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HAZARD ANALYSIS AND CRITICAL CONTROL POINTS SYSTEM OPTIMIZATION IN A GLUCOSE SYRUP FACTORY

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Abstract

The glucose syrup is a product obtained from starch slurry through hydrolysis processes. The hazard analysis and critical control points is a management system which aims to assure the safety of the food products by the identification, controlling and prevention of microbiological, chemical and physical hazards. Even if the production process of the glucose syrup is aggressive and unfavourable to the multiplication of microorganisms, the food safety hazards still exist. This paper aims to review the international literature and the general guidelines of food safety assurance in order to optimize the HACCP system already implemented in a glucose syrup factory. Several control and critical control points were identified and for each one the specific monitoring procedure was elaborated. Also, several preliminary programs were identified and centralized in order to prevent the occurrence of hazards.

Key words: glucose syrup, HACCP, food safety

Introduction

Hazard analysis and critical control points system is an “essential element” in the production process of any food product and it should be guided by specific scientific research in order to be efficient for the intended use of the respective product. The glucose syrup is a food product which offers alternative functional properties to sugar as well as economic benefits (Wiley & Sons, 2010). It is obtained through hydrolysis of starch, the process being controlled by measuring the amount of reducing sugars, named dextrose equivalent (DE). Taking into account the DE-value, the glucose syrup can be divided in several types with different properties and applications. The sugar confectionery industry uses glucose syrups with 42 DE and 68 DE, the latter being a direct replacer for inverted sugar syrup (Edwards, 2000). This is the case also for the soft drinks industry, various types of glucose syrups being used in certain “healthy” soft drinks (Mitchell, 1990). The glucose syrup is also used in the fermentation industry as a supplement (D'Amore *et al*., 1989, Piddocke *et al.*, 2009), in sport drinks to stimulate water absorption (Mettler *et al.*, 2006) and to provide natural energy, in ice cream (Silva Junior & Lannes, 2011) and jams (Javanmard & Endan, 2010).

Materials and methods

In the international literature there are several research papers which discuss topics such as difficulties and barriers for implementing HACCP system (Baş *et al.*, 2007), factors which affect the food safety management system (Sampers *et al.*, 2012), different tools able to ease the evaluating risk level of hazards (Ryu *et al.*, 2013) and even models of the HACCP implementation in several food industries.

The HACCP study followed the tasks included in the seven principles of the HACCP system described in the second edition of the joint FAO/WHO Food Standards Programme Codex Alimentarius Commission, taking into account the most recent research from literature. The steps, the specific activities and the possible improvements for each of them are presented in Table 1.

Table 1. Application of the HACCP program in the glucose syrup production process

Task according to FAO	Activity description	Improvements
Assemble HACCP Team	It is primordial to first establish a multidisciplinary team which can be able to develop an effective HACCP plan.	
Describe Product and Identify Intended Use	The glucose syrup is a product obtained by acid hydrolysis or acid and enzymatic hydrolysis of starch slurry and it is used as raw material in the food industry.	Each product was described in detail in internal product data sheets, taking into account their application in the food industry.
Construct Flow Diagram; On-site Confirmation	Every operation from the flow diagram was analysed considering also the preceding and following steps and verified in the factory.	The flow diagram was completed with the mixing operations and recipients washing.
List all Potential Hazards Conduct a Hazard Analysis Consider Control Measures	The food safety team conducted the hazard analysis by centralizing all the steps mentioned in the diagram flow, the hazards that may be reasonably expected to occur at each step (physical, chemical, microbiological), the gravity, the frequency, the hazard class and the control measurements for each hazard (Chira, 2010).	The specific microbiological hazards presented in Table 3 were taken into consideration, while the chemical and physical ones remained as previously determined.
Determine CCPs	The critical control points were identified using the decision tree presented by FAO/WHO, considering only the steps which were identified to have the risk class 2, 3 or 4 (Chira, 2010).	A previous critical control point, the temperature from the first concentration column, was re-evaluated and transformed into a control point. A new critical control point was identified as the packaging operation and marked on the flow diagram.
Establish a Monitoring System and corrective actions for each CCP	The monitoring system was developed for each CCP by setting the critical limits to be observable and measurable (Chira, 2005). The corrective actions were established.	The monitoring system for the new critical control point, the corrective actions and the responsible person for each action are presented in Table 4.
Establish Verification Procedures, Documentation and Record Keeping	The verification procedures were established using the literature, sampling plans, analysis results, corrective actions in order to demonstrate that the HACCP plan is corectly functioning.	A verification procedure was developed able to establish if the HACCP plan is properly functioning taking into account the analysis results and the records of the passed year.

