

Assessment of HACCP Safety System and Good Manufacturing Practices in a Multi-product Soft Drink Bottling Plant

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Authors' contributions

This work was carried out in collaboration between both authors. Author ON designed the study and author VII managed the study. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: To perform an evaluation of hazard analysis and critical control points (HACCP) implementation and good manufacturing practices (GMP) in a multi-product soft drink company in Nigeria.

Study Design: Semi experimental study combined with survey.

Place and Duration of Study: Study was carried out in December 2015 in a bottling facility in south-east Nigeria.

Methodology: HACCP audit and failure mode and effect analysis (FMEA) were performed and scored after responses to specific questionnaires were obtained from plant staff. The GMP compliance (%) for corrective action taken on operational audit issues was determined by scoring the number of issues corrected over the total advised. Microbial quality of products was verified using membrane filtration and fill content was established with a 500 mL measuring cylinder. The

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beverage brix (%) was determined with a density meter and CO₂ content (g/L) was ascertained using a CO₂ tester according to manufacturer's instructions. Traceability was performed by using the date code stamped on the finished bottled products as a reference point.

Results: The average percentage conformity was 90% for HACCP implementation and 74% for functioning of HACCP in practice. Application of FMEA to the audit showed that minor risks existed in HACCP implementation whereas moderate risks were found in functioning of HACCP in practice. Evaluation of GMP compliance showed that raw materials and intermediate products were traceable and a review of previous audits which covered HACCP pre-requisite programs showed 90-100% compliance with corrective action required. Checks on microbial quality, brix, fill content and carbonation showed results that were within prescribed limits which indicated that safe products were manufactured.

Conclusion: The seven principles and 12 implementation steps of the HACCP system were firmly established and GMP was effective. However, the maintenance of the HACCP structure during operations requires improvement.

Keywords: HACCP; food safety; hazard analysis; risk quantification; soft drinks, GMP.

1. INTRODUCTION

The HACCP system identifies specific hazards and their control to ensure food safety [1]. It is a prevention approach rather than testing products at the end of a process and food producers implement the system to show food safety assurance [2]. Since the first published use of HACCP in 1973 following the promotion of the HACCP system for the production of commercial foods by Pillsbury company in the United States of America, the system has been incorporated in government regulations throughout the world [3]. In Europe, HACCP implementation is mandatory for food manufacturers through Regulation (EC) No. 852/2004 [4]. Among the three main types of hazards identified with HACCP system, microbiological hazards seem to be present in every step of food processing. In some food production systems, chemical hazards are well contained and are taken care of by the suppliers of raw materials while physical hazards are related mainly to packaging [5].

According to Sperber et al. [6], HACCP can be combined sometimes with good manufacturing practice (GMP) better known as a pre-requisite program (PRP). HACCP still remains the core drivers of food safety in most food processing facilities and even though the same HACCP principles are applied around the world, the implementation and documentation are hardly the same in any two locations due to location-specific parameters. This has been proved by the investigation of Djekic et al. [7] which found that there were differences in the hygiene of various food processing establishments after HACCP implementation.

It has been pointed out [8] that since its introduction, the use of HACCP has created much debate and some businesses have considered the requirement of HACCP application with apprehension. This has led to implementation to varying degrees by food processors. In order to quantify and verify implementation, semi-quantitative [9] and quantitative methods for evaluation of HACCP systems have been developed. Quantitative methods may include FMEA. The methodology, design, implementation and integration into HACCP system in a food company has been reported by Scipioni et al. [10]. The use of Kohonen's artificial neural networks for analyzing declarative survey as a statistical tool has also been proposed [11].

