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Research Article

Development of hazard analysis critical control point (HACCP) programme and Assessment of its impact on microbial levels. A case study of the baobab pulp processing

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Abstract

The baobab fruit pulp has in the recent past gained interest in Europe and North America after being declared a novel food. This has led to increased demand and growth of the market as populations are gaining from its nutrition and economic potential, however, the baobab value chain still faces unaddressed food safety concerns. This study aimed to develop a Hazard Analysis Critical Control Point (HACCP) plan for the baobab pulp value chain in Kenya. Prior to commencing the HACCP development, training was conducted aimed at describing the steps towards HACCP development and implementation for the baobab pulp. Microbial analysis of swab samples obtained from hands, surfaces, equipment, and storage materials was done before and after HACCP training and development. Changes such as the wearing of aprons and hairnets were observed throughout the manufacturing process after the HACCP training resulting in a significant (p=0.01, 0.003) reduction of the microbial load. One critical control point was identified at the reception with the hazard of focus being aflatoxin contamination. The complete HACCP plan and the required pre-requisite programs were developed to deal with the identified hazards. HACCP training proved to be the foundation of effective HACCP development. Without HACCP implementation, achieving the objective of consistent, safe food production would be far more difficult.

Keywords: Baobab pulp, Critical control point, Food safety, HACCP plan, Microbial levels

INTRODUCTION

Kenya still battles with food and nutrition insecurity with 2.6 million people being severely food insecure (Momanyi et al., 2019). One way to alleviate this could be the use of wild edible fruits and their derived food products. These indigenous fruits are locally available and are often packed with micronutrients that can be used in food fortification (Chadare et al., 2009).

Baobab is an indigenous tree that grows in sub-Saharan Africa. Its fruit pulp is mostly used as a food ingredient in Africa whereas in the EU and America it is used as a dietary supplement (AFTER, 2011). The fruit pulp has been used locally to formulate several products which include; candies, ice cream, juices among others. The baobab leaves are equally nutritious and are utilized locally in making vegetable dishes. The baobab fruit pulp has gained a lot of interest in Europe and North America where it is marketed as a super fruit because of its nutritional profile. In response to the increase in demand, there is market growth for baobab fruits in western and southern sub-Saharan Africa (Jäckering et al., 2019).

Baobab has demonstrated the potential to act as a financial buffer especially among women and youth and bring about food security in the rural areas of Kenya, Benin, Mali, and Senegal among other African countries (Kaimba, 2020).

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Farmers, collectors, wholesalers, processors, and retailers are the main actors of the baobab value chain where 72% are female (Kaimba, 2020). Despite the potential of baobab to contribute to food and nutrition security as well as improved livelihoods through income generation, challenges such as spoilage and food safety issues remain largely unresolved. Microbial safety has emerged to be a global concern, and it has, in turn, led governments all over the world to escalate their efforts to address food safety concerns (Jacxsens et al., 2009).

The increase in demand for baobab has encouraged the harvesting of baobab fruits before they fully attain adequate dryness. The downside of premature fruits is that they could easily lead to the growth of yeast and molds due to elevated moisture levels. In addition, the increased market demand for baobab fruits has more often than not superseded the need to observe food safety. This has necessitated the need to upgrade its value chain. Without adequate adherence to the food safety system, there is no food security and therefore it is necessary to implement a food safety management system in the baobab value-chain to abate potential human health risks. Hazard Analysis Critical Control Point (HACCP) is a food safety system set to prevent hazards from finding their way into the production process of food products (Citraresmi & Wahyuni, 2018). The introduction of a HACCP framework in the food industry enhances participation, awareness, and commitment to a hazard management perspective in food production. Globally, the adoption of HACCP-based regulations as the most appropriate food safety scheme is becoming more mandatory. Before setting up an advanced safety system such as HACCP, prerequisite programs such as good hygiene practices, good manufacturing practices, and sanitary standard operation procedures should be in place to improve food safety. The main aim of this study was to develop a HACCP plan applicable in the production of baobab pulp.

METHODOLOGY

Study Site

The study on HACCP development for baobab pulp in Kenya was conducted in Vokenel Enterprises Ltd; a company that processes and packages organic baobab fruit powder and organic baobab oil located in Kibwezi, Kenya. The support of the management of the company for food safety was sought and obtained prior to the commencement of the study. Before the first visit to the company, comprehensive training materials were developed and reviewed by the HACCP consultant personnel (James et al., 2022).

