12 \pm 0.02^{B,c}$

Note: a, b, c mean significantly different between jackfruit varieties ($p \leq 0.05$)

A, B mean a significant difference between the syrup process within the same variety ($p \leq 0.05$)

Comparisons between the different varieties revealed that the Thong Prasert var. contained a higher value of bioactive compounds than Malaysia and indigenous var. ($p \leq 0.05$), with the exception of carotenoid contents as it was found that the Malaysia var. provided the highest value both before and after digestion ($p \leq 0.05$). These results agreed with the high ability of antioxidant activities of the Thong Prasert var. that were observed by DPPH and FRAP method compared to the others.

The antioxidant activity of jackfruit puree was found to be high for the Thong Prasert var. using DPPH method and this reducing power was as high as BHT standard (IC50 = 1.56 µg/ml). The loss of bioactive compounds and antioxidant activities after enzymatic hydrolysis may be due to the high temperature over a long period that was used for pasteurization at the beginning step before incubation at 55°C for 5 hr. Thus, carotenoids, ascorbic acid, and total phenolic compounds decreased due to thermal degradation and oxidation induced by the high temperature process [11].

The characteristics of jackfruit syrup were measured after evaporation (Table 4). The final TSS of syrup obtained from the Indigenous var. provided a higher value than the Thong Prasert and Malaysia var. ($p \leq 0.05$). These values were compatible with total solid content. Surprisingly, flesh jackfruit for the Indigenous var. represented lower total sugar and reducing sugar content than the others with high value of soluble solid (Table 1), but the highest values of total sugar and reducing sugar after syrup process were found ($p \leq 0.05$), as shown in Table 4.

This meant that the Indigenous var. can be hydrolyzed by complex enzyme more than the others. A lower amount of sugar content but a high value of soluble solids with a thin flesh (0.34±0.01 cm) of the Indigenous var. could be an optimum condition for high complex enzyme activity rather than the other varieties. According to the Malaysia var., even though high values of total sugar content and total soluble solids were observed for jackfruit flesh (Table 1), a lower value of reducing sugar and total sugar content of syrup was obtained compared to the indigenous var. This could be due to the flesh of the Malaysia var. (0.46±0.01cm) being thicker than the Indigenous var. (0.34±0.01 cm) as well as the Malaysia var. was firmer than the Indigenous var. This may explain that the

Malaysia var. may contain higher starch accumulation than the Indigenous var. as a harder texture of the flesh was observed resulting in incomplete digestion by a multi-component enzyme. This result was also observed for the Thong Prasert var. as the flesh thickness was 0.84 ±0.03 cm with high firmness and texture (data not shown) resulting in the lowest value of total sugar and reducing sugar contents after the syrup process. Concurrent with the previous result, dextrose equivalent value (DE) of syrup after the syrup process was between 69.9 and 72.9, while the Indigenous var. was found highest ($p \leq 0.05$) followed by the Malaysia var. and Thong Prasert var. According to the obtained DE value of syrup, these jackfruit syrups can be classified as glucose syrup type III with characteristics of clear liquid and sweet taste [12]. They can be used as an ingredient for beverage products or a source of alcoholic fermentation.

Table 3 Antioxidant activities of jackfruit puree during syrup process

Syrup process	**Jackfruit varieties**	**Total phenolic contents (μg GAE/ml)**	**IC50 (μg/ml)**	**FRAP value (μmol Trolox/ml)**
Before digestion	Thong Prasert	$58.81 \pm 2.60^{A,a}$	$1.53 \pm 0.01^{A,a}$	$0.091 \pm 0.002^{A,b}$
	Malaysia	$57.20 \pm 1.13^{A,b}$	$2.91 \pm 0.00^{A,b}$	$0.108 \pm 0.002^{A,a}$
	Indigenous	$48.74 \pm 0.71^{A,c}$	$6.28 \pm 0.03^{A,c}$	$0.054 \pm 0.0004^{A,c}$
After digestion	Thong Prasert	$51.61 \pm 0.60^{B,a}$	$22.64 \pm 0.49^{B,a}$	$0.029 \pm 0.0003^{B,c}$
	Malaysia	$44.21 \pm 0.20^{B,b}$	$22.11 \pm 0.32^{B,b}$	$0.049 \pm 0.0006^{,a}$
	Indigenous	45.93 ± 0.95^{c}	$28.93 \pm 0.68^{B,c}$	$0.045 \pm 0.0004^{B,b}$

