Conceptualization of a mango juice production company and the use of the FMECA tool

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Abstract

Continuous improvement is one of the major steps in the progression of a company. Under no circumstances is a business allowed to stagnate, otherwise it will be ruined. On the contrary, it must evolve, grow with the times, make improvements and innovate constantly! So, in order to optimize our mango juice business, we have been interested in the application of the FMEA method within the production process of the MIFT S.A., a conceptual company in order to reduce the failures of the system, improve the quality of the products, anticipate the potential problems and risk and find adapted solutions.

Keywords
Mango juice, MIFT S.A., FMECA method, quality, risk, solutions.

Introduction
In the management of a business, reducing the loss of money, time, materials, resources as well as costs, irregularities or unforeseen events and improving the performance of a business is a necessity. We must constantly innovate, improve the productivity of the company, ensure that the needs and requirements of customers are met while respecting the imposed quality standards, also ensure the safety of employees and ensure that their conditions are improved. work, etc. ; all this is therefore of capital importance within a company because it will make it possible to improve as much as possible its yields, its competitiveness in the market as well as to optimize and adapt it to the various changes occurring with this technological era more dynamic than ever! Therefore, continuous improvement is a key concept in organizational management. It allows with many tools and methods to effectively and efficiently achieve sensational progress within any organization!

However, it should be emphasized that setting up a continuous improvement process requires numerous investments in terms of human resources, financial resources and time, if it is a long-term process. Sometimes the results may be lower than expected. In addition, it happens quite often that employees fear that productivity gains resulting from continuous improvements will lead to job cuts, etc. However, a pillar of quality management, and a requirement of the ISO 9001 standard, continuous improvement is nonetheless a goal of any organization: to continuously improve the performance of all of its processes.

In that case, the use of the FMECA method is a great way to improve the quality of the products of a company, it helps continuously by identifying the problems in advance and looking for solutions for them. This will prevent the loss of time, money and resources when a problem happens because there will be a solution for this problem in advance. Therefore, we cannot prevent all the problems, but in general, we will be prepared for the most probable constraints. Then, in our conceptual company of mango juice production (MIFT S.A.), we will use the FMECA tool to understand more its effects.

Objectives
In industrial engineering training, knowledge of continuous improvement is essential. Through this research, us, future industrial engineers will be able to get to know and tame the many techniques that this concept encompasses. This will allow us have a better understanding of the concept of productivity in a company, to identify the various means to optimize it and reduce waste and dysfunctions. Therefore, the objective of this project is to better deepen our

knowledge on the issue and also apply it to a given problem or situation which, in our case, is a mango juice production company that we will analyze by then with the FMECA tool.

Failure Modes, Effects and Criticality Analysis (FMECA)

The acronym FMECA stands for Failure Mode, Effects and Criticality Analysis. This method was developed within the US Army in the early 1940s and then used by NASA for the Apollo program. FMECA is a tool used in the quality approach and in the context of operational safety which makes it possible to define the current and potential failure modes, the consequences of which affect the proper functioning of the means of production of a product, service or process. , then estimate the risks associated with the appearance of these failures in order to initiate corrective or preventive actions to be taken during the design, construction or operation of the means of production, product or process, in order to improve its quality and reliability. FMECA can therefore be applied to all systems that risk not meeting the objectives of reliability, maintainability, quality of the product manufactured and / or safety. This technique takes place in 4 stages: preparation, functional breakdown, the analysis phase and the implementation and monitoring of action plans. There are several types: the FMECA of the concept, product, process, means of production, of the machine, etc. The completion of a FMECA is recommended for companies wishing to obtain a standard or certification.

Everything you need to know to start the FMECA technique

FMECA: Failure Mode and Effects Analysis is a rigorous and preventive method aimed at identifying the potential failures of a system and / or an element. Actions must be defined to eliminate these failures, reduce their effects, and detect and prevent the causes. It is an essential tool for controlling quality and safety. It is widely used in the automotive, aeronautics and rail sectors. A method derived from FMECA is used in the food industry, chemicals and pharmaceuticals: HACCP. To start a FMECA process, before starting, you must first know the system and its environment. This information often results from functional analysis, risk analysis or feedback. Then, it is necessary to determine for what purpose the FMECA will be used and subsequently to determine the means and associated responsibilities.