Development and review of HACCP training material

The review of the HACCP training materials involved assembling the food safety-related documents and purchasing a copy of the Kenya Bureau of Standards (KEBS) HACCP standards. Documents were prepared on practical knowledge of how the process works at all times during production (including breakdowns) and a thorough understanding of all aspects of the equipment design and operation. It also covered a thorough understanding of the likely reservoirs of hazards (microbiological, chemical, and physical) in the raw materials as well as a processing environment. Finally, the factors that will enable a rise or decrease in the number/level of hazards under examination were discussed, as well as an understanding of the consequences of the presence of such hazards on product safety.

HACCP training

The training was done before HACCP development during the first visit to Vokenel Enterprises Limited. The training was provided to the production team since they are in charge of controlling the manufacturing processes and, as a result, their role in ensuring food safety and implementing HACCP is vital. The training was aimed at describing the steps towards HACCP development and implementation for the baobab pulp at the company.

It covered the following aspects:

1. The main sources of hazards in the product and their impact on product safety as well as the control required at the point of occurrence.
2. Critical control points (CCPs) and their role in ensuring product safety.
3. The monitoring procedures for the critical control points and the capturing of accurate and relevant readings for monitoring purposes. Understanding of the identified critical limits for the monitoring procedures.
4. The remedial action to be taken when a CCP deviates from the critical limit.
5. proper record-keeping processes. (Figure 1)

The steps used to develop the HACCP system in the baobab pulp processing unit were as follows;

Step 1: A team was formed comprising of a production manager, production engineer, a food scientist, HACCP consultant, and the production team.

Step 2 and 3: Product description

The product description included information such as how the product is processed, a list of ingredients (if any), preservation methods, primary packaging, storage conditions, and shelf life.

Steps 4 and 5: By observing and using the information provided by the HACCP team members, the baobab pulp

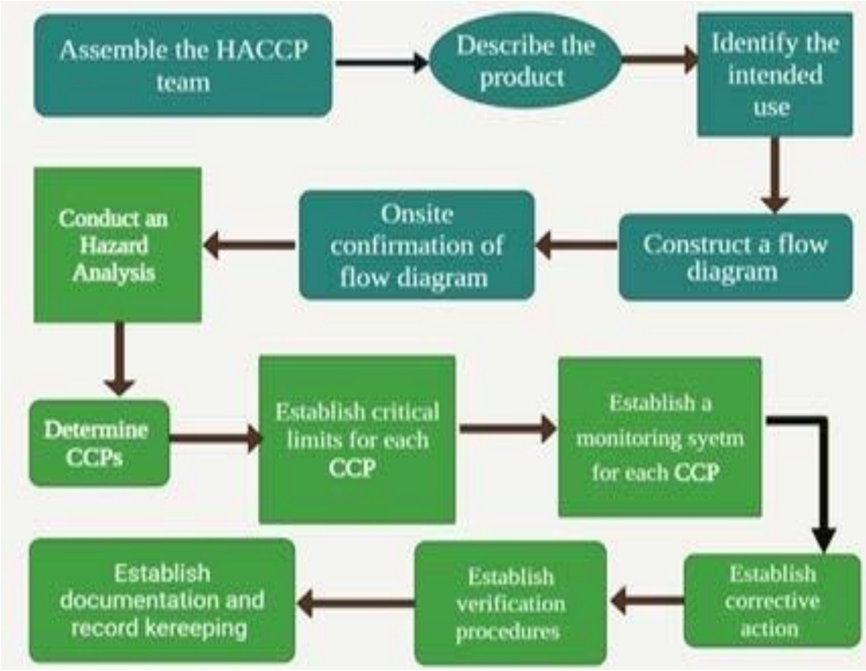

Figure 1: The twelve steps followed in developing the the HACCP system for the baobab pulp processing unit were described by East Africa Community.

flow diagram was created. Each process step from raw material reception, through processing all the way to dispatch was outlined in a flow diagram sequentially. The flow diagram was then confirmed onsite as shown in Figure 2.

Verified flow diagram A flow diagram showing activities from sourcing of baobab fruits to the finished product was developed as shown in Figure 2.

Steps 6 and 7: These steps involved a listing of all potential hazards according to the verified flow diagram, conducting hazard analysis, and the identification of the control measures. A Decision tree with likelihood and severity scale scores of 1-3 was used to identify potential hazards at each process step and to label the step as a CCP or not.

Steps 8 to 12: In these steps, critical limits were established for the identified CCPs to indicate when a CCP is in or out of control. A reliable monitoring system and corrective action steps were assigned to the identified CCPs to ensure a rectification in case of deviations. And finally, a verification system and record-keeping procedures were suggested to ensure the efficiency and manageability of the developed HACCP.

