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Developing a Verification Program for Sanitation and Pasteurisation Activities during Pineapple Juice Production

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Abstract
Pineapple juice is a popular refreshing drink served in most catering establishments in Ghana. Despite its nutritious benefits, a number of spoilage microorganisms have been associated with the juice with the most important one being Saccharomyces cerevisiae which is known to reduce the shelf life of the product. It is imperative to put in place certain control measures such as hygiene or temperature controls, which have to be verified that they are indeed under control in order to limit microbial contamination and growth. Most small and medium-sized enterprises in the food production industry in Ghana do not have quality management systems due to lack of support and technical expertise. This present work was aimed at developing an on-going verification program, based on existing literature, for the pasteurisation and sanitation activities during pineapple juice production. The main focus was on the critical factors influencing the effectiveness of the pasteurisation and sanitation activities and how verification had to be done in terms of frequency, person responsible, methods/sources of information, documentation requirements and verification data analysis. A verification program has been successfully developed and is being suggested to pineapple juice production companies for implementation.
Keywords: Sanitation, pasteurisation, pineapple juice processing, verification, quality assurance

1. Introduction

Pineapple juice is a common product on the Ghanaian market which consumers patronise because of its health benefits. During the processing of the pineapple fruit into juices, the pasteurization step is essential to inactivate pathogens and other heat-sensitive microbes which may be present, thereby extending the shelf-life and thus preventing illnesses (Tournas et al., 2006; Parish, 2009). This is an intervention step because yeasts which are still present in the product after the pasteurisation process are able to grow, even at refrigeration temperatures and cause spoilage of the juice if they reach a certain number (Tribst et al., 2009). Eventhough pasteurisation is essential, some companies do not have that in their processing steps and therefore, to ensure that fruit juice is produced which is microbiologically safe for consumption, a stringent hygiene control in the processing environment is essential (Parish, 2009). Sanitation, which is a preventive process, applies to the hygienic practices designed to maintain a clean and wholesome environment for food production, processing, preparation and storage. Strict hygienic production is crucial to ensure that the end-products are free from yeasts and of good quality (Lelieveld et al., 2005).

In order to guarantee that during pineapple juice processing, yeasts present are eliminated or contamination of fruit juice is prevented, verification activities as part of quality management systems are important. However, Mensah and Julien (2011) have found out that most small and medium-scaled enterprises (SMEs) in Ghana do not have operational quality management systems in their companies. In Ghana, the lack of verification programs during pineapple juice processing has been attributed to the lack of support and technical expertise (Personal communication with the president of the Fruit Processors and Marketers Association of Ghana). It will therefore be of great importance to offer support to pineapple juice processing companies in the development, implementation and maintenance of adequate verification programs. This work is therefore aimed at developing a verification program for the pasteurisation and sanitation processes during pineapple juice processing in Ghana.

2. Methodology

Relevant literature for the scope of this study was perused and integrated to develop the verification program. A comprehensive literature search, via the internet and available books was done to identify the critical factors which influenced the effectiveness of the pasteurisation and sanitation processes if they are out of control. These critical factors were what needed to be verified in a verification program. More literature via published articles and books encompassing quality assurance programs, more specifically verification programs was used to identify how verification needs to be done in terms of frequency, person responsible, methods/sources of information, documentation requirements and verification data analysis.

2.1 Verification activities

Verification activities provide information about whether production processes and product parameters were within acceptable critical limits during processing, which will eventually guarantee the quality of the end-product. Keener (2007) recommends verification activities to be carried out on each process within all programs

that have an influence on the food safety/quality of the end-product. These programs include sanitation programs and HACCP program. According to Keener (2007), some aspects of verification activities are on-going verification and reassessment. On-going verification is routine in nature and covers areas like regular end-product testing, calibration of monitoring tools or equipment, observation of monitoring activities and checking that the proper corrective actions are taken when there is a deviation to achieve the desired results. According to ILSI (1999), verification is the application of methods, procedures, tests and other evaluations as well as monitoring, to determine compliance with a HACCP plan. Sperber (1998) also defines verification as the determination that a HACCP system is in compliance with its original plan. It is crucial to perform verification activities on intervention (pasteurisation) and preventive (sanitation) processes to ensure that critical limits are not exceeded. Based on the literatures used which give various definitions of verification as related to HACCP, the definition of verification for the pasteurisation and sanitation activities will be formulated as the procedures that are used in order to confirm that both the pasteurisation and sanitation activities are working correctly as they were designed to after the pasteurisation and sanitation programs have been implemented.

