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HAZARD ANALYSIS AND CRITICAL CONTROL POINTS SYSTEM OPTIMIZATION IN A STARCH FACTORY

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Abstract

The starch is a product obtained through the wet-milling of corn after the germs, hulls and protein separation. Because it is used as raw material in the food industry, safety assurance during its production is important. 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 corn starch is an aggressive one and unfavorable to the microorganism's multiplication, some 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 starch factory. Several control and critical control points were identified and for each one a specific monitoring procedure was elaborated. Also, several preliminary programs were identified and centralized in order to prevent the hazards occurrence.

Keywords: *food-safety, HACCP, starch production*

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 cornstarch is a product used as raw material in the food industry (e.g.: dough, sweets, sauces, preserves, emulsified products, etc).

It is obtained through a wet-milling process of corn, after the separation of the germs, fiber and gluten. In the food industry the cornstarch has the role to stabilize the composition and to interact with other components in order to maintain the food's nutritional value and flavor (Liu, 2005).

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.

For the validation of the HACCP plan presented in Table 6 we used two methods: determination of the foreign bodies in corn and tests for surfaces hygiene (bioluminescence method).

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 cornstarch is a product obtained through the wet-milling process of corn. It is used as raw material in the food industry.	The product was described in detail in internal product data sheet, taking into account its applications in the food industry.
Construct Flow Diagram; On-site Confirmation	Every operation from the flow diagram was analyzed considering also the preceding and following steps and verified in the factory.	For an easier understanding and tracking, the Flow Diagram was split in 2 parts (starch slurry and starch), and after that each of them was completed with the modified or new-introduced steps. It is presented in figure 1.
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 3 or 4 (Chira, 2010).	The previous critical control points, the sulphur dioxide concentration from the steeping solution and the pH of starch slurry were re-evaluated and transformed in operational prerequisite programmes (oPRPs). Two new critical control points were identified 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.	In Table 6 are presented, for the new critical control points, the monitoring system, the corrective actions and the responsible persons for each action.
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 correctly functioning.	The validation of the HACCP plan was made by centralizing and interpreting the analysis results for each CCP during one year. The analysis results are presented in Tables 4 and 5. A plan for the checking the preliminary programs, PRPs and HACCP plans was developed. It should be able to assure that the HACCP system is periodically implemented, updated and improved.

For the determination of the foreign bodies in corn we used the method described in STAS 1069/1977 – “Seeds for consumption. Determination of foreign bodies and seeds with defects”. For the validation process we considered the values of foreign bodies as being the same with the values for wheat seed content, but for the analysis made for the CCP’s control we calculate only the wheat seed content (WS) from the sample using the formula: $WS\ (\%) = \frac{Nws}{m}$, where Nws is the number of wheat seed from the sample and m is the sample weight.

The tests for surfaces hygiene were performed using the bioluminescence method based on the chemical reaction which produced light when ATP come in contact with the enzyme called luciferase (figure 1), with the SystemSURE II ATP Detection from Hygiena. This system includes three components:

- SystemSURE II Luminometer – device for reading and displaying the results.
- Ultrasnap Sample Testing Device – sampling device and analysis kit in which the bioluminescence reaction takes place.
- DataSURE II Data Analysis Software –software application which allows transferring data to a computer.

The results were interpreted according to Table 2. The values from this table were taken from Hygiena - "A Guide to Rapid ATP Monitoring" and they are the producer recommended limits for any high-risk food factory.

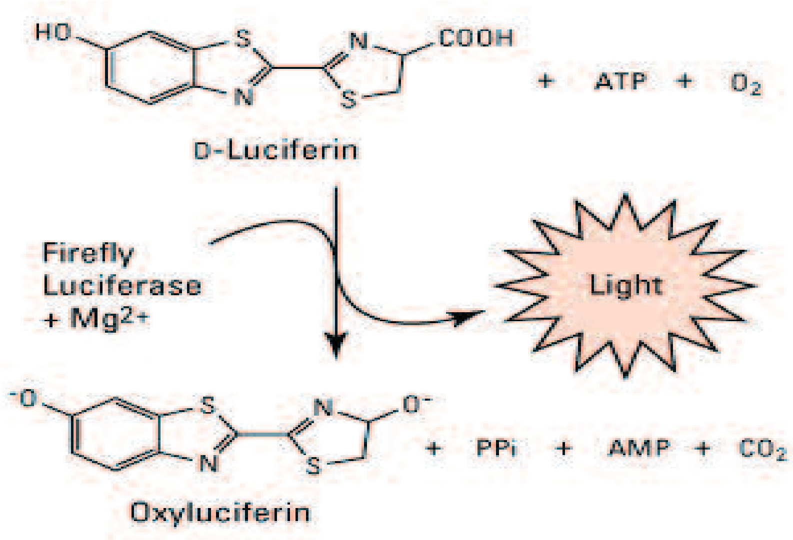

Figure 1. Bioluminescence reaction

Table 2. Setting the thresholds of surfaces hygiene for containers and materials in contact with the finished product

