

Application of a facilitating HACCP system using two innovative methods for the production of *Hibiscus* syrup by a Senegalese small and medium business (SMBs)

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Abstract

The occurrence of food-borne diseases in the end of the 20th century allowed the emergence of the HACCP system whose role was to ensure food safety. This system is usually applied by large companies and industries, but not by SMBs in the developing world because they are binding, cumbersome and unsuited to their processes. This is the case of most of the African food industries that use artisanal methods. However, two innovative methods were especially developed by Bonne *et al.* (2005) and Bonne (2013) for African SMBs allowing them a comprehensive hygiene management with the determination and rapid control of their CCP process. These methods were applied to the manufacturing process of hibiscus syrup by a Senegalese SMBs and showed that HACCP principles can be adapted to SMBs. Its success depended on the commitment of management, ownership, awareness, and staff training. These two innovative methods of HACCP system were applied to enable a Senegalese SMB to produce safe syrup of *Hibiscus sabdariffa* that meet international requirements.

Keywords

HACCP innovative methods
SMBs

Syrup of Hibiscus sabdariffa
Hygiene,

Sanitary control of Bisap

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Introduction

At the end of the 20th century, food borne diseases took a new dimension in their frequency and their impact on population health. However, in many developing countries, public health authorities undertook very few measures to investigate or prevent these diseases and they became an obstacle to the export of their products and the development of local tourism. To overcome these problems, several reports and publications related to the Hazard Analysis and Critical Control Point (HACCP) emerged in the late 80s and early 90s. But the strongest aspect of the method was its full integration into Codex Alimentarius in 1993 AFNOR (2008). HACCP appeared in the management of food safety and was promoted as a new insurance method of food safety. HACCP is a system that makes it possible to identify, evaluate and control significant hazards in food safety Standards France (2008). This standard defines terms relating to the applicable controls of all areas of the foodstuff production and it is binding in developed countries on any public or private companies which carries out an activity in the areas of primary production, preparation, processing, packaging

hygiene, storage, transportation, distribution, handling and sale or supply to food or animal feed available. In many countries, especially in developed countries, HACCP is used as a regulatory tool in the system of food control and food industries. That is why, in recent years some countries have taken steps to include HACCP in their legislation (Motarjemi and Käferstein, 1999). However, Small and Medium Business (SMBs) are generally reluctant to apply the HACCP system and think that it is heavy administratively and financially and it could slow down their activities. In general, SMBs feel that the difficulties of the HACCP system are insurmountable (Taylor, 2001). But the HACCP system is essential in the production chain in advanced and developing countries and could be a good argument in food marketing. It is argued that HACCP is essential for any economic development as it is an integral part of all market economies (Bannock and Daly, 1994). To overcome this problem, the European Committee for Standardization (CEN) had implemented the project "EC-ASEAN Economic Cooperation Program on Standards, Quality and Conformity Assessment, 2003-2005" that has resulted in two innovative methods for agribusiness SMBs, to enable them to

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comply with the requirements of European legislation on food hygiene. These methods were developed by Dr. Richard Bonne *et al.* (2005) and were defined as follows: “Comprehensive Hygiene Management Method” that defined good practices of hygiene and manufacturing in order to have a good Health Plan Mastery (HPM) and “Alternative method to the Codex Alimentarius decision tree” for CCPs identification and their control.

The aim of this study was to apply the HACCP system using these two innovative methods on the production line of the syrup of Hibiscus sabdariffa (bissap) in a Senegalese SMB. It was justified by the numerous cases of food poisoning due to the consumption of juices and fruit syrups in Senegal. These poisonings often had a microbial origin and the proliferation of contaminants was favoured by poor hygienic conditions in factories that could quickly cause food spoilage (mould, pathogenic bacteria).

