

Evaluation of Traditional Production Process of Rock Candy and Optimization of Sucrose Crystallization (Part 1)

A. Gholamhosseinpour, M.J. Varidi, M. Elahi and F. Shahidi

Department of Food Science and Technology, Ferdowsi University of Mashhad (FUM),
P.O. Box. 91775-1163, Mashhad, Iran

Abstract: The rock candy is the grown sucrose crystal which its thickness fluctuating from 3 to 30 mm. In this process, the large sucrose crystals have been produced by cooling the supersaturated solution. The mentioned method has not changed up to now and in these years many efforts were done to optimize the production process. The production of rock Candy through a scientific method is part of cooling crystallization process, which is affected by supersaturation and crystallization parameters. These parameters should be born in mind to increase the yield and the growth sucrose crystals. This research carried out in two phases. In first phase (this paper), the traditional production process of syrup studied by doing required experiments at different stages in traditional manufacturing workshop and then its different properties was compared with the experimental syrup. The physiochemical tests consist of pH, color and invert sugar percentage done on all of the traditional and experimental samples. The results showed that all of the traditional syrup properties are more critical than that experimental sample Because of the disproportion in mixing ratio of water, sugar and wastage rock candy and evaporating of water surplus amount that it overly caused in required time and heat of process.

Key words: Syrup • Supersaturation • Temperature • Invert sugar • Color • pH

INTRODUCTION

Sugar is used in various food industries such as dairy, confectionary, canning, bakery, etc. The rock candy is one of the particular products of sugar. According to historical document and literature, the rock candy has its origins in India and Persia. It named Nabat and Mishri in mentioned countries, respectively. The rock candy has medical value besides confectionery uses. The rock candy is grown sucrose crystals that it crystallized by cooling [1]. Crystallization can only take place in solutions, which are supersaturated. Above the supersaturated line crystals from spontaneously and rapidly, without external initiating action [2]. Mainly there are two traditional and industrial ways in order to rock candy production. The efficiency of traditional way is not so high [1]. The rock candy is usually produced in the manner of stagnant, whereas the industrial type is manufactured from either still or continuous ways. The purpose of this research is investigation of present conditions of rock candy traditional production, fault finding and optimization of manufacture process based on achieved results

MATERIALS AND METHODS

In the first phase of this paper, the preparation of syrup in traditional way that it used in confectionary work shops was studied and then its different properties was compared with the experimental syrup.

Traditional Method: In this way, at first water was heated in cooking pot to 50-60°C then the wastage rock candy was gradually added up so that the complete dissolving might carry out by agitating and temperature increase. Sugar was also added up after the relatively of wastage rock candy. Next to achievement of homogeneous syrup for separation of probable impurities produced syrup was filtered then flowed into final cooking pot. In this cooking stage the syrup was concentrated to required brix with temperature increase. Then the syrup was incubated in order to crystallization for 24h in incubator. Primary materials in traditional way were consisted of sugar, water and wastage rock candy. Obtained syrup from dissolving of wastage rock candy in water, obtained syrup from mixing of sugar in former syrup, the syrup before first

Table 1: Various characteristics of primary syrup next to the complete dissolving of sugar

Brix	Time (min)	Dissolving temperature(°C)	Polarity	pH	Invert sugar percentage	Color
80.85	13	104	80.69	7.9	0.018	27.3
81.97	15	104	81.81	7.88	0.019	30.96
82.80	20	105	82.63	7.88	0.020	34.69
82.97	23	106	82.80	7.87	0.021	36.63
83.83	23	106	83.66	7.85	0.023	38.23
83.90	25	106	83.73	7.84	0.023	38.11
84.72	25	107	84.55	7.86	0.023	43.64
84.75	25	106	84.58	7.85	0.023	39.67
85.60	27	107	85.43	7.88	0.025	45.12
85.65	29	108	85.48	7.86	0.026	49.04
86.48	33	113	86.31	7.88	0.028	56.11
87.25	50	114	87.07	7.25	0.058	69.09

soda adding, the syrup after first soda adding and before filtering, the syrup after filtering and before second soda adding and the final syrup (cooking-end syrup) after second soda adding formed intermediates. The produced effluent and rock candy also involved final products. Intermediates are pluralized because of long process and adding subsidiary materials such as soda and blankit (sodium hydrosulphite). The main syrup is used white sugar production because of increasing in its color and invert sugar amount [3].

Experimental Method: Mainly defect in traditional way is disproportion in mixing ratio of water, sugar and wastage rock candy. That it has intensively negative effect on the aforesaid parameters. The use of excessive amounts of water in the process and evaporating of its surplus amount are overly caused in required time and heat of process that it will be led to the increase in amount of color and invert sugar and decrease in pH, sucrose and crystallization yield. Therefore, this research was based on the temperature and water to sugar ratio. The required amount of sugar and water was exactly weighted based on needed brix (Table1), then water was poured into a sauce pan and sugar was gradually added to it. After relative heating, in order that sugar could dissolve completely in water by agitating and continuation of the heating process. Brix of the syrup was continuously measured followed by defoaming and making a full homogeneous solution, so that heating operation could immediately stop. In this way the experimental samples consist of water and sugar as primary material and cooking-end syrup as intermediate. The carried out tests on samples consisted of color, pH and invert sugar percentage which performed according to standard's instructions [4,5].

