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VISIÓN ELECTRÓNICA

A CASE-STUDY VISION

Conveyor belt for cleaning, sanitizing and drying unpackaged food

Cinta transportadora de limpieza, desinfección y secado de alimentos no empaquetados

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INFORMACIÓN DEL ARTÍCULO

Historia del artículo:
Enviado: 03/01/2023
Recibido: 17/02/2023
Aceptado: 23/03/2023

Keywords:
Biomimetic
Inefficiency
Food safety
Outbreaks
Food
Electronic system

Palabras clave:
Ineficiencia
Inocuidad alimentaria
Brotes
Alimentos
Sistema electrónico

ABSTRACT

In the world, there is currently an inefficiency at the level of food safety, in 2020 in Colombia there were 268 outbreaks of ETA'S (Foodborne diseases) involving 3079 sick people. According to the World Health Organization (WHO) in 2020, 600 million people got sick of which 420.000 died from this cause which generates different outbreaks of ETA'S [1]. This project aims to design a prototype which can preserve food safety focused on food at the time of being distributed to the final consumer, based on a traction system exerted by a conveyor belt through a hermetic box using an electronic system to drive spray lines completing the process in a drying line, thus obtaining a safer food at the time of ingestion, a saving of 70% water is achieved compared to previous prototypes used for the same purpose.

RESUMEN

En algunas regiones del mundo actualmente hay una ineficiencia a nivel de inocuidad alimentaria; en el 2020 en Colombia hubo 268 brotes de ETA'S que involucran a 3079 personas enfermas. según la Organización Mundial de la Salud (OMS), en el 2020 se enfermaron 600 millones de personas de las cuales 420.000 murieron por esta causa y además, se generan diferentes brotes de ETA'S [1].

El presente artículo propone el diseño de un prototipo que pueda preservar la inocuidad alimentaria enfocado a los alimentos en el momento de ser distribuidos al consumidor final, basado en un sistema de tracción ejercido por una cinta transportadora a través de una caja hermética usando un sistema electrónico para accionar líneas de rociadores completando el proceso en una línea de secado, de esta forma se obtiene un alimento más inocuo al momento de ingerir, se logra un ahorro del 70% agua comparado a prototipos anteriores usados con el mismo fin.

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Citar este artículo como: J. J. Daza-González, M. Y. Ortega-Jiménez, J. E. Pérez- Vega, E. O. Mestizo-Caro, "Conveyor belt for cleaning, sanitizing and drying unpackaged food", Visión electrónica, vol. 17, no. 2, pp. 284-292, july-december, 2023, https://doi.org/10.14483/22484728.21877

1. Introduction

The incidence of these diseases is a direct indicator of the hygienic-sanitary quality of food, it has been demonstrated that contamination of food can happen during its collection, transportation or distribution [4]. Ending hunger, achieve food security and better nutrition, and promoting sustainable agriculture are part of a global general objective with the approval of the Sustainable Development Goals, in which 193 members of the United Nations take part. This goal will be articulated around eight targets: five related to development achievements and three to the means of implementation [5].

Food safety is a process that involves different processes such as production, storage, distribution and preparation of food [6], of which in 2020 there were 268 outbreaks of ETA's in Colombia according to the epidemiological newsletter and worldwide they leave 420 thousand deaths annually [3].

According to the epidemiological newsletter, in 2020 there were 268 outbreaks of ETA' s in Colombia, and 420 thousand deaths annually worldwide [3]. Therefore, there are different measures taken by governments and international entities such as the Food and Agriculture Organization of the United Nations and the World Health Organization. In Colombia there is a responsibility from the government, industry, and consumers where each one has some rules [6]. In the scientific field there is no lagging behind designing and creating different chemicals, machinery, hypotheses [7-8-9-20]. This prototype consists of a disinfection system, which uses the operation of a conveyor belt that consists of a mechanical and electronic system that is activated by the detection of movement by means of an ultrasonic sensor, whose main function is to ensure a food safety; A type of conveyor belt is designed, better known as a moving floor belt, which has a mechanical system driven by an actuator, a sprinkler system inside a hermetic box distributed by phases which are distributed in washing, sanitizing, rinsing and drying.

