ผลของกระบวนการใช้ความร้อนต่อสมบัติทางเคมีกายภาพและการรับรู้ทางประสาทสัมผัสของอินทผลัมข้นหนืด

THE EFFECT OF THERMAL PROCESSING ON PHYSICOCHEMICAL PROPERTIES AND ORGANOLEPTIC PERCEPTION IN DATE PALM PASTES

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***Received:** January 15, 2019; **Revised:** February 20, 2019; **Accepted:** March 22, 2019*

บทคัดย่อ

อินทผลัม (*Phoenix dactylifera* L.) เป็นแหล่งของอาหารแห่งวัฒนธรรมของมนุษย์ที่เก่าแก่ที่สุดชนิดหนึ่งที่มีความนิยมบริโภคทั่วโลก ในปัจจุบันบางพื้นที่ของประเทศไทยได้มีการเพาะพันธุ์ การปลูก และการผลิตอินทผลัมได้สำเร็จ จนกระทั่งมีการขยายผลไปสู่การเพาะปลูกที่ขยายเพิ่มมากขึ้น อินทผลัมเป็นผลไม้ที่อุดมสมบูรณ์ไปด้วยสารพฤกษเคมีสารออกฤทธิ์ทางชีวภาพหลายชนิด เช่น สารประกอบฟีนอล ผลิตภัณฑ์จากปฏิกิริยาสีน้ำตาลโดยมีเอนไซม์เกี่ยวข้องและผลิตภัณฑ์จากปฏิกิริยาเมล์ลาร์ด (Maillard's reaction products, MRPs) ซึ่งโดยส่วนใหญ่ผู้บริโภคนิยมบริโภคอินทผลัมในรูปแบบของอาหารขบเคี้ยว งานวิจัยนี้มุ่งที่จะศึกษาการพัฒนาผลิตภัณฑ์เพื่อเพิ่มมูลค่าและรองรับอินทผลัมที่มีคุณภาพต่ำ โดยอาศัยกระบวนการใช้ความร้อนในการผลิตผลิตภัณฑ์อินทผลัมข้นหนืด โดยในการศึกษาได้วิเคราะห์ถึงสมบัติทางเคมีกายภาพ ปริมาณสารประกอบฟีนอลโดยรวม ฤทธิ์ต้านอนุมูลอิสระ DPPH และคุณสมบัติทางประสาทสัมผัส พบว่า เมื่อการเคี่ยวโดยใช้ความร้อน (อุณหภูมิตรงกลาง 75±5 องศาเซลเซียส) มีผลทำให้ค่าพีเอช ปริมาณความชื้น ความขาว เปลี่ยนแปลงสัมพันธ์เชิงเส้นตรงกับระยะเวลาในการเคี่ยว ขณะที่ในเวลาเดียวกันนั้นปริมาณของแข็งและความหนืดมีการเปลี่ยนแปลงอย่างค่อยเป็นค่อยไป การเคี่ยวอินทผลัม นาน 20-30 นาที มีผลทำให้ได้ผลิตภัณฑ์ข้นหนืดที่มีลักษณะที่สามารถในการเกลี่ยแผ่ได้ดีและมีความหวาน ในขณะที่การเคี่ยวอินทผลัม นาน 35-45 นาที ทำให้ได้ผลิตภัณฑ์อินทผลัมข้นหนืดที่มีความหนืดสูงและมีกลิ่นคล้ายน้ำผึ้งที่เข้มมากขึ้น

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Abstract

The date palm (*Phoenix dactylifera* L.) is an oldest staple ethnic food with worldwide consumption. In some part of Thailand, the date palm was also successfully bred, planted and reproduced. Date fruits are rich of phytochemicals and bio-active compounds such as polyphenolic compounds, enzymatic browning products and Maillard's reaction products (MRPs) that mainly used as a nutritious ingredient in the confectionery. This work aimed to study a way to valorize the low-grade date fruits by thermal processing for the production of date palm paste product. In this study, the physicochemical properties, total phenolic content, antioxidative property (DPPH) and organoleptic properties were analyzed. By the results, the decreasing of pH, moisture content and whiteness of the pastes were linearly correlated with the treatment time. Whereas, the total soluble solid content and viscosity were gradually increased, simultaneously. The processing of the date fruit flesh was carried at 75+5°C for 20-30 min provided the paste with dominant characteristics in spreadable with sweetness. Whereas, the treatment of the fruit flesh at the same condition for 35-45 min gave the high viscosity pastes with strong honey flavor.

