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INGENIERÍA INDUSTRÍAL

Diseño de un modelo para la administración de inventarios en un cultivo de fresa, basado en el modelo de pedido para un solo periodo y las métricas 6 sigma

INDUSTRIAL ENGINEERING

Inventory management model design in a strawberry crop, based on the model order for a single period and six sigma metrics

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Resumen

La administración de inventarios es parte de las actividades fundamentales de toda empresa, por tanto, de su adecuado manejo dependerán los resultados de actividades posteriores. Los modelos de inventario parten del supuesto general de que los productos presentan un tiempo de vida ilimitado, sin embargo, en algunos sistemas existe una generación de costos adicionales, asociados al deterioro de la calidad de los productos, llamados perecederos. A partir de las condiciones productivas, de gestión de inventarios y de control de desperdicio, el presente estudio incluye una propuesta de diseño de un modelo para la administración de inventarios en un cultivo de fresa, basado en un modelo de inventario para productos perecederos, conocido como el modelo de pedido de un solo periodo y la aplicación de métricas 6 sigma, para la consideración y control del nivel de desperdicio y las limitantes de capacidad productiva del cultivo. A partir del modelamiento planteado, se realiza una prueba de verificación del funcionamiento teórico del mismo El modelo a nivel teórico es funcional, permitiendo evidenciar en un periodo de planeación de un mes, que el modelo permite establecer adecuadamente la cantidad óptima de recolección recomendada; relacionando capacidad esperada de recolección respecto a capacidad real disponible; así como a partir de la cantidad de desperdicio en el cultivo en un periodo determinado, permitiendo establecer controles en el cultivo, teniendo en cuenta el factor de calidad seis sigma y su aplicación como indicador de ocurrencias de desperdicio, que permite garantizar a nivel teórico la planeación y momentos de renovación de cultivo.

Palabras Clave: *Administración de inventarios, capacidad, cultivo de fresa, desperdicio, productos perecederos, 6sigma.*

Abstract

Inventory management is part of the core activities of any company, therefore, of its proper management will depend on the results of subsequent activities. Inventory models are based on the assumption that the products also have an unlimited lifetime, however, in some systems there is a generation of additional costs, associated with the deterioration of the products quality, called perishable items. On the basis of the productive conditions, inventory management and waste management, the present study includes a proposal for the design of a theorical model for the inventory management in a strawberry crop, based on a perishable ítems inventory model, known as the single period inventory model and the implementation of 6 sigma metrics, for waste level consideration and control and the limitations of the crop productive capacity. A theoretical verificarion test to check the operation was performed, identifying that the model is functional, allowing to evidence in a planning period of a month, that the model allows to adequately establish the recommended optimal amount of collection; linking expected harvesting capacity regarding actual available capacity; as well as the amount of waste in the crop in a given period, allowing to establish controls on the crop, taking into account the quality factor of six sigma and its application as an indicator of occurrences of waste, which allows to guarantee in a theoretical level the planning and crop renewal periods.

Keywords: *Capacity, inventory management, perishable items, six sigma, strawberry crop, waste.*

1.Introduction

The success of any company, is linked to the balance between its operational and strategic activities. The planning and adequate management of inventory, has an impact on the productivity of the company, therefore, the support of the decisions taken according to this, it is important to avoid failures and losses, which in the long term can bring consequences reflected in the costs and profits. The information recorded in demand and its accuracy, are critical factors for achieving low levels of inventory, planning of production and to maintain a level of satisfaction in the customer. To achieve effective management of inventories, it is necessary to establish policies, which serve as support to decision-making and provide relevant information for the company normal operation. Inventory models, are based in the assumption that the products have an unlimited life time, however, on some systems their deterioration is generated more quickly, resulting in higher costs. These are caused by the penalty that is incurred by degrading the products quality, which by their nature are called perishable (1,2).

