Proceeding
The 2nd International Conference of the Indonesian Chemical Society 2013
October, 22-23th 2013

Brown Sugar Color for the Sugar Quality Assessment

Julius Pontoh

Department of Chemistry, Faculty of Mathematics and Natural Sciences
Sam Ratulangi University. Manado
pontohjulius@yahoo.com

Abstract

Brown sugar is one of the food sweeteners produced locally in all over regions in Indonesia. Traditionally brown sugar is produced in the form of molded as cylinder in a bamboo shell or half cup made from coconut shell, but recently brown sugar is produced in the form of granulated or crystalline. Brown sugars sold in the market are very various in the quality. Each farmer produces sugar based on his circumstances and method. They produce sugar in various qualities from time to time. Therefore, the consumers always have some difficulties to purchase the sugar for their own purpose. Sugar color is one of the important criteria's of any food. For brown sugar, the color can be determined by using the naked eyes. The color in brown sugar is representing by the chemicals in the sugar formed during the sugar processing. The objective of this paper is to determine either color can be used to assess the quality of the brown sugar. In order to do this, two set of experiments have been conducted. The first one is to develop a method that more objective to determine the brown sugar color and the second one is to determine various quality criteria's including the pH and reducing sugars for various brown sugar samples and their relationship to the color. It is show that the brown sugar quality can be determined by the sugar color. The darker the color, the lower the brown sugar quality.

Keywords: Palm Sugar; Sugar Quality; Reducing Sugar

Introduction

Brown sugar is one of the food sweeteners produced locally by the farmers from mainly sugar palm (aren) and coconut trees. In North Sulawesi, brown sugar is produced mainly from sugar palm (*Arengapinnata*) trees only. The sugary sap from the male flower is collected and evaporated by boiling until become sticky juicy then transferred into a mould or keep stirring and cooling till become granulated. Therefore brown sugar is sold as either block or granulated sugar.

The sugary sap contains sucrose, protein and mineral (Pantoh, 2007). Therefore it is very ideal medium for microorganism to grow. Depend on how the farmer controls the sanitation; the sap will be contaminated by various microorganisms. The microorganisms will ferment the sugar into various compounds. Yeast (*Saccharomycescerevisiae*) will convert sucrose into glucose and fructose and then into ethanol. Other bacteria such as *Acetobacter* will convert the ethanol into various organic acids such as acetic and lactic acid. Bacteria *Leuconostocmesenteroides* will convert sucrose into dextran.

ISBN: 978-979-96595-4-5

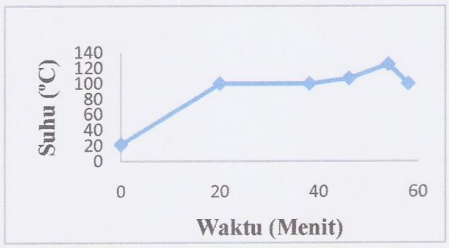
The presence of these microorganisms will change the chemical composition of the sap including the acidity (pH). The chemical composition of the sap depend on the sanitation of the equipments using by the farmer and how long the sap collection in the trees and how long the sap sitting for transportation before processing by boiling the sap. During those times, the fermentation is still going on. These conditions will influence the quality of the sap before processing. The sap quality will determine the brown sugar quality. Due to each farmer has different method how to treat the sap, the quality of the sugar is very various. Even a farmer can produce brown sugar with different quality from time to time. Just depend how he treat the sap before boiling.

Brown sugars are sold in the market in various qualities make the consumers get disappointed to buy the products. Even though there is a quality standard for brown sugars issued by "Badan Standarisasi Nasional" (SNI 01-3743-1995 for "Gula Palma" Anonymous, 1995) but it is not mention about the brown sugar grade. The standard including the form, flavor, color, water content, reducing sugar, sucrose, non water soluble materials, ash and selected heavy metals. For the color is only mention from browning yellow to brown.

For food quality, color is one of most important quality criteria. Color is not only the representative the chemical components in the food but also using by consumers to select the product. The color for brown sugar is formed during the boiling of the sugary sap during processing (Apriyantono, et al., 2002 and Ho, et al., 2008). In the market various color of brown sugars are sold from browning yellow to dark brown. Because the color is represent the chemical composition of the sugar then the color can be used for quality assessment.

