Longevity of the process of selling rice in bulk in municipal markets

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**A B S T R A C T**

Municipal markets began to be built more than 90 years ago in Ecuador, some have already been remodeled and there are also new buildings with modern designs but within them the process of selling rice in bulk remains in this XXI century. The object of study of this work is the market “Las Manuelas” located in the province of Guayas in the canton of Duran. Method of selling bulk rice exposes this product to some types of food hazards, so the aim of this research is to determine the index of criticality of the activities related to this long-lasting process that is currently being promoted as a process that does not pollute the environment. Observation technique was applied to make the food circulation diagram and the AMEF methodology was used to obtain the criticality index (CI) and according to the decision tree of the World Health Organization the critical control points were established. Results obtained showed that the activity of storage and dispatch of bulk rice within the municipal market presented the highest ICs, under these parameters the importance of establishing preventive actions that could give a turn to this type of business.

**Introduction**

Global rice consumption for 2019 was approximately 506 million tons, compared to 499 million metric tons in 2018, this increase is due to growth in the population rate of Asia and African economies that demand food, these data show the high consumption of this grass, China is the largest consumer of rice with about 144 million metric tons, followed by India with 100 million, while Brazil is the country with the highest consumption of rice for Latin American countries. (STATISTA, 2020).

In Ecuador, rice is the second most important product in the basic food basket, according to data from the National Institute of Statistics and Census [INEC], n.d., and represents 47.3% of the daily intake of carbohydrates (Martínez & Ramos, 2018). The high consumption of this cereal is generated by being part of the eating habits of most Ecuadorians and is its main component in the three daily meals, another attraction for its high consumption is the price, since it is very accessible to all economic levels, this availability for the consumer is given by the management of the method of bulk sales in municipal markets and shops for over 90 years.

Bulk selling is a type of trade that has taken off again, either for savings, variety or to encourage responsible and ecological purchasing (Revista líderes, 2019). Promoting this method of sale because it does not contaminate the environment without taking into account the food hazards involved in exposing the rice in an open sack inside a municipal market stall as was done in the previous century, is to prioritize the environment over human health.

Rice is a food with an almost neutral pH, made up of carbohydrates, protein and fat and, to a lesser extent, vitamins and minerals. It therefore represents an excellent growth medium for certain bacteria, especially when rice is processed by boiling. B. cereus spores can survive well in dry rice and also after cooking (Chavarrías, 2012). This bacterium is a producer of intoxications and clinical infections, such as bacteremia, septicemia, infections of the nervous system, respiratory system, meningitis, endocarditis, pericarditis, abscesses, eye infections, among others (Cortés-Sánchez, Díaz-Ramírez, & Salgado-Cruz, 2017).
Everyone has the right to expect that the food they eat is safe and suitable for consumption. Safety refers to all those risks associated with food that can affect people’s health, both natural risks and those caused by contamination, by the incidence of pathogens, or that can increase the risk of chronic diseases such as cancer, cardiovascular diseases and others (Food and Agriculture Organization of the United Nations, 1997). For this reason, bulk sale of rice in open sacks with a low health risk assessment is considered as a null hypothesis and as an alternative hypothesis this sale method has a high health risk assessment.

Index of criticality and critical control points in the activities involved in the process of selling rice in municipal markets under the bulk method allows the lifting of an action plan that supports the need for rice to be packed in the piler under presentations less than standard to continue to meet the demand of municipal markets that require rice in small quantities for economic reasons or use a dispenser that ensures the safety of the product by each local to avoid the use of open bag of rice.

Based on some of the phenomena and observations mentioned above, the formulation of the research problem is as follows: 1) What is the index of criticality of the activities related to the process of selling rice in bulk? 2) Is there a probability of bacterial growth in the open rice sacks that are exposed on the premises within the municipal market?

The aims and objectives of this study: i) To determine the index of criticality of the activities related to this long-lasting process, ii) Calculate the probability of bacterial growth in open rice bags that are exposed on the premises within the municipal market

The reminder of this study is organized as follows. The next section provides a review of extant literature. The third section discusses the methodology and data. Finally, conclusions and implications of the study are presented in the final section.

