THE OPEN PAN SUGAR OPTION IN SUDAN

Mahmoud Mansour Osman*

***Food department, Industrial Research and Consultancy Center IRCC P.O.Box 268, Khartoum, Sudan**

ABSTRACT

The objective of this study is to investigate the technical and application aspects of the open pan sugar OPS in the Sudan. Therefore, pilot scale experimental plant has been installed to manufacture OPS sugar and OP syrup from indigenous sugar cane. The pilot plant consisted of small roll mills driven by mechanical engines and open boiling pans to concentrate the juice using bagasse as thermal energy source. OPS confectionery products were made and quality control as well as, sensory evaluation tests was conducted for the produced products .As quality references two Indian OPS samples were analyzed, while local made commercial syrup samples were also analyzed as quality reference for OP syrup. The results showed that, the sensory evaluation of the OPS sugar varied between fair and good at (p=0.05). The comparison results revealed that,, the main quality parameters of the OPS and the Indian samples one and two consequently showed sucrose 72.8% ,invert sugars 10.2 %,dry solids 93 %, color 15000 ICUMCA and microbial count moulds and yeast M&Y 10^3,while the Indian sample one showed 72.8% ,10.2%,93.1% ,15000 ICUMCA,10^3 and Indian sample two showed78.5% 5,5.2%,97.1%, 14500, 10^3. By comparing the results the dry solids of the Indian sample two showed higher significant difference at (p=0.05).On the other hand, the OP syrup represented sucrose 65%, invt. Sugars 9.75%, dry solids 74.7%, color 11100 ICUMCA, M&Y 10 ^{3}. The comparison between the OP syrup and the tested commercial syrups revealed significant difference. The sensory evaluation of the OPS made confectionery products, showed that, at (p=0.05) excellent results were given by the dry sweet, fair results by pasta and cake and poor results by jam. Regarding the shelf life of those OPS products after 48 h it appeared that the moulds and yeast M&Y growth showed 10 of the hard sweet, 10^6 of the jam, pasta and cake, while the permitted count of those products is less than 10^5 -10^6 .This attributed to the fact that the shelf life of those products is proportional to the moisture contents.

Key words: Open pan sugar (OPS), Sensory evaluation, Options, Sugar Colour.

INTRODUCTION

Regarding the population increase in the Sudan versus sugar supply it appears that there is a gap between the production and supply. According to the report prepared by the Sudanese ministry of finance and national economy the actual sugar local demand per capita is 80- 90 kg/day representing total annual of 1600 tons. While, the local production is 800 thousand tons/year that means a gap of 800 tons annually. This gap corresponding 40-45 kg per day per capita, which is now partially covered by import? Indeed, the population increase at a rate of 2.8% will keep consistent predicted gap in case of no rational polices. To medicate the problem the government implications and strategies now including, improvement of the existing sugar factories efficiency to achieve the designed capacity which is 1200 thousand tons/year ,by the year 2019, second to accelerate the execution of the proposed sugar projects (Fifth Economic Implementation Program for ,2015- 2019). However, one of the white sugar alternatives which is widely produced by the Third World countries are the open pan sugar and syrup abbreviated OPS and OP syrup. The published statistic data of sugar production, usually considering the refined sugar produced by large scale technology and rarely mentioning the sugar cane sweet products which are made by primary and medium level technologies, irrespective to that, those

products are produced worldwide and consumed under different local names and brands. In India they are called jaggery and gur while in South America known as panela (Raphael, 1983)). Despite the local names of OPS, usually their common features are that during the process, the sugar crystals left to coagulate and not separated from the molasses, so the final color of OPS is dark brown due to adhered molasses. Briefly, the most common process of OPS comprises, cane crushing to extract the juice, addition of hydrated lime solution to maintain the juice pH to 8-8.5, at this stage coagulation and precipitation of mud and some soluble impurities occurs. Then the clear juice is decanted and concentrated in open pans. The concentrated syrup is either been in liquid form for consumption, or further evaporated to dryness to form solid brown sugar .The modified type of OPS (Open pan Sugar) is known in India as Khandsari and it is produced by the clarification of the sugar cane juice, and sulfutation of the juice (addition of SO_2 gas) to improve the color and enhancing microbial inhibition and then concentration of the juice followed by the centrifugation to separate the crystals from the molasses (Spencer and Meade,1945). With reference to Open pan syrups they are used in many countries in the confectionery blends. On the same context, USA studies indicated that since the year 2000 the demand of caloric sweeteners decreased except that of edible syrups for direct consumption and confectionery blends (U.S. sugar supply and use 2004). Open pan sugar and syrup has no certain standard specification, their acceptability depends on their appearance, taste and hygiene. This study is an endeavor to introduce other alternatives more technology simple and cheaper cost technology than the large scale sugar refineries. This study investigated the processing and quality aspects as well as the acceptability of the OPS and their confectionaries by the local consumer.

