Comparative Studies with Selected Physico-Chemical Characteristics and Single Factor Analysis of Variance of Locally Produced and Industrial Processed Sugar Products in Aqueous Medium

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***Abstract*: - Brown sugar as a product of sucrose crystals and molasses has presented some specific characteristics that significantly deviated from the refined white sugar. Identified physicochemical properties**

[Turbidity (T), total dissolved solids (TDS), pH and electrical conductivity (EC)] were adopted in comparing and assessing the properties of these two products in water. The statistical mean values of pH, EC, TDS, and T of the brown sugar (BS) serial solutions as supported by single-factor ANOVA are 7.72 (slightly alkaline), 0.672uS/cm, 431.8ppm and 167.8NTU respectively and for refined white sugar (WS), the mean values for pH, EC, TDS, and T are 6.98(Slightly acidic), 0.002uS/cm, 17.4ppm and 7.6NTU respectively. The significant differences between the brown sugar (BS) and the white refined sugar (WS) were directly estimated by the magnitudes of the statistical F values (F_{stat}), which has to be greater than the critical F values (F_{crit}) with respect to these four parameters. F_{stat} for pH, EC, TDS, and T are all greater than their respective F_{crit} as thus;

pH [($F_{stat} > F_{crit}$)=12.79439 > 5.317655],

EC [($F_{stat} > F_{crit}$)=21.40881 > 5.317655] ,

TDS [($F_{stat} > F_{crit}$)=26.77300 > 5.317655] and

T [($F_{stat} > F_{crit}$)=21.31919 > 5.317655].

These outcomes explicitly revealed and confirmed the dissimilarities between these two sugar products.

Hence, with recommendations to support the production, consumption, and applications of brown sugar against the white type.

***Keywords:* Brown sugar, white sugar, physicochemical parameters, single-factor ANOVA and aqueous media**

I. INTRODUCTION

Sugar is a major supply of energy which enhances our wellbeing, but could also be dangerous when in excess as it contributes to a number of health challenges such as type 2 diabetes [1].There have been serious deliberations and arguments about the uses or consumption of sugar and its products [2]. Meanwhile, brown sugar is extensively used where there are general and cultural acceptances of the product. Validating the type or form of sugar that is actually healthy, is a question that needs to be rationalized by scientific claims and assertions. White and brown sugars are products of sugarcane juice extract with different physical and chemical characteristics. Brown sugar is an aggregate of white sugar (sucrose crystals) and molasses, sugar-derived dark syrup that gives the darker color and with minerals addition. The darker sugar contains fewer calories but more calcium, iron and potassium contents compared to white sugar [3]. White sugar basically provides a neutral taste that makes it an adaptable constituent in baking because of its easy nature of mixing and acceptable taste. Since brown and white refined sugar basically differs in color and taste, then the same must be obtainable with other physical and chemical characteristics. However, it is very essential to acknowledge that the consumption of any form of sugar especially the processed sucrose (white) must be controlled in preventing the potential dangers they can induce [4]. Raw sugar undergoes less or no further processing compared to white sugar which basically undergoes the process of extraction from the cane, boiling, filtration/clarification with a chemical agent, usually phosphoric acid and calcium hydroxide with high speed spinning towards achieving the crystals [5].Physically, brown sugar is coarser than white sugar crystals and this property makes their products to be more natural and attractive aesthetically. Brown sugar generally retains some essential metals with the potential of supplying magnesium, calcium, potassium, and iron. [6], [7]. “The New York Times” reported that a teaspoon of brown sugar supplies just 0.02mg of iron and brown sugar retains between 5 -10 percent molasses [8]. Furthermore, suspending some fractions of molasses in the crystals of sugar makes it soft and more nutritious [9]. Brown sugar can as well qualify as a raw material in the production of various confectionery products such as bakery and sweetened beverages [10]. The necessities for sugary drinks, usually establish a rising demand from urban areas, where sweetened beverages are becoming more and more admired, and is expected to remain a driving force in sugar production alongside the value additions. [11]. White sugar crystals are 99.9 percent sucrose and they can further be ground into different particle sizes for use in household and other technical applications [12].Mixing crystals of white sugar with a range of molasses gives a spongy and a lumpy product as the quantity of molasses to be added may depend on the manufacturer requirements [13]. Nevertheless, there is a strong need and rationale to experimentally validate the differences between these two products as this paper adopted some selected physical and chemical parameters in the evaluation, assessment, and analysis of these two products comparatively in an aqueous system.

II. EXPERIMENTAL

I. Materials and Methods

Commercial brown and white sugars were purchased in a local market within Zaria metropolis. Distilled water, HI 9813-5 multimeter (TDS, pH, and electrical conductivity), 2100P turbidity meter and 100ml

Borosilicate beakers were used for the entire analysis.