2.2 Critical factors which influence the pasteurisation process

Efficient thermal processing of foods is based on the knowledge of the right temperature and time that is required to kill the most heat resistant microorganism of food quality concern in a particular food product (Osaili, 2012). In the selection of the appropriate temperature-time setting for pasteurisation, certain factors which influence the thermal response of the product and its associated microorganisms have to be considered and validated. These validated factors which influence the pasteurisation process are what need to be verified to ensure that the pasteurisation process runs as desired and critical limits of validated factors are not exceeded. A thermal processing schedule that defines all the factors that must be controlled so that the food product is processed sufficiently to get rid of microorganisms should be available (Tucker and Featherstone, 2011). Details of the critical process, equipment and product factors that have an influence on the effectiveness of the pasteurisation process have been given by Tucker and Featherstone (2011). Critical limits of these factors have to be validated and verified during pasteurisation.

A critical product property which influences the pasteurisation process when it is out of specification is the pH range. There is an established link between the thermal death time of most microorganisms and the pH of the food. The pH of food products that are pasteurised should not vary significantly for the established pasteurisation parameters. More than 0.2 pH units' differences are considered to be significant for most products (Tucker and Featherstone, 2011).

Critical process-related factors which influence the pasteurisation process when they are out of specification are the pasteurisation temperature and time. During pineapple juice processing, the pasteurisation temperature and times determined to be effective for the destruction of almost any vegetative form of yeasts were 70□C for 27.91 minutes or 75□C for 13.5 minutes (Tchango et al., 1997 and Tribst et al., 2009). These settings will reduce the yeasts counts by about 10^9. If the pasteurisation temperature and time used are lower than the acceptable standards, the process will not be effective in eliminating spoilage yeasts.

Critical equipment-related factor that influences the pasteurisation process is the monitoring equipment accuracy. When monitoring devices are inaccurate, the use of inappropriate temperatures and times for pasteurisation will occur and the effectiveness of the process will be compromised. Devices which are used for monitoring process parameters (e.g. temperature) should be checked at regular intervals and tested for accuracy. The use of measuring equipment that has been properly calibrated is needed for effective measurement of the pasteurisation parameters (Drosinos and Siana, 2007). The thermometer that is used for monitoring pasteurisation temperature has to be calibrated before its first use and at least every 6 months after, using a thermometer of known accuracy accurate. The thermometer has to be accurate to within +/- 0.25°C throughout the defined range of scale (CFIA, 2010).

Critical people-related factors which influence the effectiveness of the pasteurisation process are personnel knowledge and competence and personnel compliance to procedures. It is important that personnel who are responsible for the pasteurisation process have the required knowledge and competence (Sperber, 1998). This will ensure that they will be able to take the appropriate corrective actions when deviations occur. Personnel compliance to pasteurisation processes is a human factor that influences the effectiveness of the pasteurisation process. Personnel need to be able to accurately measure and report product properties and process parameters (Drosinos and Siana, 2007) to ensure that deviations are noticed as soon as they occur and appropriate corrective actions are taken.

2.2.1 Verification activities during pasteurisation

1. *Observation and interview of the CCP monitoring person.* According to Sperber (1998), knowledge about the hazard that is being controlled, the importance of that control to the product quality, the acceptable critical limits, how to perform the monitoring procedure and record the results as well as the corrective actions to take in case there is a deviation are essential to ensure that the process goes on accordingly. Therefore verification of personnel knowledge on these issues through interviews should be done. It is also necessary to

verify the competency of personnel who are in charge of the pasteurisation process because personnel competency is important when accurate measurement of pasteurisation parameters are considered (Drosinos and Siana, 2007). Verification of personnel compliance to established procedures is needed because it will give information concerning personnel activities during pasteurisation activities and whether they are complying with laid down procedures. Observation of the person responsible for monitoring during pasteurisation is important in order to ascertain if established procedures are being complied with. Observation and interview of CCP monitoring person should be done when the person is new to the activity and quarterly afterwards by Quality Assurance personnel.