FMECA proceedings

Step 1: Initialize

- Constitute a working group of people from various fields to have several visions or points of view;
- Formalize the subject, the objectives and the limits.

Step 2: Analyze

- Realistically study the imaginable risk points known from experience and their consequences for the client (causes, frequencies, effects);
- Perform a functional analysis of the various functions of a product, process, etc.

Step 3: Evaluate

- Evaluate and prioritize potential failures;
- Decide to make action plans

Step 4: Find solutions

- Find solutions to put in place to resolve the failures encountered (often during brainstorming sessions).

Step 5: Track

- Analyze the proposed corrective solutions.

Step 6: Apply

- Corrective solutions, validated during monitoring, are applied. This is a very important step because we effectively correct the potential failures.

Step 7: Check

- Check the effectiveness of measures taken in the field;
- Capitalize on the experience by archiving the study in a database.

Conceptual business presentation

During the last decades, Haiti is losing more and more its originality and local products are less and less exploited. The market for natural agricultural products in Haiti is a neglected, poorly structured and reckless market. So, to rediscover our identity, the company MIFT S.A. found itself obliged to offer a local aperitif which is its famous mango puree.

Figure 1. Mango Juice

The mango is above all a fruit of consumption and local marketing. The fragility and perishability as well as the attacks of fruit fly larvae severely limit marketing, and exports require special attention. However, it is the third most exported commodity in the country in raw form without any transformation, it is a fruit that contributes to the satisfaction of human needs in many facets, whether in terms of cosmetics, food etc. Its juice retains the physicochemical, nutritional and organoleptic characteristics of the variety of mango from which it is extracted. Consumed fresh, mango juice is rich in carotene, vitamins C, B1, B2 and mineral salts; it makes an excellent drink for people of all ages. Therefore, the company MIFT S.A. specialized in the agri-food sector targets any category of people.

Knowing that this fruit is very fragile and perishable, MIFT S.A. takes precautionary measures and practices this activity according to certain international quality and safety standards. Knowledge and applications of these standards differ: Certification according to the HACCP system, certification according to ISO 22 000 or even good hygiene practices / good manufacturing practice (BPH / BPF) and certification for the processing of organic mango. MIFT S.A. organizes adequate training for staff on the use of standards, its equipment is suitable for processing and microbiological analyzes of processed products are carried out. The quality control of processed products is carried out in our laboratories to analyze the physicochemical, microbiological parameters.

Our method of supplying suppliers is the MRP (Material Resources Planning). Most often, the volume of mango purchased is closely related to the need for production. And our sources of supply are:

- The great owners of mango, carrot, pineapple and mint plantations.
- Agri-food stores (sugar, powdered vitamin C)
- Department stores (cardboard boxes, solar panels, batteries, regulator, electrical wires, sorting and washing machine, juice extraction, water tanks and filter, pasteurizer, etc.)

Finally, we offer our customers four types of organic products with mango:

1. Mango juice
2. Mango and carrot juice
3. Mango and pineapple juice
4. Mango and mint juice

Mango juice production process at MIFT SA

The transformation of mango into juice is done in several stages namely: sorting, washing, peeling, pitting, juice extraction and finally pasteurization. Here are the details:

Figure 2. The washing machine

Sorting and washing the fruits

The first steps in the mango juice making process are sorting and washing. We have a first department where we clean the fruits and mint. The operations carried out therefore consist in manually sorting the mangoes, carrots, pineapples and mint leaves and eliminating those of poor quality. Then, the fruits selected to continue the production process are washed and cleared of improprieties and waste using a machine. This therefore allows a quick cleaning of the fruits thanks to a strong pressure of hot water to eliminate the microbes. Also, we have a washing machine for each type of fruit as well as for mint leaves.

Peeling, pitting and juice extraction

Figure 3. The peeling, pitting and extraction machine

Thanks to a juice extraction machine, the peeling, the pitting process which consists of removing the mango stones as well as the extraction of juice are done very quickly. The washed mangoes are poured into the machine which presses and extracts all the pulp from the mangoes on the one hand and on the other hand expels the peels and stones. The final product obtained is organic mango puree without additives. Other extraction machines perform this same process for pineapples and carrots. Thus, one collects their juice easily. Mint leaves are first dried by a dehydrator machine, sorted by hand and transformed into powder thanks to another machine. The unwanted parts (kernel, skin or peel of the various fruits) which can affect the quality of the product are thrown in a place to be transformed into compost and sold.

