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Efficacy of Affination on Quality Parameters of White Sugar During Refining Process

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

At laboratories of Delta Sugar Company, Kafr El-Sheikh Governorate, Egypt, as well as Food science Department Faculty of Agriculture, Minia University, Egypt during 2019 working season was carried out this work. It was particularly designed to evaluate the affination process of raw sugar at different temperatures on refined sugar quality parameters during sugar refining process under prevailing industrial conditions.

The obtained results revealed that there were a significant differences among raw cane sugar samples in the all studied physiochemical traits, i.e. moisture, sucrose, reducing sugars, starch, dextran and color (ICUMSA units) except total sugars and ash % , Significant effect of dextran addition for sugar type, where white sugar was affected more than raw sugar, and added dextran level, significant effect of affination syrup temperature on physiochemical properties of white sugar, i.e. dextran, starch, sucrose, ash, and colour, except reducing sugars percent was non-significant it can be concluded from the present research that affination syrup temperature at 70^{o}C is the best treatment under the study conditions regarding white sugar quality and can be recommended to the industry for further processing and quite near to the standards of white sugar.

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Keywords: Affination; raw sugar; dextran; color.

1. INTRODUCTION

Raw sugar is an intermediate product of refining and affination process of sugar manufacturing that consists of pale yellow to brown sugar crystals covered with a film of syrup. This is in fact, an intermediate stage in the production of sugar, having sucrose (Pol) 98.37%, reducing sugars 0.45%, other organic matters 0.55% ash 0.26% and water 0.37%. It is of yellowish-brown color due to the presence of molasses and has burnt flavor with coarse crystal. There is approximately apart from sucrose, contains reducing sugars (glucose and fructose), inorganic ash (mainly calcium and potassium salts) and other organic matter which includes gums, amino acids and colour components, essentially from the cane. These impurities must be removed from the sucrose during refining. The raw sugar is mingled with hot affination syrup which melts just the outermost layer of the raw sugar crystal. This outer layer contains the largest concentration of color. The resulting syrup from melting of the outer layer, is separated from the sugar crystals in a centrifuge. The bulk of the colorants are removed during the affination step (about 50% of raw sugar color) and then during the clarification step (about 40% of melt liquor color). Raw sugar, having water contents 0.25- 1.1% [1,2,3].

Refined sugar is a more common product for the average consumer, and can be defined by its purer properties compared to its raw counterpart. The raw sugar is melted to remove these impurities and is essentially purified twice, resulting in a product fit for human consumption. Its white, crystalline appearance is what most consumers would think of when they think of sugar in its table-top form [4,5]. So, this work was carried out to study and evaluate the affination process of raw sugar at different temperatures on refined sugar quality parameters during sugar refining process under prevailing industrial conditions.

2. MATERIALS AND METHODS

At laboratories of Delta Sugar Company, Kafr El-Sheikh Governorate, Egypt, as well as Food science Department Faculty of Agriculture, Minia University during 2019 working season was carried out this study.

2.1 Materials

Accumulating representative samples (15 samples) of raw sugar which came from Brazil to Hawmadia refinery sugar, the sample collected represent 100,000 ton of raw sugar.

2.2 Analytical Methods

2.2.1 Physical property

Color analysis was determined as outlined in by using color meter Color f was determined measuring the absorbance of diluted samples at 420 nm as ICUMSA units [6].

2.2.2 Chemical composition

Moisture content of samples was determined by drying the samples at 70°C until constant weight. Sucrose content was determined as described in [7]. Total sugars and reducing sugars were determined by the Lane and Eynone Volumetric method. Starch and dextran were determined spectrophotometrically as described in [7].

2.2.3 Affination

The raw sugar is mingled with hot affination syrup at three temperatures (60, 70 and 80 ^{O}C) which melts just the outermost layer of the raw sugar crystal. This outer layer contains the largest concentration of color.

2.2.4 Statistical Analysis

Results were statistically analyzed by analysis of variance (ANOVA) each experiment in triplicate repeated at least twice and the values presented in terms of means ± standard error using Costat 6.400 (Cohort Software, CA, USA) according to [8].

3. RESULTS AND DISCUTION

3.1 Physiochemical Properties of Raw Sugars Samples

Data tabulated in Table,1 shows Physiochemical properties of the studied raw sugars samples, i.e. moisture, total sugars, sucrose, ash, reducing sugars, starch, dextran and color. Results cleared that there was a significant difference among raw cane sugar

samples in the all studied traits except total sugars and ash %. The moisture contents of the different raw sugar samples were in the range of 0.05–0.08%. The moisture contents of the sugar are adaptable because of the non-reducing sugars during the process of manufacturing. Our results are in same line with those of [1,3,9].