Thresholds	**Corresponding limits**	**Interpretation**
Pass	≤ 10 RLU	The surface has been adequately cleaned
Caution	11 – 29 RLU	The control point surface may not have been adequately cleaned.
Failed	≥ 30 RLU	The surface is dirty or contaminated, and must be cleaned again and re-tested until a Pass or Caution level is achieved.

RESULTS AND DISCUSSIONS

The first and most important step in the development of a HACCP study is the establishing of the HACCP team. The starch 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 factory took as reference has a HACCP plan which 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 points were insufficient to reduce the danger of microbiological contamination, the real hazard being the cross-contamination.

The old CCPs, concentration of sulphur dioxid solution having the critical limit 0.16% and the pH of starch slurry having the critical limit 6.9, were consider redundant due to the fact that according to the production procedures these values are impossible to be achieved. Taking into account that the concentration of sulphur dioxid solution used for corn steeping must be included in the range 0.18 – 0.22% and the pH-value for the food starch must be included in the range 4.5 – 5.5, the old CCPs were kept only as oPRPs.

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 (Samuels, 1993). 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.

A special topic took into account in the HACCP study was the gluten free starch status. To assure it, the HACCP team fixed as new CCP the wheat seed content in corn to be max. 0.5%.

The updated flow diagram is presented in figure 2 and includes the CCPs newly identified. For them we establish a monitoring plan presented in Table 3. In order to obtain a fast result, these new CCPs will be monitored using a daily tests based on wheat seed identification and ATP detection.

In table 4 we centralized the results obtained during a whole year (October 2012 – September 2013), after the evaluation of hygiene status of surfaces which come in contact with finished products. The results show that the working equipment and operators hands have a higher contamination than the packaging, but without any value higher or equal to 10 RLU, meaning that the prerequisite programs are implemented, complied and effective. For the starch packaging the results were around the values 0 and 1, very rarely achieving the values 4, 5 or 6 RLU.

Table 3. Microbiological criteria for corn starch process (Samuels, 1993)

Contaminated place	**Identified microorganisms**
Starch slurry storage tanks	*Fusarium sp., Absidia sp., Penicillium glaucum, Aspergillus niger, Lactic bacteria (Lactobacillus)*
Dehydrating starch slurry centrifuges	*Faecal streptococci, Staphylococcus aureus, Faecal coliforms, Fusarium spp., Aspergillus spp., Penicillium spp., Geotrichum spp.*
Process water	*Faecal streptococci, Staphylococcus aureus, Faecal coliforms, Fusarium spp., Aspergillus spp., Penicillium spp.*
Mixing dehydrated starch bunker	*Faecal streptococci, Staphylococcus aureus, Faecal coliforms, Fusarium spp., Aspergillus spp., Penicillium spp., Mucor spp., Rhizopus spp.*
Walls	*Aspergillus niger*
Finished product (cornstarch)	*Escherichia coli, Coliforms, Staphylococcus aureus, Faecal Streptococci*

Table 4. Centralization of the analyzes results of hygiene status surfaces for the period Oct. 2012 – Sept. 2013

	Hygiene status of surfaces: MAX. 10 RLU																							
Surface	Oct.12				Nov.12				Dec.12				Jan. 2013				Feb. 2013				Mar. 2013			
Equipment	8	7	6	2	5	4	3	5	2	4	5	1	4	3	6	4	5	7	7	6	4	3	5	7
Hands	8	5	8	1	2	5	3	4	3	5	5	2	4	6	2	3	4	5	3	5	2	3	4	5
Starch packaging	2	0	1	0	3	0	1	1	0	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0
Surface	Apr. 2013				May. 2013				Jun.13				Jul.13				Aug.13				Sep.13			
Equipment	3	3	3	3	3	4	2	4	5	4	7	4	5	3	4	5	2	6	1	3	6	6	4	3
Hands	3	2	1	4	2	1	2	1	3	2	5	3	2	3	4	3	3	4	1	1	2	4	1	0
Starch packaging	0	1	1	0	0	1	0	1	0	0	0	0	3	4	0	0	0	0	0	0	0	0	0	0

