J. Food and Dairy Sci., Mansoura Univ., Vol. 8 (10): 401 - 404, 2017

Quality Parameters of Cane Juice and its Liquors During the Processing Stages of Raw Sugar under Prevailing Industrial Conditions.

Tawfeuk, H. Z. and R. A. Gomaa
Food Sci. & tech. Dept.; Fac. Agriculture and natural resources; Aswan University; Aswan, Egypt.

ABSTRACT

The objective of the present work was to evaluate the changes in cane juice quality and its liquors during the main stages of raw sugar processing under prevailing industrial condition at Kom Ombo raw sugar factory, Aswan, Egypt during 2016/2017 working season. Results revealed that a noticeable inversion of sucrose content due to microbial action in mill train system in compared with mixed juice. Also the mud filtrate juice was characterized by low purity and glucose ratio, the clarification process had no effect on the quality with the exception of the reduction of fructose level may be due to alkalinity and high temperature. Results showed also glucose was the dominating reducing sugar through the extraction and clarification steps. The starch content of the factory clear juice was much lower than those of the crude juice. Although the pre-evaporation, evaporation and syrup sulphitation steps had no remarkable effects on the carbohydrate ratios of the sugar liquors. The apparent purity of strike A (mixed of sugar crystals and liquors which obtained from crystallization and cooking processes) was higher than the other of the syrup indicating the addition of rich liquors at crystallization step. The final molasses had 42.1 purity and 70.7 RS%S. although the glucose was still the dominant reducing sugar in molasses. Fructose was present in relatively a high amounts indicating the inversion of sucrose or conversions of other reducing sugars into fructose. On the other hand starch remained in the final molasses revealed to its separation in the centrifuges, yet appreciable amounts were present in raw sugar due to the selective absorption of starch during sugar crystallization.

Keywords: cane juice, quality, processing, primary juice, diffusion juice, brix, syrup, reducing sugar, starch.

INTRODUCTION

Production of good quality white sugar the aim of the economical sugar manufacturing from sugar cane is preservation, extraction and recovery of the maximum yield of sucrose from sugar cane. The steps of raw sugar cane processing are: juice extraction, clarification, evaporation, crystallization, centrifugation, and final drying of the sugar production (Anon, 1974; Prieto, 1997 & Cargill and Winter bach, 1996). Extraction of the sugar cane juice from the sugar cane sticks using a roller mill apparatus or diffuser apparatus, filtration of the extracted sugar cane juice through a screen filters, stabilization of the pH of the juice in a non-acidic solution of calcium hydroxide, flocculation of the sugar cane juice with the mixture of water and natural flocculate product, evaporation of the sugar cane juice concentrate and extraction of the sugar cane from evaporator (Gonzaies, 2001).

The purpose of clarification process is to remove impurities from the juice as early as possible in process. This elimination has to be done to prevent the loss sucrose or reducing sugars in a considerable quantity. The juice usually contains considerable colloidal and fine suspended matters, which are removed by clarification and addition of some soluble compounds, are also done by means of chemical treatment, heating and settling. The concentrated clarified juice resulting from the fourth vessel is called syrup (Laksameethana sana *et al*, 2012). The rate of syrup withdrawal is controlled to give the desired brix value. The operation known in the factory as sugar boiling is essentially the process of crystallization, which is carried in single effect vacuum evaporators designed for handing viscous materials and known as vacuum pans. The vacuum pan is thus an evaporative crystallizer, i.e. a crystallizer in which degree of super saturation is controlled and maintained by evaporating solvent as a solute crystallizes out.

At Kom Ombo sugar factory, Aswan Governorate, Egypt the extraction of the juice from cane was done by the milling tandem and diffusion system. In diffusion system the bagasse coming out from the first mill is fed to the diffuser; which is followed by two dewatering mills then the bagasse is subjected to counter current washing with lower concentration juice.

The present study was carried out to estimate and evaluate the quality parameters of cane juice and its various liquors during the main stages of raw sugar processing under prevailing industrial conditions.

MATERIALS AND METHODS

Materials

Samples were withdrawn at each of the following 12 stage along the manufacturing of cane sugar line at Kom Ombo raw sugar factory, Aswan, Egypt during 2016/2017 working season as follow:-

1-Primary juice of tandem system.
2- Secondary juice of tandem system.
3- Mixed juice of tandem system.
4- Primary juice of the pre-diffusion mill.
5- Diffusion juice.
6- Mud filtered juice.
7- Factory clear juice.
8- Pre-evaporation juice.
9- Pre-sulphated syrup.
10- Sulphated syrup.
11- Strike A.
12- Final molasses.