Keywords: Antioxidant, Date palm paste, Organoleptic perception, Physicochemical Property, Thermal processing

Introduction

The date palm (*Phoenix dactylifera* L.) is one of the oldest plants widely cultivated in in North African, the Arabian Peninsula, the Middle Eastern and Asian countries and has been used as a staple food for over 6000 years [1-2]. Nowadays, the production and commercialization of dates are continuously increasing, therefore, dates were also introduced to cultivated in new countries such as Australia, India, Pakistan, Mexico, South Africa, South America, and the United States. In recent years, the date palm was also successfully bred and planted in some parts of Thailand. Date palm is not just a food source, but it is also played an important role in the economy, society, and environment [3-5]. Because of their high nutritional value, great yields, and long shelf-life, date fruits are being consumed in modern cultures as a high value confectionery for their pleasant flavor, odor, taste and texture, thus it has been used for flavoring foods, beverages and medication [6].

The ripening of date fruits is divided into three stages, mature (khalal), semi-ripe (called rutab) and fully-ripe (called tamr). In general, dates are mostly harvested at the fully ripened stage, that is after the development of total soluble solids (TSS) of 60–70°Brix. Most dates are either consumed as fresh dates or processed products. The fresh ripened dates fruits are consisted sugars (52.6 - 88.6 %), fibers (3.6 - 10.9%), proteins (1.1 - 2.6%), and ash (1 - 1.9%) [7]. However, the simple sugars like glucose, fructose, sucrose and rare sugars (e.g. arabinose, mannose, rhamnose, psicose, etc.), are varying in contents amongst date cultivars, ripening and seasons [6, 8-10]. These make its relishing of sweet, succulent, and exotic flavor. Moreover, the dates are a good source of dietary fibers and some important minerals included iron, potassium, selenium, calcium and vitamins (C, B_1, B_2, A, riboflavin and niacin), but it is low in fat and protein contents [8, 11].

Date fruits have also been possessed a stronger antioxidant activity in which correlated to the polyphenolic compound content, that are characterized as a potential source of antioxidants and free radical scavengers, which can act as hydrogen donors, reducing agents, metal chelators, and singlet oxygen quenchers [7, 12-13]. Date fruits can serve for some phytochemicals with various biological effects, such as anti-mutagenic, anti-carcinogenic, anti-oxidant, anti-microbial, and anti-inflammatory [12, 14]. Besides health impacts, date fruits potent to diminish the incidence of cancers, especially pancreatic cancer due to anti-tumor activity or anti-mutagenic properties and boosting of immune system [15-16]. Moreover, the intake of date fruits may also benefit on glycemic and lipid control in diabetic patients because they contain high rare sugars, insulin unrecognized sugars [17].

Moreover, date fruits can also be processed as a variety of value-added products, such as in the form of dried products, pastes, date syrups, juice concentrates, jams, date butters, date bars, chutneys, date relishes, and pickles, etc. Moreover, date oil and date coffee are some of the by-products derived from date seeds [18-19]. In addition, during the processes, the non-enzymatic reaction of a reducing sugar and the amino groups of a protein or peptide is called the Maillard reaction, which is one of the most important phenomena occurring during the processing, cooking, and storage of foods. The Maillard reaction affects the development of colorants and flavoring agents that leads to the unique chemical and physical properties of the products. A part of which called "Maillard reaction products (MRPs)", that maylead to some beneficial effects associated to dates including development of brownish color of baked foods, the formation of compounds with anti-oxidant [18-21] anti-carcinogenic, and anti-mutagenic properties [22-23].