Microbial Analysis

To determine the state of hygiene of the processing environment microbial analysis was done. Swab samples were collected from the personnel hands, preparation surfaces, milling equipment, and storage materials before and after HACCP training and development. Sterile cotton pre-moistened with peptone water was used in collecting the swabs and a sterile ruler was used to demarcate a 25 cm^2 sampling area. The swabs were then aseptically reinserted into their respective tubes; the tubes were then tightly closed, stored, and transported to the laboratory in a cool box at 4°C. The swabs were each analyzed in duplicates for the *E. coli*, total coliforms, total plate count, and yeasts and molds according to the AOAC microbiological methods (AOAC International, 2002). All media was purchased from Sigma-Aldrich (England, UK).

The swabs were transferred into 1 ml of 0.1% sterile peptone water and mixed uniformly using a bench vortex Mixer® (AHN, Nordhausen –Germany) after which two serial dilutions (10^{-1} and 10^{-2}) were made *E. coli* was enumerated on sorbitol-MacConkey plates, total coliforms on violet red bile agar (VRBA), total aerobic counts on plate count agar (PCA), and yeasts and molds on potato dextrose agar (PDA). The spread plate method was used as the plating technique for the three microbial analyses where 0.1 ml of sample serial dilutions were plated. The *E. coli*, total coliforms, total plate count, and yeasts and molds were assessed after incubating sorbitol-MacConkey plates at 37°C for 24 hours, VRBA plates at 35℃for 48 hours, PCA plates at 37°C for 48 hours, and PDA plates at 25°C for 5 days (Park et al., 2015;

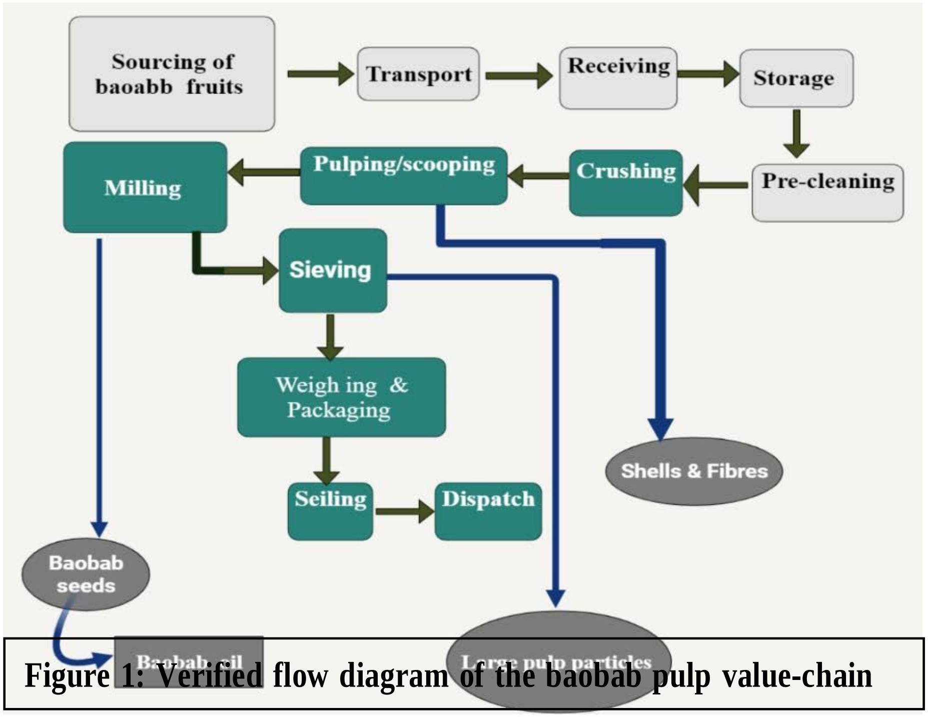

Figure 2: The steps used to develop the HACCP system for the baobab pulp processing unit.

Witthuhn et al., 2005). The results were expressed as the number of colony-forming units per gram of baobab sample (CFU/g).