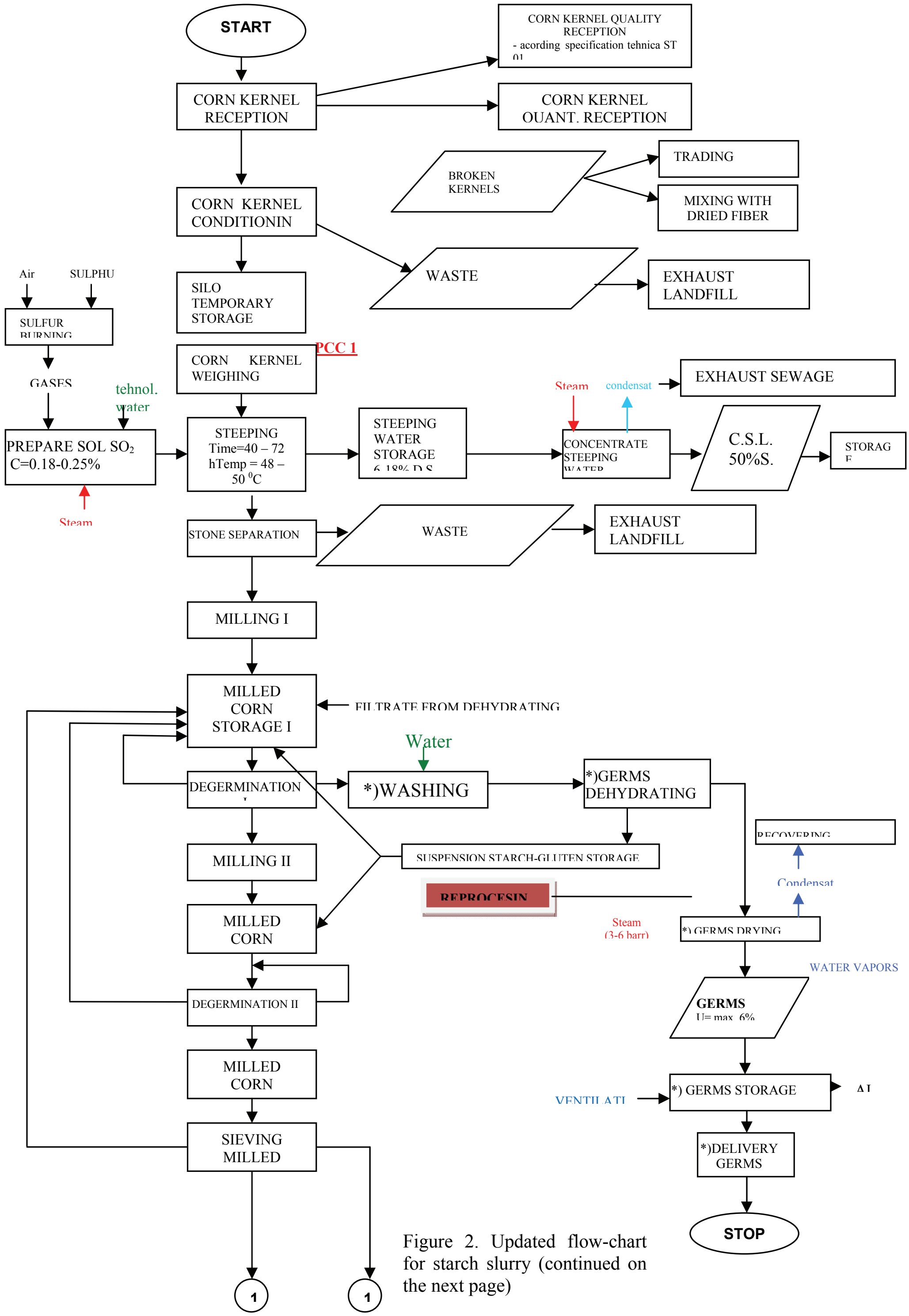

Figure 2. Updated flow-chart for starch slurry (continued on the next page)

