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Quality characteristics of rice jam with added palmyra palm sugar (*Borassus Flabellifer Linn.*) as inner beauty material

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Abstract

Modern people prefer foods and snacks with high sugar content, and as the consumption rate increases, the obesity rate worldwide is increasing every year, along with its severity. Therefore, in this paper, the reduction of the sugar content in jam was experimented with, which is a problem due to its high sugar content, and to report the possibility of healthy functional rice jam by using Palmyra palm sugar, a natural sweetener consumed by diabetic patients. As a result of the experiment, Palmyra palm sugar, which lowered the sugar content to 45%, showed a high antioxidant effect and overall preference for rice jam, suggesting that it could be a potential health functional rice jam, and it is expected to be an opportunity to increase the frequency of palm sugar intake.

1. Introduction

In today's society prioritizing health, many changes have occurred in diet and food choices. As interest in health and food safety increases due to changes in consumer perception, the consumption of nutrient-rich functional foods, low-calorie and natural sweetener products is increasing. Accordingly, product development and research using natural sweeteners are also increasing. In addition, a lot of attention was paid to beautifying the body's outward appearance in the past, but now more people are not only interested in maintaining their external appearance but also taking care of their inner physical health as well.

This can be called inner beauty, and the concept of inner beauty food as edible cosmetics and beauty functional food has emerged. It is scientifically proven to have anti-oxidative and anti-inflammatory effects by helping to prevent and improve skin ageing through the nutritional supply of vegetables, fruits and nuts, which are physiologically active substances. (Lee *et al*., 2017; Kim *et al*., 2018) Also, it can be said that palm sugar is included in inner beauty foods. The most important thing is to manage one's health through eating habits, lifestyle and to take care of your health and skin, regular consummation improves even one cell in our body. As time goes by, Inner Beauty Food has been attracting attention with continuous interest and is helping to prevent diseases.

Rice is mainly composed of carbohydrates, but it also provides minerals (magnesium, manganese, selenium, iron, phosphorus) and vitamins (thiamine, niacin, folic acid), and contains a small amount of protein and calcium (Mahender *et al*., 2016; Ravichanthiran *et al*., 2018). It also contains 8 essential amino acids that help improve healthy hair and skin, vision, heart, lungs, nervous system and brain function, acting as a protein source and is free of gluten, cholesterol, fat, and sodium (Frei and Becker, 2004; Han *et al*., 2015) in modern society, it is considered suitable because it is used as a raw material for jams in a variety of beans, vegetables, and dried fruits, in addition to fruits. When making jam, 60 to 65% of the fruit and fruit weight sugar should be added followed by pectin, gelatin, lemon juice, and more. Water activity should be lowered to 0.8 or less to inhibit microbial growth. Jam has been in the spotlight as processed food with increased preservation, but problems such as obesity, tooth decay, excessive secretion of insulin, nervousness, and decreased immunity are raised due to excess sugar when making jam. Accordingly, the development and research of jams that have lowered the sugar ratio or

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replaced natural sweeteners are being actively conducted (Hyvonen and Torma, 1983). However, research papers using palmyra palm sugar are incomplete. Palmyra palm sugar (*Borassus Flabellifer Linn*.) Belongs to the *Arecaceae* family, and is a type of sugar. Palm sugar is produced in Cambodia, India, Indonesia, Ethiopia, and Malaysia, and is cultivated in warm areas such as Florida, Southern Hawaii, and Thailand as the main producer of palm sugar (Morton, 1988). Palmyra palm sugar has been used as a traditional sweetener in Asia for thousands of years and is gaining popularity around the world as the importance of natural sweeteners grows over time (Srikaeo and Thongta, 2015). Palmyra palm sugar produced in Cambodia is known to have produced syrup and sugar and exported to the United States and China, including Korea. In Korea, palm sugar is used in various sauces and jams, fruit syrup, *Japchae*, pizza, rice cakes, brownies, muffins, and bread.