Materials and methods

Hygiene analysis and determination of program prerequisites (PRP) in a Senegalese food company

For this study, the method on “HACCP, GMP and GHP for ASEAN SMEs” applied as part of the “Better Training for Safer Food in Africa (BTSF-Africa, EC/UA program)” created by Bonne (2013) was used to compensate some inadequacies, misunderstandings of HACCP as defined in Codex Alimentarius. Both methods are based on the same principles with the aim of ensuring food safety. The present work was based on two innovative methods which are: the guide for the “Comprehensive Hygiene Management” which permits to manage GHP and GMP within the company and the “Alternative method to the Codex decision tree” for identification of hazards and preventive measures and the determination of CCP and their control (Bonne, 2013). PRP on hygiene in the food industry are the precursors of GHP and GMP. They are presented differently in Codex Alimentarius - CAC/RCP 1 (2003) and the Comprehensive Hygiene Management Method (2010). The confusing and redundant presentation of hygiene prerequisite program by the Codex Alimentarius explained that this method was misunderstood and unenforceable by African SMBs.

HACCP plan and alternative HACCP method

The HACCP system as described in the Codex Alimentarius - CAC/RCP 1 (2003) consists of 12 steps summarized as follows:

- Steps 1 to 8: Study of the HACCP
- Steps 9 to 12: Implementation of the HACCP

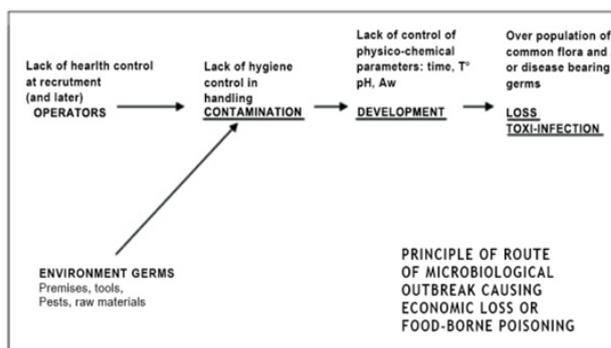


Figure 1. Mode of occurrence of food incidences

plan

- Comparison of the two methods for the identification of hazards and preventive measures

At this stage, the “alternative method to the decision tree” of Bonne (2005, 2013) defined all biological, chemical or physical hazards that may cause contamination of the product during the duration of the process managed by GHP and GMP. This innovative method was based on the fact that process steps leading to acute food poisoning (CFTI) were considered as CCP (Figure 1). Risks were estimated using hazards caused by multiplication and/or survival (depending on parameters) of microorganisms. This method was compared with that described by Codex Alimentarius.

- Comparison of the two methods for the determination of CCP

The codex uses the decision tree to determine CCPs, but it does not fit all situations or production sectors especially in SMBs, as it is not always possible to clearly identify the existence of a CCP. To solve this problem of determination of CCPs in their process, Bonne *et al.* (2010), in the “Guidelines on HACCP, GMP and GHP for ASEAN SMBs”, have set up a simplified approach for SMBs called “The Alternative Method to the decision tree of Codex Alimentarius”. In this guideline, Bonne *et al.* (2010) defined a CCP as a step of the process, whose parameters were controlled and monitored and whose critical thresholds were defined. To define CCP in SMB, Bonne *et al.* (2010) proposed to trace the fabrication diagram of the product in a table with five columns as follows:

Columns 1 and 2 represent the sources of contamination therefore managed by GHP and GMP. The parameters described in column 3 are responsible for the multiplication and survival of hazards which result in a CCP (figure 2).

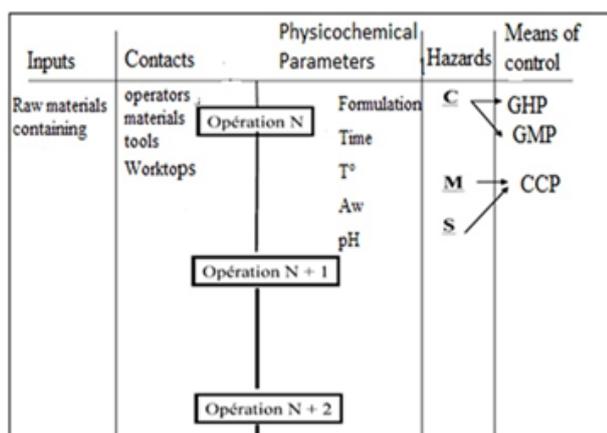


Figure 2. The Alternative Method to the decision tree of Codex Alimentarius

Results

Quality diagnosis of the Hibiscus sabdariffa syrup process in the Senegalese company