Aflatoxin Analysis

Aflatoxin contamination is one of the potential hazards at the reception and is mostly affected by the period the baobab fruit stays on the tree after maturity and drying and the storage conditions. Aflatoxin contamination is one of the potential risks at the reception, and it is primarily influenced by how long the baobab fruit remains on the tree once it has matured. Aflatoxin analysis was done to determine the safety and concentrations in and outside the fruits due to the nature of the baobab fruits storage structure, which exposes the fruits to humidity, particularly during the rainy seasons. In triplicate, two grams of powdered baobab shell (outer) and baobab pulp (inner) samples were weighed and added to an extraction solution containing 1 g sodium chloride in 25 ml (methanol: water 80:20 v/v). This was centrifuged at 10000 rpm for 5 minutes. Five milliliters of the supernatant were then transferred to a 50 ml centrifuge tube and diluted with 40 ml of the 2% PBST (phosphate-buffered saline with tween) solution (Karaca & Nas, 2006). This was then filtered into vials using a 0.2 µm pore size syringe filter. Aflatoxin quantification was done by injecting 20 µl of the samples into a SHIMADZU HPLC system equipped with a fluorescence detector RF 20A operated at an excitation wavelength of 350 nm and an emission wavelength of 450 nm, Auto-sampler SIL 20AHT, CTO 10ASVP column oven set at 40°C and LC20AD quaternary pump. A mobile phase of acetonitrile: methanol: water (10:30:60 v/v) was used at a flow rate of 1 ml/min (Table 1).

Data Analysis

Data were analyzed using STATA for windows version 12.1, 2011 package by StataCorp Inc., USA. Means and standard deviations (SD) were calculated for all microbial counts. The microbial data were subjected to a paired student T-test to evaluate any differences in microbial loads before and after HACCP training and development at significant levels of $p \leq 0.05$. The data from aflatoxin analysis were subjected to an independent student T-test to assess differences in aflatoxin levels between the inner and outer surfaces of baobab fruits at significant levels of $p \leq 0.05$ (Figure 3).

Prerequisite Programs – (PRPs)

The prerequisite programs serve as the basis for the development, implementation, and continuousmaintenance of the HACCP (Milios et al., 2012). An assessment of the PRPs was done according to the general principles of the Codex Alimentarius on good manufacturing practices (GMPs) and good hygiene practices (GHPs). The study revealed that the environment and the premise conditions were suitable for the production of baobab pulp, however, there were key areas of concern discussed below.

Table 1. The baobab pulp description along the Kenyan baobab value chain.

	Baobab pulp
Processing	Baobab fruits are harvested from trees. The hard shells are cracked open and the pulp is separated from the seeds and the shell. This is milled, separated into coarse and fine lots (particle size 3 to 600 µm), and then packaged.
Storage conditions	Refrigeration
Shelf life	3 years under refrigeration
Indented use	Made into juice by mixing with water. An ingredient in yogurt and smoothies. Added to tea, marinades, or sauces
Packaging	Mini plastic Ziploc packages
Target customer	General population