2. State Of The Art

A bibliographic review of fruit disinfectant machines with similar characteristics was carried out, in order to show the best mechanisms to reach such an objective, demonstrating each one of the processes that make possible a good disinfection process. The articles consulted are mentioned below. Method and apparatus for washing fruits and vegetables

According to the invention of David K. Lewis (2014) it includes a machine for washing a product with a fluid and is configured to receive a moving conveyor that is submerged at one end by an antimicrobial agent and carrying with it the fruits towards the other, the process ends up storing them in a tank with water completing the disinfection and washing phase to subsequently dry them, [7].

Device to optimize fruit washing: according to the invention executed by Manuel Garcia Portillo (2015), it provides a new fruit washing device that optimizes the washing process by reducing the amount of water, which also allows to reduce the amount of energy to perform the drying of the fruit; the device comprises a conveyor line where the fruit to be washed is deposited and includes a rinsing system that is provided with adjustable nozzles,[8].

Machine and method for cleaning, drying and disinfecting products: Helen Di Panni's machine has an upper and lower basket to contain the products as well as spray arms to direct the water towards the products. The upper basket is motorized so it rotates in order to provide better cleaning of the products, while the lower basket can be rolled in and out of the machine for easy loading and unloading. The spraying force is adjustable and the motor rotation speed also allows for special product handling,[9].

Vegetable washing and bleaching machine: the machine created by Richard J. Goodale (1975) uses a washing vessel or tank supplied with water where vegetables are poured and the water is agitated to move the vegetables into a portion of the tank. The

vegetables are removed from the water in the tank by a wire mesh conveyor that moves them through the blanching chamber where jets of steam are thrown over the top and bottom of the vegetables as long as they move through the chamber,[10].

And, Machine for rapid cleaning and drying of batches of foodstuffs; Gerard A Tiby in 1969 creates a machine made up of a tank defining a chamber accessible from the top, a substantially rigid basket placed within said chamber and including a bottom wall supporting a side wall, a nozzle mounted on said wall to provide jets of cleaning water toward articles placed within said basket, and a drive for rotating and basket while spraying water from said nozzle to provide an outward flow of water around the articles and to dry the products after the water spray is cut off, [11].

3. Theoretical framework

Nowadays, food safety has become one of the greatest risk factors for mankind since it comprises a large part of the transmission of outbreaks of ETA's. This has made it necessary to discover new ways to disinfect food, carry out research, guidelines and action plans to mitigate the spread of this type of disease. In this way, research has been carried out to find new decontamination agents which are known as biocides and disinfectants which, when applied correctly, reduce the probability of contracting some type of ETA'S, [12-13-17-20].

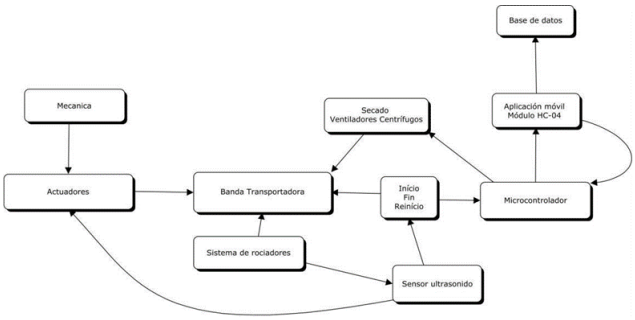
In the field of food disinfection, conveyor belts have represented the way to mechanize the movement of food, thus different types of conveyor belts have been implemented. In the industry there are currently three different types of conveyor belts which are used in various applications depending on their structure, the first type of belt mostly used for the transport of heavy material due to the way it distributes its forces this type of belt is known as roller belt, [21]. the second type of belt is known as a screw conveyor belt which consists of a screw located in the center of a compartment which rotates to transport the material, this type of belt is mostly used for grains, [22], the last type of conveyor belt is known as moving floor conveyor belt, this type of belt has the same operation of the roller belt with the variation that it has a conveyor belt on the surface which allows the transportation of smaller or larger material; in this type of belt two guide rollers and an actuator performs the movement of the belt. [23].

The irrigation or sprinkler systems is mostly used for crops, these have a fairly broad scope since they are usually focused on irrigation of crops, in this way there are different types of nozzles which are adapted to the type of irrigation that is desired in this case are implemented plastic nozzles misting which provide a very fine spray or better known as mini sprinkler to obtain a power of bathing the food very uniform, [26-25], this type of nozzles are transverse sprinkler nozzles, this type of irrigation system requires a hose connection between the nozzles and the main system of connection to the water supply for this is required a 4mm hose of flexible PVC with T-type connectors and unions, for the part of the two main agents are used two 25 liter plastic tanks and these are connected to two actuators which will perform the transport of the tanks to the nozzles.