Palm sugar has excellent taste and is in the limelight for its low glycemic index. The sap from palmyra palm flowers is high in polyphenols and flavonoids and contains large amounts of coenzyme Q10, aspartic acid, threonine, serine, glutamic acid, glycine, alanine, valine, phenylalanine, lysine, arginine, cysteine, and tryptophan. It also contains isoleucine, leucine, histidine, and methionine, making it a good source for health promotion. It also contains Vitamins A, B_1, B_2, B_3, B_5, B_6, C, D_2, E and folic acid (Srikaeo and Thongta, 2015; Le *et al*., 2020). In other studies, palmyra palm sugar was found to be rich in antioxidants, vitamins and minerals because it minimizes refining and processing with unrefined sugar (Jaffé, 2015; Victor and Orsat, 2018). Moreover, interest in the properties of polyphenols derived from natural processed sugars such as palm sugar and unrefined sugar (NCS) as antioxidants are gradually emerging. Scientific studies have shown immunological, anti-toxic and cytoprotective effects on unrefined sugar (unrefined sugar) NCS and naturally processed sugar products. Finally, the hypertensive effect and diabetes showed positive effects (Jaffé, 2012). Although food studies are using artificial sweeteners and other natural sweeteners, food research using rice and palm sugar is insufficient. Therefore, we aimed to confirm the potential as an inner beauty material by comparing and analyzing the antioxidant effect of rice jam added with palmyra palm sugar.

2. Materials and methods

The rice used in the experiment was non-glutinous from Ganghwa-gun, Incheon, South Korea milled in January 2020, and purchased from Garak Alpha Mart. Palmyra Palm Sugar was purchased from the Internet (Company: Hesed, Origin: Kampong Chhnang, Cambodia). Made with only rice and palm sugar, the 5 types of jam were made at 0%, 15%, 30%, 45%, and 60% ratios.

0%: rice: 200 g, water: 800 mL, palmyra palm sugar: 0 g

15%: rice: 170 g, water: 680 mL, palmyra palm sugar: 30 g

30%: rice: 140 g water: 560 mL, palmyra palm sugar: 60 g

45%: rice: 110g, water: 440 mL, palmyra palm sugar: 90 g

60%: rice: 80 g, water: 320 mL, palmyra palm sugar: 120 g

2.1 Production of rice jam

The rice is washed 5 times and submerged for 7 hrs, and later strained for 30 mins to drain the water. Water and rice 4 times the weight of rice in a blender (hands blender model BL5912-2) were added and ground for 1 min and 30 secs. It is then boiled in a pot with continuous stirring with a rubber spatula to avoid burning it. At this time Palm sugar was added by measuring 0%, 15%, 30%, 45%, and 60% of the total amount of rice. When the rice is cooked, the palm sugar was added and stirred until homogenous for 3 mins. The glass bottle was sterilized in boiling water and dried. The finished product was placed in a sealed state and left to cool at room temperature.

2.2 Measurement of water content

The moisture content of palm sugar jam was measured using a Moisture meter (OF21E, Jeiotech Co., Republic of Korea). Approximately 2 g of the sample was taken regularly, and the constant weight of the container was obtained according to the atmospheric pressure heat-drying method. The sample was heated in a drying machine at 105°C for 24 hrs or more until a constant weight is obtained. After it was cooled in a desiccator, the weight was recorded to measure the moisture content. Moisture content measurement was conducted in triplicates.

2.3 Measurement of chromaticity

For chromaticity measurement, jam is spread evenly in a Petri dish and a colour difference meter (CR-300, Konica Minolta, Osaka, Japan) is used. The brightness (L, Lightness) was taken as *L* value, the redness (*a,* Redness) was taken as the *a* value, and the yellowness (*b*, Yellowness) was taken as the *b* value. This was measured repeatedly 3 times to obtain an average value.

2.4 Measurement of pH

The ratio of ten times distilled water was added to the palm sugar jam, homogenized with a vortex for 2 mins. The filtrate was obtained by filtering the sample with filter paper (Whatman No. 2, England) and the pH was measured in triplicates using a pH meter (555A, Thermo Orion, USA).