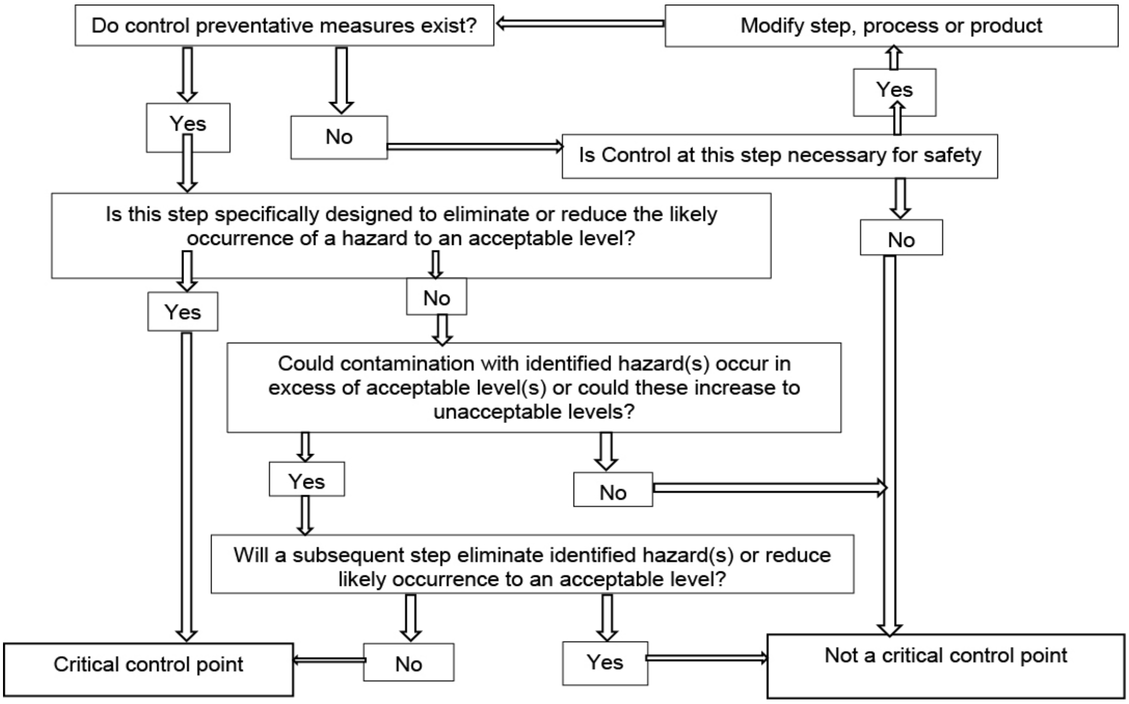

Figure 3: Decision tree used to identify potential hazards at each process step and to label the step as a CCP or not.

Storage of baobab fruits:

The storage site was ideal for storing baobab fruits since it raises the fruits above the ground and provides adequate aeration; however, it posed a food safety risk during rainy seasons because rainwater can easily seep into the baobab fruits from the sides of the storage structure. It was proposed that the sides of the storage structure should be covered to provide a barrier for the rains.

Premise condition

The implementation of a food safety management system can be hampered by incorrect plant layouts and poorly engineered equipment. However, well-designed and structured premises would ensure the safety of food products, maintaining hygienic conditions, effective cleaning, and control insect infestations. The premise was set up in such a way as to permit good food hygiene practices. It however did not shield the finished product from cross-contamination since the product flow was not mapped out. In addition, the walls were not rodent and insect-proof. Renovations were proposed to keep insects and rodents out, as well as a shift in product flow to keep finished products away from the raw materials. In collaboration with management, a sanitation protocol for personnel hygiene and cleaning was also created.

Maintenance and cleaning

The facility and equipment were washed regularly. While repairs had not been carried out in a while, the equipment was still fit for processing. The management was given the task of implementing the drawn maintenance, sanitation, and cleaning procedures.

Pest control and waste management

A pest control contractor had been hired by Vokenel Enterprises Ltd. There was a pest control schedule and protocol in operation, which had been documented. A regular waste disposal system is operated by the county garbage collection scheme. The wastewater treatment plant of the county council takes liquid waste directly. It was suggested that solid waste should be disposed of daily.

Personal hygiene guidelines

Personnel had access to a sanitation (toilet) facility. The premises needed redesigning to offer stringent cleanliness, hand washing and foot infecting, and correct management of personal protective equipment (PPE). Personal hygiene execution was advised, as well as the use of head covers, footwear, and aprons for staff handling processing, packaging, and storage of baobab pulp. Production personnel was required to undergo a medical examination and issued a food handler's certificate, with their compliance monitored. Monitoring of the cleanliness and hygiene of the employees was proposed. Visitors and all other contractors who could come into contact with the facility were to be subject to the same rules.

Traceability

In the event of a hurdle, the traceability system in place was in terms of baobab farm, year of production, the month of harvest, and day of harvest, ensuring that any recall procedures were implemented quickly. A traceability index including batch number, incoming date, and output date was recommended, as well as the First in First Out (FIFO) approach to traceability. A structured protocol was in place for dealing with consumer concerns.

Staff training

The training was done for all the staff whose awareness, support, consent, and participation in HACCP are necessary for the full realization of the HACCP benefits. The training schedule was functional and was designed to take into account the baobab production process from reception to dispatch, understanding standards and the procedures required to maintain the integrity of the products and product labeling. The training also helped in achieving dedication from senior management down to operational personnel. For newcomers and those returning to the premises after a long absence, refresher training was recommended.

Microbial Analysis

The primary goal of the microbial analysis was to ensure that all possible sources of contamination have been detected. It has also been used in other studies to assess the likelihood of occurrence of hazards and to establish sanitation standard operating procedures (SOPs) (Kvenberg & Schwalm, 2000), (Kokkinakis & Fragkiadakis, 2007). In this study, microbial analysis was deemed vital in determining the effectiveness of the prerequisite programmes. A significant difference was observed between the microbial analysis from the first set of swabs and the second set Table 2. The first set of swab microbiological analyses was done before any training, and the second set was obtained during the second visit six weeks after the training. The E. *coli*, total coliforms, total plate count, and yeast and mold loads were significantly (p=0.01, 0.0009, 0.003) lower. The significant reduction of the microbial loads in the personnel hands, the cracking machete, storage buckets, and the pulping machine demonstrated the impact of the implementation of the personal hygiene and sanitary operation prerequisite programmes. A similar trend was observed in a study on the microbiological quality of ice cream after HACCP implementation done in Greece (Kokkinakis E et al., 2008). The output in this study is also comparable to a study done by (Kussaga et al., 2017) on the microbiological performance of Hazard Analysis Critical Control Point (HACCP)-based food safety management systems.