Samples 1-5 were taken in order to study and compare the two systems of juice extraction employed at Kom-Ombo factory. Namely, the tandem and the Egyptian diffuser systems while samples 6 and 7 were intended to show the effect of the chemical treatment adopted for clarification, which is the phpspho-sulphi-defecation process, on the major carbohydrates of cane juice. The remaining samples should give a general picture of industrial stages of raw sugar production.

Preparing of cane sugar samples

Samples were withdrawn of each sampling devices, through 12 consecutive hours 100 ml aliquots of the withdrawn sample were combined to from a composite sample representing the working period of 12 hours. During the compositing period, the sample were kept at 6^{o}C and preserved by adding saturated alcoholic mercuric chloride (2.5 ml/ liter).

Processing stages:

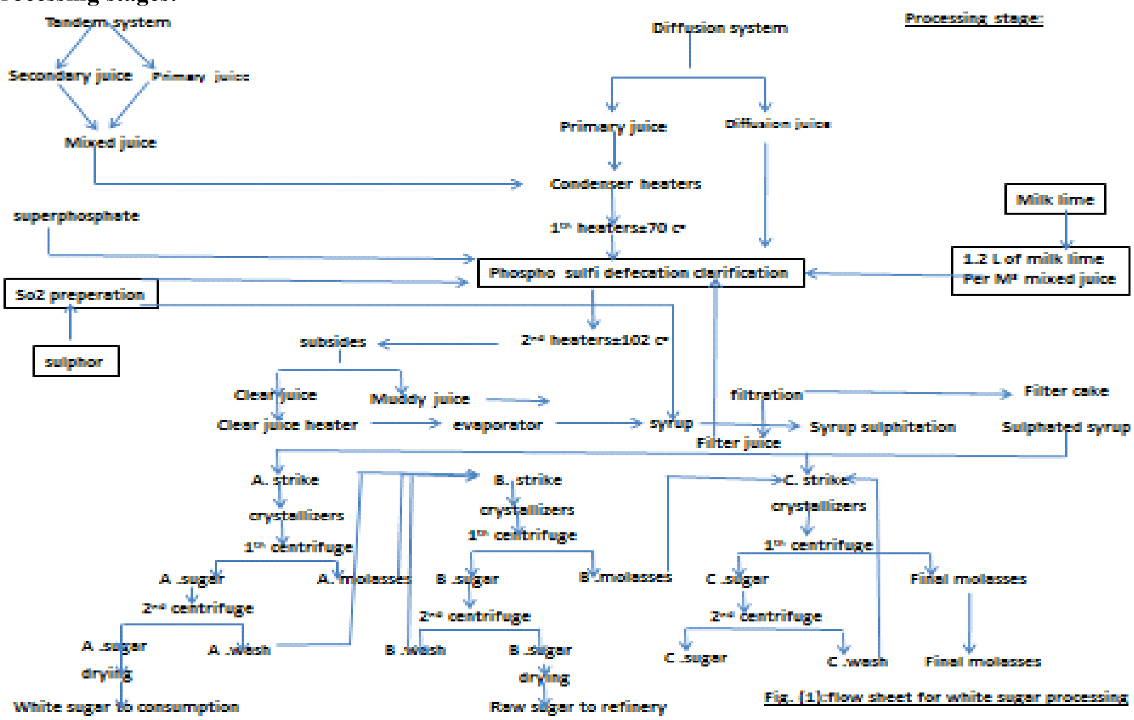

Fig. 1. flow sheet for white sugar production at Kom Ombo sugar factory

Analytical methods

- Brix was determined by Abbe refractometer at 20°C according to laboratory manual as reported by (Anon, 1985).
- Sucrose content was determined according to the method described by De Whally (1964).
- Purity represents the percentage of sucrose in the total solids content of the investigated samples (Anon, 1994).
- Reducing sugars were determined by Lane-Eynon volumetric method, as -described by Payne (1968).
- Glucose and fructose were determined using HPLC according to Jadhav *et al* (1995).
- Starch was precipitated by the addition of 95 % ethyl alcohol. After the filtration and washing with 80 % ethyl alcohol, the precipitated starch was re-dissolved by boiling with calcium chloride solution 30 %, and then determined spectrophotometerically according to AOAC, (1990).