A previous report [12] argued that even though HACCP is relatively well developed in large food processors in developed countries, it is still far from widespread application in developing countries. The report noted that the quality of implementation has varied even where HACCP has been established for a long time among larger food manufacturers in Europe and the USA. In the developing countries, there is a campaign to increase awareness in all sectors. A cross-sectional, quantitative research of 440 food handlers in South Africa [13] found that 93.2% of food handlers did not know about HACCP and 91.4% of food preparation facilities surveyed did not have a HACCP program in place. In Nigeria, the guidelines for the establishment of food manufacturing plants published by National Agency for Food and Drugs Administration and Control (NAFDAC) shows that HACCP implementation is on a voluntary basis or mandatory for certification [14].

Presently in Nigeria, NAFDAC can sanction companies that are deemed big enough to implement HACCP and GMP if they fail or neglect to do so. The campaign by regulatory agencies has led to several evaluations of local food production in Nigeria for HACCP implementation. Several studies have been carried out and suggestions for critical control points in some food processes have been advised. The processes evaluated so far include the identification of hazards and critical control points (CCPs) for *fufu*, a cassava food product processed in South-West Nigeria [15]. Control measures and proper monitoring procedures for wet product processing were highlighted. In a fish processing study [16], it was suggested that seafood processors may be sources of microbial hazards. The need to improve hygienic practices as well as HACCP implementation in public food service outlets in order to obtain safe processed seafood products for consumption was advised. The importance of HACCP awareness for processors and owners of seafood processing plants was also emphasized. Also, training of processors on HACCP, processing, environmental sanitation and personal hygiene to improve the safety of traditional fermented legume-based condiments has been pointed out [17]. An investigation of the microbial CCPs in the preparation and handling of complementary foods in 120 households in Imo state, Nigeria has been carried out [18] and it was found that the stages where insufficiently high temperatures were used to reheat the food and the process of adding certain powder ingredients where no further heat treatment was applied were high-risk points.

In these aforementioned Nigerian studies, small food processing was analyzed and the major focus was on microbial hazards without a quantitative analysis of the 7 principles and 12 implementation steps of HACCP system [19]. The reports of quantitative HACCP evaluation in Africa that captures all the principles and implementation steps are not common in literature and more studies need to be carried out to complement the efforts of government regulatory agencies towards raising HACCP awareness for all food processors. Therefore the aim of this study was to perform a quantitative evaluation of HACCP implementation in a multi-product soft drink company in Nigeria in order to establish the effectiveness of the principles of HACCP food management system in a bottling facility. The compliance to good manufacturing practices was also determined.

2. MATERIALS AND METHODS

2.1 Company Profile

This study was carried out in a soft drink bottling plant in south-east Nigeria. The company has the capacity to produce up to 500,000 bottles per day and manufactures carbonated soft drinks of different package sizes and flavors. The flavors include caramel, orange and lemon. In addition to the carbonated soft drink lines, another line is dedicated to the manufacture of table water. The ISO 9001 and 22000 programs are implemented in the plant and the company uses the approach of making sure that each bottled product meets and exceeds required standards. Monthly verification of product conformity to required standards is carried out by the franchise owner of the bottling plant by sampling between 8-10 bottles out of millions produced and supplied to the plant's distribution area.

A process flow diagram for operations (Fig. 1) shows that water is treated on site whereas CO₂ and granulated sugar is obtained from third-party suppliers. Raw materials must pass the incoming raw materials inspection program. The plant's processes have key performance indicators that are monitored daily. The HACCP food safety system program is mandatory in the plant's operations and the GMP program is a precursor to the HACCP program. During internal and external audits, the HACCP audit will not normally proceed if there is a GMP failure. Production involves mixing water with concentrate and granulated sugar to get final syrup which is blended with carbonated water to make carbonated soft drinks. Table water is manufactured by drawing water from a deep well after which treatment is carried out by passing the water through several filters before ozonization. This study was performed by the authors under the observation of one bottling staff personnel who is trained in implementing the HACCP program.