Behavioral Changes

The HACCP implementation had visible effects. The onsite documentation and records were valid and appropriately in use which made it easier for inspection and mistakes less likely to occur. During production, aprons, hairnets, and gumboots were among the noticeable changes. There were also handwashing and foot sanitizing stations on the site. Hand sanitation was also introduced during production, taking place at intervals of 30 minutes. The general hygiene of the premises and the surroundings significantly improved, as demonstrated by the cutting of grass around the compound, the cleaning of floors and work surfaces, and the reduction of microbial. The positive impacts realized

Table 2. Microbial loads for the swabs before and after HACCP training.

	Personnel's hands		Cracking Machete		Storage Buckets		Pulping machine	
Microbe	Before	After	Before	After	Before	After	Before	After
E.coli	5±0.55	0	103±0.72	0	17±0.33	0	39±0.12	0
Total coliforms	55±0.12	3±0.41	87±0.36	5±0.17	75±0.63	0	63±0.71	0
Total plate count	20±0.43	2±0.02	107±0.75	10±0.92	29±0.03	6±0.07	33±0.32	7±0.89
Yeast and molds	13±0.03	0	16±0.39	2±0.04	36±0.05	4±0.09	43±0.35	5±0.43
P-value	0.01		0.0009		0.003		0.0001	

were similar to those of a study on HACCP implementation in school food service (Kokkinakis & Fragkiadakis, 2007).

Aflatoxin Analysis

Aflatoxin analysis showed a significant difference between the aflatoxin (G1, G2, B2) levels in the outer surface of the fruit and the pulp inside (p=0.04, 0.01, 0.009). Dried fruits such as baobab are prone to mold growth and mycotoxin formation due to their high sugar content, method of harvest and drying conditions. The exterior surface of baobab fruits, if infected by mold may grow rapidly and more so if the drying process is not effectively carried out. These fungi can produce mycotoxins and hence causing economic losses in the long run (Al Ghamdi et al., 2019). The age of baobab fruits was mentioned as a factor while procuring baobab fruits for baobab pulp manufacturing. Fruits harvested in past seasons are more likely to be moldy, depending on how the farmers stored the fruits. Some storage practices expose baobab to humidity leading to mold growth. The findings of the aflatoxins analysis on the outer and inner surfaces of the baobab fruits revealed that the shell acts as a protective barrier against the mycotoxins. Mycotoxins, on the other hand, can easily migrate from the outer surface to the pulp during processing. To prevent this from happening a conveyer belt was suggested to help transfer the cracked fruits to the scooping station during the production of baobab pulp. This ensures that scooping occurs promptly after each fruit is broken, as opposed to formerly when all cracked fruits were piled together in one bucket to be scooped afterward (Table 3).

Hazard identification

Inadequate hazard detection during the development of the HACCP framework has been reported as a major barrier to successful HACCP implementation. The following hazards were identified, along with their potential control measures, after an understanding of the hazards, classification, and integration into the system (Table 4).

Establishment of the critical control points/ Operational pre-requisite programs, monitoring procedures, and corrective actions

CCP1 – Processing step 3 (Reception)

The first CPP was identified at the reception where baobab fruits could be a potential source of aflatoxin contamination. It is a critical step since there is no subsequent step that can eliminate or reduce the levels of aflatoxins. The baobab fruit suppliers must be pre-qualified to ensure that all of the farm's fruits are produced in the right way, only those who grow organically are approved and given the duty of supplying. In addition to pre-qualifying suppliers, the following steps were implemented: only fruits from that season were to be sourced, and fruits from previous seasons were to be rejected, the production team was to inspect the fruits' surfaces for any moldy fruit and reject it; during processing, the FIFO (First In First Out) principle was to be adopted to stop the baobab fruits overstaying at the reception bay; and finally, the baobab structure was to be covered on the sides to avoid rains from seeping into the fruits (Figure 4).

OPRP 1 and OPRP 2- processing steps 8 & 9 (Scooping and Milling)

The OPRP 1 and 2 identified at the scooping and milling steps with bacteria and yeast and molds as the target hazards. This was identified in the baobab processing flow diagram during the hazard analysis. To help abate the hazards, several monitoring procedures were identified. The pulp contact surfaces and storage buckets were to be cleaned and sanitized with a food-grade soap. During production, the production team was required to wash and sanitize their hands at regular intervals of 30 minutes. They

Table 3. Aflatoxin analysis of the inner pulp and the outer shell of baobab fruits.