RESULTS AND DISCUSIONS

Ten samples were withdrawn from each processing through 10 successive days. Results in Table 1 and 2 showed quality of cane juice throughout the extraction and clarification stages, other results in table 3 presents the quality parameters of the different liquors between the clarification and crystallization stage.

The purity of the factory primary juices (samples 1 and 4) was lower than that of the freshly harvested cane in the same period in which this experiment was carried out (February). Glucose ratio (RS%S) of the primary juices was twice as high as that of those in fresh practically in mature cane. Such an increase observed in glucose ratio this may be due to crushing cane at various stages of maturity and/or the milling of cane which has under gone various degrees of deterioration.

There were an additional drop in the purity and corresponding increase in RS%S can be observed between the primary juice of the mill train system and its mixed juice as showed in sample3.

Table1. Quality of cane juice during extraction and clarification stages.

Samples		Quality parameters				
		Purity	RS%S	G% brix	F% brix	Starch in brix ppm
1	Mill train primary juice	84.2	4.9	2.77	0.09	2258.0
2	Mill train secondary juice	84.2	4.9	2.77	0.09	2258.0
3	Mill train mixed juice	82.1	6.5	3.86	1.42	2492.0
4	Diffusion system 1st mill primary juice	85.4	4.3	3.69	1.00	2588.0
5	Diffusion juice	80.7	5.7	4.63	0.00	3106.0
6	Mud filtrate juice	77.1	3.2	5.4	1.25	546.0
7	Factory clear juice	82.6	5.3	3.86	0.46	1373.0

Where: RS = Reducing Sugar, G = Glucose, F = Fructose, S = Sucrose

Results also indicated that sample (5) represents the diffusion juice or the juice extracted from bagasse leaving the first mill by the diffuser. The purity and RS%S of the diffusion juice were 80.7 and 5.7; respectively being comparable to those present in the prepared bagasse for diffusion (Sayed, 1972 and Qudsieh , *et al* 2001).Sample (6) represents the mud filtrate to juice, which contains the sugar remaining in mud from the clarifiers. Such filtrate is characterized by low purity and low RS%S. The mud filtrate juice is recycled with the crude factory juice during the clarification process.

Factory clear juice in (sample 7) represents collective product of the extraction and clarification steps. Glucose was found to be the dominating reducing sugar, while Fructose content was low but measurable in all stages. Throughout the extraction and clarification steps, glucose content was low but measurable in all stage tested except in the diffuser juice, this may be possibly and due to the destruction and conversion to other compounds.

The starch content of the various juices was high indicating the extraction of starch along with the sugars. The diffusion juice was the highest and its starch content revealed that the diffuser extracted higher starch than all mill system under the working conditions that prevailed during the sampling period. However, Figueira *et al* (2011) found that when the working conditions in the diffuser were adjusted, the juice extracted by the mill contains lower starch content than those of that extracted by the mill train.

Table 2. Quality parameters of raw and clear factory juices.

Quality parameters	Raw juice	Clear juice
Purity	83.3	82.6
RS% S	5.6	5.3
RS% B	4.7	4.3
G% B	3.7	3.9
F% B	0.99	0.48
Starch on brix ppm	1617.0	1509.0

The factory clear juice was compared with the mean factory crude juice to evaluate the effect of clarification steps and the results are presented in Table 2. Data showed that the treatment process had little or no effect on juice quality with the exception of reduction of fructose level must be due to the effect of alkalinity and high temperature. Kornvalai *et al* (2008) found glucose more stable during the clarification process than fructose. The fructose destruction during clarification increased the apparent purity of clarified juice to more than that of the raw juice. Moreover; Dionisi *et al*. (2008) concluded that the reducing sugars underwent various reactions in alkaline solution during clarification.

Although data in Table 2 also showed no remarkable differences between the starch content in the raw and clear juices. the results in Table (1) give indicated that starch can be partially removed during the clarification process. The clarification process may precipitate some of the starch of crude juice as indicated by the presence of starch in the mud filtrate is recycled in to the factory clear juice. The starch of the factory clear juice was much lower than those of the crude juice but was still high enough to cause processing difficulties in the following sugar manufacturing and refining steps.

Eggleston *et al* (2002) and Fabiane *et al* (2012) reported that some starch removal during clarification under specified conditions. Starch removal during the juice clarification by the technique adopted in the Egyptian sugar factories needs to be thoroughly studied in order to set suitable clarifications, that induce maximum starch precipitation without affecting the efficiency of the process.

