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Development of crystallized palm-syrup sugar as a natural sweetener

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Abstract

The palm syrup is from naturally grown palm trees. Owing to its unique odor and taste, the syrup has high potential to be a new sweetener which is natural and chemical-free. Thus, this research was to develop the crystallized sugar formulation and processes. Besides palm syrup, brown sugar was added in the production steps. Mixture ratios of syrup and brown sugar were varied to get the final solution concentration prior to crystallization occurred. The crystallization temperature was controlled throughout the experiment. The result showed that 83±1 °Brix of 60% syrup and 40% brown sugar mix achieved high yield of 3-4 mm crystal size. As crystallization period increased, the CIE color values (L*, a* and b*) increased which indicated the brighter color of mixture solution. Focus group result showed a favor of natural brown color and taste of the crystals despite its slow dissolving in the beverage. The sweetness was perceived even with a small amount of crystals was added. Since it is natural and chemical free, the crystallized sugar produced by this process had good color, unique taste and a possibility to be a new form of natural sweetener in the market.

Keywords: palm syrup, crystallized sugar, brown sugar, natural sweetener.

Introduction

The palm syrup is from naturally grown palm trees. Most of this syrup is locally consumed and traditionally processed as the bottled palm juice, palm wine, and palm sugar. Since the raw palm syrup is composed of high invert sugar, it is quite difficult to develop or transform into the new products which create the higher value than the existing products. Previous research attempted to produce granulated sugar from low-grade (D) maple syrup with 4% and 6% inverted sugar by automated technique and obtained the crystal size in microns in 90 min (Aider, et al., 2007a; Aider, et al., 2007b). Beside the technology employed, the addition of other raw materials into the mixed syrup during the supersaturating period is also of interested. Owing to its unique odor and taste, the syrup has high potential to be a new sweetener which is natural and chemical-free. Thus, this research was to develop the crystallized sugar formulation and processes from palm syrup.

Materials and Methods

Samples

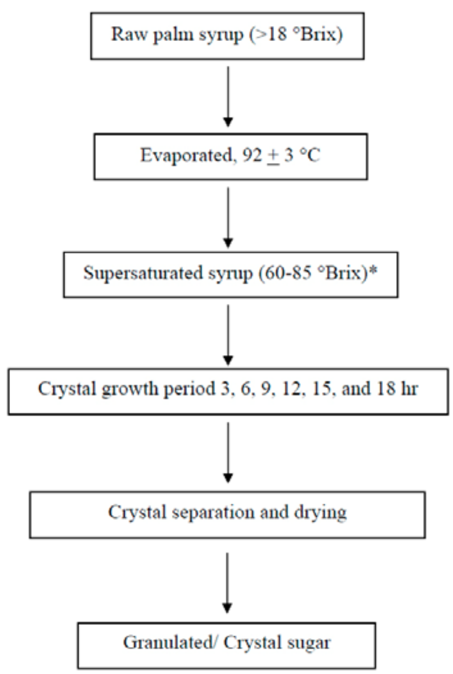
The palm syrup used in this study was purchased from the palm juice producers at Wat-Bhot province, Phitsanulok, Thailand. The properties of syrup were analyzed for soluble solid and invert sugar content, and syrup was immediately stored in the refrigerator after collection. The soluble solid content of palm syrup is usually no less than 18 °Brix.

Chemicals

Zinc acetate dehydrate ($Zn(CH_3COO)_2 \cdot 2H_2O$), potassium ferrocyanide ($K_2Fe(CN)_6 \cdot 3H_2O$), copper sulphate ($CuSO_4 \cdot 5H_2O$), sodium hydroxide ($NaOH$), sodium potassium tartrate ($NaKC_4H_4O_6 \cdot 4H_2O$) and methylene blue were from Merck (Darmstadt, Germany).

Crystallized palm-syrup sugar production

Besides palm syrup, brown sugar was added in the production steps. Mixture ratios of syrup and brown sugar were varied to get the final solution concentration prior to crystallization occurred. The crystallization temperature was controlled throughout the experiment. Flow diagram of crystallized palm-syrup sugar production was shown in Figure 1.