The climate condition also affects to the date fruits quality since efflorescence to fertilization, maturation and ripening. Harvesting of an immature bunch of date fruits may lead to low-grade dates that are discarded, despite being rich in valuable compounds and bioactive substances [24]. Unfortunately, the higher atmospheric humidity in tropical zones makes the date fruits defects during ripening and had lower grade. Therefore, more than a quarter of which was discarded. Such a problem was found in Thailand's date palm farmers, especially in rainy season.

Objectives

This work aimed to valorize date fruits by thermal processing to produce date palm paste product (to support the low-grade date problem) and also to study the effect of the thermal processing on the physicochemical properties and organoleptic characteristics.

Methods

Samples

Full-ripen date palm fruits (Deglet nour cultivar) were used throughout this study. The fruits were purchased from a supermarket in Mahasarakham Province that imported from Saudi Arabia.

Sample preparation

The date flesh was screened, soaking in hot water to discard impurities, and the chopped to size less than 5 mm after seed removal. Five hundred grams of which was mixed with 1000 mL of water by

blending for 10 min in a kitchen blender (Moulinex, France). Then, the sample was filtered through a three-layer cloth sheet. After that, the sample was dehydrated by curing in a 2L double pot (stainless steel) to control for the temperature at the center point at 75±5°C. After the paste was formed by observing at a top of spatula with a film of paste, the heating was stop and the paste still be handling stirred and accelerated cooling until the temperature lower than 60°C. The sample treatments were prepared separately at 20, 25, 30, 35 and 40 min of thermal treatment time.

Chemical Analysis

Determination of moisture, pH and total soluble solids

Moisture contents in the date fruit and the paste samples were determined according to the method of AOAC (2000). Measuring of pH was conducted by dissolving 5 g of sample in 50 mL of distilled water and then measured by pH meter (ADWA-1040, Hungary)[25]. After that, the total soluble solids (TSS) was measured by using a portable hand refractometer (ATAGO, Master 3-T, Japan).

Determination of colour values

The samples of date palm paste were weighted to 100 g and spread a sample holder in the same ratio of surface area. After that, the colour was measured in the CIE Lab (*L*, a*, b**) by Chroma meter model CR-400 (KONICA MINOLTA, Model cr-400, Japan).

Determination of viscosity

The viscosity of 300 mL paste sample was measured by a probe number 06/07 at 25°C, a Brookfield (SJ-LDVD-1, China) [26].

Determination of total phenolic content

Determination of total phenolic content (TPC) was modified from Kujala and others, (2000). Two grams of date palm paste was mixed with 10 mL of chilled 80% ethanol (w/v) was added and mixed before transferring to centrifuge tubes. The supernatant part was collected after centrifugation at 10,000 x *g* at 4°C for 20 min. Four hundred microliters of supernatant were mixed with 2 mL of 10% Folin-Ciocalteu reagent (v/v) for 8 min. Then 1.6 mL of 7.5% sodium carbonate (w/v) was added and then incubated for 2 h. The absorbance was measured at 765 nm with a visible spectrophotometer (Model Thermo Spectronic, USA). In this study, gallic acid was used to contribute the standard curve of the total polyphenolic compounds) [27].

Analysis of DPPH radical scavenging activity

The antioxidant activity of the samples was determined the hydrogen donating activity by DPPH radical scavenging activity by using the method of Mohd-Esa and others (2013). An aliquot of sample was mixed, and serial diluted with 100 mM Tris-HCl buffer (pH 7.4). Then, an equivalent volume of 500 µM DPPH in ethanol was added to the mixture with vigorous shaking, and then standing in the darkly place for 20 min before measuring of the absorbance at 518 nm. The DPPH radical scavenging activity was then calculated in the term of IC_{50} (concentration of the sample that providing 50% of inhibition/scavenging) [28].

Organoleptic Profiling Analysis

The samples were freshly prepared and stored at 4°C until used (within 48 h). Two hundred and fifty grams of each sample was served to 10 trained panellists (18 to 35 years). The panellists were persons who were screened and recruited from MSU panellist database, based on their sensory sensitivity and ability to describe sensations perceived from the samples and the same commercial products. They should be participated in discussion and development of the specific terms in product descriptive profiles. A generic descriptive analysis method of Lawless and Heymann (2010) was applied in this study. Panellists undertook a 24-hour training programme. A 10-cm unstructured line scale was used in the training sessions to evaluate the sensory intensity. The panellists were asked for the perceived sensory descriptions in the terms of quality and intensity. The development of terms for taste, oral and odour perception was done separately by the general descriptive analysis (GDA) guideline [29]. After the terms were agreed, all panellists were examined in the performance tested for reliability and validated before they were qualified and ready to evaluate the sample profiles.