Water treatment and storage

This process consists of treating the water by completely removing bacteria, organic matter and the salt it contains with an automatic filtering system carried out by a machine like this one.
Then the treated water is stored in a stainless-steel tank for use.

Figure 4. The water treatment machine

Storage and mixing

In this part of the process, the mango puree that has been collected is sent to a tank in order to be mixed with the other ingredients (water and sugar). These ingredients are well dosed so that the juice is neither too much nor a little sweet. Thus, the mango juice is finalized.For the mango and carrot juice, another reservoir is used where the carrot, mango, water and sugar are mixed. Similarly, for the mango and pineapple juice, another reservoir is available to perform the mixture or dosage of ingredients (mango, pineapple, water and sugar). Finally, for our last product, which is mango juice with a hint of mint, we carry out the same operation (mango, mint, water and sugar), but in another tank.

Figure 5. The tanks

Figure 6. The pasteurization machine

Pasteurization of mango juice

To better preserve our different mango juices without altering the taste, we choose to use the method of Fast Pasteurization or High Temperature Short Time (HTST) which consists of heating the juice, using a machine, to a temperature which varies between 80 and 95 ° C for a period of between 15 and 30 seconds. This is the most widely used method in the juice industry since its effects on the nutritional characteristics of mango are minimal and it is faster to implement. However, it alters the vitamin C intake of the fruit a little, to remedy this, we therefore add vitamin C to our juices after this process. Thus, we provide our customers with a good fresh mango juice, with several flavors, as if it were homemade!

Bottle washing and sterilization

Before being sent to the filling department, our bottles are washed and sterilized using a device in order to comply with food safety standards and thus protect our customers.

Figure 7. The bottling, encapsulation and labeling process in a Japanese company

Bottling, encapsulation and labeling

In the end, each type of mango juice is sent to a different department where it is then placed in 1-Litre glass bottles which are encapsulated using a machine. They are filled to the maximum to prevent the air from altering the taste of the juice. This same machine then proceeds to the labeling. And finally, the juice bottles are placed in sets of 12 in cardboard boxes in which are inserted cardboard dividers to prevent rubbing of the bottles and to make them more secure. Finally, our mango juices are then ready to be sold!

FMECA: A preventive approach

A business process consists of a set of systems that must be perfectly organized and integrated. A system consists of several processes, a process of several processes, a process of several activities and tasks. If we identify everything that could not work in the systems and if we can eliminate the probable causes of the failures that may arise, then all systems would work correctly, without conflicts, without stopping, with a total quality perspective. This logic leads to taking measures a priori and not a posteriori. Hence the importance and the need for a preventive approach to achieve total quality.

Approaches such as product inspection and control as well as statistical process control are insufficient to solve, prevent and avoid problems that may later appear in the different systems of a company's business process. Among the tools and techniques for preventing potential problems, the FMECA method is a simple and very effective method. FMECA is the acronym for "Failure Mode and Effects Analysis". This technique aims to study, identify, prevent or at least reduce the risk of system, process or product failures.

The French standardization association (AFNOR) defines FMECA as “an inductive method which makes it possible to carry out a qualitative and quantitative analysis of the reliability or security of a system. The method consists in methodically examining the potential failures of the systems (analysis of failure modes), their causes and their consequences on the functioning of the whole (the effects). After a prioritization of potential failures, based on the estimation of the level of failure risk, i.e., criticality, priority actions are triggered and monitored.

Globalization and competition are such in many industrial sectors that companies have difficulty in making mistakes, whether in their organization or in the quality of their offer. And rather than waiting for errors to impact the activity, it is preferable to adopt a preventive approach both in terms of resources, products and processes. This is the whole point of FMECA, a method developed by the American army in the 1940s and then used by the aerospace industry in the years for quality management.

How can FMEA's approach help improve the productivity of the mango juice company (MIFT S.A.)?