Brown Sugar Processing

Brown sugar from sugar palm is processed from the sugary sap. The sap is collected from the male flower after periodically hitting the stalk with a wooden harmer for several weeks. After the stalk is cut, the sap will flow through the slice. The sap collected in a vessel made from bamboo or plastic container. The sap is collected twice a day (morning and late afternoon). Some farmers adding natural preservative such as bark or twigs of manggostan tree to the vessels, but some only wash with hot syrup for sanitation. After collection, the sap is boiling to evaporate the water. Boiling is done in an open pan that taking 1 to 3 hours for 30 to 40 liters juice. A typical boiling temperature can be seen in Figure 1.



Gambar 1.Perubahan brix dansuhuselamapembuatangulaaren

The temperature by the end of processing can reach to 130 °C for about 10 minute before it bring down for molding or granulation. The end of processing determined by the farmer by dripping the syrup. If the dripping syrup form a brittle line while it is cooling then the boiling can be stopped.

Color Formation

Color formation in the brown sugar is caused by complex chemical reactions including Maillard reactions and caramelization. The Maillard reactions occur in many food containing two precursors including reducing group such as reducing sugars (glucose and fructose) and amine group such basic amino acids (lysine, arginine and histidine) in protein. The Maillard reaction will produce color chemicals such as hydroxymethylfurfuraldehide and mellanoidines started at the temperature above room temperature. Caramelization is a process happen at higher temperature (more than 120 °C) the reactions including breaking down the sugar molecules to form new complex polymers. Because the processing temperature of brown sugar up to 130 °C (Figure 2), the caramelization reactions take place.

ISBN: 978-979-96595-4-5

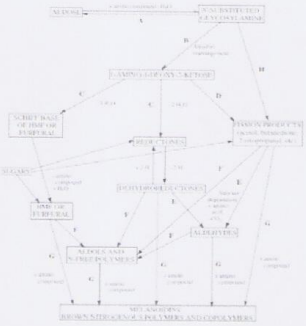


Figure 2. Outline of Color Formation through Maillard Reactions

Food Color Measurement

There are various methods to measure food color that can be divided into two groups: measuring the reflectance light and measuring the transmitted light (Marsili, 1996). The first group is based on the measuring of the reflectance light from the food surface using a special instrument called colorimeter or recently using electronic camera. The color is determined by dividing into three categories including hue, chroma/saturation and lightness/darkness. The second group is based on the transmitted or absorbed light. This measurement using spectrophotometer, so the sample should be in the liquid form. Depend on the food color, the measurement is done at certain wavelength.

In order to follow the browning reactions due to Maillard and mellanoidine reactions, the brown color is monitored at the wavelength of 420 or 490 nm (Whistler and Daniel, 1985). ICUMSA (International Commission for Uniform Methods of Sugar Analysis) using two wavelengths (420 and 720 nm; Altenburg, 2000). The Australian Sugar Mills adopted the same method. The reason for the 420 nm is due to the yellow to brown color of the product. The 720 nm is to correct the turbidity of the samples.

The formula to calculate the color is (Anonymous, 1991)

Color Index = a*420 – 2 a*720

a* is the attenuation of absorbance = $\frac{A\,x\,1000}{bc}$

ISBN: 978-979-96595-4-5

whereas A = absorbance

b = length of cell

c = concentration (g/mL)

Method Development of Brown Sugar Color

In order to measure the brown sugar color more objectively, a method using spectrophotometer has been developed (Pontoh, 2013). The method was developed based on the color analysis for white crystalline sugar (Anonymous, 1991 and Altenburg, 2000). The results show that the best concentration of sugar for color analysis is 1.25 g/100 mL for light color brown sugar and 0.6 g/100 mL for dark color brown sugar (Figure 3). It also show that the concentration range from g/mL to g/mL giving a linier relation to the absorbance.