2.5 Measurement of viscosity

Viscosity measurement was set at 45°C, and a sample was placed in a Jacketed Reaction Vessel and measured using a rotary viscometer (LVT, Brookfield model: LVT, USA). The viscosity was measured in triplicates.

2.6 Measurement of Brix

The soluble solid content was measured using a small digital refractometer (PAL-2, ATAGO CO, Itabashi -ku, Tokyo, Japan).

2.7 Total phenol and flavonoid contents

The total polyphenol content was measured by applying the health functional food code method (Korea Food and Drug Administration 2012). About 2 g of palm sugar jam is taken in a 100 mL concentrated flask, 30 mL of distilled water was added, and sonicated at room temperature for 10 mins until fully dissolved. Then, 100 mL was transferred into a volumetric flask, later 7.5 mL of distilled water, 0.5 mL of Folin-Ciocalteau'phenol regent (Sigma-Aldrich, St. Louis, MO, USA), and 1 mL of 35% Na_2CO_3 (Sigma-Aldrich) solution was added to 1 mL of a sample diluted with distilled water. After it was left to react in the dark for 1 hr, the absorbance was measured at 760 nm using a UV/Vis spectrophotometer (UV-2460, Shimadzu Co., Kyoto, Japan). The calibration curve was prepared using tannic acid (Sigma Aldrich) as the reference and standard for the total polyphenol content.

The total flavonoid content was measured according to the method of Moreno *et al*. (2000). In the total polyphenol pretreatment method, 0.5 mL of the sample was placed in a 15 mL centrifuge tube. Then, 1.5 mL of 95% ethanol, 0.1 mL of 10% aluminium nitrate, and 0.1 mL of 1 M potassium acetate are subsequently added. After, 5 mL of distilled water was added to the diluted sample and left for 40 mins at room temperature. The absorbance was measured at 415 nm using a UV/Vis spectrophotometer (UV-2450, Shimadzu Co., Kyoto, Japan). The total flavonoid content was calculated and referenced against the calibration curve using quercetin (Sigma Chemical Co.).

2.8 Sensory evaluation

Major of Rice Cake Manufacturing Management and Major of Medicinal Crop in Sungkyul University consisted of a total of 10 students to evaluate colour, flavour, texture, taste, and overall preferences. The rating is on a 5-point scale, with 1 being 'very bad' and 5 being 'very good'. A total of 10 g of the jam stored at refrigerated temperature was served 3 times at 0%, 15%, 30%, 45% and 60%.

2.9 Statistical analysis

All tests were performed in triplicates. Descriptive statistics such as mean and standard deviation were calculated to statically analyse the total polyphenol and flavonoid content. To test the statistical significance of the results, a *t*-test was performed.

3. Results and discussion

3.1 Physicochemical properties of rice jam added with palmyra palm sugar

The water content, pH, chromaticity, viscosity and ° Bx of rice jam supplemented with palmyra palm sugar are shown in Table 1. The water content of the rice jam supplemented with palm sugar was 78.73±0.04 when

Table 1. Changes in water content, pH, and chromaticity of rice jam supplemented with palm sugar.

		Concentration (%)				
		0	15	30	45	60
Water content		78.73±0.04	63.91±0.03**	69.53±0.72***	67.99±0.16***	58.03±0.22***
pH		6.93±0.01	6.35±0.02***	6.10±0.02***	5.85±0.01***	5.55±0.01***
	L	86.25±0.5	59.69±0.52***	59.26±1.74***	37.4±1.36***	31.41±1.01***
Chromaticity	A	-1.28±0.07	7.15±0.41***	6.89±0.69***	13.84±0.11***	13.61±0.29***
	B	0.55±0.25	29.88±0.23***	34.82±1.28***	31.82±0.04***	23.43±0.62***
Viscosity		1401666.67±10408.33	940000±1000***	26100±264.58***	2300±100***	321.67±3.51***
°Bx		0.50±0.00	1.57±0.06***	2.00±0.00	2.37±0.06***	3.17±0.06***

Values are presented as mean±SD.
* p<0.05: Means in a column are significantly different at 5% significance level by *t*-test.
** p<0.01: Means in a column are significantly different at 1% significance level by *t*-test.
***p<0.001: Means in a column are significantly different at 0.1% significance level by *t*-test.