2.2 Assessment of GMP

2.2.1 On-site process verification and product traceability

Process verification was carried out with spot checks during production. Three finished carbonated products were collected from the production line. One bottle was used for microbial analysis and another bottle was used to determine the fill content. The third bottle was

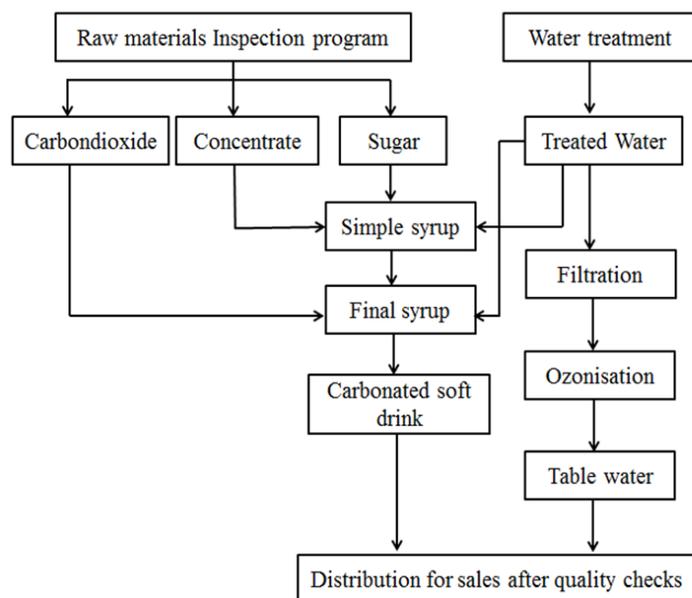


Fig. 1. Process flow in the multiproduct soft drink factory studied

used to ascertain if product CO₂ and brix were within prescribed levels. The same tests were performed on another set of three bottle samples drawn randomly from the finished warehouse store. Fill content was verified with a 500 mL measuring cylinder. The beverage brix (%) was determined by a density meter (Anton Paar, DMA 4500, Austria) and CO₂ content (g/L) was ascertained using a CO₂ tester (Steinfurth, CO2MS1, Germany) according to manufacturer's instructions. Tests were performed on three occasions at random.

Traceability was performed by using the date code stamped on the finished bottled products as a reference point. The date code primarily shows the best before date but it can also show the day the product was made. To trace the batches of raw materials and intermediate products used to manufacture the products, three products were picked at random from different pallets in the warehouse storage area for the exercise. Various storage rooms were then visited and records of the batches of raw materials and intermediate products were examined to determine if they match the date of production stamped on the finished bottled products collected from the warehouse.

For microbiological analysis, tests were carried out for yeasts and mold, total bacteria count and coliforms using membrane filtration performed

previously [20]. This involved carrying out standard industrial membrane filtration by using a sterile multi-branched stainless steel manifold and filter holder system with different nutrient pad media sets (Sartorius, Göttingen, Germany) according to manufacturer's instructions. Also, the membrane filter was attached to a nutrient pad after filtration and incubated at 25°C for 5 days for yeasts and mold (0.65 µm filter) and 37°C for 24 h for bacteria (0.45 µm filter). Incubation of cells on cetrinide (CT) media was carried out at 42°C for 48 hrs. Colonies if any were counted as colony forming units (CFU) per 100 mL or 20 mL of membrane filtration sample. The nutrient pad media sets used included tryptone glucose extract media for total bacteria count, tergitol triphenyl tetrazolium chloride media pad for coliforms and enterobacteria, cetrinide nutrient pad for *Pseudomonas* species and other non-fecal pathogenic bacteria and Schaufus Pottinger (SP) nutrient pad for yeasts and mold.

2.2.2 Review of pre-requisite programs audits

A review of compliance with previous corrective actions advised in audits that covered pre-requisite HACCP programs was carried out on records made available by the facility. A total of 7 previous audits from different firms were reviewed and it included the good manufacturing program (GMP) which covers all aspects of

operations and is regarded as the main PRP that is linked with the HACCP program [19]. Percentage compliance for corrective action taken on operational audit issues was determined by scoring the number of issues corrected over the total advised. Audits reviewed included those carried out by the company under study (internal audit), NAFDAC, Standard Organization of Nigeria (SON), Weights and Measures of Federal Ministry of Environment, State Environmental Protection Agency, the franchise owner and third-party audit specialists.