* Mixture ratios of syrup and brown sugar were varied in this step

Figure 1: Flow diagram of crystallized palm-syrup sugar production.

Chemical analyses

Moisture content in the crystals was measured by sand pan technique (Nielsen, 1994) and water activity was measured by equilibrating a sample in a chamber held at constant relative humidity (Fennema, 1985). Reducing sugar in the mixture solution was determined by Lane-Eynon method (AOAC, 1990).

Sugar color measurement

The sugar color was determined in CIE system by a color reader model CR-10 (Konica Minolta sensing Inc., Osaka, Japan). The parameters determined were L* (lightness), a* (-a* to a* indicated green to red) and b* (-b* to b* indicated blue to yellow), C* chroma (saturation), and H* (hue angle), as defined by the following equations: $C^* = (a^{*2} + b^{*2})^{1/2}$ and H* = arctan (b*/a*).

Accelerated shelf life testing (ASLT) of the crystallized palm-syrup sugar

ASLT was conducted at two testing temperatures; 30 °C and 50 °C, which differed by 20 °C for the desired real time aging (DRTA) of 30, 60, 90 and 120 days. The accelerated aging time duration (AATD) was calculated from equations (Figure 2). Quality factors such as moisture content, water activity, color (L*, a*, b*). Sensory characteristics were also determined by the focus group.

AAR = Accelerated Aging Rate
AATD = Accelerated Aging Time Duration
DRTA = Desired Real Time Aging
AAT = Accelerated Aging Temperature (50 °C)
AT = Sample Storage at Ambient Temperature (30 °C)
Q10 = Accelerated Aging Factor;
Q10 = 2.0 for industry standard and 1.8 for conservative option

From equations:

Step 1: $AAR = Q_{10}^{((AAT - AT)/10)}$
Step 2: AATD = DRTA / AAR

So: $AAR = 2^{((50-30)/10)} = 2^{(2)} = 4$
AATD = 30days/4 = 7.5 days ~ 1 weeks
AATD = 60days/4 = 15 days ~ 2 weeks
AATD = 90days/4 = 22.5 days ~ 3 weeks
AATD = 120days/4 = 30 days ~ 4 weeks

Figure 2: Calculation of the accelerated aging time duration (AATD) for ASLT of the crystallized palm-syrup sugar (Singh, 2000).

Sensory characteristics of crystallized palm-syrup sugar evaluated by focus group

Thirty consumers were selected and separated into 3 groups; teenager, offices and housewife based on the occupation and the product usages. Focus group sessions were separately performed according to Meilgaard et al. (1999). Focus panel were asked to discuss the product characteristics and the package design comparing to the commercial sweetener products. The desirable sensory characteristics of samples were evaluated according to ASLT. The color, odor, flavor and overall acceptance of products and the panelist opinions were evaluated on a 9-point hedonic scale and a 5–point just-about-right scale, respectively (Meilgaard et al., 1999).

Statistical analysis

The experiment was repeated at least three times and was conducted on separate lots of palm syrup collected in different weeks. The study was designed as a randomized complete block design and the separate lot served as the blocking variable. All analyses were performed with Excel®, 2003. Data were reported as mean ± SD ($\alpha = 0.05$). The Correspondence Analysis plot identified the trends of the focus panel opinions related to the sensory attributes of the crystallized palm-syrup sugar.

Results and Discussion

Effect of processing on product qualities

Mixture ratios of syrup and brown sugar were varied from 60-85 °Brix (data not shown) to get the final solution concentration (supersaturated syrup) prior to crystallization occurred. The result showed the crystal (Figure 3) occurrence at supersaturated syrup concentration of 83±2 °Brix (~ 60% syrup and 40% brown sugar mix) that achieved high yield of 3-4 mm crystal size.

Figure 3 : Crystallized palm-syrup sugar.

Physical properties of the crystallized palm-syrup sugar

As crystallization period increased the CIE color values (L*, a* and b*) and C* increased, which indicated the brighter color of mixture solution. These parameters gave the information on the reddish-brown color of the crystallized sugar. Significant correlations of the color (L*, a*, b*, C*and H*) between crystal sugar and syrup mixer solution were given (Table 1).