4. Methodology

The methodology implemented for the development of the proposed prototype is described in a block diagram (Figure 1), where a modular methodology for the construction of the system is shown. The stages consist of a mechanical part which aims to operate the actuators and the conveyor belt, a system of modules and sensors which are programmed to the microcontroller which receives the signal to start or shut down the machine, and a mobile application which gets data from users and gives options for maintenance.

Figure 1. Block diagram prototype operation.



Source: Own.

4.1. Sprinkler system

Sprinkler systems are the most used systems to spray liquids, these allow to adjust the spreading area of the fluid, so the resources are optimized and the process is more effective, even more when they can be activated for a certain time. Therefore 7 lines of Sprinklers which are made up of a certain number of nozzles connected to each other by hoses to cover most of the surface of the fruit, most of which are located in the hermetic box where each line consists of three nozzles, a nozzle on the right side wall, another on the left side wall and the last one on the top; each line has a function and an order established as follows, Table 1:

Table 1. Sprinkler lines.

SPRINKLER LINE	FUNCTION
one and three	its function is to apply water to the fruits to prepare them to receive the decontaminating agent
two	its function is to apply the decontaminating agent to the fruit from all three angles
four	its function is to apply the biocide to the fruit from the three angles
five and six	: they are the most important since they are in charge of rinsing the fruit to remove both the biocide and the decontaminating agent from the surface of the fruit so that they do not come into contact with consumers. These sprinkler lines are powered through motor pumps or solenoid valves that are inside the machine and that are activated by measured times for a complete disinfection and a total elimination of the biocide and the decontaminating agent.
seven	it is located in the drainage system pointing towards the conveyor belt, has the function of cleaning the belt of debris that may remain after passing the fruit through it, which is why it will be active when the belt is in motion

Source: Own.

4.2. System start, stop and restart

For this system, ultrasonic sensors were used, which measure the distance through ultrasonic waves. The head emits an ultrasonic wave and receives the reflected wave that returns from the object. This sensor measures the distance of the object by counting the time between emission and reception, [33].

4.2.1 Programming

This sensor measures the position of the fruit on the conveyor belt, which we can program each action depending on how far the fruit is from the sensor, activating the different actuators as shown in Table 2.

Table 2. Actuators.

Distance(cm)	actuator
≤ 5	• Three-phase motor (conveyor belt) • Motor DC (brush) • Solenoid valve(SPRINKLER LINE 7) • hermetic box lights turn on
25	Solenoid valve(SPRINKLER LINE 1)
35	Motor pump(SPRINKLER LINE 2)
45	Solenoid valve(SPRINKLER LINE 3)
55	Motor pump(SPRINKLER LINE 4)
65	Solenoid valve(SPRINKLER LINE 5)
75	Solenoid valve(SPRINKLER LINE 6)
>77	fans

Source: Own.

4.3. Mechanical system

The mechanical systems that are integrated in the machine are composed of two actuators (one DC and one AC) so each one has its own application; one exerts the force of movement for the belt and the other exerts the force of the cleaning brush for the belt.

4.3.1. Transmission design

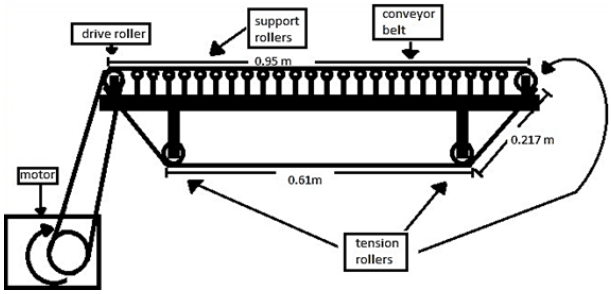
The three-phase actuator SIEMENS 3-MOTOR 1LA7 070-4YB62, [28] anchored to a speed reducer with 1:10 ratio, with a chain transmission design, developed with two sprockets of 18 steps which results in a transmission ratio in the chain of 1:1, the chain is a single strand of 92 sprockets with a length of 1. 21 m

which infers a distance between sprockets of 0.474 m, for the torque or moment of force of the motor a result of 132.277267 Nm is obtained.