2. *Review of CCP monitoring records.* Monitoring records for the CCPs need to be reviewed to verify that monitoring has been performed and recorded appropriately and the appropriate corrective actions had been taken when there was a deviation. Records of critical product properties and process parameters should be verified that that they were within limits for the process target (which is the elimination of yeasts from the fruit juice). It is of utmost importance to verify that temperature-time settings and product pH are within critical limits for the pasteurisation process. This verification activity should be done by the line supervisor or according to the quality management system plan daily or once per production shift (Sperber, 1998). Monitoring records for the pasteurisation process need to be reviewed monthly by quality assurance personnel to verify if monitoring personnel have done the right thing (Sperber, 1998). This is meant to ensure that the process has been monitored well and the appropriate corrective actions had been taken in case of a deviation.

3. *Review of equipment calibration records.* Equipment that are used to monitor the CCP should be calibrated on a frequency as established in the quality management system plan and documented. These documents should be used to verify the calibration status of the equipment of focus. The calibration status of equipment gives information concerning the accuracy of the equipment. Verification of calibration status of measuring equipment should be done according to the quality management system plan. A proposed frequency for reviewing calibration records of monitoring equipment is once per week and this should be done by the line supervisor (Keener, 2007).

4. *Periodic measurement of yeast counts in food product after pasteurisation.* Fruit juice processors must ensure that after pasteurisation, the population of the target microorganisms will be reduced by 99.999%, also known as a 5-log cycle or 100,000 times reduction (Goodrich et al., 2012). After pasteurisation, yeasts present should be less than 10cfu/ml (Stannard, 1997). Periodic testing for the target organisms for which the pasteurisation process has been designed to control should be carried out on final product to ascertain whether the pasteurisation process is effective or not. This testing should be carried out by a quality assurance person.

2.3 Critical factors which influence the sanitation process

In order for sanitation activities to be effective, the chemical properties of disinfectants used are very important. In a research to identify the fungicidal efficacy of various commercial disinfectants used in the food industry, Korukluoglu et al., (2006) concluded that the ability of disinfectants to eliminate microorganisms is reliant on their concentrations and exposure times as well as the type of microorganism to be eliminated. They observed that quaternary amine compound (QAC) disinfectants were the most effective against all the microorganisms (yeasts and moulds) tested. In addition, they realised that peracetic acid and alcohol based disinfectants were most effective in eliminating yeasts. However, aldehyde and iodophors based disinfectants had the least effect on the yeasts as they were more resistant to those disinfectants. It was also observed that different concentrations of the disinfectants and contact times had different fungicidal properties on the target microorganisms (Korukluoglu et al., 2006). According to the same authors, exposure time of 3 minutes was needed to kill all S. cerevisiae cells at a concentration of 0.1% peracetic acid. For aldehydes, an exposure time of 10 minutes was needed to kill all yeasts at a concentration of 0.5%. QAC with Alkyldimethylbenzylammonium chloride as the main active component needed an exposure time of 5 minutes at 2% concentration to kill S. cerevisiae cells present. QAC with Benzalkanium chloride as the main component needed an exposure time of 5 minutes at 0.5% concentration to kill S. cerevisiae cells present. This research clearly shows that different disinfectants, concentrations and contact times have different fungicidal properties.

Personnel competence is also important during sanitation. Personnel responsible for sanitation must be able to carry out sanitation activities as required at all times, notice deviations when they occur and implement the appropriate corrective actions for those deviations. In addition, personnel compliance to established sanitation procedures is necessary to ensure that the sanitation process goes on as desired.

2.3.1 Verification activities during sanitation

Verification planning of cleaning and sanitation should contain information pertaining to what has to be verified, responsibilities, the actual verification activities/methods that would be performed and frequencies. These verification activities should provide information concerning the critical limits of the factors that relate to the sanitation effectiveness and whether those critical limits were within acceptable ranges. All verification activities should be documented and the records reviewed weekly. These records could be microbiological reports, chemical test measurements or checklists. The verification activities for the sanitation process are given as

follows (FIICC, 1999; Government of Manitoba);