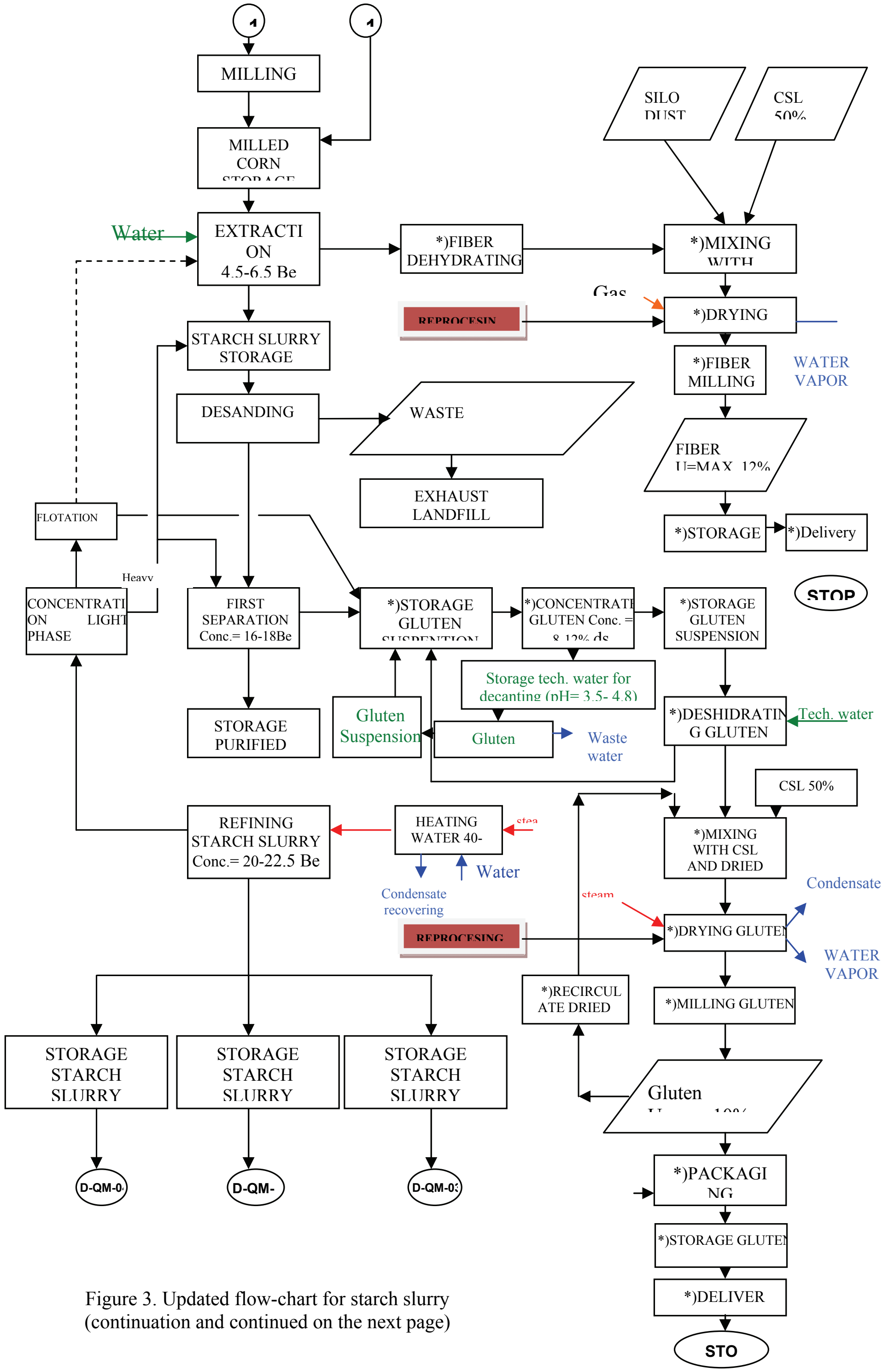

Figure 3. Updated flow-chart for starch slurry (continuation and continued on the next page)