4.3.2. Conveyor belt Design

In order to implement the conveyor belt it was determined the design of a moving floor belt which consists of a driving roller, which is responsible for directing the movement generated by the engine to the conveyor belt, this can be shown in the Figure 2.

Figure 2. Mechanical parts conveyor belt.



Source: Own.

In this case the assembly of three tension rollers which have the function of tensioning the conveyor belt was performed; these rollers including the driving roller are metal rollers with an outer diameter of 0.0254 m and a length of 0. 27m, these rollers are the ones that are going to support the force of the motor and the tension of the belt, for this reason it is necessary a resistant material, which also generates an ETA's is the power of friction that has this material of this form taking into account this the rollers are going to be covered with a non- skid material for a better traction of the belt, In the case of the support rollers, which are those that will support the passage of the food in the intermediate part of the conveyor belt to give it firmness and avoid the elongation of the conveyor belt, 30 PVC rollers with an external diameter of 0.0127m are used. 0127m which generates a spacing between the support rollers of 0.02m and a spacing between the support rollers and the tension rollers of 0.03 m, the conveyor belt is made of synthetic leather with a length of 1.994 m and a width of 27 cm, this conveyor belt has tabs that protrude from its surface to help the transition of the food from its initial point to the end.

4.3.3. Brush design

The motor chosen to perform the brush movement was taken into account with respect to a motor not of much speed, but of strength to perform a deep cleaning of the belt in this way was chosen a motor RF-500TB-14415, [29], anchored to a high tension speed reducer with reduction ratio 1: 30, the brush used for belt cleaning is made of thin rigid plastic fibers which ensures a complete cleaning of the belt without the risk of affecting the material, the motor is anchored directly to the brush with a metal shaft support, [30].

4.4. Drying system

For the design of the drying system, two FLJ 130 centrifugal fans were used, connected by a steel tube, and 4 auxiliary fans were also used in order to have a higher flow rate.

4.4.1 Air flow rate

OMS and FAO are clear that food must be delivered completely dry, because if it is wet, the amount of ETA's increases, [1] In order to satisfy this parameter, we proposed the union of the two centrifugal fans which individually have a flow rate of 260m2/h and by joining them we have a total of 520m2/h.

4.5. Mobile application

The mobile application was developed in MIT App Inventor which is an intuitive and visual programming environment that allows everyone to create fully functional applications for Android and iOS smartphones and tablets, [28] the way of programming in this software is through blocks which have a hierarchy when they are used.

4.5.1 Conexión con el microcontrolador

In order to make the communication between the microcontroller and the mobile application, it was done through a Bluetooth module HC-06 which serves as a slave when it is in this configuration is ready to listen to connection requests as we can see in Figure 4, which is a diagram of how the communication is.

Figure 4. Application blocks diagram.

Source: Own.

4.5.2 Database

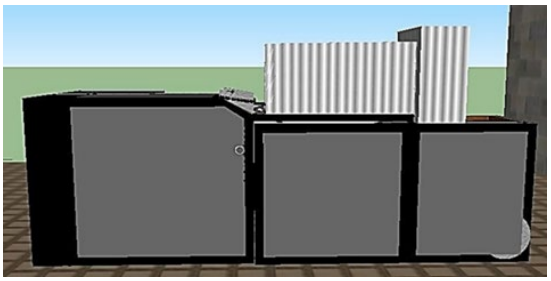
In order to create the database, the google firebase platform was used, in which we have different tools such as realtime database, crash reporting, test lab, remote config among others, [31] in which all the data is stored in the cloud, so we can save users data, and users can send the current status of the machine if it requires maintenance.

4.6. Structural conditioning of the prototype

4.6.1. External structure

The external structure of the prototype was designed based on the research carried out on the types of conveyor belts taking into account that the prototype was divided into four parts, The structure is made entirely of wood. This structure unites three types of different types of wood in which quintuplex was used in the parts where a greater force can be generated or where there can be a concentration of weights because this material has a better response in these aspects, the other parts of the structure were made from chipboard and mdf. Figure 5 shows the parts that are considered the main structure of the prototype, these parts are highlighted in black.

Figure 5. Side view of the 3D designed prototype.