Results and discussion

The first and most important step in the development of a HACCP study is the establishing of the HACCP team. The glucose factory from Tandarei has established a multidisciplinary team called “food safety team” which includes only factory employees from seven departments, as follows: production, maintenance, quality control, sales, purchasing, human resources and quality

management. The team members have knowledge and experience regarding the glucose syrups as well as the technology used and they are trained regarding the food safety.
The glucose syrup consists of a mix of several saccharides being characterised by refraction (Brix), dry substance, pH, colour (chromaticity value expressed in ICUMSA units), density and dextrose equivalent. Also, a very important aspect is the carbohydrate composition: glucose, maltose, maltotriose and higher saccharides which give glucose syrups specific application in the food industry. Table 2 presents the sugar composition typical for syrups obtained by acid hydrolysis and by acid-enzyme hydrolysis. In order to be more specific, each product has its own product data sheet in which the specific properties are mentioned, as well as the specific applications and methods of handling.
The factory taken as reference has a HACCP plan which has proved to be efficient until now. However, external auditors and authorities recommended a revision of this plan, in order to take into consideration the effects of changes made in the last year into the factory.
After the new hazard analysis we found that the changes made in the factory did not affect the product from the viewpoint of food safety. Instead, we found that the existent critical control point was insufficient to reduce the danger of microbiological contamination, the real hazard being the cross-contamination. Firstly, by taking into account that in our case the microorganisms are inhibited or even destructed at temperatures ranging from 75 to 82^{0}C, as the ones used in the concentration installation, the old CCP was considered redundant and kept only as a CP.
From a hygienic point of view, the hazards from cross-contamination, briefly presented in Table 3, could come from equipment, tanks, storage tanks, packaging and personnel manipulation (Mironescu & Mironescu, 2006). On the other hand, the chemical and physical hazards could appear from the facilities, equipment and also from the personnel. Some of these possible hazards can be eliminated through preliminary programs, but the others only with specific preventing measures.
The updated flow diagram is presented in figure 1 and includes the CCP newly identified. For it we established a monitoring plan presented in Table 4. In order to obtain a fast result, this new CCP will be monitored using a daily test based on ATP detection.

Table 2. Typical sugar composition for glucose syrups (source: http://www.starch.dk)

Acid Converted Glucose Syrups			
Sugar	***30 DE***	***42 DE***	***55 DE***
Dextrose % of DS	10	19	31
Maltose % of DS	9	14	18
Trisaccarides % of DS	10	11	13
Higher sugars % of DS	71	56	48
Acid Enzyme Converted Glucose Syrups			
Sugar	***28 DE***	***42 DE***	***63 DE***
Dextrose % of DS	5	6	37
Maltose % of DS	8	45	34
Trisaccarides % of DS	16	16	16
Higher sugars % of DS	71	33	13

Table 3. Microbiological criteria for glucose syrup process (Mironescu and Mironescu, 2001).