2.3 Quantitative HACCP Audit and FMEA

The HACCP audit covering the seven principles and 12 implementation steps of the HACCP system [19] was carried out. To determine if targets were met, the plant records were examined and compared to the critical limits set out in the plant's HACCP program. The results were subjected to the HACCP audit questions and failure mode and effect analysis (FMEA) reported by Trafialek and Kolanowski [21]. Briefly, the HACCP audit which consisted of 147 questions (see reference 21) covering the 7 HACCP principles and 12 implementation steps was awarded scores for conformity after which the results were analyzed to assess the risk to food safety. The use of FMEA involved the calculation of three coefficients. This included severity (S), occurrence (O) and detectability (D). The coefficients were assigned values in the range from 1 to 10 and the relative risk index (R) was calculated by multiplying the three coefficients. The average percentage conformity for HACCP implementation and functioning of HACCP in practice were then established after which low, moderate or high-risk scores were assigned. The hypothesis for this study was that HACCP implementation in the facility studied can prevent hazards from reaching a high-risk situation.

3. RESULTS AND DISCUSSION

3.1 GMP Evaluation

3.1.1 Process verification and traceability spot checks

Finished product testing is often not very effective for controlling food safety but it may be used for process and product verification [22]. It has been pointed out [23] that verification is designed to assess whether a system has

continued to function as intended and it can determine if a system or the hazards associated with the food product has changed so that safety cannot be ensured. Process verification can be performed internally or externally by a production facility using a wide range of methods. In food producing companies, the nature of these tests is mainly microbiological or physico-chemical. A production system with good GMP manufactures products that are within specified parameter limits and demonstrates that safe products are produced.

The spot checks carried out found that the process parameters were within prescribed limits (Table 1) of the bottling plant. The CO₂, brix, fill height and microbial analysis were consistent within the range of results found in the process control records in the plant during the audit period. The microbiological results did not show any growth on all the nutrient media plates after incubation and were similar to a microbiological count of finished soft drink products reported previously [24]. The findings show that the sanitation condition of the bottling equipment is good. The plant has a triple layer monitoring system. During production, a technician records a process control check after which it is verified by a shift manager before a final signing off by the overall quality assurance manager. The documentation and process verification observed in this study showed that there was adequate tracking of the bottling process and there was the capacity to correct a deviation from the critical limits if required.

The European Union law describes traceability as the ability to track any food, feed, food-producing animal or substance that will be used for consumption, through all stages of production, processing and distribution [25]. As a minimum, in the plant studied, the raw materials, date of production and sales release record for every bottle produced must be traceable. The traceability exercise using the date code on the bottles analyzed were able to show the batches of raw materials (CO₂, granulated sugar, concentrate) and intermediate products (simple syrup, final syrup) used for making the products. Product release notes from the quality assurance department were also ascertained. The fact that the random bottles of finished products can be traced upward, and tracked downward at any time required [26] within the facility shows that product recall or quarantine of products that are not within specified limits can be achieved using batch details. The traceability system helps to

minimize the production and distribution of unsafe or poor quality products and reduces the potential for liability [27]. The facility's traceability system can be improved by using video surveillance [28].

3.1.2 Pre-requisite programs audit compliance

A report [29] has explained that the good hygiene practices that are the basic conditions necessary to maintain a hygienic environment constitute the HACCP PRPs. The PRPs may include premises and structure, plant and equipment, cleaning and sanitation, supplier control, storage, distribution and transport. Others are waste management, pest control, personnel hygiene and fitness to work, training and supervision, working instructions and standard operating procedures. In that report, it was pointed out that a food business which carries out low-risk activities may have all the hazards controlled by PRPs, with no need for implementing full food safety management system based on the principles of HACCP. The bottling plant in this study had all the aforementioned PRP programs in place and program documentation was available on an electronic database accessible to staff.