Statistical Analysis

The analysis of variances was tested for the significant difference at $P<0.05$ by the Duncan's multiple range tests of the triplicate determinations using SPSS packaging program (version 10.5). The study on the sensory analysis of the samples was designed as randomized complete block. Data obtained from the panel was subjected to analysis of variance (ANOVA). The Principal Component Analysis (PCA) was applied to elucidate the sensory profiling of samples in the present sensory attributes by using a software of SPSS

Results

In this study, the date flesh was used as raw material to produce the date fruit paste. The fruits contained 82.87% of moisture content with TSS 8.05°Brix, pH 5.77. The results represented to the quality of the sample was in the several ranges found in the full-ripen dates. The thermal processing of the date palm extract was conducted at 75 ± 5°C to avoid the partial over dry during the treatment and to prevent losing of some bioactive compounds. By this process, the sample was dehydrated and form a soft paste within 20 min and retained 56.49% moisture content. The moisture content of the paste was lower with time consumed (Table 1). Whereas, the pH of the paste was decreased during the increasing of thermal treatment time. It could be caused by the hydrolysis of polysaccharides/some complex sugars, especially sucrose. In addition, the TSS was increased with longer time in dehydration [30].

Table 1 Thermal processing time on moisture content, pH and TSS.

Treatment time (min)	Moisture (%)	pH	TSS (°Brix)
Control*	82.87±0.87	5.77±0.03	8.05±0.11
20	56.49±0.23^{a}	5.24±0.02^{b}	3.24±0.10^{b}
25	55.85±1.05^{a}	5.17±0.03^{c}	3.18±0.13^{b}
30	41.28±1.61^{b}	5.33±0.02^{a}	4.23±0.11^{a}
35	39.67±1.32^{b}	4.90±0.03^{d}	4.14±0.16^{a}
40	37.43±0.94^{c}	4.89±0.02^{d}	4.13±0.10^{a}

Note. The different superscripts in the same column denotes the significant different at P<0.05, *Control: the raw date fruits, did not use to compare.

By the process, the date palm paste was increased in dark-brownish by visual observation that related to the lowering of L^*-value with more time consuming, however, among all of color parameters (L^*, a^* and b^*-values) did not significant difference (Table 2). As found in six commercial date cultivars, the *Hunter-L* values of whole date fruits varied in the general range of 18.44 – 21.06. The *Hunter-a* values and *Hunter-b* values were in the range of 1.8 – 5.04 and 3.9 – 6.9, respectively. The difference of the color values leads to distinct of date fruit cultivars that mainly determinate by the genetic variability [31-32]. The thermal treatment for paste setting at of the date flesh became lighter in color that indicated by the L^*-*values* was in the range of 36.18 – 38.43. The Hunter L^*-*values* of the date palm paste was in the range of 37.57 – 47.05 that was coincided with the study of Al-Jassas and others (2015). The a^*-*values* were varied from 2.72 – 3.29, indicated that the date palm paste was in red-brown tint. The b^*-*values* were in the same range from 12.18 –12.70 by 20-35 min of curing, but, the b^*-*value* was decreased to 11.02 after 40 min of treatment. The paste was increase in dark-brownish color due to the Maillard reaction and caramelization that lead to the production of MRPs that further affects to the color of the pastes [30].

Table 2 Color changes and whiteness index during thermal processing of the date palm paste.

Time	Color value		
(min)	L^{*ns}	a^{*ns}	b^{*ns}
20	38.43±0.28	3.04±0.21	12.37±0.20
25	38.40±0.19	2.72±0.28	12.70±0.17
30	37.98±0.43	3.11±0.30	12.57±0.28
35	37.59±0.43	3.09±0.61	12.18±0.56
40	36.18±0.81	3.29±0.55	11.02±0.31

Note. ns = non-significant.