II. Brown and white Sugar serial Solution

2, 4, 6, 8 and 10g of crushed brown sugar and the same white sugar were weighed accordingly and separately into 100ml distilled water (2g/100ml, 4g/100ml, 6g/100ml, 8g/100ml and 10g/100ml) in a clean and labeled 250ml beaker in both cases.

III. Physicochemical Analysis

Visual, pH, electrical conductivities, total dissolved solids, and turbidities were conducted on each of the samples.

III. RESULTS AND DISCUSSION

Table l. Selected properties of varying concentration of Brown sugar in water

Brown Sugar	2(g/100ml)	4 (g/100ml)	6(g/100ml)	8(g/100ml)	10(g/100ml)
Visual	Light yellow	Yellow	Light brown	Brown	Dark brown
pH	7.8	7.8	7.8	7.6	7.6
Electrical Conductivity (μS/cm)	0.23	0.53	0.63	0.93	1.04
TDS (ppm)	173	350	447	569	620
Turbidity (NTU)	65	126	169	213	266

Table ll. Selected properties of varying concentration of White sugar in water

White Sugar	2(g/100ml)	4 (g/100ml)	6(g/100ml)	8(g/100ml)	10(g/100ml)
Visual	Colourless	Colourless	Colourless	Colourless	Colourless
pH	6.4	6.6	7.2	7.3	7.4
Electrical Conductivity (μS/cm)	0	0	0	0	0.01
TDS (ppm)	4	6	6	7	15
Turbidity (NTU)	11	13	17	20	26

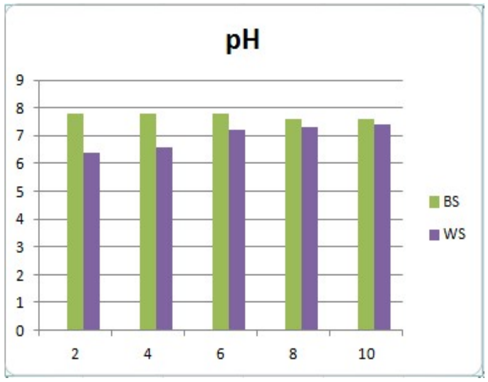

Figure I. pH values of brown and white sugars solutions

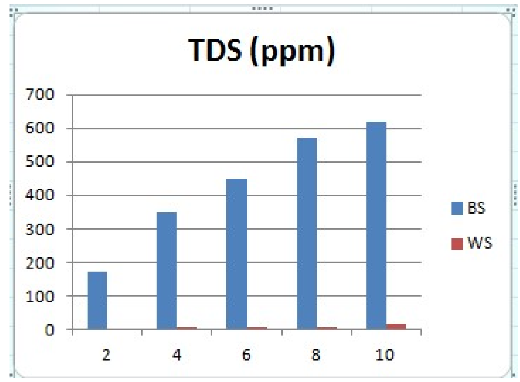

Figure III. Total dissolved solids in brown and white sugar solution

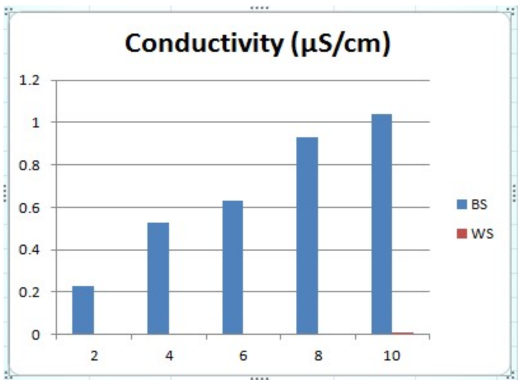

Figure II. Electrical conductivities brown and white sugar

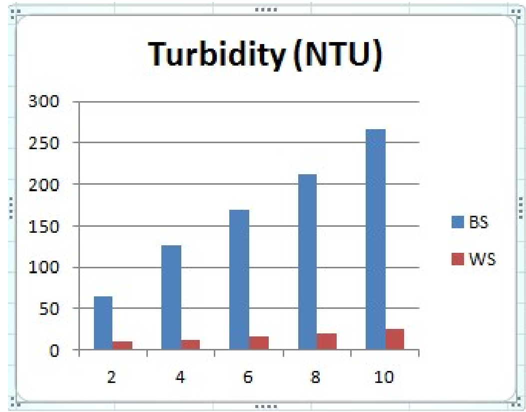

Figure IV. Turbidities of brown and white Sugar solutions

Table III. Analysis of variance between the varied pHs of the white and brown sugar solutions.