1. *Inspection of the Actual Cleaning Process.* During sanitation, personnel compliance to established sanitation protocols should be verified through observations by the cleaning supervisor. This inspection may include checking the actual cleaning process to know if the sanitation procedure is being carried out according to the documented protocol, whether the cleaning chemical is being applied correctly and if the cleaned surface has been rinsed properly and no debris remains. There is the need to verify that sanitation methods which are used are the methods that have been validated to be effective in producing clean processing equipment and facilities. The methods which need to be verified include type of chemical being used for sanitation and the contact time for the application of the chemical.
2. *Checks of Sanitising Solutions*. There is the need to review records of concentrations and application times for sanitising solutions to confirm that established procedures were used during sanitation. Cleaning and sanitising solutions should be verified by trained company personnel through tests. This should be done daily before sanitation activities are commenced or weekly.
3. *Inspection Using the Senses (Look, Smell, Feel).* Someone in the company who has been tasked with the sensory evaluation of the cleanliness of equipment and premises should do this activity immediately after cleaning and prior to production. Sensory inspections include visual inspections of cleaned surfaces to ensure that they look clean because no debris has been left, smelling the work area to make sure that no unwanted odours are present and touching work surfaces to ensure that there are no grease or solid particles.
4. *Microbiological Assessment.* Sanitation efficiency should also be verified by quality assurance personnel through microbiological tests after sanitation. This can be done with the use of swabs, or contact plates and should be done after the last step in the cleaning process has been completed. Microbiological records for sanitation should be verified weekly or twice per week by the sanitation supervisor. According to Hakala (2001) as cited by Lehto et al., (2011) food processing surface/equipment hygiene guidelines for yeasts are – good (<1 cfu/cm^2), moderate (1-5 cfu/cm^2) and unacceptable (>5 cfu/cm^2). Despite these required standards, food processing companies can establish their own levels based on their own processing environment settings that provide the desired outcome (FIICC, 1999). Microbiological records for sanitation should be verified weekly or twice per week by the sanitation supervisor.

Table 1 provides a verification program for both the pasteurisation and sanitation processes.

Table 1: Verification program for pasteurisation and sanitation (Prepared from NACMCF (1998); Sperber (1998); FIICC (1999); Keener (2007); Kirezieva (2009) and Government of Manitoba)

What needs to be verified during pasteurisation and how verification should be done	
Personnel knowledge	Frequency • When the person is new and • Quarterly thereafter
	Responsibility • Quality Assurance Personnel
	Sources of information/methods • Observation of personnel • Interviews of personnel
	Documentation requirements • Records detailing activities that were carried out, findings and corrective actions should be made.
	Verification data analysis • Data obtained after verification should be analysed and used for the correction and improvement of personnel knowledge. The verification data should be analysed and compared to the following requirements to get details of the current situation Knowledge about - the hazard that is being controlled - the importance of that control to the product quality, - the acceptable critical limits, - how to perform the monitoring procedure and record the results - the corrective actions to take in case there is a deviation
Pasteurisation time and temperature setting	Frequency • Once daily or • Once per shift
	Responsibility • Line Supervisor
	Sources of information/methods

	• Actual inspection
	Documentation requirements • Records detailing activities that were carried out, findings and corrective actions should be made
	Verification data analysis • Data obtained after verification should be analysed and used for the correction and improvement of pasteurisation time and temperature setting. The verification data should be analysed and compared to the following requirements to get details of the current situation - Pasteurisation time and temperature should be according to what has been documented and is required (Temperature and time settings at 70□C for 27.91 minutes or 75□C for 13.5 minutes which is considered ideal for pasteurisation)
Personnel compliance to procedures	Frequency • Monthly
	Responsibility • Quality assurance personnel
	Sources of information/methods • Review of Records for monitoring and corrective actions
	Documentation requirements • Records detailing activities that were carried out, findings and corrective actions should be made
	Verification data analysis • Data obtained after verification should be analysed and used for the correction and improvement of personnel compliance to procedures. The verification data should be analysed and compared to the following requirements to get details of the current situation - Personnel adherence to established protocols.
Measuring equipment calibration	Frequency • Once per week
	Responsibility • Line supervisor
	Sources of information/methods • Review of Calibration records
	Documentation requirements • Records detailing activities that were carried out, findings and corrective actions should be made
	Verification data analysis • Data obtained after verification should be analysed and used for the correction and improvement of measuring equipment calibration. The verification data should be analysed and compared to the following requirements to get details of the current situation - The thermometer that is used for monitoring pasteurisation temperature has to be accurate to within +/- 0.25°C throughout the specified scale range - The thermometer shall be calibrated upon installation and at least every 6 months thereafter using a thermometer of known accuracy
Product properties (pH)	Frequency • Once daily or • Once per shift
	Responsibility • QA personnel
	Sources of information/methods • Testing
	Documentation requirements • Records detailing activities that were carried out, findings and corrective actions should be made
	Verification data analysis • Data obtained after verification should be analysed and used for the correction and