Materials and Methods

Experimental work

On pilot scale an open pan sugar (OPS) batch was produced by cane crushing to extract the juice, juice reception in the reaction tank, juice liming by addition of food grade hydrated lime brought from Kenana Sugar Co.Ltd. The lime was added to maintain the juice PH to 8-8.5 .The treated juice was agitated for 15 min and left for 2h to precipitate the mud .the formed mud was then cautiously decanted through the bottom of the reaction tank. The clear juice was then decanted by gravity to the open boiling pan. The juice was concentrated to total solids of 95%.The concentrated mass left to dry by natural cooling. By the same process a syrup batch with a concentration of 70% was made. The produced brown sugar and the syrup were analyzed. For comparison two samples of Indian made OPS brought from Hydra bad were also analyzed. While five locally manufactured commercial syrup samples were purchased from the local market were analyzed for reference. Those syrups included Kenana amber, Kenana syrup, Modhish syrup, Said syrup and Tate &Lyle syrup.

By using the produced brown sugar and the syrup, batches of different confectioneries were made without addition of preservatives. The produced products were:

- Hard sweets.

- Pumpkin's jam.

- Bakeries including pasta and cakes.

Sensory evaluation,

The sensory evaluation for the produced products hard sweets , pumpkins jam and the bakery products was carried out by scoring procedure described by Avanta (2010),that, the characteristics of the tested products , taste ,texture, color, appearance and overall acceptability were assessed by 10 members semi trained panelists .According to table.3 the numbers in the first rank represented the highest limit of the scale , 5 (extremely like) and 1 (extremely dislike) or unaccepted ,while the points in the below ranks described the means of the score

reflecting the feelings of the panelists out of 5 which means excellent while 4 good , 3 fair ,2 poor and 1 extremely dislike. Group Variation among treatments were statistically analyzed using .As well as the shelf life of the made products was determined during the storage of the batches at room temperature

Reducing sugars and sucrose were determined by the method described by (ICUMSA, 1970).

Moisture was determined by the method described by (ICUMCA, 1974).

The total dry solids were determined gravimetrically after moisture retarding.

The ash was determined by weighing approximately 3g of the sample in weighed porcelain crucible and burnt in a muffle furnace at 550± 5 to gray color. The ash weight was then calculated by subtracting the weight of the empty crucible from the total weight of the crucible and sample.

Color, the color of the samples was determined according to (ICUMCA1994) method, N.Gs 2/3-9 using automatic digital sucroscan 3122/0605(MAARC LABS.P.V.LTD) at wave length of 420 nm

Shelf life determination

The microbial growth was determined after 48h storage at 25C° by the procedure described by FAO Food and Agricultural Organization manual of food quality control (1992) following the methods that, for the OPS syrup and sugar the growth of moulds and yeast was tested by PDA potato dextrose agar method, while the dry sweet, jam and the bakery products were tested by APC aerobic plate count agar method. As reference, the results were compared with the Sudanese Standards SDS No.519 for brown sugar, syrups and jams, SDS No.2050 for dry sweets and SDS No. 2017 for bakeries (Sudanese microbiological standards for food, 2001).

Results and Discussion

(Table1) representing the result of the sensory evaluation provided by the method described previously. The evaluation comprised taste, flavor, color, appearance and texture. BY providing the test of significant at (P= 0.05) the OPS sugar as per panelists showed good taste, good flavor and texture, while color, appearance, showed poor results.

Table -1 Results of the sensory evaluation of OPS sugar and OPS syrup.