Accelerated shelf life testing (ASLT) of the crystallized palm-syrup sugar

Chemical properties

Significant decreases of moisture content and water activity of the crystals from 1.23% to 0.47% and 0.46 to 0.22 were observed as the storage time and temperature increased. The predicted moisture content and the predicted water activity were almost the same point as the observed values.

Table 1: Correlations of the color between crystal sugar and syrup mixer solution.

Variables	L* Crystal	a* Crystal	b* Crystal	L* Syrup	a* Syrup	b* Syrup	C* Crystal	H* Crystal	C* Syrup
a*_Crystal	0.360								
b*_Crystal	0.629**	0.795***							
L*_Syrup	0.352	0.011	0.153						
a*_Syrup	0.188	-0.110	0.095	0.768***					
b*_Syrup	0.381*	-0.011	0.145	0.903***	0.772***				
C*_Crystal	0.601***	0.849***	0.995***	0.129	0.064	0.122			
H*_Crystal	0.269	-0.476**	0.136	0.207	0.292	0.1986	0.043		
C*_Syrup	0.341	-0.045	0.134	0.913***	0.877***	0.982***	0.108	0.239	
H*_Syrup	0.296	-0.056	-0.070	0.349	-0.001	0.456*	-0.069	-0.039	0.346

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Sensory characteristics of crystallized palm-syrup sugar

The opinions across the panel groups on the color, flavor/taste attributes for of the crystallized palm-syrup sugar itself and when mixing with the beverage of choices were not significantly different (p-value of 0.46, 0.14 and 0.14, respectively), except the odor with p-value of 0.002 (Figure 4). Focus group result showed a favor of natural brown color and taste of the crystals despite its slow dissolving in the beverage. The sweetness was perceived even with a small amount of crystals was added, especially in group of office-staff panelists who were identified as the light-medium user (84.6% of the variance explained in C1) (Figure 5). Sensory characteristics of crystallized palm-syrup sugar evaluated by focus group during storage by ASLT method were shown (Figure 6).

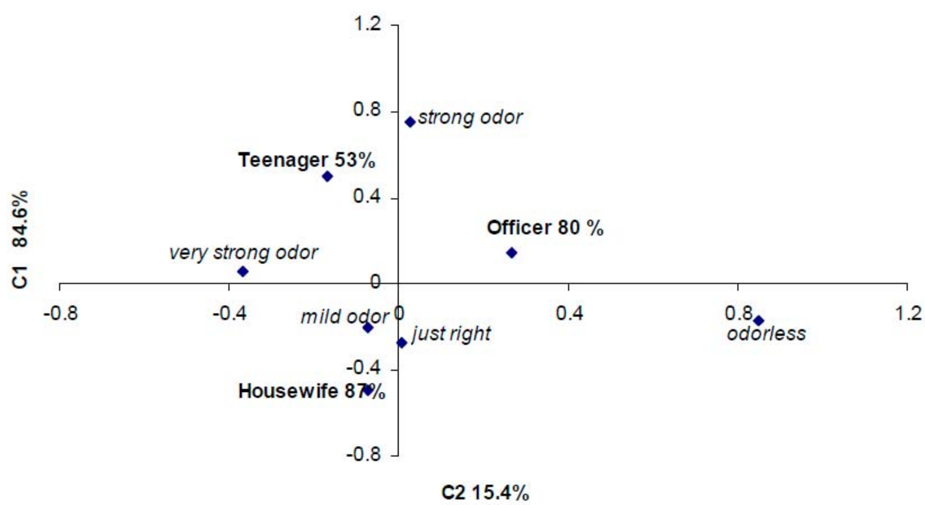


Figure 4: Focus panel opinions related to the odor of the crystallized palm-syrup sugar.