Note: a, b, c mean significant differences between jackfruit varieties ($p \leq 0.05$)

A, B mean a significant difference between the syrup processes within the same variety ($p \leq 0.05$)

As shown in Table 4, a clear liquid of syrup was found high for the Indigenous var. presented as a high value of percentage transmittance ($P \leq 0.05$), followed by the Thong Prasert var. and the Malaysia var which were compatible with DE value. The high turbidity of syrup obtained from the Thong Prasert var. and the Malaysia var. could be high pectin substance suspended in the syrup. As mentioned before, the flesh of the Thong Prasert var. and the Malaysia var. were thicker than the Indigenous var., thus more pectin substance accumulated in the cell wall. Therefore, cell disruption by the crushing process, followed by the enzyme activity for digestion of polysaccharide in the cell wall and middle lamellae resulted in the release of soluble pectin suspended in the syrup, thus leading for juice turbidity [13]. In contrast, the thin flesh of jackfruit of the Indigenous var. provided a good characteristic of syrup as a clear liquid. Even though lower bioactive compounds and antioxidant activities of jackfruit syrup using Indigenous var. were observed, high values of reducing sugar as well as high DE values were obtained ($P \leq 0.05$).

Conclusions

Jackfruit can be an alternative source for syrup process as it contains high total soluble solid with high bioactive compounds and antioxidant activities. The Thong Prasert variety contained high bioactive compounds with high ability for antioxidant activities compared to the Malaysia and Indigenous varieties. Decreases of bioactive ingredients and the ability of antioxidant activities were observed after the enzymatic digestion process. However, the Indigenous variety provided a good characteristic of syrup type III which can be used as an ingredient for beverage products or alcoholic fermentation, but bioactive compounds and its antioxidant activities could not be preserved after the syrup process. However, the Thong Prasert and Malaysia varieties can be good sources for functional syrup but not with good characteristics.

Table 4 Jackfruit syrup characteristics of three jackfruit varieties

Syrup characteristics	Thong Prasert var.	Malaysia var.	Indigenous var.
Total soluble solid (Brix)	64.5 ± 0.28^{b}	63.7 ± 0.07^{c}	65.3 ± 0.07^{a}
Total solid (µg/ml)	459.05 ± 2.24^{c}	482.87 ± 0.45^{b}	501.87 ± 0.91^{a}
Total acidity (% as citric acid)	0.99 ± 0.01^{a}	1.11 ± 0.01^{c}	0.97 ± 0.02^{b}
pH	4.8 ± 0.14^{a}	4.7 ± 0.28^{b}	4.7 ± 0.14^{b}
Reducing sugar (%)	91.5	94.4	94.8
DE-Value	69.9^{c}	70.9^{b}	72.9^{a}
Viscosity (cPs)	3.6 ± 0.21^{a}	3.5 ± 0.17^{b}	3.2 ± 0.32^{c}
%Transmittance	23.6 ± 0.01^{b}	20.13 ± 0.40^{c}	29.35 ± 0.01^{a}
Carotenoid (µg/ml)	0.41 ± 0.02^{a}	0.21 ± 0.02^{b}	0.18 ± 0.16^{c}
Total phenolic contents (µgGAE/ml)	91.50 ± 0.76^{a}	90.07 ± 3.73^{b}	85.89 ± 2.55^{c}
Ascorbic acid (mg/ml)	0.26 ± 0.06^{a}	0.23 ± 0.07^{b}	0.13 ± 0.06^{c}
IC50 (µg/ml)	1.24 ± 0.00^{a}	3.09 ± 0.00^{b}	6.82 ± 0.00^{c}
FRAP value (µmol Trolox/ml)	0.053 ± 0.0015^{b}	0.104 ± 0.0048^{a}	0.051 ± 0.0008^{b}

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