RESULTS AND DISCUSSION

Syrup: Various characteristics of primary syrup next to the complete dissolving of sugar have been shown in Table 1.

Dissolving Time: The required temperature and time for complete dissolving are increased with brix. As Fig.1 shows in the production of primary syrup, the more brix needs the more process time [1]. The necessary time for temperature increase to 106°C is not so long while the temperature increase from 107 to 114°C needs longer time. The reason is that the thermal conductivity decrease caused by brix increase.

By comparison produced syrup in traditional and experimental ways notable difference were observed so in order to reach Bx=85.17 needed 115°C, 25 min and 106°C, 25min, respectively (Fig.2). The main cause of this difference is the overuse of water in traditional way that it has require more time for evaporation and excision of surplus water from mentioned syrup. Furthermore the use of sizable wastage rock candy and cold sugar addition in the middle of cooking operation increase time of process.

pH: The higher the solving time and temperature, the lower pH because of sucrose hydrolysis. Hydrolysis of sucrose leads to production of lactic and formic acid which will be caused the more loss of pH [1]. In

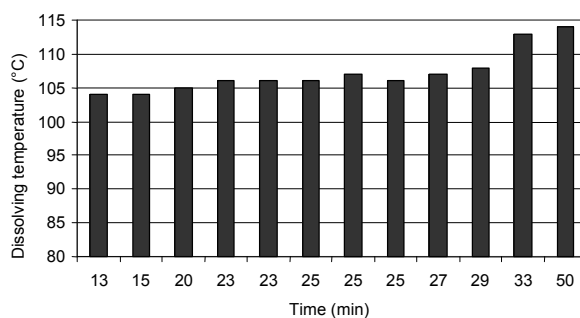


Fig. 1: Variation of dissolving temperature with time in the different syrup

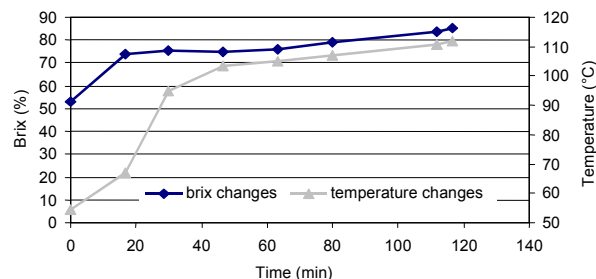


Fig. 2: Variation of temperature and brix with time

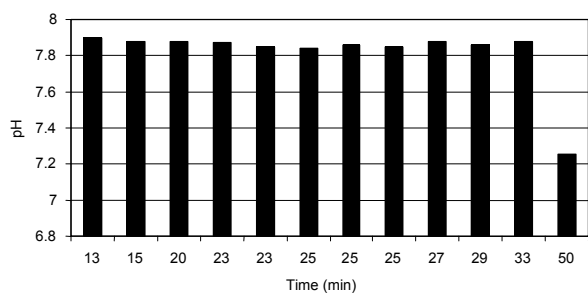


Fig. 3: Variation of pH with time in the various syrups.

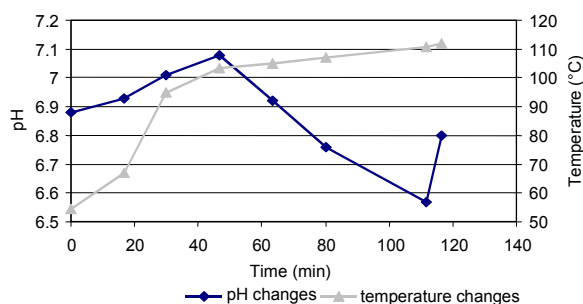


Fig. 4: Variation of pH and temperature with time

experimental production, various syrups differed significantly in pH in the brix range of 80.85-86.48 but the more Increase in brix is resulted in the more loss in pH, that its reason is the use of higher temperature for a long time (Fig.3).

The loss of pH in traditional production is more than that of experimental production because the wastage rock candy and effluent are used in the former which create the first pH decrease in syrup. Also in this way the used temperatures and time are critical. Fig.4 shows variation of pH with time. The reason of the increase in pH is first adding soda and sugar and second adding soda in the beginning and ending of cooking operation, respectively.

Invert Sugar Percentage: Increasing in the brix will be caused an increase in the temperature and time, therefore, sucrose will be affected by high temperature for a long time and this means more hydrolysis of sucrose. In experimental production the invert sugar percentage is not so high that is cause of the use of sugar as only primary material and low temperature and time. Nevertheless in critical brix (SS=1.6) invert sugar amount is increased (Fig.5).

The rate of sucrose hydrolysis in traditional way is more than that in experimental way because of longer time, the higher temperature and the use of wastage rock candy and effluent[8].