Assessment of food safety management systems is a verification activity with the objective of evaluating the compliance with set standards [30] and the previous records of compliance are important criteria to be considered. The review of previous audits which covered HACCP prerequisite PRPs showed that the facility studied promptly corrected issues raised (Table 2). At the beginning of this study, two GMP audit issues were outstanding. The first issue had to do with broken down hand driers in the toilets used by production operatives. Although disposable towels and soap were provided as an alternative, most of the audits preferred the hand driers. New hand driers were installed during this study and use of disposable towels was discontinued. The second audit issue which made the plant score less than 100% compliance in some audits (Nos 1, 5, 7; Table 2) was the absence of an effluent treatment plant. The bottling plant had oil traps and a small outdoor pond from effluent water as proof that the effluent did not have any adverse effect on fauna and flora. Also, the factory is located in an industrial area belonging to a regional government that has

plans to build a central effluent treatment plant for all the companies operating in the industrial estate. However, the environmental agency in the region has encouraged the bottling plant to build one since the government's plan was taking too long to materialize. The facility studied was hopeful that bureaucracy will become clearer so that they can plan for further effluent treatment.

To the best of the knowledge of the authors, reports of GMP assessment of bottling companies in Africa are rare. However, an assessment of GMP standards in food production has found that sometimes it is hard to know exactly how to adjust standards to production [31]. The literature review of common GMP problems in food safety and applicable controls has been reported [32] and the general consensus is that food business operators should ensure GMP compliance for food safety and official controls should be in place to check food business operators' compliance [33].

The implementation of ISO 22000 which deals mainly with PRPs in the plant is significant because some investigators have predicted that ISO 22000 may be the new standard bound to replace HACCP on issues related to food safety [34] and that systems like GMP and Good Hygiene Practice (GHP) are pre-requisites which leads to lower number of CCPs. In that review, it was reported that several companies have either implemented or are on the point of implementing ISO 22000, but there are many others that are reluctant to implement it because the new standard is too demanding in terms of bureaucratic work. The company audited in this report had the intent to implement the newest best practice available and this was visible through several notices around the plant. There may be changes in food management systems in the near future because a world-wide joint FAO/WHO food standards program codex committee on food hygiene have discussed [35] the revision of the general principles of food hygiene (CAC/RCP 1-1969) and its HACCP annex with a view to coming out with a holistic food management system. The Nigerian participants supported the pre-requisite programs to be called operational pre-requisite program (OPRP) and did not want any more additional principles because the seven HACCP principles have served as a good and effective backbone of HACCP for decades.

3.2 Quantitative HACCP Audit and FMEA Analysis

The summary scores of the HACCP audit and details of risk calculations after the FMEA analysis are outlined in Table 3. The 12 implementation steps and 7 principles of the HACCP system were covered. The details of the audit showed that 100% conformity was obtained in three implementation steps (Part I; Table 3) whereas no part of the functioning of HACCP in practice (Part II; Table 3) had 100% conformity. This suggests that application of HACCP during operations requires more improvement than providing proof that HACCP is implemented in the plant. There were only minor risks in HACCP implementation and the average percentage of conformity was 90%. However, moderate risks were found (principles VI and VII) in the functioning of HACCP in practice and average percentage conformity was less than (74%) that of HACCP implementation. The results differed in the findings of a previous investigation [21] after 2 bakeries were assessed. In that study, it was shown that moderate risks existed in parts I and II of the HACCP audit whereas only part II of this study showed moderate risks. The reason for these differences may be operational because the bakeries make products that are different to the soft drink company and also the different company sizes could have an effect on compliance. Moreover, it has been shown that the degree to which the objectives of HACCP are achieved can differ between two processing facilities [36]. It has been reported that strict adherence to quality and safety management systems like HACCP in non-alcoholic beverage industry like the facility studied can ensure the quality of the final product [37]. However, the results of the studies in the aforementioned bakery and this study had some similarities in that overall percentage conformity was higher in part I than part II of the audit (Table 3). The area that had the least score overall was record keeping and documentation in part II (Principle VII) possibly because staff focused on process monitoring documentation first before HACCP documentation which caused lesser time to be allocated to HACCP documentation during processing.