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palm sugar content was 0%, while it was 63.91±0.03 ($p<0.01$), 69.53±0.72 ($p<0.001$), 67.99±0.16 ($p<0.001$) and 58.03±0.22 ($p<0.001$) at 15%, 30%, 45% and 60%, respectively. Thus, moisture content was highest in the control group, and the level appeared to decrease at 15%, but gradually increased by 30%, but again decreased by 45%. The pH was 6.93±0.01 when the palm sugar content was 0%, while it was 6.35±0.02 ($p<0.001$), 6.10±0.02 ($p<0.001$), 5.85±0.01 ($p<0.001$) and 5.55±0.01 ($p<0.001$) at 15%, 30%, 45% and 60%, respectively. Thus, it was found that the pH tends to decrease as the amount of palm sugar added increases. A significant difference was observed depending on the sugar content. The *L* value was 86.25±0.50 when the palm sugar content was 0%, while it was 59.69±0.52 ($p<0.001$), 59.26±1.74 ($p<0.001$), 37.4±1.36 ($p<0.001$) and 31.41±1.01 ($p<0.001$) at 15%, 30%, 45% and 60%, respectively. It was found that it decreased significantly as the content of palm sugar increased, but there was no significant difference, between 15% and 30%. Furthermore, the *a* value, which indicates redness, was -1.28±0.07 when the palm sugar content was 0% while it was 7.15±0.41 ($p<0.001$), 6.89±0.69 ($p<0.001$), 13.84±0.11 ($p<0.001$), and 13.61±0.29 ($p<0.001$) at 15%, 30%, 45% and 60%, respectively. This was found to increase as the content of palm sugar increased, but it showed a tendency to decrease from 30% to 15%, and it can be seen that the numerical value decreased from 60% to 45%. The *b* value which indicates yellowness was 0.55±0.25, when the palm sugar content was 0%, while it was 29.88±0.23 ($p<0.001$), 34.82±1.28 ($p<0.001$), 31.82±0.04 ($p<0.001$) and 23.43±0.62 ($p<0.001$) at 15%, 30%, 45% and 60%, respectively. It appears to increase, followed by decreasing as the higher the content of palm sugar, the higher the value, but it can be seen that it gradually decreases at 45%. The viscosity was 1401666.67±10408.33 when the palm sugar content was 0%, while it was 940000±1000 ($p<0.001$), 26100±264.58 ($p<0.001$), 2300±100 ($p<0.001$) and 321.67±3.51 ($p<0.001$) at 15%, 30%, 45% and 60%, respectively. It was found that the amount of palm sugar added had an effect, and it was found that there was a large change in the content of palm sugar in the farm sugar rice jam. The °Brix was 0.50±0.00 when the palm sugar content was 0%, while it was 1.57±0.06 ($p<0.001$), 2.00±0.00, 2.37±0.06 ($p<0.001$) and 3.17±0.06 ($p<0.001$) at 15%, 30%, 45% and 60%, respectively as the sugar content increases as the content of palm sugar increases.