Contamination place	Microorganisms identified
Storage tanks of starch slurry	*Fusarium sp., Absidia sp., Penicillium glaucum, Aspergillus niger, Lactic bacteria (Lactobacillus)*
Storage tanks of carbon-kieselguhr suspension	*Escherichia coli, Aspergillus niger*
Plastic containers	*Penicillium glaucum, Aspergillus niger, Aureobasidium pullulans, Leuconostoc, Bacillus*
Walls	*Aspergillus niger*
Final product (glucose syrup	*Penicillium glaucum, Aspergillus niger, Aureobasidium pullulans, Leuconostoc, Bacillus, Escherichia coli*

Table 4. Monitoring plan for the proposed CCP in the acid and acid-enzymatic glucose syrup production process

Important hazard	Control measures	Critical limit	Monitoring			Corrective action	Responsible
			Responsible	Method	Frequency		
Moulds and bacteria	Using of food-grade disinfectant detergents	30 RLU	Hygiene responsible	Rapid tests	Once per day	Re-sanitization	Operators

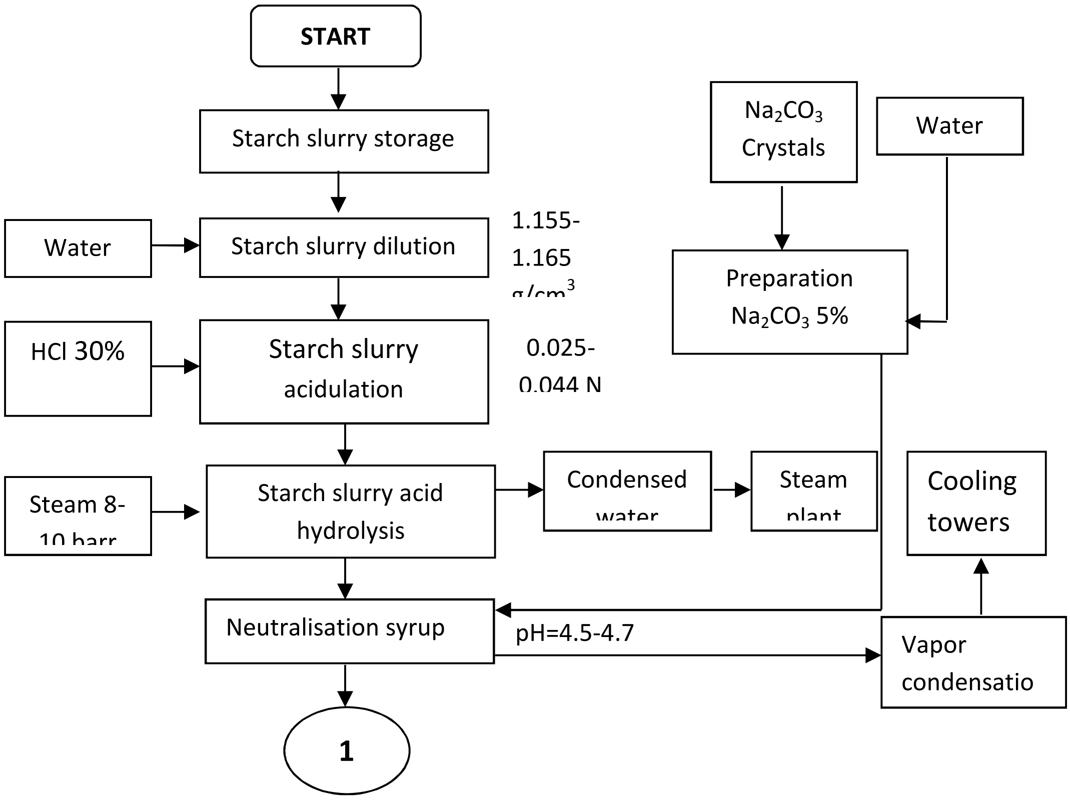

***Fig. 1.* Updated flow diagram for the acid and acid-enzymatic glucose syrup** (continued on the next page)

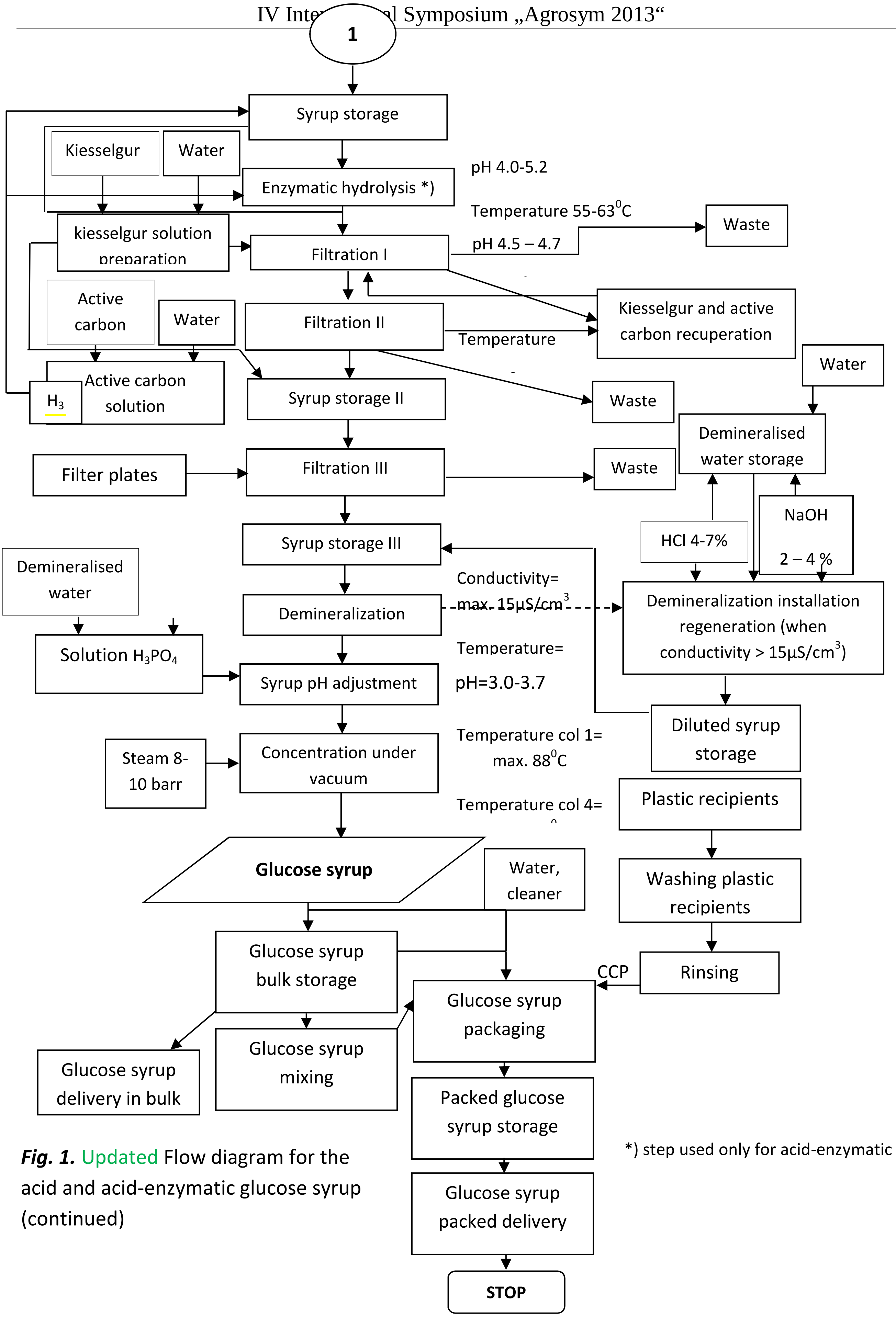

Fig. 1. Updated Flow diagram for the acid and acid-enzymatic glucose syrup (continued)

*) step used only for acid-enzymatic

Conclusions

The HACCP system already implemented by the factory, although proven as efficient until this moment, was re-evaluated in this study. By reviewing the newly technical and scientific proofs and possibilities it turned out that the current HACCP plan needed some improvements in order to be more effective and to take into account the real hazards, CCP and critical limits.
Although the glucose syrups are used in the food industry only as raw material and they undergo supplementary treatments before becoming a “ready to eat” product, the microbiological hazards still exist and have to be carefully monitored. Even if the production process is not favourable for the growth of microorganisms, the microbiological hazard can appear from cross-contamination and this fact was taken into consideration in this study.

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