Product	Taste	Flavor	Texture	color	Appearance	acceptability
Full mark	5^{a}	5^{a}	5^{a}	5^{a}	5^{a}	5^{a}
OPS sugar	4^{b}	4^{a}	4^{b}	2^{b}	2^{b}	3^{b}
OPS syrup	3^{b}	3^{b}	3^{b}	2^{b}	3^{b}	3^{b}
± SD	1.0	1.0	1.0	1.75	2.54	.89

Mean values having different superscript letters in columns are significantly different at (P= 0.05)

As well as acceptability showed fair result. This attributed to the fact that due to the high boiling temperature during the concentration of the sugar cane juice to OPS, part of the sugar caramelizes and forms caramels taste, meanwhile the color of the boiled mass gets darker (Spencer, and Meade, 1945). In the sugar refineries caramels formation and sugar browning are beyond the low quality of the sugar. To avoid the sugar browning, the refineries under go sucrose crystallization under reduced pressure and consequently low boiling point. The sensory evaluation of the OPS syrup showed fair results, except the color which showed dark brown. (Table 2) Showing the comparison results of the local made OPS sugar with two OPS Indian samples.

Table-2 Analytical results of the produced OPS sugar samples compared with Indian OPS samples

Analysis %	OPS	Indian sample.1. (OPS)	Indian sample.2. (OPS)	± SD
Sucrose	72.8[a]	72.8[a]	78.5 [b]	3.2
Invt. Sugars	10.2 [a]	10.2 [a]	5.2 [b]	3
Dry solids	93 [a]	93.1 [a]	97.1 [b]	1.8
Moisture	7 [a]	6.9 [a]	2.9 [b]	1.3
Ash	2.2 [a]	2.2 [a]	2.9 [b]	1.4
Color (ICUMCA)	15000 [a]	15000 [a]	14500 [a]	360
Microbial growth(48h) M&Y	10^{3} (a)	10^{3} (a)	10^{3} (a)	0

Mean values having different superscript letters in rows are significantly different at (P= 0.05)

The sucrose content of the local OPS sample showed insignificant difference compared with Indian sample 1, while significant compared with Indian sample 2 and the later showed competitively higher sucrose. The inverted sugars showed insignificant difference between OPS sample and Indian sample 1 while, the Indian sample 2 showed significant lower reading. According to (Table 2) the same manner of the significant test was showed by the dry solids, moisture and ash of the compared samples. The highest color reading was shown by the OPS sample which is significantly differ from the Indian samples 1 and 2, the later showed lower color samples. At 97% confidence level and correlation coefficient between (+1,-1) strong positive correlation between the sucrose contents and the dry solids of the tested samples was identified while negative correlation between the sucrose and the inverted sugars was identified, the later relation could be due to gradual conversion of sucrose to inverted sugar, associated with formation of hydroxymethylfurfural (H.M.F) and consequent browning of the boiled sugar (Spencer and Meade, 1945). The microbial reading gave insignificant difference between the examined OPS samples. With reference to (Table 3)the highest sucrose

contents were shown by the OPS syrup while the sucrose contents of the commercial syrups show lower sucrose and higher inverted sugars comparatively.

Table.3 .Analytical results of the produced OPS syrup compared with the

Analysis %	Syrup (OPS)	Tate& Lyle	K(amber)	K(treacle)	S(syrup)	M(syrup)	±SD
Sucrose	65^{b}	31.8^{a}	32.48^{a}	33.56^{a}	34.22^{a}	33.45^{a}	6.6
Invt. sugar	9.75^{b}	48.33^{a}	48.33^{a}	47.35^{a}	46.38^{a}	45.55^{a}	19.2
Dry solids	74.7^{b}	81^{a}	82^{a}	81^{a}	81^{a}	82.6^{a}	4.7
Moisture	30^{b}	19^{a}	18^{a}	19^{a}	19^{a}	17.4^{a}	4.7
Ash	5^{a}	5.57^{a}	5.6^{a}	7.52^{b}	7.57^{b}	6.58^{ca}	1.03
Total sugars	70	80.13^{a}	80.81^{a}	80.81^{a}	80.6^{a}	79^{a}	2.3
Purity	94^{b}	99^{a}	98.5^{a}	99.7^{a}	99.5^{a}	95.6^{b}	2.3
Color	11100^{b}	2000^{a}	2400^{a}	9179^{cb}	2212^{a}	1893^{a}	4.8×10^{2}
Microbial growth (48h) M &Y	$10^{3\,b}$	$10^{2\,a}$	$10^{2\,a}$	$10^{2\,a}$	$10^{2\,a}$	$10^{2\,a}$	3.6×10^{2}