3.2 Analysis of total phenol and flavonoid contents in rice jam supplemented with palmyra palm sugar

The total phenol and flavonoid content of rice jam supplemented with palm sugar is shown in Table 2. The total phenolic content was 46.92±0.06 at 0%, while it was 161.86±0.97 ($p<0.001$), 247.48±1.65 ($p<0.001$), 324.78±1.97 ($p<0.001$) and 460.42±4.17 ($p<0.001$) at 15%, 30%, 45% and 60%, respectively, showing a significant increase. Total flavonoid content was 8.17±0.04 at 0%, while it was 18.63±0.25 ($p<0.001$), 46.27±1.15 ($p<0.001$), 37.4±0.91 ($p<0.001$), and 10.42±0.79 ($p<0.05$) at 15%, 30%, 45% and 60%. As the palm sugar content increased, the flavonoid levels tended to increase but decreased from 45%. The palm sugar used in this study showed a difference according to the content, but the total phenol content was found to increase significantly. Therefore, the results showed that the total phenolic content is the main cause of the increase in antioxidant effect as the concentration of palm sugar increases. According to a recent study, palmyra palm syrup has antioxidant and antibacterial properties (Reshma *et al*., 2017).

3.3 Sensory evaluations of rice jam supplemented with palmyra palm sugar

Results of the sensory evaluation results of rice jam with added palm sugar are shown in Table 3. They were evaluated for colour, flavour, texture, taste, and overall preference. These preferences for palm sugar rice jam increased as its content increased. On the other hand, the sample containing 45% of palm sugar scored the highest in taste and overall preference. Therefore, considering physiological activity and organoleptic aspects, rice jam with 45% palm sugar is the most suitable and is expected to contribute to consumption by enhancing the usability of the rice and palm sugar used in this experiment. As modern society aims for better health, rice is preferred over wheat, and foods with high sugar content are gradually lowered, as more consumers are trying to avoid high sugared food. This research was conducted to study sugar substitutes and to identify the potential uses of palm sugar as functional sugar with polyphenols and flavonoids. Since this paper has experimented with rice

Table 2. Total phenol and total flavonoid contents of rice jam supplemented with palm sugar.

	Concentration (%)				
	0	15	30	45	60
Total phenol	46.92±0.06	161.86±0.97***	247.48±1.65***	324.78±1.97***	460.42±4.17***
Total flavonoid	8.17±0.04	18.63±0.25***	46.27±1.15***	37.4±0.91***	10.42±0.79*

Values are presented as mean±SD.
* $p<0.05$: Means in a column are significantly different at 5% significance level by *t*-test.
***$p<0.001$: Means in a column are significantly different at 0.1% significance level by *t*-test.

Table 2. Total phenol and total flavonoid contents of rice jam supplemented with palm sugar.

	Concentration (%)				
	0	15	30	45	60
Colour	2.37±0.12	2.90±0.10**	3.60±0.00***	3.97±0.06***	4.23±0.12***
Flavour	2.40±0.00	2.70±0.10*	3.70±0.06***	4.13±0.06***	4.30±0.10***
Texture	2.27±0.06	2.83±0.06***	3.47±0.12***	3.60±0.17***	3.77±0.06***
taste	1.97±0.12	2.57±0.06***	3.40±0.00***	4.20±0.10***	4.13±0.06***
Overall preference	2.23±0.06	2.63±0.06***	3.40±0.00***	4.10±0.10***	4.03±0.06***

Values are presented as mean±SD.
* $p<0.05$: Means in a column are significantly different at 5% significance level by *t*-test.
** $p<0.01$: Means in a column are significantly different at 1% significance level by *t*-test.
***$p<0.001$: Means in a column are significantly different at 0.1% significance level by *t*-test.

jam using palm sugar, future studies should investigate the antioxidant effect and anti-diabetic effect when other foods are made by reducing the amount of palm sugar.

4. Conclusion

The food industry including its consumers has higher preferences for utilizing naturally made sweeteners. Therefore, this experiment and preference survey on the quality characteristics of rice jam using palm sugar has found that the rice and palm sugar contains beneficial polyphenols, flavonoids, and resulted in an overall good preference. The limitation of this study is that it was conducted with small numbers of parameters due to the coronavirus. Hence, it would be best to conduct a preference survey with 300 and 500 people as the current preference survey was insufficient on a larger scale. Also, since the amount of sugar in each food is different, suggested studies should be conducted on the addition of Palmyra palm sugar when making other foods in the future.

Conflicts of interest

The authors declare no conflict of interest.

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