**Literature Review**

**Conceptual Background and Hypothesis Development**

**Bulk Sales**

Bulk sale project Gramo Verde is inspired by the story of Salvador Achondo who, together with other colleagues, founded Algramo as a company, whose idea originated in a neighborhood in Chile. They themselves decided to live in one of the populations most affected by poverty in the country, settling in the commune of La Granja, living the day to day difficulties of the environment. One of the aspects that worried Salvador the most was the fact that he was paying much more for buying in small quantities than having bought a larger product. This affected him so much that he proposed a solution: to create a machine whose technology would combine paying and dispensing in bulk the amount that the client wanted to buy by paying in bulk the necessary amount (Celis, Tovar, & Yate, 2018).

**Packaging**

Packaging acts as a silent seller, conveying the image of the product and the manufacturer’s signature. It is an instrument of decision of the marketing of the products for its direct sale, which contains a suitable fraction of the consumer; that informs on the characteristics of use as they are: storage, conservation, properties, among others, also allows the identification of its origin across its image for the design, color and form, which serve as factor of differentiation between an increasing number of people looking for a product with a natural image (Cervera, 2016).

**Rice**

Rice is part of the group of cereals, this grain of rice also called seed when it is just harvested is formed by the fruit or cariope and by the shell, the latter is composed of glumella, industrially it is considered to be the rice with shell that included by the set of cariopse and glumella (Pincioli, Ponzio, & Salsamendi, 2015).

Rice contamination can occur during harvesting, piling, grain storage, transport, marketing in warehouses, markets, supermarkets, shops and in the cooking process of the food. The storage is an infectious focus because the grains continue to breathe producing carbon dioxide, water and energy (heat), the same that is influenced by the hot and humid climate in tropical regions that is the case of our object of study the "Mercado las Manue拉斯", which favors the growth of fungi and insects that cause their deterioration, having advantage the regions of cold and dry climate (Martinez & Ramos, 2018).

**Bacillus Cereus**

*Bacillus cereus* belongs to the B. cereus group which comprises the species B. cereus, B. mycoides, B. pseudomycoides, B. thuringiensis, B. weihenstephanensis, B. cytotoxicus, B. toyonensis and B. anthracis. These are Gram-positive, endospore-forming facultatively anaerobic members of the genus Bacillus and, within the group, toxin production is an important way by which disease is caused. *Bacillus cereus* causes two distinct forms of foodborne disease: a diarrheal syndrome and an emetic syndrome, both through the production of distinct toxins (Griffiths & Schraft, 2017).
This bacillus measures 1.1-1.2 μm in diameter and 3-5 μm in length, Gram positive, mobile (peritric flagella), optional anaerobic which can grow in a pH range of 4.9-9.3, minimum water activity of 0.93, temperature of 4 °C to 48 °C and NaCl concentrations up to 7%. It is capable of forming spores, which are resistant to low humidity, high temperatures, dehydration, radiation and acidity (Cortés et al., 2017).

**Food Safety**

Everyone has the right to safe, nutritious and sufficient food. Even today, about one in ten people in the world get sick after eating contaminated food. When food is not safe, children cannot learn and adults cannot work. Human development cannot take place. Safe food is fundamental to the promotion of health and the eradication of hunger, two of the main goals of Agenda 2030. There is no food security without food safety, and in a world where the food supply chain has become more complex, any adverse food safety incident can adversely affect public health, trade and the economy on a global scale. However, food safety is assumed. It is often invisible until you have food poisoning. Harmful foods containing bacteria, viruses, parasites or harmful chemicals cause over 200 diseases, ranging from diarrhoea to cancer. (FAO, 2019).

Consumers have the right to demand that the food available in domestic markets is safe and of good quality (FAO, 2019).

**Critical Control Point (CCP):**

A step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. (FAO, 1997)

A critical control point is defined as the step at which control can be applied and which is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level (Couto, 2014).

**Hazard analysis**

The hazard classification is: a biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect (FAO, 1997).