The statistical data in Table,1 revealed that the values of sucrose% of raw sugar were affected significantly by the samples. The mean values of sucrose% for the samples of raw sugar were in the range of 98.07 – 99.20%. The decreasing in the value of polarization was might due to the fluctuation in the processing of raw sugar and also the coloring compounds and the impurities may have an interaction in the determination of this parameter. While for the values that are highest for some samples might be due to the more sucrose contents because raw sugar still needs further processing in order to make it palatable for human consumption [10,11,3].

The results in Table,1 referred that the values for starch content of raw sugar were significantly affected by the samples. The mean values for starch content were in the range of 270 – 410 ppm. The values for dextran content of raw sugar were significantly affected by the samples. The mean values for dextran content were in the range of 323 – 548 ppm. Also, Data in same pervious Table, pointed out that the values of reducing sugars of raw sugar were significantly affected by the samples. The mean values for reducing sugars% were in the range of 0.14 – 0.17%. Such result is in accordance with those recorded by [1,3].

Color values of raw sugar were significantly affected among the samples of raw sugar as shown in Table 1. The mean values for the color contents in different raw sugar samples were in the range of 653 – 725 ICUMSA units might be due to the impurities and interaction in the determination of this parameter. Sugar crystals are covered with molasses having a brown golden in color. Another way that sugar quality is measured is through ‘color’. The term color refers to a wide range of complex and molecular components that contribute to the overall appearance of sugar. The color is dependent on the residual molasses that are not removed in the refining process [1]. Such finding was in accordance with those found by of [3,5,9].

3.2 Effect of Dextran Addition for Sugar on Sucrose % of White and Raw Cane Sugar

Data recorded in Table 2, is shown a significant effect of added dextran of sugar on sucrose % of sugar. Where, white sugar contained the higher increase value (100.12 %) of sucrose% as a result of dextran addition for sugar, while, raw sugar scored the lower increase value (99.45%). This result might be due to the higher value of sucrose% of sugar was the higher in white sugar than raw sugar. Dextran is a complex high molecular weight glucose polysaccharide, produced by *leuconostoc mesenteriodes* bacteria [4]. Dextran elevates and gives false Polarization being a highly dextrorotatory substance [12]. They indicated that the harmful effect of dextrans begins at their formation due to the irreversible sucrose consumption. The formation of one-gram dextran molecule required 4 gram of sucrose molecule.

Also, the results in the same Table pointed out that added dextran level for sugar had a significant effect on sucrose % of sugar type. Increasing quantity of dextran from zero to 50, 250 and 350 ppm led to an increase in sucrose% of sugar by 0.13, 0.45 and 0.55 %, respectively. This finding This is due to the dextrorotatory characteristic of dextran's that polarize approximately three times more than sucrose producing a high false Pol value [13].

A significant interaction was shown in Table 2, between sugar type (A) and added dextran level (B) with regard to sucrose % of sugar. The highest value of sucrose% (100.40%) of sugar was obtained in white sugar with added dextran level at 350 ppm. These results are in agreement with those found by [11,13].

3.3 Effect of Affination Syrup Temperature on Physiochemical

3.3.1 Properties of sugar during refining process

Data recorded in Table 3, shows a significant effect of affination syrup temperature on physiochemical properties of white sugar, i.e. dextran, starch, sucrose, ash and color except reducing sugars% was non-significant. Where, affination syrup temperature at 70 ^{o} C recorded the lowest values of dextran, ash and color of white sugar (242.50 ppm, 0.004%, 99.68% and 488.50 ICUMSA units, respectively) and also it

contained the highest value of sucrose% (99.68%). However, the highest values of dextran, ash % and color of white sugar (419.33 ppm, 0.037%, and 594.50 ICUMSA units, respectively) were recorded for affination syrup temperature at 60 ^{o} C and it scored the lowest value of sucrose% (99.54%). This result might be due to some factors affect the color of the sugar, some of these factors include color type, ash constituents, boiling time, polysaccharides and purity of pan feed liquor. Polarisation (pol) essentially measures the purity of the sugar, with the apparent sucrose content in the product provided as a mass percentage. The higher the polarisation, the purer the sugar is; the lesser the polarisation, the more impurities are present in the sugar [4,3]. The presence of impurities