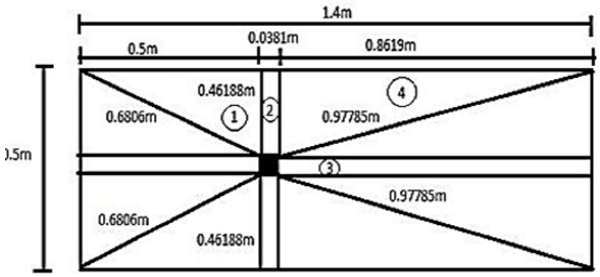


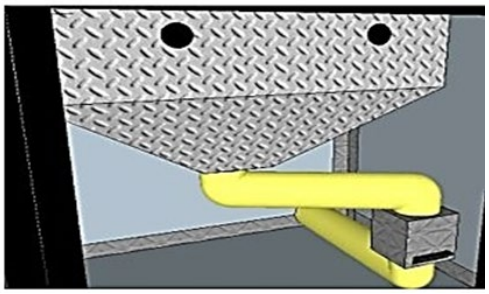
Source: Own.

4.6.2. Drainage structure and solid waste trap

The drainage system is a group of galvanized sheets assembled in a type of well that will take all the wastewater and will lead to a pipe of 0.0381 m, then it will lead the waste to a solids trap also made of galvanized sheet which allows to extract a grid of the waste box or black trap. Figure 6 shows the measurements of the drainage along with a 3D view of it and in Figure 7 you can see the measurements and the black box in the same way.

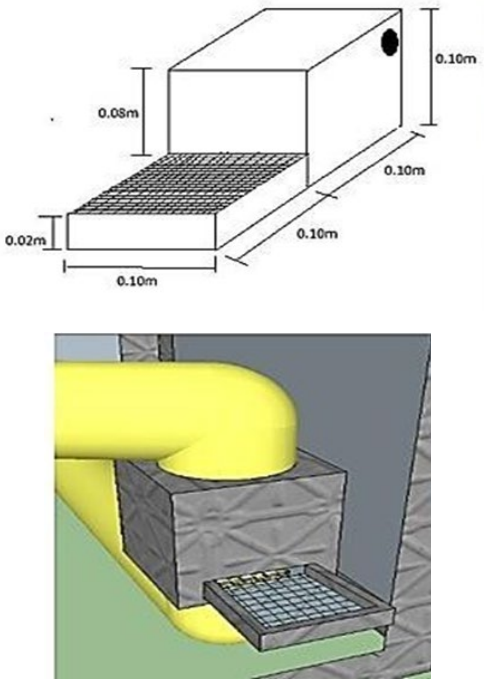
Figure 6. Drainage measurements and side view of the 3D design.





Source: Own.

Figure 7. Measurements of the black box and side view of the 3D design.



Source: Own.

5. Analysis and results

Along the development and building process of the prototype several decisive factors were identified. In order to provide a solution to food safety for the final consumer in an effective way and according to the standards set by the entities in charge, which are the WHO and FAO, we propose a prototype composed of a conveyor belt that has a system of rollers that move by means of an engine connected to these by a bicycle chain, has a sealed box containing a sprinkler system distributed in stages for the use of water, disinfectant and biocides, At the end of the hermetically sealed box is the last stage of drying to comply with one of the regulations that establishes that food must be delivered dry to the end user.

The solution proposes a cleaning system for the conveyor belt at the bottom with a brush and a sprinkling system that is activated when the belt is in motion, this system was proposed to avoid that when the conveyor belt turns around, it comes out clean without any type of impurities and thus avoid the procedure to present failures due to accumulation of these in the belt.

For the drying system, multiple tests were carried out to verify the specific time for the optimal drying of the food, since the drying time for foods with a soft shell is a little longer than the opposite with a food that has a more rigid shell, in order to satisfy the safety standards, delivering mostly dry food as specified.

6. Conclusions

By performing food disinfection and washing tests with the prototype, a high level of effectiveness is proven, accomplishing WHO and FAO standards and delivering a final product that satisfy food safety standards. Unlike different existing machines that focus on a specific food.

To optimize optimal washing and disinfection of food, a sensing system is implemented which has different stages of washing food with water, disinfectants and biocides; it was previously programmed by stages and times for optimal performance, it also has a final drying phase to deliver dry food at the end of the process, as it is required by the food safety entities in order to accomplish the standards established.

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