Samples		Aflatoxin ppb (×10^3)			
	Code	G2	G1	B2	B1
Inner pulp	18BIN	0.94	0	0	0
	18GIN	1.21	0.53	0	0
	20BIN	3.91	0.53	0	0
	20GIN	1.26	0.54	0	0.019
	20RIN	1.36	0	0	0.010
	20TIN	1.12	0	0	0
Outer shell	18BO	1.98	0.53	0	0.009
	18GO	3.68	0.56	0.06	0.08
	20BO	1.58	0.76	0.07	0
	20GO	14.4	0.54	0.06	0.026
	20RO	4.82	0.53	0	0.017
	20TO	9.28	0.53	0.07	0.005
P-value		0.04	0.01	0.009	0.20

Table 4. The hazards along each baobab pulp processing line and their possible control measures.

Processing step	Physical, biological, and chemical hazards	Source	Control measure
Sourcing baobab fruits	Foreign materials, pesticides, cracked fruits, old fruits	Farm activities, the harvesting process	Sorting of raw materials, inspection at the farm before sourcing.
Transport	Dirt, grease	Farm activities, transport vehicle	Proper inspection of the transport vehicle to ensure its cleanliness and no grease leakages.
Receiving	Cracked fruits, foreign materials	Farm activities, transportation process	Fruits inspection and sorting
Storage	Insects, old fruits, snakes	Environment, farms activities	Fruits inspection and sorting, continual maintenance of the store
Pre-cleaning	Itchy furs, stones, bacteria	Fruits, personnel hands, environment	Sorting, protective clothing, pre-cleaning in a different area than the cracking area
Breaking	Shell, bacteria	Fruits, contact surfaces	Personnel hygiene and facility cleaning,
Scooping	Fibre, insects, dust, bacteria, mold	Fruits, environment, Personnel hands	Personnel hygiene and clean environment, scooping in a clean area protected from any environmental contaminants
Milling	Seeds, fibre, grease, metal pieces, dust, rust, bacteria	Fruits, processing equipment, personnel hands, Environment	personnel hygiene, providing an outlet for the seeds after processing, regular maintenance of the milling machine, proper cleaning and drying of the milling machine before processing
Sieving	Fibre, shells, dust, bacteria	Fruits, environment, personnel hands, processing equipment	personnel hygiene, clean sieve of proper size, the processing area should be shielded from any environmental contaminants
Packaging, weighing & labeling	Glue, ink, bacteria, dust	Packaging material, labeling ink, personnel, environment.	Use of food-grade glue and labeling ink, avoiding contact of the glue and ink with the product, protecting the area against environmental contaminants
Storage	mold	Environment	Maintaining a hygienic environment and proper storage conditions

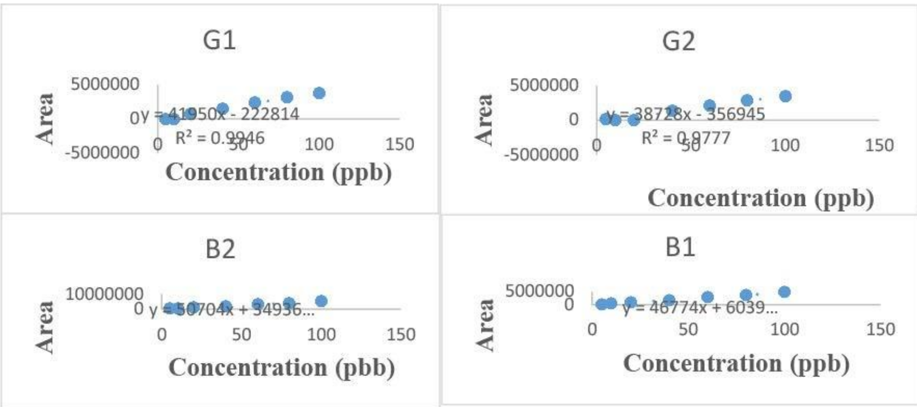

Figure 4: Aflatoxins standard curves.

were also required to wear white aprons and hairnets while processing. Any member of the production team was to be excused from duty in the event of injuries or open wounds on the hands. The baobab pulp storage buckets were to be washed and sanitized with a food-grade soap and an alcohol-based sanitizer. The milling machine was to be cleaned before production and allowed to dry adequately, and it was then to be sprayed with ethanol. To avoid dust accumulation, the milling machine was to be covered while waiting for another batch to be processed. It was also proposed that the milling machine be air blown at high pressure and ethanol sprayed before processing. After processing, the pulping or milling machine was to be covered to prevent dust while waiting for another batch to be milled.