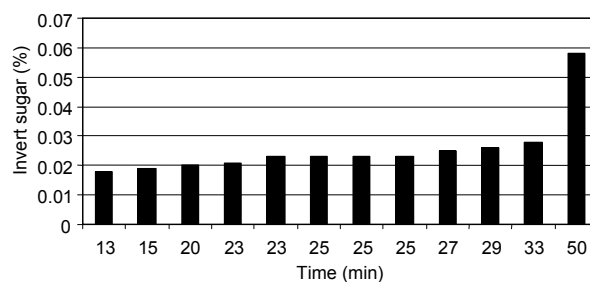


Fig. 5: Variation of invert sugar percentage with time in the various syrups

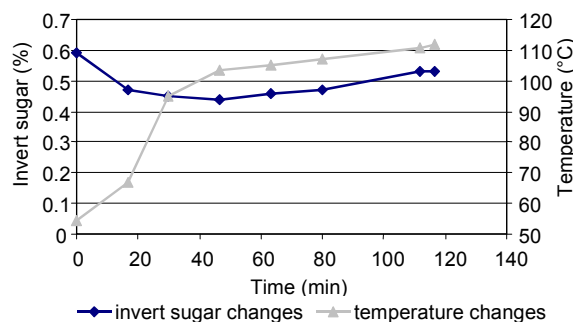


Fig. 6: Variation of invert sugar percentage and temperature with time

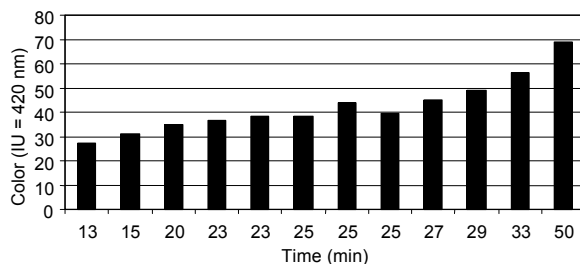


Fig. 7: Variation of color with time in the various syrups

Color: Sucrose hydrolysis causes color creating. To increase color in syrup, time and temperature are two main factors. For instant, the increase in the color amount for diluted syrup at 85°C is equal 40 ICUMSA units /h ($\lambda=560\text{nm}$) [6]. In high temperature the effective factors on color amount (temperature, invert sugar percentage, brix, pH and amino acids content), enhance the color formation [7]. The more brix, the more sucrose inversion because syrup will stay in high temperature for longer time in order to sugar is completely dissolved. The syrup is become acidic with sucrose hydrolysis, therefore, the amount of glucose and fructose sugars are raised. In such conditions, HMF (hydroxy methyl furfural), as effective factor on color will be produced, especially from fructose. According to Fig.7 the amount of color has been increased with brix and time [1].

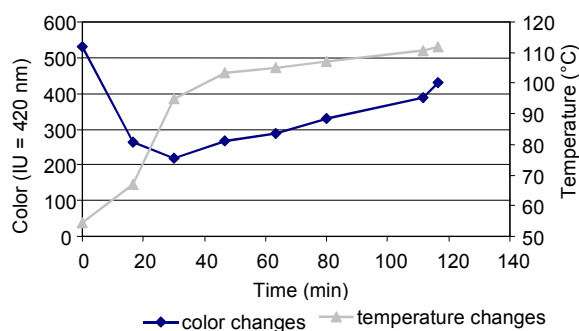


Fig. 8: Variation of color and temperature with time

Since time and temperature in traditional way more than that in experimentally way, thus produced syrup from former is more turbid [8]. As shown in fig.8 in the beginning of process, color decreases because of adding sugar and soda during operation. The increase in the syrup temperature will causes ascending increase of color, because of sucrose inversion.

CONCLUSIONS

According to results, the use of traditional way is caused the negative effect in the production process. Since in sucrose crystallization, each of non sugar materials are caused decreasing in production yield and high loss, thus it must be inhibited from sucrose hydrolysis, especially by the control of the consumed water amount.

REFERENCES

1. Van der Poel, P.W. and H. Schiweck, 1998. Sugar technology beet and cane sugar manufacture pp: 70-94, 163-198, 649-818 & 966-967. Verlay Albert Bartens Pub.
2. Earle, R.L., 1983. Unit operations in food processing (2nd ed., Chapter 9) The New Zealand Institute of Food Science & Technology Pub.
3. Van der Poel, P.W., H. Schiweck and T. Schwartz, 2000. Zuckertechnologie, pp: 1001-1008.
4. International commission for uniform methods of sugar analysis, Methods Book (1994).
5. Reinefeld, D. and F. Schneider, 1978. Analytische Betriebskontrolle der Zuckerindustrie. Verlag Dr. Albert Bartens. Berlin.
6. Dobryzki, J., L. Ryngajlo and Gazeta Cukr 48. 1990. 101-104, Adsorbentien als inhibitoren beim farbanstieg von säften. Zuckerindndustrie, 116. 1991. Nr. 2, pp: 164.
7. Hage, A.G. and W. Mauch, 1994. Kinetics of color development in sucrose solution at high temperatures. Zuckerindustrie 119, Nr. 5, pp: 420.
8. Imming, R., K.M. Bliesener and K. Buchholz, 1994. The fundamental chemistry of colour formation in highly concentrated sucrose solution. Zuckerindustrie, 119, Nr. 11, pp: 915-919.