Moreover, the formation of pasting texture led to viscosity increasing. Table 3 shows the trend of the paste viscosity. At the 20-30 min of thermal treatment, the viscosity was gradually developed. While, the high viscosity was observed after 30 min of treatment, it was changed 18,849 - 48,418 cps. Obviously,

the rheological behavior of the pastes had been changed during 35-40 min of thermal treatment. The paste possessed a unique stickiness and gluiness and cohesiveness. The viscosity of the date palm paste was firstly affected by the hydrolysis of various components such as derivative glucans, pectin, xylans, etc. After that, the contribution of the paste yielding by dehydration, and re-polymerization of polysaccharides, therefore, the viscoelasticity of the paste was drastically developed [10, 34].

Table 3 Thermal processing time on viscosity of the date palm pastes.

Time (min)	*Probe No.*	*Speed (rpm)*	*Viscosity (cps)*
20	S06	50	11,633±242^{e}
25	S06	50	16,233±266^{d}
30	S06	50	18,840±187^{c}
35	S06	20	48,416±293^{a}
40	S07	20	21,026±182^{b}

Note. the different superscripts in the same column denotes the significant different at P<0.05

Furthermore, the TPC in the date palm paste was developed during the treatment (Table 4). The highest TPC was observed in the 40 min treatment samples. Whereas, the DPPH radical scavenging activity by IC_{50} was in the range of 0.04 – 0.07 mg/mL. By the thermal processing of date palm pastes the MRPs were developed and played important roles in anti-oxidative activity as found in date palm syrups [35].

Table 4 Thermal processing time on total phenolic compounds and DPPH radical scavenging activity.

Time (min)	*Total polyphenolics (g/mL)*	*DPPH scavenging activity (IC50, mg)*
20	0.028±0.01^{cd}	0.06±1.68^{ns}
25	0.023±0.01^{d}	0.05±0.53^{ns}
30	0.038±0.01^{c}	0.04±3.22^{ns}
35	0.051±0.01^{b}	0.06±6.08^{ns}
40	0.065±0.02^{a}	0.07±4.59^{ns}

Note. the different superscripts in the same column denotes the significant different at P<0.05

After the organoleptic analysis was conducted, 5 characteristics of the date palm paste were termed included brownish colour, honey flavour, sweetness, texture, spreadable ability. By the thermal processing of date palm paste, there was no significant difference in the 5 organoleptic characteristics (Table 5). However, some interested data could be observed. The pastes by 30 min of treatment provided the most favourable in overall with the overall score of 6.94 with the dominant characteristics of sweetness and texture profiles. Whereas, the honey flavour was highest obtained from the 40-min treatment of the date palm paste.

Table 5 Sensory Characteristics of the date palm paste at various treatment time.

Characteristic	Thermal treatment time (min)				
	20	25	30	35	40
Brownish	6.56±1.23^{ns}	6.46±1.54 ^{ns}	6.12±1.43 ^{ns}	6.40±1.56 ^{ns}	6.22±1.44 ^{ns}
Honey flavor	6.08±1.63^{ns}	5.88±1.65^{ns}	6.06±1.53^{ns}	6.22±1.52^{ns}	6.30±1.59^{ns}
Sweetness	6.70±1.40^{ns}	6.54±1.47^{ns}	6.68±1.45^{ns}	6.44±1.76^{ns}	6.34±1.77^{ns}
Texture	6.20±1.27^{ns}	6.36±1.45^{ns}	6.60±1.41^{ns}	6.44±1.51^{ns}	6.24±1.49^{ns}
Spreadable	6.68±1.30^{ns}	7.18±1.00^{ns}	6.72±1.42^{ns}	6.70±1.31^{ns}	6.70±1.39^{ns}
Overall	6.64±1.32^{ns}	6.90±1.01^{ns}	6.94±1.42^{ns}	6.78±1.36^{ns}	6.56±1.42^{ns}

Note. ns = non-significant.