Table (3) showed the quality parameters of different liquors between clarification and crystallization stages. The pre-evaporation, evaporation and syrup sulphitation steps (samples 8-10) had no remarkable effect on the carbohydrate ratio of the sugar liquors. Sample 2 represents the results of the crystallization process before the separation of sugar crystals. A rise in purity and a drop in starch were observed in strike A. the reducing sugars especially fructose increase slightly in strike A. Such observations can only be attributed to the addition of rich liquors, possibly sucrose solution to the syrup before or at this stage.

Table 3. Quality parameters of successive factory liquors.

Sample		Quality parameter of successive factory				
		Purity	RS%S	G% brix	F% brix	Starch in brix ppm
7	Factory clear juice	81.0	5.5	5.12	1.41	832.0
8	Pre-evaporation juice	81.0	5.5	5.38	1.58	860.0
9	Pre-sulphated syrup	80.1	6.1	5.82	1.50	718.0
10	Sulphated syrup	81.0	6.1	5.27	1.46	720.0
11	Strike A	83.0	6.4	5.46	2.00	406.0
12	Final molasses	41.2	40.7	13.94	4.46	1050.0
13	B-Sugar	41.2	40.7	13.94	4.46	450.0

Table (3) showed the purity, RS%S, G% brix, F% brix and starch in brix ppm. in the final molasses (sample12). The apparent purity of molasses represents the irrecoverable sucrose lost in the final molasses. The reducing sugars percent sucrose of molasses amounted to 40 which may be a reason, among others, causing the incomplete recoverability of sucrose. Glucose was still the dominant reducing sugar in molasses. Nevertheless fructose was also present in high amounts in molasses indicating the inversion of sucrose and/or conversion of other reducing sugar into fructose (Zeqing *et al*, 2017).

Table (3) showed also that the majority of can starch remained in the final molasses, yet appreciable amounts were selectivity adsorbed by the sugar crystals during crystallization stage which accounts for the relativity high starch content in B-sugar (sample13). Starch is assumed to be present in molasses film around the raw sugar crystals. So, from the above mentioned data in table 1, 2 and 3 it could be observed that the plantation white sugar produced at Kom-Ombo sugar factory is always found to contain higher starch than B-sugar (sugar which obtained from second massecuite).

REFERENCES

Anon. (1974): Mumias sugar company limited. Anew project in Kenya. Sugar Y. Azucar, 69: 6: 41 - 43, 151 – 152 & 156.

Anon (1985). Laboratory Manual for South African Sugar Factories including the Official. Methods. South African Sugar Technologist's Association, Mount Edgecombe, South Africa.

Anon. (1994) International Commission for Uniform Methods of Sugar Analysis, Methods Book, ICUMSA, England

AOAC (1990): Official Methods of Analysis, 13th Edition Association of Official Chemists, Washington, DC, U. S. A.

Cargill, T.M.& A.H.Winterbach (1996): An imovative sugar mill. Construction and first two years of operation at Komati. International Sugar journal, 98: 1169: 225 - 226 & 228 - 229.

DeWhally. H. C. S (1964): ICUMSA Methods of Sugar Analysis. International Commission for Uniform Methods of Sugar Analysis. El-Sevier Publishing Company, Amsterdam, London, New York.

Dionisi, IV Aoki, RJ Calabrese (2008): Sugar cane juice clarification process US Patent 7,338,562, mar. 4.

Eggleston, G., Monge, A. & Pepperman, A. (2002): Preheating and incubation of cane juice prior to liming: a comparison of intermediate and cold lime clarification. Journal of Agricultural and Food Chemistry, 50, 484–490.

Fabiane Hamerski, Vı´tor R. da Silva, Marcos L. Corazza, Papa M. Ndiaye & Arislete D. de Aquino (2012): Assessment of variables effects on sugar cane juice clarification by carbonation process. International Journal of Food Science and Technology, 47, 422–428.

Figueira, A; Hoffmann, P Carvalho; H, H, SATO (2011): Sugarcane starch: quantitative determination and characterization. Ciênc. Tecnol. Aliment, Campinas, 31: 806-815, jul.-set.

Gonzaies, J.E. (2001): Method for producing sugar cane juice. United State Patent, US 6: 245: 153 BI.