	improvement of product properties (pH and water activity) The verification data should be analysed and compared to the following requirements to get details of the current situation - pH range should be less than 0.2 units
End-product	Frequency • Once daily or • Once per shift
	Responsibility • QA personnel
	Sources of information/methods • Testing
	Documentation requirements • Records detailing activities that were carried out, findings and corrective actions should be made
	Verification data analysis • Data obtained after verification should be analysed and used for the correction and improvement of the whole pasteurisation process. The verification data should be analysed and compared to the following requirements to get details of the current situation - yeasts present should be <10cfu/ml
What needs to be verified during sanitation and how verification should be done	
Personnel competence	Frequency • During sanitation
	Responsibility • Cleaning supervisor
	Sources of information/methods • Observation of personnel, checking actual cleaning process
	Documentation requirements • Records detailing activities that were carried out, findings and corrective actions should be made
	Verification data analysis • Data obtained after verification should be analysed and used for the correction and improvement of personnel competence. The verification data should be analysed and compared to the following requirements to get details of the current situation - sanitation procedure should be according to the documented sanitation program, - cleaning chemical should be applied correctly according to the documented requirement, - cleaned surface should be rinsed properly according to the documented procedures and no debris should remain.
Sanitation methods (type, concentration and contact time of sanitising solutions)	Frequency • Weekly
	Responsibility • Cleaning supervisor
	Sources of information/methods • Records review • Tests • Observations
	Documentation requirements • Records detailing activities that were carried out, findings and corrective actions should be made
	Verification data analysis • Data obtained after verification should be analysed and used for the correction and improvement of sanitation methods. The verification data should be analysed and compared to the following requirements to get details of the current situation - Concentration of sanitation chemical is according to what is required and documented - Contact time for the sanitation chemicals should be according to what is required and documented

	- Type of sanitation chemical is according to what is required and documented.
Personnel compliance to procedures	Frequency • Monthly
	Responsibility • Quality assurance personnel
	Sources of information/methods • Review of Records for monitoring and corrective actions
	Documentation requirements • Records detailing activities that were carried out, findings and corrective actions should be made
	Verification data analysis • Data obtained after verification should be analysed and used for the correction and improvement of personnel compliance to procedures. The verification data should be analysed and compared to the following requirements to get details of the current situation. - sanitation procedure should be according to the documented sanitation program, - cleaning chemical should be applied correctly according to the documented requirement, - cleaned surface should be rinsed properly according to the documented procedures and no debris should remain
Sanitation effectiveness	Frequency • Immediately after all cleaning processes have been completed, Twice per week or a weekly review of microbiological records
	Responsibility • QA personnel
	Sources of information/methods • Microbiological tests • Microbiological records review
	Documentation requirements • Records detailing activities that were carried out, findings and corrective actions should be made
	Verification data analysis • Data obtained after verification should be analysed and used for the correction and improvement of the whole sanitation process. The verification data should be analysed and compared to the following requirements to get details of the current situation - Yeasts on processing equipment should be <1 cfu/cm^2
Sensory cleanliness of equipment and premises	Frequency • Immediately after cleaning • Prior to production
	Responsibility • Someone in the company who has been tasked with the sensory evaluation
	Sources of information/methods • Sensory inspections (visual inspections, smelling the work area and touching work surfaces)
	Documentation requirements • Records detailing activities that were carried out, findings and corrective actions should be made
	Verification data analysis • Data obtained after verification should be analysed and used for the correction and improvement of the whole sanitation process. The verification data should be analysed and compared to the following requirements to get details of the current situation - Equipment should look clean because no debris has been left - no unwanted odours should be smelled - no grease or solid particles should be felt

3. Conclusions

There are many advantages associated with having an operational verification program which include providing assurance that the sanitation and pasteurization processes are effective, improving both pasteurisation and

sanitation processes as well as timely noticing deviations and taking the appropriate corrective actions. The verification program detailed in Table 1 may be used as a guide by the pineapple juice processing companies during the development of their verification programs because it was developed with the use of reliable scientific literatures. Technically competent personnel are needed if the company wants to do this in-house (Mensah and Julien, 2011). This is a cheaper alternative as compared to using an external quality consultant to develop verification programs but it is a very time-consuming process and results are not always as desired (Aggelogiannopoulos *et al.*, 2007). In addition, to have an operational verification program in the pineapple juice processing companies, there may be the need to invest in new equipment and tools and to make some modifications to the production process (Aggelogiannopoulos *et al.*, 2007). This may necessitate the documentation and provision of standard operation procedures for all activities that are carried out during the processing of pineapple juice. Management will also have to assign verification tasks to individuals who are capable of adequately executing verification activities.

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