The hygiene diagnosis of the Senegalese SMBs permitted to detect a high contamination during the manufacturing process. For example, the antiseptic solution used for hand washing had not bactericidal activity and staff had a very low level of training on good hygiene and manufacturing practice. Microbial contamination was very high on the step after extraction ($12.64 \cdot 10^3$ UFC/mL for aerobic mesophilic total flora and $15.64 \cdot 10^4$ UFC/mL for yeast flora), and after the filtration step (the aerobic mesophilic total flora was $18.91 \cdot 10^3$ UFC/mL and $12.5 \cdot 10^3$ UFC/mL for yeast flora), (Ndiaye *et al.*, 2014) because of the flow of materials and personnel who were in contact with the product and the environment were not suitable for syrup production. However, the system could be improved by implementing the HACCP approach. This approach required staff training compliance with Good Hygiene and Manufacturing Practices (GHP, GMP). It allowed implementing various Prerequisite Programs (PRP) and “operational prerequisites programs” (oPRP) for the proper operational safety control system. The result of the hygiene diagnosis using the comprehensive hygiene management method in the food industry for Senegalese SMBs showed the strengths and areas of improvements for the implementation of the HACCP system in the Senegalese SMB.

The main benefits noted and obtained in this Senegalese SMB were:

- SMB General Management commitment to implement the HACCP system for better control in terms of safety of its products,
 - At the time, the company was installed on an industrial area,
 - Production equipment of the company was

in good condition,

- Wearing work clothes was mandatory for all members of staff,
- Respect of the FIFO (First In First Out) on raw materials and products,
- Description of the composition and intended use of the finished product,
- Medical examinations and deworming campaigns were carried out on the production staff annually,
- Implementation of a document management system of the company.

However, despite these advantages, the SMB had many areas of improvement which were the different PRP:

- ✓ Strengthening staff training on hygiene,
- ✓ Increasing the control of good hygiene practices on cleaning of the environment (cleaning and disinfection plan and establishing the plan against destroying vermin, the equipment and hands,
- ✓ Increasing the waste management system in the SMB,
- ✓ Establishing procedures for the purchase of raw materials,
- ✓ Recording all system procedures to ensure traceability.

The hygiene diagnosis showed that the main obstacle in the SMBs was the low level of training of most staff. Program prerequisites hygiene should be well defined and Codex Alimentarius - CAC/RCP January (2003) should be applied. GHP generally suited, the difficulty lies in the GMP assimilation by workers that is closely related to intellectual level, skills and predispositions, especially for workers who ensure production. This factor is usually a major barrier to the success of HACCP in SMBs (Ehiri, Morris and Mc Ewen, 1995; Walker, Pritchard and Forsythe, 2003).

Implementation of the HACCP system by innovative methods

Implementation of the various stages of the HACCP system was followed for the SMB. Only steps 6 and 7 which are the identification of hazards and preventive measures and identification of CCPs are described. They were applied using the two innovative methods: “Comprehensive hygiene management method in the food industry” allowing the identification of hazards and preventive measures and the “Alternative method to the decision tree Codex Alimentarius” for identification of CCPs and their control.