The different monitoring procedures were outlined for all CPPs and OPRPs in the HACCP plan as a result of this study.

The target hazard for the CCP1 detected at the reception was aflatoxins. This was based on the company's experience with aflatoxin incidences in finished goods as a result of the raw materials. Farmers were reported to supply moldy baobab fruits from the previous season, some of which have already produced aflatoxins. In Kenya, the maximum aflatoxins limit for baobab products are 10 g/kg for total aflatoxins (AFB1, AFB2, AFG1, AFG2) and 5 g/kg for AFB1 (EAC, 2016). Some of the monitoring procedures put in place for this step were; All fruits were to be inspected to ascertain they were of that season, the fruits were to be inspected for any moldy surfaces, and every batch was to be analyzed in an accredited lab for total aflatoxins and aflatoxin B1. As for the OPRPs, the 4W 1H rule (What, Where, Who, when (Frequency), and How) was used to monitor (Kokkinakis E et al., 2008) (Tables 5,6).

Table 5. Identified CCPs for baobab pulp HACCP plan.

CCPs	Process step	Hazard	Critical limits	Monitoring procedure	Frequency	Preventive measure	Corrective action	Records	Responsible person	Verification procedures
CP No 1	Reception	Total Aflatoxins (AFB1+AFB2+AFG1 +AFG2) μg/kg Aflatoxin B1, μg/kg	10 5	Baobab fruits inspection for compliance for every batch by the QA -laboratory aflatoxin analysis	Every delivery	Withholding of the baobab fruits awaiting inspection and approval	Rejection of the batch if they do not comply with the raw material specification	Raw material specification	QA personnel	Check the raw material verification records and get quarterly reports from accredited labs for aflatoxin tests

Table 6. Identified OPRPS for the baobab pulp HACCP plan.

OPRPs Processing step	Hazard	Monitoring					Preventive measure	Records
		What	When	Where	Who	How		
1-Scooping 2-Milling	Yeast and molds, Escherichia coli, Bacillus cereus, Staphylococcus aureus, Shigella, Salmonella,	Washing and sanitizing	Every 30 mins	Production area	All Production staff	SOP	Regular handwashing and sanitizing with a food-grade alcohol-based sanitizer. Proper production attire (white aprons and hairnets) Production personnel should not be allowed in the production area if; they haven't washed and sanitized hands, are sick and have open wounds, have not acquired a medical certificate	Handwashing and sanitizing records Medical certificates

Establishing verification procedures, documentation, and record-keeping:

Every three months, the quality assurance personnel are to conduct internal verification. The conformity between the HACCP manual and the records and the actual situation in the field is to be checked during the verification and updated as required. A HACCP system certification agency is to conduct the external verification. The documentation is conducted as part of the monitoring process. Any remark about the CCP, OPRP, critical limits, monitoring procedures, corrective action, and remarks about verification was to be properly documented and recorded during the baobab pulp processing. This data will be used by Vokenel Enterprise Ltd during the implementation process.

Cost-benefit analysis:

HACCP implementation comes with costs such as external consulting services, Staff training, prerequisites implementation, investments in new equipment, structural improvements to plant and buildings, hiring new staff, product testing, managerial time, staff training, quality department operational costs, and record keeping (Milios et al., 2012). While the costs of implementing HACCP cannot be minimized, there could be a long-term advantage in terms of reduced product waste or rework. The benefits of the HACCP system include increased ability to enhance manufacturing processes, increased ability to attract new consumers, access to new markets, and retention of existing customers, decrease in product wastage and production costs and increase in product prices (Semos & Kontogeorgos, 2007) (Lupin et al., 2010)(Citraresmi & Wahyuni, 2018).

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CONCLUSION

The food industry has a mandate to manufacture safe food, and regulatory agencies have to inspection system to ensure product safety. Both industry and regulatory bodies have a responsibility to provide safe food to the general public. One of the reliable ways to achieve the above is through the development of HACCP. HACCP training proved to be the foundation of effective HACCP development; without it, achieving the objective of consistent, safe food production would be far more difficult. There were significant changes after the training was completed. Production personnel, for instance, welcomed the use of aprons and hairnets. A clean manufacturing environment was also observed, with microbial loads on surfaces and staff hands significantly reducing. In this study, the crucial need for the existence and operationalization of GMPs and Standard Sanitation Operation Procedures (SSOP) was revealed, and hence the suggestions for improvement of premises to support these basic tenets of a HACCP plan.

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