Jadhav, S.J. Natu, R.B. Khanapure, V.M., (1995): (Vasantdada Sugar Inst., Pune (India) Dept. of Sugar Chemistry).

Kornvalai, P., W. Jaturonrusmee; W. Mingvanish ; C. Nuntiwattanawong ; S. Chunwiset, K. Santudrob and S. Triphanpitak (2008): Minimization of sucrose losses in sugar industry by pH and temperature optimization. The Malaysian Journal of Analytical Sciences, 12: 513 – 519.

Laksameethanasana.P, N. Somla, S. Janprem, N. Phochuen (2012): Clarification of sugarcane juice for syrup production. Procedia Engineering 32, 141 – 147. Elsevier.

Payne, J. H. (1968): Cane diffusion. The displacement process in principle and practice. International Society of Sugar Cane Technologists, 13: 103.

Prieto,T. (1997): The Okeelanta sugar factory. A report on the expansion of Florida's second oldest mill sugar Y. Azucar, 72: 6: 58 - 60 & 131-132.

Qudsieh, H; S, Yusof; A, Osman and RA HYPERLINK "https://scholar.google.com.eg/citations?user=2gaARIEAAAAJ&hl=en&oi=sra"Rahman (2001): Physico-chemical changes in sugarcane (Saccharum officinarum var yellow cane) and the extracted juice at different portions of the stem during development and maturation. Food Chemistry, Elsevier.

Sayed, G. E (1972): quality of cane juice changes during sugar cane maturation. The Egyptian sugar and distillation co., sugar cane Dept. Tech. Bull, No. 36.

Zeqing X; Liao, X; and Guo, S; (2017): Analysis of Sugarcane Juice Quality Indexes. Journal of Food Quality .Volume 2017 Article ID 1746982, 6 pages. https://doi.org/10.1155/2017/1746982.

معايير جودة عصير القصب وارحقته خلال الخطوات التصنيعية للسكر الخام تحت الظروف الصناعية السائدة.

هشام زكريا توفيق و رضا عبد الموجود جمعة
قسم علوم وتكنولوجيا الأغذية – كلية الزراعة والموارد الطبيعية- جامعة أسوان – أسوان - مصر

أجريت هذه الدراسة بغرض تقدير المقاييس المختلفة لجودة عصير القصب وأرحقته أثناء الخطوات الرئيسية لانتاج السكر الخام تحت الظروف الصناعية السائدة بمصنع سكر كوم امبو- محافظة أسوان خلال موسم ٢٠١٦/٢٠١٧ . وقد أظهرت النتائج وجود تحول فى السكروز نتيجة النشاط الميكروبى وذلك عند مقارنة العصير الرئيسى والعصير المختلط. وقد تميز عصير رائق المرشحات بانخفاض النقاوة والسكريات الاحادية والسكروز ولكن محتوياته من النشا كانت عالية. وقد كان الجلوكوز هو السكر المختزل السائد خلال مرحلة الاستخلاص والترويق، وقد لوحظ عدم وجود تأثير لعمليات معالجة وترويق العصير على الجودة بإستثناء خفض مستوى الفركتوز نظرا لأثر الحرارة والقلوية العالية، كان محتوى العصير الرائق من النشا كانت أقل بدرجة كبيرة عنها فى العصير الخام، ولم تكن لعمليات التبخير المبدئى والتبخير ومعالجة الشربات بغاز ثانى أكسيد الكبريت اثر واضح غير مرغوب فيه على المحتويات السكرية. وكانت درجة النقاوة الظاهرية لطبخة سكر (أ) أعلى من الشربات مما يدل على احتمال إضافة أرحقة غنية خلال عملية البلورة. وكانت درجة نقاوة المولاس النهائى خلال فترة الدراسة ٤١,٢ وكانت السكريات الاحادية ٧,٧ على الرغم من أن الجلوكوز هو السكر الاحادى السائد فى المولاس إلا أن وجود الفركتوز بنسبة عالية فى هذه المرحلة يدل على تحويل السكروز أوتحول السكريات الاحادية الاخرى إلى سكر الفركتوز، وعلى الرغم من تواجد كمية كبيرة من النشا فى المولاس النهائى إلا أن كمية لايستهان بها منه وجدت فى السكر الناتج ويرجع ذلك إلى إمتصاصه إختياريا أثناء عملية البللورة أو تركيزه فى غشاء المولاس المحيط ببلورات السكر الخام.