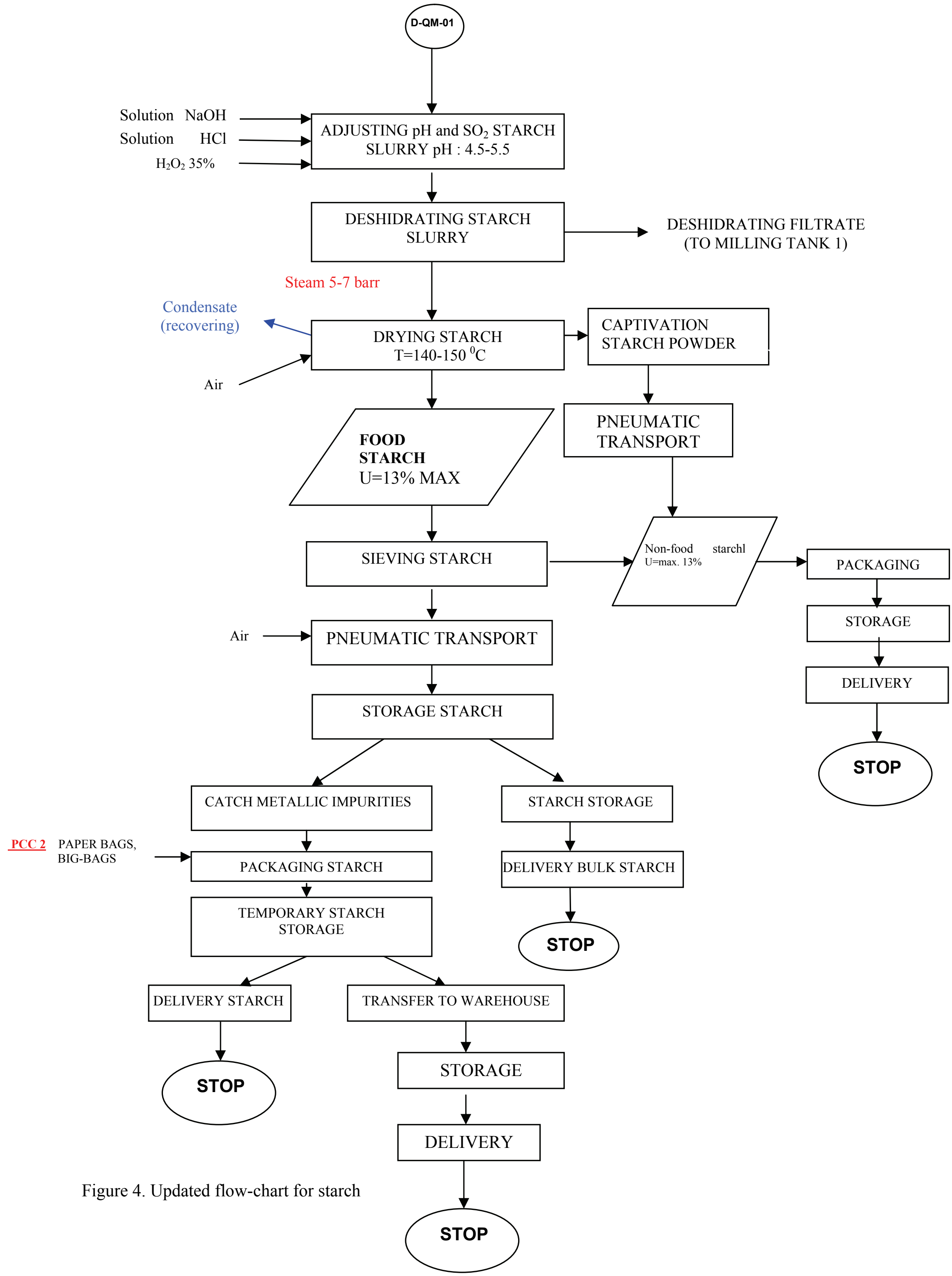

Figure 4. Updated flow-chart for starch

Table 5. Centralization of the foreign bodies analyzes results in corn for the period Oct. 2012 – Sept. 2013

	Foreign bodies in corn: MAX. 0,50 %											
	Oct.12	**Nov.12**	**Dec.12**	**Jan.13**	**Feb.13**	**Mar.13**	**Apr.13**	**May.13**	**Jun.13**	**Jul.13**	**Aug.13**	**Sep.13**
Foreign bodies (%)	0.32	0.33	0.31	0.32	0.27	0.27	0.27	0.28	0.25	0.23	0.36	0.36

Table 6. Monitoring plan for the proposed CCPs in the corn starch production process

Important hazard	**Control measures**	**Critical limits**	**Monitoring**			**Corrective action**	**Responsible**
			Responsible	**Method**	**Frequency**		
Allergens (wheat gliadin)	Identification of wheat seed content in the corn entered in the steeping tanks	0.5 %	Raw material technician	Instruction for determination of foreign bodies in corn	After each steeping tank filling	Produce non-food starch	Production Manager
Bacteria and moulds - packaging	Test for hygiene of surfaces at the batch reception	10 RLU	Hygiene Responsible	Test for hygiene of surfaces	Once per day randomly (min. 1% from packaging)	Change packaging batch, contact packaging supplier	Hygiene Responsible

Data centralized in Table 5 represents the foreign bodies' analysis results averages for corn made in the period October 2012 – September 2013. These values include the wheat seed content in corn and we considered that they couldn't be higher than the foreign bodies' content. Even if we supposed that the values from the table represent itself the wheat seed content they are below the maximum limit, 0.5%.

In conclusion, the values presented in Tables 4 and 5 lead to the validation of the HACCP plan presented in Table 6.

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 cornstarch is used in the food industry only as raw material and it is 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 favorable 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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