- ✓ Hazard identification and preventive measures

Table 1. Identification of hazards and preventive measures in the Senegalese SME

Process Steps	Hazards	Original risk	Preventives measures
Soaking	Microbial contamination	Equipment (bowl), Operator (hands)	The material must be clean, disinfected with bleach, use effective antiseptic (antibacterial) to wash hands, use disposable gloves and change them every 30 min (BPH, BPF)
Manual separation	Microbial contamination	Gloves	Use disposable gloves or wash hands regularly with an effective antiseptic solution (BPH, BPF)
First filtration	Microbial contamination	Equipment (screens, pot, jug) Operator	Disinfect equipment with an antiseptic solution, wash hands or use disposable gloves that are changed regularly (BPH, BPF)
Transfer	Microbial contamination	Equipment (bucket)	Clean the equipment
Second filtration	Microbial contamination	Equipment (cotton sieve cap, jar, jug, bowl), operator	Clean the equipment, use washable pockets and sterilizable cotton; Wash hands regularly or use disposable gloves (BPH, BPF)
Formulation	Contamination and microbial multiplication	Equipment *Brix	Clean the equipment. Measurement with a Brix refractometer (BPH/BPH/CCP)
Pasteurization	Microbial survival and development of spores	Time / temperature	Measure the temperature with a probe and control time with a chronometer (BPF/CCP)
Recovery after pasteurization	Microbial contamination	Equipment (bowl)	Deleting this step allows to cool in the pasteurizing vat
Packaging	Cross-contamination by the material and operators	Equipment; Operator (number high enough)	Use of glass bottles which can be sterilized or pasteurized. Or provide a filling system for the pasteurizing tank.

Table 2. Identification of Critical Control Points (CCP) in the Senegalese SMB

Inputs	Contacts	Operations	Physico chemical Parameters	Hazards	Control methods
Chalice bissap	Operators bowls	Weighing	Weight	Contamination	GHP / GMP / hands and equipment clean (bleach)
Water	Operators bowls	Soaking	Water ratio/ chalice weight 2h	Contamination	GHP / GMP / hands and equipment clean (bleach)
	Operators Bowls	Separation		Contamination	drinking water GHP / GMP / hands and equipment clean (bleach)
	Operators Bowls metal filter	Filtration		Contamination	GHP / GMP / hands and equipment clean (bleach)
	Operators bowls	Settling	Time 15 min	Contamination	GHP / GMP / hands and equipment clean (bleach)
	Operators bowls	Transfer		Contamination	GHP / GMP / hands and equipment clean (bleach)
	Operators bowls hydrophilic cotton	Filtration		Contamination	GHP / GMP / hands and equipment clean (bleach)
Sugar	Operators bowls skimmer	Formulation	Brix= 65° respect the sugar / water ratio	Contamination/ Multiplication	GHP / GMP / CCP Systematically measure Brix degrees after addition of sugar and to respect water/sugar ratio
	Pasteurization tanks	Pasteurization	T° 80°C Time 20 min (Vp = 200)	Contamination/ Survival	GHP / GMP / CCP always check the pasteurization scale with a temperature probe and a timer
	Bowls	Cooling	T° 70°C	Contamination	GHP / GMP / use refrigeration to stop the pasteurization
Bottles	Operators Equipments	Packaging	Volume	Contamination	GHP / GMP Bottling mechanical system
Water	Operators bowls	Cooling	T° 10-15°C	Contamination	GHP / GMP / waterproof seal
	Pallets	Storage	Room temperature	Contamination	Verify the shelf life

Table 3. Health plan mastery of hibiscus syrup production revised after evaluation by the Alternative method to the decision tree

Inputs	Contacts	Operations	Physico chemical Parameters	Hazards	Controls and correctives methods
Dried hibiscus calyces	Bags	Storage	T° 20-25°C Humidity brightness	Contamination	GHP / GMP Waterproof bags. Dark and dry warehouse
	Environment Operators Crusher Operators bowls	Weighing	Weight	Contamination	GHP / GMP / hands and equipment clean (bleach)
Water	Tanks incorporated stainless steel sieve	Soaking	Water ratio/ chalices weight 2h	Contamination	GHP / GMP / hands and equipment clean (bleach) drinking water
	Automatic Pump System	Filtration		Contamination	GHP / GMP clean environment
	Automatic pump system using pocket filter sterilizable	Filtration		Contamination	GHP / GMP hands and equipment clean (bleach), sterilizing the filter bag
Sugar	Operators bowls skimmer	Formulation	Brix 65° Respect the sugar / water ratio	Contamination/ Multiplication	GHP / GMP / CCP If Brix < 65, it is necessary to increase the quantity of sugar in the product during processing progress and to re-examine the ratio calyces/eau for the other productions. ¶ If Brix >65, the product should be diluted ¶
	Pasteurization tanks	Pasteurization	T° 70°C Time 20 min (Vp = 20)	Contamination/ sterilization	GHP / GMP / CCP If the temperature of pasteurization ranges 70 to 90°C, the duration of pasteurization will vary between 20 and 5 min respectively. More the temperature is high, more the duration decreases
	Cooling system	Cooling the product	T° 10°C Time < 2H	Contamination	GHP / GMP Sterile cooling system A probe for measuring the temperature
Bottles	Automatic packaging system	Packaging	Volume of fill and seal bottles	Contamination	GHP / GMP Mechanical filling and closing of bottles
Pallets	Operators	Storage	T° ≤ 30°C Time 12 months		GMP / Electronic thermometer incorporated respect FIFO