Quality is a fundamental concept in the policy of MIFT S.A. Thus, the use of FMECA can help us achieve our objective on the issue. So, let's see how this analysis can help improve productivity following the ergonomic approach with regard to:

- Efficiency (organization, method, etc.)
- Safety (Standards, physical risks, etc.)
- Favorable conditions and comforts (environmental factors)

Efficiency

Efficiency is the ability of an individual, a group of individuals, a machine or a technique to obtain the maximum results with the minimum of means, costs, effort or energy. . It is the ability to rationally achieve good performance for a given activity or job, to optimize the means available or allocated to achieve a result. Using the FMECA tool, we can analyze the failures that are likely to occur in the process, know the causes, examine their effects and their criticality in order to make the system more productive and efficient.

To reduce the risks associated with the use of the machines and equipment used (tractor, generator, pump, etc.) or the packaging station (graders, sorters, packers, forklift trucks, etc.), it will be necessary to follow scrupulously the instructions of the manufacturers.

Table 1. Efficiency Table

Risks	Causes	Effects	Gravity	Means of prevention
Machines break down	Lack of maintenance	Production stop	Very critical	Establish a regular upkeep and maintenance program by referring to the manufacturers' instructions: lubrication, oil change, parts change
Direct or indirect contamination of fruit by machines	Oil or fuel leak	Impaired taste of mango juice	Very Critical	Check for leaks and repair them automatically
Disruption of sorting, grading and packaging lines	Lack of upkeep and maintenance	Poor sorting of mangoes, contamination of mangoes bad grading in the filling of bottles.	Critical	Rigorous monitoring of established upkeep and maintenance programs
Exposure of mangoes to chemical risks of various kinds	Poor chemical risk assessment	Contamination of mangoes by organic pollutants, accumulation of toxic elements, by nitrates (excess fertilizers) or by pesticide residues	Very critical	Carry out a precise assessment of the chemical risks existing at the farm level and determine the most appropriate and cost-effective measures.
Malfunction of refrigeration installations in storage	Irregular verification	Very serious consequences on the quality of mangoes, break in the cold chain, risk of contamination	Very critical	Establishment of a maintenance and verification program
Bad sorting	Lack of employee concentration or lack of knowledge	Bad taste imparted to the juice	Critical	Employee training, help from a supervisor

Security

Preserving the health of consumers has become a major concern at the start of the new millennium marked by the weight of civil society in general and consumer leagues in particular. The requirements in terms of sanitary quality and traceability, which appear not only in increasingly strict regulations but also in quality standards or specifications offered or imposed on producers, reflect the desire of consumers to know where, how and when the food they eat has been produced.

In addition to chemical risks (residues of phytosanitary products, presence of metallic trace elements or other pollutants), which can be managed within the framework of Good Agricultural Practices (GAP) and Good Phytosanitary Practices (GPP), primary production is subject to risks of biological and physical origin. In ACP countries, where the fruits and are produced under special conditions having regard to the human and material resources available, the biological and physical risks, which can arise from different stages of the production process, are often ignored or poorly estimated. In this context, it becomes essential to control all hazards at all stages of the product life cycle (design, production, storage, transport, processing, marketing) in order to guarantee the safety of staff and consumers. Hence the usefulness of the FMECA tool.

Table 2. Security Table

Risks	Causes	Effects	Gravity	Prevention mode
Injury to staff members	Improper handling of machines	Bad atmosphere at work, and fear of operating devices among other employees, reduction in the number of employees	Not very critical	Good training in the use of machines
Contamination by insects and other foreign bodies.	Unhealthy premises, poor control of foreign bodies	Bad image projected by industry; certification not awarded	Very critical	Establish a monitoring and control program for foreign bodies, use of a checklist, cleanliness of premises and facilities: walls, floors, doors, ceilings, wearing of gloves and hoods, etc.
Loading of contaminated products	Residues of chemicals from cleaning and disinfection of premises, odors from previous products	Customer dissatisfaction,	Very critical	Place the products in airtight environments
Insufficient pasteurization	Temperature probe failures	Retention period not respecting the set deadline	Critical	Regular calibration of temperature probes used for temperature control.
Heat input from the outside air (in the event of a leak), heat given off by breathing the product, accumulation of ethylene	Insufficient air circulation	Deterioration of mangoes	Very critical	Allow for air circulation below and through the load to protect the mangoes.