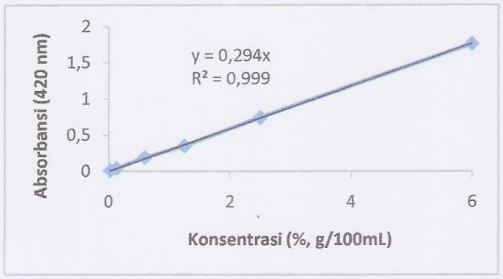


Figure 3. Effect of Sugar Concentration to the Absorbance at 420 nm

Various brown sugar samples have been analyze using this method and it is found that there have a strong relationship between the spectrophotometric measurements and their visual colors (Figure 4). Therefore this method can be used to evaluate the brown sugar color. The figure shows that the color index from 25000 to 30000 has wide visual color index. It means that the method cannot clearly differ the visual color at those visual color index range.

ISBN: 978-979-96595-4-5

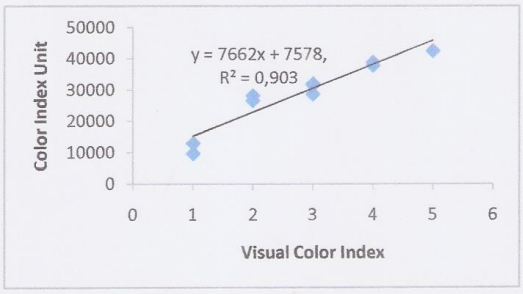


Figure 4. Relation between Visual Color Index and Color Index

Color and the Quality Properties of Brown Sugar

An experiment has been setup to find out the relation between color and various properties of the brown sugar (Kalengkongan, et al., 2013). The results show that there has a relationship between the color index and the pH (Figure 5). It shows that the lower the pH, the darker the color. The brown sugar pH varies from 5.9 to 4.2 These results show differently as found by Nurlela (2002) found the pH varies from 5.9 to 5.4 and there was no significant relation between the color and the pH. This is could be due to their sample is very limited.

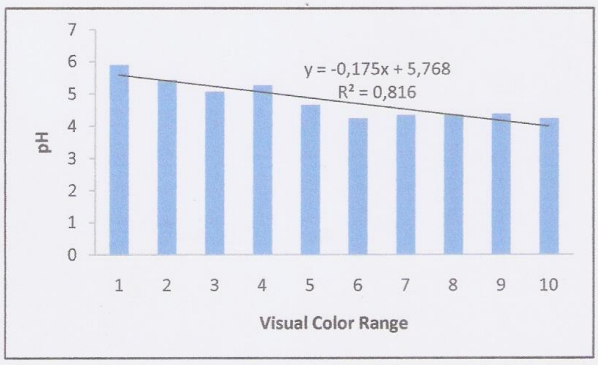


Figure 5. Relation between Visual Color of Brown Sugars and Their pH of Brown Sugar

Even during the sugar processing, the pH is going down (Ho, et al., 2008), but lower brown sugar pH is also the result of the initial sap quality. The initial pH of the fresh juice is about 8, but it decreases significantly during sitting due to the activities of contaminated

microorganisms. The longer the juice sitting before processing, the lower the pH. The juice pH has been used for quality control at Masarang Palm Sugar Factory. For example, the sugar palm juice pH below 7.5cannot be accepted for sugar production. The lower pH can enhance the browning reaction as the result lower juice pH will produce darker sugar. This is slightly different with the common believe that low pH will prevent browning reaction (Whistler and Daniel, 1985). Lower pH will promote hydrolysis of sucrose (a non reducing sugar) to become reducing sugars. These reducing sugars will enhance the browning reaction byproviding carbonyl (aldehyde and keton) groups.

Reducing sugar content is another important quality criteria. Fresh juice from sugar palm sap consist almost sucrose. Therefore, the presence of reducing sugar is an indication of poor quality of brown palm sugar. The higher the reducing sugar content the lower the sugar quality. Figure 6 shows the relationship between the color and the reducing sugar content. The darker the color, the higher the reducing sugar content. These results almost agrre with that found by Nurlela (2002) that the darker the color tend to have higher reducing sugars.