Mean values having different superscript letters in rows are significantly different at (P=0.05)

This due to the synthetic inversion of the sucrose by addition of dilute hydrochloric acid or citric acid during manufacturing of the commercial syrups to prevent sucrose crystallization after packing as well to increase the sweetness due to production of fructose which is sweeter than glucose. Significant color difference was shown by the OPS and Kenana treacle both showed highest color value consequently compared with the other syrups. With reference to (Table 3), the commercial syrups showed insignificant difference between their colors. The difference in color and purity of the syrups depends on the purity of the primary liquor that the syrup is made of. In order to improve the color of the syrup various purification techniques are available to improve the purity. Back to table 3 the higest purities were shown by Kenana treacle 99.7%, Saeed 99.54% ,Tate&Lyle 99%,Kenana amber 98.5%, Modhish syrup 95.6%and OPS 94% consequently .Those commercial syrups are made of either white sugar, or purified intermediate sugar products like raw sugar and refinery molasses, while OPS is made of low purity semi clarified cane juice. (Table 4) shows the sensory evaluation of the OPS made products.

Tale .4. Sensory evaluation of the products made from OPS

Product	TASTE	Flavor	Texture	color	Appearance	Acceptability
Full mark	5 [a]	5 [a]	5 [a]	5 [a]	5 [a]	5 [a]
Dry sweet	5 [a]	4 [a]	4 [a]	4 [a]	4 [a]	4 [a]
Jam	3 [b]	2 [b]	2 [b]	2 [b]	2 [b]	2 [b]
Pasta	3 [b]	3 [b]	3 [b]	3 [b]	3[b]	3[b]
Cakes	4 [a]	3 [b]	3 [b]	3 [b]	3 [b]	3 [b]

Mean values having superscript letters in columns are significantly different at (P= 0.05)

Excellent results were shown by the dry sweet, jam results between fair and poor, pasta presented fair results. While the cakes represented good and fair results. Regarding the composition and characteristic of the OPS sugar, caramels taste and odor of the OPS sugar comprises the acceptability measures for the OPS made products, both are desired in the dry sweets while the molasses odor is not desired in the cake. Sensory evaluation of jam varied between fair and poor while of pasta is fair. (Table 5) representing the microbial growth on the OPS made products after 48h incubation period. As proved by preceded studies that the microbial count and growth rate on the sugar products is opposite proportional to the sugar concentration and purity, while direct proportional to the moisture contents and the quantity of the non sugars in the product (Spencer and Meade, 1945). OPS is consisting of molasses which contains organic and inorganic materials consequently, organic acids, nitrogenous substances and minerals, wherein nutrients for the microbial growth. The hard sweets showed only 10 while the cake and pasta showed 10^6 which are higher than the permitted level by SDS No 519 which representing 10^4-10^5 and this could be due to their comparatively higher moisture than that of the dry sweets.

Table-5 Shelf life of the Products made from OPS versus the moisture contents

Type of OPS_Product	Hard sweet	Pumpkin's jam	Pasta &Cakes
Plate count M&Y (48h)	10	10^6	10^6
Permitted microbial level	10^4-10^5	10^4-10^5	10^4-10^5
Moisture%	7%	30%	20- 15%

Mean values having superscript letters in columns are significantly different at (P= 0.05)

Conclusion and Recommendations

The data of this study concerning sugar consumption and demand, revealed that, in the future the gap in the sugar supply is going to increase therefore, like other third world countries one of implications to be studied and incorporated in the national sugar production strategy is the OPS production option. To realize this, series of investigations and trials are required including, the acceptance level of the OPS products by the local consumer, second dissemination of awareness among the local sugar confectioneries, how to manufacture acceptable products. This piece of work was an endeavor to produce local OPS and provide sensory and physiochemical evaluations including the OPS themselves and their confectioneries. Although the results revealed fair parameters, these study recommending intensive techno- economic and social investigations, before deciding. Preceded studies concerning the local OPS, sugar syrups and their confectionaries were conducted by Hashim *et al.* (2009), Mahmoud (991) and Mahmoud (1990) who agreed that OPS could partially contribute to solve the problem.

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