Table 1. Physiochemical properties of raw sugars samples

No. of Sample	Property							
	Moisture%	Total solids %	Sucrose%	Ash %	Reducing sugars %	Starchppm	Dextran ppm	Color*
1	0.07 c	99.93	98.90 cd	0.11	0.14 b	386 d	485 c	670 e
2	0.07 c	99.93	99.00 bcd	0.11	0.15 b	370 g	350 i	662 f
3	0.08 b	99.92	98.90 cd	0.12	0.17 a	385 d	425 e	653 gh
4	0.08 b	99.92	98.80 cde	0.11	0.17 a	400 b	323 m	655 fgh
5	0.06 d	99.94	98.50 fg	0.12	0.17 a	385 d	525 b	675 de
6	0.06 d	99.94	98.90 cd	0.11	0.14 b	401 b	343 j	660 fg
7	0.07 c	99.93	98.72 def	0.11	0.17 a	380 e	360 h	680 c
8	0.07 c	99.93	98.86 cde	0.12	0.15 b	375 f	362 g	710 b
9	0.06 d	99.94	98.40 a	0.11	0.14 b	385 d	548 a	690 c
10	0.07 c	99.93	98.07 bc	0.11	0.17 a	410 a	325 l	650 h
11	0.05 e	99.95	98.50 fg	0.12	0.17 a	385 d	323 m	725 a
12	0.07 c	99.93	99.20 ab	0.11	0.14 b	270 g	388 f	652 h
13	0.09 a	99.91	98.44 fg	0.11	0.17 a	375 f	439 d	660 fg
14	0.05 e	99.95	98.40 g	0.11	0.17 a	360 h	282 n	721 a
15	0.07 c	99.93	98.60 efg	0.11	0.15 b	393 c	338 k	690 c
Overall Mean	0.068	99.93	98.81	0.11	0.158	384	387.73	676.87
F value	**	Ns	**	Ns	**	**	**	**
LSD at 0.05	0.003	-	0.29	-	0.02	1.53	1.70	7.76

*Notes: Values in the same row with different superscripts are statistically significant from each other (p < 0.05). *= ICUMSA units, Ns = Non significant*

Table 2. Effect of dextran addition on sucrose% of white and raw cane sugar

Content of added dextran to sugar, ppm (B)	Sucrose % of sugar type (A)		
	White sugar	Raw sugar	Mean
Zero	99.80 d	99.20 h	99.50 d
50	99.96 c	99.30 g	99.63 c
250	100.30 b	99.60 f	99.95 b
350	100.40 a	99.70 e	100.05 a
Overall mean	100.12 a	99.45 b	99.78
F value	**	**	**
LSD at 5%	A=0.006	B=0.015	AB=0.021

Notes: Values in the same row with different superscripts are statistically significant from each other (p < 0.05)

Table 3. Effect of affination syrup temperature on physiochemical properties of white sugar during refining process

Property		Affination syrup temperature			Mean	F value	LSD 0.05
		60 °C	70 °C	80 °C			
Dextran	Before	536.50			536.50	-	-
(ppm)	After	419.33 a	242.50 b	305.50 b	322.44	**	75.69
Starch	Before	385			385	-	-
(ppm)	After	379 ab	383.50 a	375.5 b	379.33	*	4.58
sucrose %	Before	99.43			99.43	-	-
	After	99.53 b	99.68 a	99.58 b	99.59	**	0.06
Reducing	Before	0.15			0.15	-	-
sugars%	After	0.08	0.08	0.08	0.08	Ns	-
Ash %	Before	0.12			0.12	-	-
	After	0.037 a	0.004 b	0.005 b	0.015	**	0.007
Color	Before	682.50			682.50	-	-
(ICUMSA	After	594 a	488.50 c	534 b	535.50	**	9.82
unit)							

Notes: Values in the same row with different superscripts are statistically significant from each other ($p < 0.05$). Ns = Non significant

(non-sugars) in the sugar solution may influence the sucrose crystallization. In fact, impurities in supersaturated solutions significantly affect the nucleation, growth rate, morphology, and also the agglomeration rate of the crystals. Among these impurities, we find the dextran which has already been recognized as a serious problem in sugar processing. Dextran is a branched polymer of dextrose (glucose) of very high molecular weight, belonging to the group of colloids. The presence of dextran causes a significant increase in the viscosity, elongated crystals, lower evaporation rates, longer wash and separation cycles in centrifuges, and loss of sugar to molasses [14]. Our finding is in accordance with those found by of [1,5].

4. CONCLUSION

Through this study, the results showed Thus, it can be concluded from the present research that affination syrup temperature at 70°C is the best treatment under the study conditions regarding the sugar quality and can be recommended to the industry for further processing and quite near to the standards of white sugar.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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