Risk analyses are qualitative or quantitative models that allow the assessment of the probability and severity of a given hazard in food, together with its effects and consequences on the health of consumers. A risk is the likelihood that a food will cause undue health effects in consumers because of the presence of one or more physical, chemical or microbiological hazards in the food (Rojas, Tello, & Morera, 2014)

Hazards are part of the prevention required for biological, chemical and physical foods, therefore, the implementation and compliance with the HACCP system identifies as instruments from the international perspective encompassing the guarantee of food safety from the manufacturer or supplier in the tasks of collection, preparation, production, distribution and marketing of food (Campoy, Moraga, & de la Torre, 2015).

The storage is an infectious focus because the grains continue to breathe producing carbon dioxide, water and energy (heat), the same that is influenced by the hot and humid climate in tropical regions that is the case of our object of study the "Mercado las Manuelas", which favors the growth of fungi and insects that cause their deterioration, having advantage the regions of cold and dry climate (Martinez & Ramos, 2018). Based on this theory, the hypotheses are:

H1: The criticality rate of the bulk rice sale process is high

H2: There is a high probability of bacterial growth in the open rice bags that are exposed on the premises within the municipal market.

**Research and Methodology**

Participants of the investigation are the rice merchants of the municipal market "Las Manuelas" of the canton Duran, in this market there are 40 premises, this quantity represents the population and sample, for the study only the sale in bulk is considered, since some premises also sell rice in presentation of 25 pounds and 100 pounds.

**Data Analysis Technique**

The data analysis model of this research is given under an exponential function, where the criticality index (CI) is a function of time in days, since some commercial premises sell a bag of rice between 1 and 15 days, the less time the exposure of the open bag of rice in the environment.

\[ IC = 125 (0.008)^{0.01 t} \]

IC = Criticality Index

\( t = \text{time in days} \)

125 = Maximum Criticality Index value

125 (0.008) = Minimum Criticality Index value
Circulation diagram of bulk rice dispatch in the market was made to identify the activities where contaminants proliferate, survive or are sources of contamination, for which the symbolism shown in Table 1 was used.

### Table 1: Symbols used in food flow diagrams

| Symbol | Interpretation |
|--------|----------------|
| !       | Possibility of initial contamination of food or water with foodborne pathogens |
| △       | Possibility of contamination with foodborne pathogens from surface or food contact equipment |
| ▼       | Possibility of contamination with foodborne pathogens from the food handler. |
| □       | Process phase |
| 🕗       | Possible phase of the process, which is not always executed. |
| ↓       | Direction that the food follows. |
| PCC     | Critical control point: monitoring method. |
| ✗       | Destruction of vegetative bacteria if boiled or cooked at temperatures close to boiling, but the spores survive. |
| ○       | Possibility that microorganisms survive. |
| +       | Possibility of bacterial proliferation. |
| ◯       | Bacterial proliferation unlikely. |
| S       | Spores |

### Failure Mode and Effects Analysis

Failure Mode and Effects Analysis [MAEF] methodology contributes to the improvement of the reliability and optimal maintenance of a product or system through the investigation of risk points, in order to minimize them through appropriate actions.

For the calculation of the criticality index, the parameters and values used in the risk categorisation set out in table 2 were used.
### Table 2: Parameters and values used in risk categorization