In another study [38] that included ISO certified and non-certified companies involved in beverages and other products, it was found that the overall assessment of the HACCP principles in certified food businesses was higher than in non-certified ones. However, the investigators

found that functioning of HACCP principles in practice was lower than the system implementation in all business groups, regardless of the type of food industry. In all cases, both implementation and functioning of HACCP principles were evaluated higher in certified than in non-certified food businesses. Overall, the three-dimensional features of the HACCP objectives namely hazard identification, hazard assessment and hazard controls [39] were evident in the bottling facility. The hypothesis that HACCP application can prevent hazards from getting to a high-risk situation is true on this occasion since no high-risk score was obtained after FMEA was carried out.

3.3 Factors That Affect HACCP Implementation

Gaps can begin to exist, mostly due to lack of motivation after initial HACCP implementation [40] and if left unchecked the system may deteriorate. Also, if there is a deficiency in the HACCP team's knowledge about how to apply HACCP principles it could lead to weaknesses in the system [41]. The motivation and reason for HACCP implementation vary among food processors. For the processing facility studied, it appears that the motive for HACCP implementation is mainly regulatory compliance and may explain why the percentage conformity was higher in part I than part II of the audit (Table 3). Also in part II, verification procedures (principle VI) had a low score possibly because some staff did not believe that verification has led to improvement in HACCP implementation even though documentation in the plant showed how the use of the HACCP decision tree tool helped reduce the number of critical control points. Some staff had the opinion that critical limits had been in the plant for years and HACCP implementation did not affect the numeric cut-off of any parameter in many control points. This was mainly because the critical limit in several PRP in the plant also served as the limit in some control points of the HACCP program. A definitive finding is that some key performance indicators' limits served the dual purpose of HACCP food safety program compliance and quality assurance monitoring. This made some plant staff to presume that the HACCP implementation is just a change of nomenclature for normal plant operations. The effect of this attitude was that plant staff struggled to distinguish between the quality control aspects of manufacturing processes and food safety requirements of HACCP.

Table 1. On the spot process verification of key parameters during HACCP audit

Parameter (Limits)	Production samples	Warehouse samples
Brix (7-14%)	10.41 ± 0.00 (%)	10.37 ± 0.01(%)
CO ₂ (3-7.9g/L)	7.80 ± 0.00 (g/L)	7.50 ± 0.01 (g/L)
Fill Height (332.5-367.5 mL)	355 ± 1.15 (mL)	350 ± 0.00 (mL)
Yeasts (1 CFU/mL)	0 CFU/ 20 mL	0 CFU/20 mL
Mold (1 CFU/mL)	0 CFU/ 20 mL	0 CFU/20 mL
Total Bacteria (25 CFU/mL)	0 CFU/ 100 mL	0 CFU/100 mL
Coliform (0 CFU/mL)	0 CFU/ 100 mL	0 CFU/100 mL

± = standard deviation

Table 2. Compliance level of GMP and other issues flagged from audit of pre-requisite programs

Auditing firm	Compliance (%)
1. Company under study (Internal audit)	95
2. NAFDAC	100
3. Standard Organization of Nigeria	100
4. Weights and Measures of Federal Ministry of Environment	100
5. State Environmental Protection Authority	90
6. Franchise owners	100
7. Third Party Audit specialists	96

In most food processing environment, no HACCP plan can be effective without good GMP and issues concerning food safety and quality may overlap. It has been pointed out [1] that while the application of HACCP to all segments of the food chain is possible, it is assumed that all sectors should operate according to good manufacturing practices and the Codex general principles of food hygiene. Also, the ability of an industry sector to support or implement the HACCP system depends on the degree of its adherence to these practices. Furthermore, in that report, it was highlighted that even though HACCP is the system of choice in the management of food safety within such systems, the application of the HACCP system is compatible with the implementation of total quality management systems such as the ISO 9000 series.