Favorable conditions and comforts (environmental factors)

Failure Modes, Effects, and Criticality Analysis (FMECA) is a rigorous method of detecting potential defects that can be applied to a product or process (Lyonnet, 1997). It is a tool that makes it possible to assess the potential risks that may arise during the process, then to prioritize them and to put in place corrective actions. Applied to environmental risks, this method can be called failure mode, effects and environmental criticality analysis or FMECA-E.

FMECA-E was developed in the environmental field in 1999 (FMECA-E) by the Swedish consulting agency HRM / Ritline for use in the product development process (Wendel, 1999). FMECA-E makes changes to the FMEA method by replacing the causes of faults linked to an activity or a product by environmental aspects and the effects by environmental impacts.

The aim of this method is to identify, assess and prioritize the significant environmental impacts of an activity (an installation) or a product throughout its life cycle in a systematic way, in the aim of determining the necessary actions in order of priority to reduce the assessed environmental impact. It is through this evaluation that the method constitutes a decision support tool.

Table 3. Environmental factors table

Risks	Environmental aspects	Environmental impacts	Gravity	Reduction of impacts
Gas emission by machines	Malfunction of machinery	Air pollution	Critical	Reliable machine behavior
Loud noises emitted by the motors	Poor condition of devices	Disturb surrounding people	Not very critical	Machine optimization
Plastic bottling (non-degradable element)	Use of plastic packaging	Environmental pollution	Critical	Use of glass packaging.
Dispose of mango residues and unusable mangoes in inappropriate places	Willingness to get rid of waste immediately	Air pollution with foul odors	Not very critical	Use peels and residue as compost

Conclusion

The FMECA is a prevention method that can be applied to an organization, a process, a means, a component or a product in order to eliminate, as much as possible, the causes of potential failures. By applying these principles within MIFT SA, we have been able to anticipate accidents as well as unexpected events so that they do not slow down or interrupt our production process. The FMECA evaluation and examination grids greatly facilitate the study of our system and make it possible to define the criticality of possible problems in order to take appropriate measures depending on their seriousness. In the end, the tool FMECA, like any continuous improvement tool, effectively optimizes a business as we has implement it in the MIFT S.A. company, we has anticipated the most probable problem that would happen in efficiency, security and environmental factors and look for potential and effective solutions for them. As we could see, the FMECA technique is a very useful tool that could not only reduce risks and problems but also improve the quality of the products in the company. Therefore, the company will be more productive and satisfy its customers more in term of quality, which was the goal of the MIFT S.A. company.

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Biographies

Neïka Fidelia was born on October 07, 1997 in a fairly modest family and she was fortunate to have been educated in one of the most prestigious schools in Cap-Haitian, the city in which she was born. She lived there practically all her childhood; she witnessed her diligent work to arrive to complete her classic cycle. She is currently pursuing her final year of Industrial Engineering studies at Quisqueya University. She is keenly interested in innovation, optimization and teamwork, hence her career choice and her interest in constantly learning. She often participates in training based on environmental economics and natural resource management and environmental assessment of

development policies and projects. She believes that industrial engineering can serve the environmental cause and participate in its development.

Bleed Ilsaint was born on January 29, 1999, in the city of Cap-Haitian, in the northern part of the Republic of Haiti. He completed his primary studies at Calhoun Spady Missionary School and secondary studies at Martin Luther King College with Mention: Excellent. Growing up, he was able to discover what he liked most in his life was to plan, organize, find the easiest way to do a task while being more productive than others by starting by creating a system of arranging books in the library of his elementary school. It is in the same order of ideas that after his classical studies, he left his hometown to come to the capital to study Industrial Engineering. Since 2017 at Quisqueya University. His dream is to participate greatly in solving one of the greatest challenges facing his country: industrialization, by helping to create and organize industries, which will generate more jobs, more turnover for his country.

Thayana Prézil is a 4th year Industrial Engineering student at University Quisqueya. After graduating, she will hold a Master degree in International Business specializing in import and export because she is interested in the commercialization and transformation of natural products. Interested in the subject of the environment, she collaborated on the CapVertHaïti (CVH) project to develop urban agriculture in Haiti and raise awareness about the importance of protecting the environment. Because of that, she has successfully completed online training courses about Understanding and analyzing the challenges and actions of Sustainable Development as well as Environmental Economics and natural resource management. She is always willing to learn and have new experiences in order to grow and improve professionally and personally.