The evaluation of the manufacturing process of hibiscus syrup in the SMB (step 6) permitted to the authors to identify different hazards of contamination and / or microbial growth or survival, their origin, and various preventive measures (Table 1).

✓ Identification of Critical Control Point of the syrup of Hibiscus sabdariffa process

The analysis of the step 7 of the process has produced all GHP, GMP and CCP of the syrup production chain established by the SMB whose activity was transforming calices of Roselle in syrup (Table 2). Table 1 showed that all microbial

contaminations were managed by GHP and GMP, and the risks of multiplication and survival of microorganisms (stages of formulation and pasteurization) were considered as CCPs (Table 2). Critical thresholds were determined after several tests with the SMEs.

The Health Plan Mastery (HPM) of the SMB changed after evaluation by applying the Alternative Method (Table 3). The automation of some process steps (soaking, filtration) of hibiscus syrup manufacture had resulted in the removal of other steps (separation, settling, and transfer) where the

risk of microbial contamination with the staff and the equipment were very high. The new plan for health mastery was taken into account by the company. Thus, the storage step of raw materials was identified as a potential critical point of contamination. Therefore, filtration steps have been automated to reduce the sources of product contamination. The use of a refrigerant to cool the product after pasteurization and packaging automation were propositions that have been made and accepted by the company but the equipment was not yet acquired at the end of 2014.

Discussion

The simple manufacturing processes used by the Senegalese SMB were not adapted to the application of HACCP but it was noted that human resources were the key elements for the implementation of HACCP. World Health Organization (WHO), (1999) confirmed that in every business, many obstacles are related to human forces. This study revealed that the main PRP found during the hygiene diagnosis were difficult to set up because of the low education level of the staff. This was also the conclusion reached by the Codex Committee on Food Hygiene (CCFH) (2001) who said that hygiene diagnosis showed that the major obstacles for food companies, especially small businesses, were the lack of management commitment, training and motivation. However, the overall approach to manage sanitary problems in African food industries, while using the rules of GHP and GMP codex, has to be logical and simple in order to be used.

The implementation of the HACCP system in the Senegalese SMB with the use of the two innovative methods was carried out with success but with some difficulty. Overall, the effective implementation of HACCP in the SMB was hampered by a complex set of factors as business demand, legal requirements and quality management, business size, human resources, technical support and assessors, HACCP prerequisites and time scale. As an example, the study of Celaya *et al.* (2007) showed that 56.7% of Spanish SMBs had a favourable HACCP Plan while 28.4% had obtained the approval of the HACCP system. It is clear that in each country, the development of HACCP in the food chain is influenced by a complex set of factors (Taylor and Kane, 2005).

Conclusion

International organizations (WHO and FAO) and all countries of the European Union promoted the systematic implementation of HACCP for all

companies that operate in the food industry. In practice, HACCP is applied by large companies and industries but SMBs and especially African SMBs meet some difficulties, especially those in developing countries. The two innovative methods which take into account the overall sanitary management in the food industry and the rapid determination of critical points were very suitable for the Senegalese SMB and could be applied in most of the African SMBs. The example of our study showed that the success of this model will depend on the commitment of management, ownership, motivation and training of personnel with continuous monitoring of the system.

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