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

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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

Sugars are 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 According to historical document and literature, the rock candy has its origins in India and Persia.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 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 agitation 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 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

<table>
<thead>
<tr>
<th>Brix</th>
<th>Time (min)</th>
<th>Dissolving temperature(°C)</th>
<th>Polarity</th>
<th>pH</th>
<th>Invert sugar percentage</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>80.85</td>
<td>13</td>
<td>104</td>
<td>80.69</td>
<td>7.9</td>
<td>0.018</td>
<td>27.3</td>
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<tr>
<td>81.97</td>
<td>15</td>
<td>104</td>
<td>81.81</td>
<td>7.88</td>
<td>0.019</td>
<td>30.96</td>
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<tr>
<td>82.80</td>
<td>20</td>
<td>105</td>
<td>82.63</td>
<td>7.88</td>
<td>0.020</td>
<td>34.69</td>
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<tr>
<td>82.97</td>
<td>23</td>
<td>106</td>
<td>82.80</td>
<td>7.87</td>
<td>0.021</td>
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<tr>
<td>83.83</td>
<td>23</td>
<td>106</td>
<td>83.66</td>
<td>7.85</td>
<td>0.023</td>
<td>38.23</td>
</tr>
<tr>
<td>83.90</td>
<td>25</td>
<td>106</td>
<td>83.73</td>
<td>7.84</td>
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<td>38.11</td>
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<tr>
<td>84.72</td>
<td>25</td>
<td>107</td>
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<td>7.86</td>
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<td>50</td>
<td>114</td>
<td>87.07</td>
<td>7.25</td>
<td>0.058</td>
<td>69.09</td>
</tr>
</tbody>
</table>

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, 25 min, 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].

![Fig. 1: Variation of dissolving temperature with time in the different syrup](image1)

![Fig. 2: Variation of temperature and brix with time](image2)
Fig. 3: Variation of pH with time in the various syrups.

Fig. 4: Variation of pH and temperature with time in 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].

**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 ($\lambda=560$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 cause 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