| Severity | Probability of occurrence | Probability of detection |
|----------|---------------------------|--------------------------|
| **Value** | **Criteria** | **Value** | **Criteria** | **Value** | **Criteria** |
| 1        | Scarce. The quality characteristics of the product are not affected. | 1 | Remote. Doesn't exist documentary history that shows that the risk arose previously. | 1 | Existing control measures will detect almost safe the deviation of the quality parameters in the product in a specific process step. |
| 2        | Mild. The quality of the final product is not affected, but there are deviations from the manufacturing procedures. Includes cosmetic or minor defects that lead to some customer dissatisfaction; corrective action may be necessary. | 2 | Unlikely. They correspond to incidents extremely isolated. | 2 | High probability that the design control detects the deviation of the parameters of product quality in a specific process step. |
| 3        | Moderate. Product quality can potentially be compromised. Further investigation or quality verification is required prior to release or storage. | 3 | Occasional. The mistake has been observed and detected earlier | 3 | Moderate probability that design control detects the deviation of the parameters of product quality in a specific process step. |
| 4        | High. The results of the process or the product do not meet customer specifications; results warrant rejection of the product. | 4 | Common. The risk presents some recidivism in appearing. | 4 | Remote or very low probability that the control of design detect the deviation of the quality parameters in the product at a stage of specific process. |
| 5        | Very high. The failure in the process potentially affects the purity, the health integrity or the life of the final product. It involves non-compliance with legal requirements or a serious impact on health and life of the consumer | | Frequent. Risk is unavoidable and presents itself consistently. | 5 | Existing control measures will not fully detect deviation of the parameters of product quality in a specific process step. |

**Source:** Cartín et al., (2014)

Criticality index [IC] was calculated using the following formula:

\[ IC = S \times O \times D; \]

- **S** = Risk Severity
- **O** = Probability of occurrence
- **D** = Probability of detection

Hazard Analysis and Critical Control Point [HACCP] classification of hazard types was analyzed for each activity of rice dispatch in the municipal market under the tree diagram defined by the Food and Agriculture Organization of the United Nations [FAO].
**Proceed to next hazard**

**Acceptable levels need to be defined**

Source: FAO

Figure 1: HACCP worksheet

Result and Discussion

Flow chart of food circulation

Food can be contaminated naturally or due to poor management practices at any stage from production to final disposal on the consumer's table; this can happen when it comes into contact with soil, irrigation water, rain, air, some organic fertilizers, agrochemicals, carriers, packaging materials, domestic and wild animals, machinery and equipment, among other elements (Rodríguez, Sosa, Hernández, & Martínez, 2018).
Below is the flow chart of food circulation:

![Flow Chart of Food Circulation](image)

**Figure 2:** Food circulation diagram of piled rice in the "Las Manuecas" market.

**Criticality Index**

Activity of the food handler is characterized by being in direct and continuous contact with food products. These products may be in a raw, semi-finished state and the food handler interacts with them throughout a process that may range from the reception of the products to their presentation for consumption. The effects of poor practice of this work activity include consequences on the health of the handler and on the health of others, mainly consumers, through intoxication or infection (Gómez, 2016).

Bulk sale of open-bag rice presents a high health risk assessment and therefore the null hypothesis is rejected. The below table shows the criticality indexes of the activities of the bulk sale of rice in the municipal market "Las Manuecas":