In other parts of the world, a study [42] that compared the implementation of HACCP systems in Chinese and Mexican meat exporting companies showed that the improvement of process control was a motivation for Chinese companies whereas getting into new markets was important for the Mexican companies. It was

found that the main motivation for both countries was the improvement of product quality. Several other factors which were observed in part in this study can affect HACCP implementation. This may include lack of consistency in the definition of terms observed in Poland and Germany [43] and lack of necessary commitment of food processing staff reported in Oman [44] and Spain [45]. Other deficiencies found in the United Kingdom include staff not having the scientific expertise to comprehensively identify the significant risks in their businesses [46].

A detailed review [47] on factors influencing HACCP implementation highlighted lack of awareness of HACCP, no perceived benefits, lack of training, management regressions, and variability of production lines. Other factors in that report include individuality of each product, the variability of the consumers' demands and small size of a company. While some of these issues may be beyond a company, a systematic training program will reduce poor implementation. The facility studied will need to work on staff apathy to improve maintenance of the HACCP structure during operations.

Table 3. FMEA table showing severity (S), occurrence (O), detectability (D) and risk (R) scores

Evaluated criteria	Audits results			FMEA		
	Mean score	Conformity	S	O	D	R
<i>Part I: implementation of HACCP</i>						
Step 1. Establishment of HACCP team	5.00	100	1	1	7	7
Step 2. Description of products	4.60	92	2	2	4	16
Step 3. Identification of intended use	3.29	66	3	6	1	18
Step 4. Construction of flow diagram	3.92	78	4	4	3	48
Step 5. On-site confirmation of flow diagram	5	100	4	4	3	48
Step 6. Principle I. Conducting a hazard analysis	4.5	90	7	2	1	14
Step 7. Principle II. Identification of critical control points (CCP)	4.75	95	7	2	3	42
Step 8. Principle III. Establishment of critical limits	5	100	7	1	7	49
Step 9. Principle IV. Establishment of monitoring systems for each CCP	4.82	96	8	2	4	64
Step 10. Principle V. Establishment of corrective action	4.33	87	8	3	3	72
Step 11. Principle VI. Establishment of verification procedures	4.80	96	9	2	4	72
Step 12. Principle VII. Establishment of documentation and recordkeeping	4.0	80	6	4	4	96
<i>Part II: the functioning of HACCP in practice</i>						
Principle II. Identification of critical control points (CCP)	3.75	75	10	5	2	100
Principle III. Establishment of critical limits	4.5	90	10	3	4	120
Principle IV. Monitoring of CCPs	3.57	71	10	5	2	100
Principle V. Establishment of corrective action	3.5	70	10	5	3	150
Principle VI. Verification of procedures	3.7	74	10	5	6	300*
Principle VII. Record keeping and documentation	3.15	63	10	7	6	420*

*moderate risk

4. CONCLUSIONS

The motivation to implement HACCP in the facility studied was to meet and exceed regulatory requirements and produce safe food products for customers. The evaluation of the bottling facility showed that all aspects of the seven principles and 12 implementation steps of the HACCP system were firmly established. However, from the scores obtained, the implementation of the HACCP structure in place during operations requires improvement. Re-training of staff on HACCP may be beneficial. Also, GMP compliance was very good and if maintained, there would be no issues that may affect the implementation of the HACCP program. It appears that the hypothesis that the implementation of HACCP procedures guarantees success in ensuring food safety was correct on this occasion since no high-risk result was obtained from the risk calculations. This does not rule out food safety issues in the facility studied when a holistic picture is considered.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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