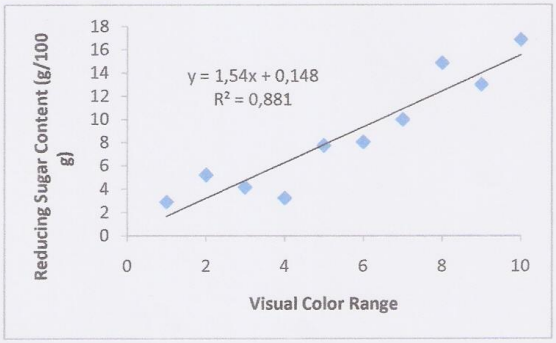


Figure 6. Relation between the Visual Color of the Brown Sugars and Their Reducing Sugar Content

Reducing sugars are the products of microbial activities upon sucrose *Saccharomysescerevisiae* is a yeast produce enzyme invertase converting sucrose into glucose and fructose (Itoh, et al., 1985). These reducing sugars have carbonyl group that can react with amine group from amino acids to start the Maillard reaction. Therefore the higher the reducing sugar the higher the Maillard reaction to produce darker color.

ISBN: 978-979-96595-4-5

Conclusion

A method for color measurement of palm sugar has been developed. The method has been used to determine various sample of commercial brown palm sugars. The measurements have been found correlated to the visual color of brown sugar. Color index measured by the method has a significant relation to some quality properties of brown sugar especially to the pH and reducing sugar content. Therefore, the visual color can be used to assess the quality of brown sugar. The darker the color of brown sugar the lower the quality of the sugar.

References

Altenburg, W. 2000. The Analysis of Sugar and Molasses. In: Chou, C.C. (Editor). Handbook of Sugar Refining.A Manual for the Design and Operation of Sugar Refining Facilities. John Willey & Sons, Inc. p:661-685.

Anonymous.1991. Standard Laboratory Manual for Australian Sugar Mill. Volume 2: Analitical Methods and Tables. Bureau of Sugar Experimental Stations. Brisbane, Australia.

Anonymous. 1995. *Standard Nasional Indonesia Gula Palma* (SNI: 01-3743-1995). BadanStandarisasiNasional

Apriyantono, A., A. Aristyani, L.Y. Nurhayati, S. Budiyanto and S.T. Sukarto. 2002. Rate of Browning Reaction during Preparation of Coconut and Palm Sugar. International Congress Series. 1245:275-278.

Ho, C.W., W.M. Wan Aida, M.W. Maskat and H. Osman. 2008. Effects of Thremal Processsing of Palm Sap on the Physico-Chemical Composition of Traditional Palm Sugar. Pakistan Journal of Biological Sciences 11:989-995.

Itoh, T., C.H. Widjaja, A. Matsuyama, M.Z. Nasution and J. Kumendong. 1985. Compositional Characteristic of Nipa – Palm Juice of High Sugar Content from Palm Tree. Proceeding of the IPB-JICA International Symposium on Agricultural Product, Processing and Technology. IPB and Japan International Cooperation Agency.p 233-240.

Kalengkongan, C., J. Pontoh, F. Fatimah. 2013. "*Relationship Between Color and Selected Brown Sugar Properties*". In preparation for publication.

Marsili, R. 1996. Food Color: More than Meets the Eye. Food Product Design. October 1, 1996

Nurlela, E. 2002. "Study of Factors Infulence Color Formation in Brown Sugar". Thesis at Faculty of Agriculture Technology, InstitutPertanian Bogor.

Pontoh, J. 2007. *Chemical composition of palm brown sugar*. Report to Masarang Foundation. Tomohon.

Pontoh, J. 2013. *Method Development for Brown Sugar Color Analysis*. Paper submitted to Buletin Palma.

Whistler, R.L. and J.R. Daniel. 1985. Carbohydrates. In: Fennema, O.R. (Editor). Food Chemistry.Second Edition, Revised and Expanded. Marcel Dekker, Inc. p:69-137.

ISBN: 978-979-96595-4-5

ISBN : 978-979-96595-4-5

Proceeding

The 2nd International Conference of the Indonesian Chemical Society 2013

ICICS 2013

Research in Chemistry for Better Quality of Environmental

Universitas Islam Indonesia, Yogyakarta, Indonesia
October, 22 - 23th 2013

Abdul Kahar Muzakkir, Conference Hall
Universitas Islam Indonesia (UII), Yogyakarta.
Kampus Terpadu, Jl. Kaliurang KM 14,5 Sleman, Yogyakarta.