| Activity Description                                      | Criticality Index |
|-----------------------------------------------------------|-------------------|
| Receive the rice in sack of 1 quintal                     |                   |
| Store the rice in the room                                |                   |
| Open sack of rice to ship in bulk (per pounds)            |                   |
| Dispatch the rice in bulk (per pounds)                    |                   |
| Minimum time: 1 day                                      |                   |
| Maximum time: 15 days                                    |                   |
| Activity                        | Hazard                              | Cause or Origin                                                                 | S  | O  | D  | IC | Preventive action                                                                 |
|--------------------------------|-------------------------------------|--------------------------------------------------------------------------------|----|----|----|----|----------------------------------------------------------------------------------|
| **Receive from the rice sack** | Chemical: Liquid filtration in the transfer | The rice sack is made of a material where you can filter liquids                | 1  | 2  | 1  | 2  | Change the sack material to provide more protection for the rice.                  |
| **Store rice, sealed sack**    | Physical: Presence of foreign material or objects | The fragility of the sack material allows foreign objects to enter.             | 3  | 2  | 3  | 18 | Change the sack material to provide more protection for the rice.                  |
|                                | Chemical: Waste from other materials sold on the premises such as: disinfectants and detergents. | The rice sack is made of a material where it can filter liquids.                | 3  | 2  | 3  | 18 | Change the sack material to provide more protection for the rice.                  |
|                                | Biological: Zone of proliferation of b. cereus. | Storage temperature, average 25ºC, the heat causes the rice to release water and generate an area of proliferation of b. cereus. | 4  | 4  | 4  | 64 | Keep the market air conditioner on                                                 |
| **Open sack of rice to be sold in bulk** | Physical: Presence of foreign material or objects | The open rice sack is sensitive to intentional or unintentional deposition of foreign objects. | 4  | 5  | 5  | 100 | Use a dispenser to protect the rice from external agents and also avoid selling a rice that has had 15 days open, refer to the last part of the sack. |
|                                | Chemical: Presence of foreign liquids or solids. | Rice merchants also sell detergents that could fall into the open sack of rice. | 4  | 3  | 2  | 24 |                                                                                |
|                                | Biological: Zone of proliferation of b. cereus. | Open rice sack can get water from passing customers because the aisle is narrow and create a wet area inside the rice sack that will grow bacteria. The last part of the sack to be sold is more biohazardous. | 4  | 5  | 5  | 100 |                                                                                |
| **Dispatching the rice in bulk** | Physical: Presence of foreign material or objects | The rice sack is open and uncovered, so any foreign agent could fall into it.   | 4  | 5  | 5  | 100 | 1. Use a dispenser to protect the rice from external agents and also avoid selling rice that has been open for 15 days, refer to the last part of the bag. |
|                                | Chemical: Waste of other materials or products. | Waste from other materials sold on the premises such as: disinfectants and detergent | 4  | 3  | 2  | 24 | 2. Another option is not to sell rice in bulk in the municipal market, and to manage with the stackers so that they will come rice in additional presentations to the standard like: 1 pound, 5 pounds and 10 pounds. |
Determination of CCP

For the determination of the critical control points, the activities that obtained the highest rates of criticality were considered.

**Table 4: Determination of CCP**

| Activity                                | Hazard                                   | Cause or Origin                                                                 | Q1 | Q2 | Q3 | Q4 | CCP / OPQ |
|-----------------------------------------|------------------------------------------|--------------------------------------------------------------------------------|----|----|----|----|-----------|
| Store rice, sealed sack                 | Biological: Zone of proliferation of b. cereus. | Storage temperature, average 25ºC, the heat causes the rice to release water and generate an area of proliferation of b. cereus. | SI | NO | SI | SI | OPQ      |
| Open sack of rice to be sold in bulk.   | Physical: Presence of foreign material or objects. | The open rice sack is sensitive to intentional or unintentional deposition of foreign objects. | S  | NO | SI | NO | PCC      |
|                                          | Biological: Zone of proliferation of b. cereus. | Open rice sack can get water from passing customers because the aisle is narrow and create a wet area inside the rice sack that will grow bacteria. The last part of the sack to be sold is more biohazardous. | ISI| NO | SI | NO | PCC      |
| Dispatching the rice in bulk            | Physical: Presence of foreign material or objects. | The rice sack is open and uncovered, so any foreign agent could fall into it. | S  | NO | SI | NO | PCC      |
|                                          | Biological: Zone of proliferation of b. cereus. | Handling of rice generates an area of bacterial growth. | SI | NO | SI | NO | PCC      |

**Conclusions**

Selling bulk rice exposes this food product to the environment, making it sensitive to the dangerous physical, chemical and biological, since this long-lasting sales process requires keeping an open sack of rice at the foot of each municipal market, which will be so for 1 to 15 days, depending on its rotation. Using the methodology of Modal Analysis of Effects and Failures, it was determined that this part of the process has the highest index of criticality. Among the corrective actions taken to reduce the food risk, it is suggested that a grain dispenser be used to sell the rice in bulk, or the piling machines could sell rice in a different presentation than the standard so that the municipal market continues to comply with the dispatch of the rice in small presentations.

It was also identified that there is a high probability of bacterial generation in rice by having the bag open due to the average annual temperature of the canton Duran which is 24.7 º C, which increases within the market because of the design of its infrastructure, these climatic conditions are within the ideal range for the proliferation of Bacillus cereus, which is capable of forming spores that are resistant to heat, therefore in the cooking of rice are not completely eliminated and people eat them.

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