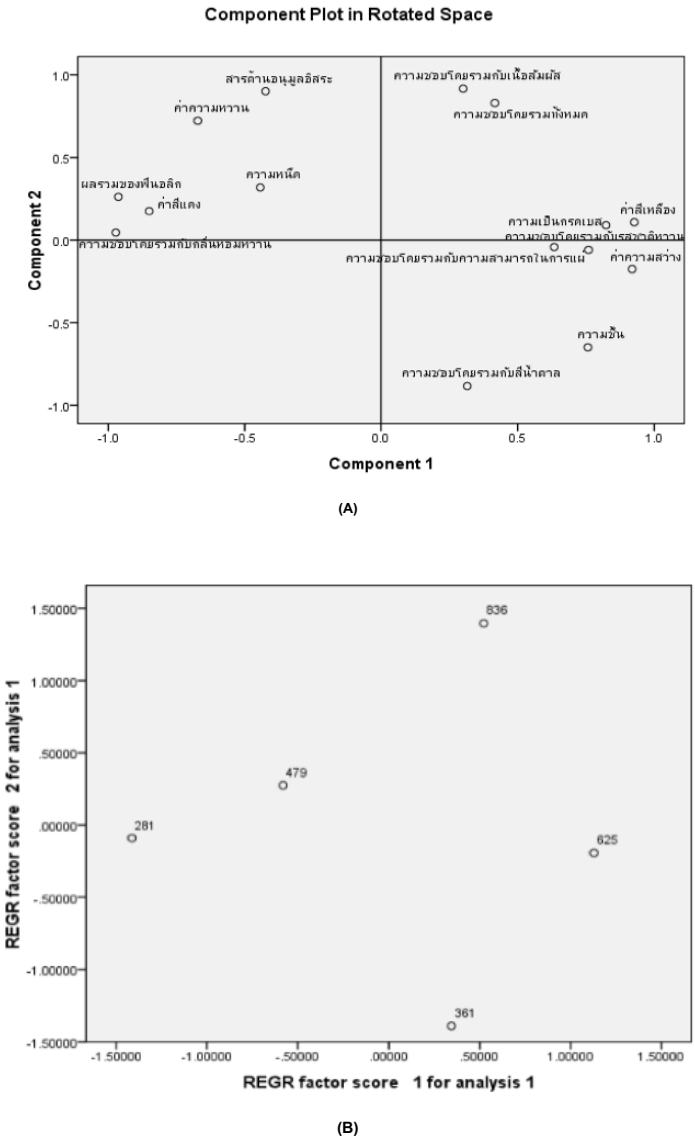

Figure 1. Principal Component Analysis (PCA) of the relationship between the means of chemical and sensory perception (A) and the viscosity of date palm paste (B).

The spreadable ability of the pastes was tested by spreading on 2×2 cm white breads. It was found that the treatment of the paste for 25 min was the most favourable to the panellists with the score of 7.18. Moreover, by PCA analysis of the pre-dominant characteristics of the date palm paste were the spreadable ability, honey flavour (PC1) and sweetness that related to the moisture content and phenolic compounds (PC2) (Figure 1).

It could be suggested to a potential of the date fruits to be used as an ingredient for making of dessert and beverages. In accordance to the study of Manickavasagan and others (2013), a side of an ethnic foods, date fruits showed a great potential to be used as an ingredient along with several foods. The date fruits provided the most preferable in sweetness and aroma to the panellists [34]. Moreover, the date fruits may be used to reduce the consumption of sugar (glucose) that benefits on health.

Conclusions and Discussion

The production of the date palm paste might be an alternative way to valorize the by-products or underutilized date palm fruits or low graded date fruits. The thermal processing at 75°C of date fruits provided the pastes with spreadable with sweetness (20-30 min) and high viscosity with stronger honey flavor (35-40 min). By this, it could be suggested that date fruits had a valuable potential product with some unique of flavor, taste and texture profiles. Furthermore, the palm fruit pastes should be further elucidated for their potential as an alternative sweetener as a functional food.

Acknowledgement

This work was financial supported by Annual Research Budget (2016), Faculty of Public Health, Mahasarakham University.

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