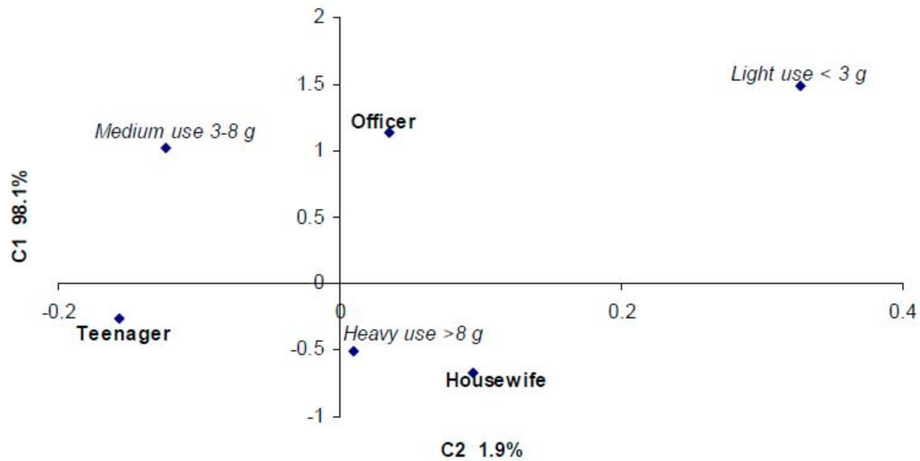


Figure 5: Consumption of the crystallized palm-syrup sugar for the focus panel.

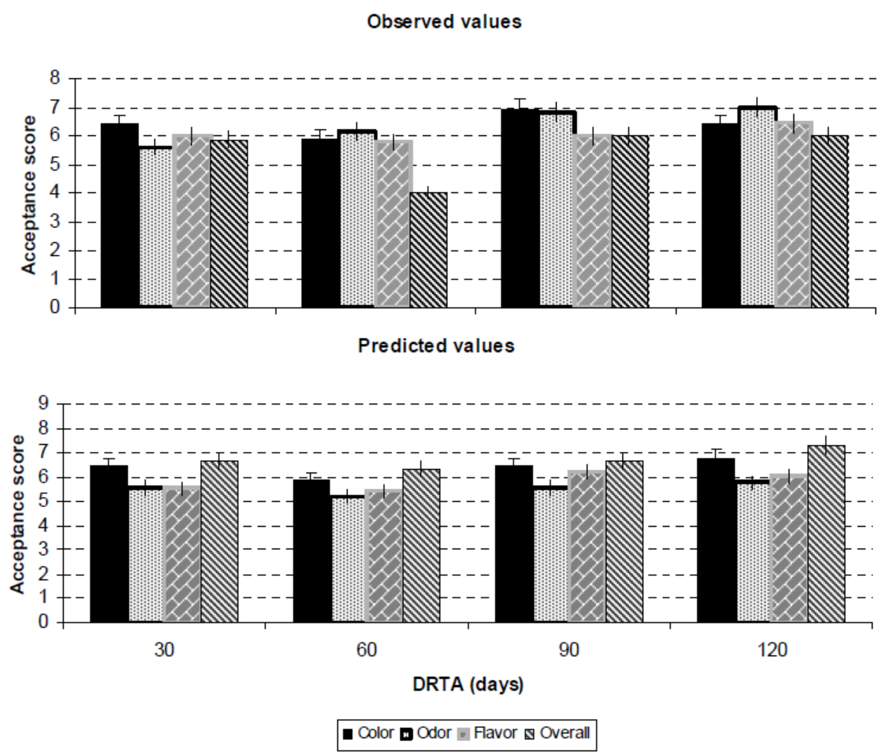


Figure 6: Sensory characteristics of crystallized palm-syrup sugar evaluated by focus group.

Conclusions

Overall qualities of the crystallized palm-syrup sugar were evaluated according to ASLT for Desired Real Time Aging (DRTA) of 120 days. No significant differences ($p>0.05$) in acceptance of product attributes (color, odor, flavor and overall acceptance) were found throughout ASLT. The opinions across the panel groups on the color, flavor/taste of the crystallized palm-syrup sugar itself and when mixing it with drink of choices were not significantly different with p-value 0.46, 0.14 and 0.14, respectively, except the odor with p-value of 0.002. Focus group indicated a favor of natural brown color and taste of the crystals despite its slow dissolving in the beverage The sweetness was perceived even with a small amount of crystals was added, especially in the office-staff panel group that was identified as the light–medium user. Since it is natural and chemical free, the crystallized sugar produced by this process has good color, unique taste, and is a promising source to be a new natural sweetener in the market.

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