ANOVA: Single Factor								
DESCRIPTION					Alpha	0.05		
Groups	*Count*	*Sum*	*Mean*	*Variance*	*SS*	*Std Err*	*Lower*	*Upper*
pH.WS	5	34.9	6.98	0.202	0.808	0.146287	6.573841	7.386159
pH.BS	5	38.6	7.72	0.012	0.048	0.146287	7.313841	8.126159
ANOVA								
Sources	*SS*	*df*	*MS*	*F*	*P value*	*F crit*	*RMSSE*	*Omega Sq*
Between Groups	1.369	1	1.369	12.79439	0.007221	5.317655	1.599649	0.541166
Within Groups	0.856	8	0.107					
Total	2.225	9	0.247222					

Table IV. Analysis of variance between the varied Electrical conductivities of the white and brown sugar solutions

ANOVA: Single Factor								
DESCRIPTION					*Alpha*	*0.05*		
Groups	*Count*	*Sum*	*Mean*	*Variance*	*SS*	*Std Err*	*Lower*	*Upper*
E.C. WS	5	0.01	0.002	0.00002	0.00008	0.102391	-0.28228	0.286284
E.C. BS	5	3.36	0.672	0.10482	0.41928	0.102391	0.387716	0.956284
ANOVA								
Sources	*SS*	*df*	*MS*	*F*	*P value*	*F crit*	*RMSSE*	*Omega Sq*
Between Groups	1.12225	1	1.12225	21.40881	0.001695	5.317655	2.069242	0.671148
Within Groups	0.41936	8	0.05242					
Total	1.54161	9	0.17129					

Table V. Analysis of variance between the varied Total dissolved solids of the white and brown sugar solutions.

ANOVA: Single Factor								
DESCRIPTION					Alpha	0.05		
Groups	Count	Sum	Mean	Variance	SS	Std Err	Lower	Upper
TDS.WS	5	87	17.4	35.3	141.2	56.63126	-139.834	174.6336
TDS.BS	5	2159	431.8	32035.7	128142.8	56.63126	274.5664	589.0336
ANOVA								
Sources	SS	df	MS	F	P value	F crit	RMSSE	Omega Sq
Between Groups	429318.4	1	429318.4	26.773	0.000849	5.317655	2.314001	0.72046
Within Groups	128284	8	16035.5					
Total	557602.4	9	61955.82222					

Table VI. Analysis of variance between the varied Turbidities of the white and brown sugar solutions

ANOVA: Single Factor								
DESCRIPTION					Alpha	0.05		
Groups	Count	Sum	Mean	Variance	SS	Std Err	Lower	Upper
Turb.WS	5	38	7.6	18.3	73.2	24.53365	-60.5163	75.71633
Turb.BS	5	839	167.8	6000.7	24002.8	24.53365	99.68367	235.9163
ANOVA								
Sources	SS	df	MS	F	P value	F crit	RMSSE	Omega Sq
Between Groups	64160.1	1	64160.1	21.31919	0.001716	5.317655	2.064906	0.670176
Within Groups	24076	8	3009.5					
Total	88236.1	9	9804.011					

Both Table I and II discloses the outcome for the four parameters that were adopted for the two sugar samples. Figure I, II, III, and IV are the bar charts of the same selected parameters which clearly illustrated the differences between these two forms of sugar products. Additionally, single-factor ANOVA was applied in establishing the significant differences with the pH, electrical conductivities, turbidities and total dissolved solids of the two sample solutions. Table III, IV, V and VI are the one factor ANOVA of pH, electrical conductivities, total dissolved solids and turbidities of a white and brown sugar solution with varying concentrations. The mean values of pH, electrical conductivities, total dissolved solids and turbidities of the white and brown sugars are 6.98, 0.002uS/cm, 17.4ppm,7.6 NTU and 7.72, 0.672uS/cm, 431.8ppm and 167.8 NTU respectively. Furthermore, the ANOVA tables explicitly expressed the significant differences with respect to the four selected parameters on each of these sugar products. pHs was with a statistical F value of 12.79439 higher than the critical F value of 5.317655; electrical conductivities with statistical value F of 21.40881 and higher than the critical F value of 5.317655; total dissolved solids was with statistical value F of 26.773 and higher than the critical F value of 5.317655 and for turbidities with statistical value F of 21.31919 and higher than the critical F value of 5.317655.

IV. CONCLUSION

Despite the organoleptic, hygroscopic and physical characteristics of brown sugar, it has been established that more minerals (electrolyte) are present compared to refined and processed white sugar. Molasses is an active organic component of brown, unrefined sugar. However, for the fact that calcium, potassium, iron, and magnesium are present in trace amounts according to previous research, brown sugar still maintains meaningful and significant features against the white conventional form. Logically, these observations could perhaps suggest the needs, applications, and benefits of brown sugar. As well, sugar manufacturers and food scientists can be technically creative with this form of sugar just by taking advantage of its chemical (minerals) compositions and value addition with other nutritional products. Efforts and awareness with the benefits of taking brown sugar ought to be intensified among the sugar producers and the stakeholders in this industry. Brown sugar is affirmed to be healthier and perhaps will the expectation of controlling diabetes and cutting down the resources required in processing raw sugar with the applications of synthetic chemical agent (calcium hydroxide and phosphoric acid).

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