The Fragaria vesca, commonly known as strawberry, is a species belonging to the family rosacea, specifically to the genus Fragaria, hence its scientific name. It is highly demanded due to its organoleptic properties, however, their conservation and life; defined in an average of 5 to 9 days depending on the handling factors; make the strawberry a highly perishable product. The production process of a strawberry crop, is associated with duration of 2 years, given in stages, the first stage known as stage of vegetative character with an approximate duration of 4 to 6 months and includes the planting and control of the seedlings that start the crop. The second stage called as productive stage, ranked as the one with the highest performance in the crop with an approximate duration of 7 months, corresponds to the production of the false fruit for harvest; at this stage, on average there is a generation of fruits, each 3 days. Subsequently the third stage corresponds to the pruning and renewal which average duration is 2 months. The fourth stage, corresponds to the second session of production; whose duration is 7 months likewise; where the average production per plant decreases, but the productive periods are held on average once every 3 days. Finally pruning and final renewal is performed (3-6).

The demand for consumption of strawberry in a crop, during the production stages, generally is associated with a probabilistic character, based on 2 types of consumption, direct orders and pre sale. It is necessary to consider the waste generation levels, which can be associated with 2 elements, pests and diseases that can occur during the vegetative stage and the absence of traceability and control in the crop; some of the most common causative agents of alterations in plant operation, deterioration, stains and deformations are the fungi, viruses and/or bacteria that attack the root and foliage or fruit, representing waste levels. The implementation of Good Farming Practices - GFP; defined as the control standards and marketing of products in the market, considering the quality, safety and minimal environmental impact, as well as the Integrated Pest Management - IPM; defined as a system of scheduled monitoring of crops; they represent tools, to ensure the follow-up to the cultivation and the vectors that represent a possible generation of waste, however, not being rigid systems but flexible models to the users, in some cases, its implementation is not associated with a methodology that allows an adequate adaptation (3).

On the basis of the productive conditions, inventory management and control of waste exposed, the present study includes a proposal for the design of a inventory management model in a strawberry crop, based on an inventory model for perishable products, known as the single period inventory model and the implementation of 6 sigma metrics, seeking to apply the concept of Six Sigma quality involves ensuring that the variation of the quality characteristics presents a defect rate of 0.002 ppm (parts per million), world-renowned or associated with a zero defects process, framed in the DPU, DPO and Y metrics representing sigma level, for waste level consideration and control and the limitations of the crop productive capacity. The mathematical formulation associated, the logic of the model and the test of theoretical and practical results are presented. This article arises as a product of the research project INV_ING_1915 called "Aplicación para dispositivos móviles para el manejo de la información en un cultivo de fresa" of Militar Nueva Granada University.

2.State of the art

2.1. Perishable ítems Inventory models

Inventory management, has established itself as one of the most used economic alternatives, to reduce the cost structure within an organization. This is carried out through the analysis of the demand, product type, market conditions, on the basis of models that allow to adjust such behavior to strategic planning. Inventory models, are based on the assumption that the products have a limited life span, however, on some systems, their deterioration is generated more quickly, resulting in higher costs. These are caused by the penalty that is incurred to degrade the products quality, which by their nature are called perishable. As a result, their management is focused on ensuring its availability, mitigating the losses by maturity (7,8).

In addition, the perishable products, have the status of a continuous supply, taking into account that must be delivered to the retailers in times that reduce their degradation, avoiding the loss of interest on the part of the consumer. To achieve this goal, organizations should establish strategies such as promotions, once it has been detected that the expiration date is close, managing to recover part of the expected revenue without losing the product. Despite this, the continuing investigations in this field seek to implement the optimization of the time and amount of delivery, minimizing perceived losses (9,10).

The perishable ítems inventory models, are classified according to the demand behavior in the system or its life span. According to the demand type, if it is deterministic, the inventory change can be determined by a prediction of constant demand. If it is stochastic, can be represented through a probability function. In relation to the life span, there are three types of inventory models: with life fixed and known, to establish products with a specified expiration time; with constant deterioration rate, based on the inventory change by period that is affected by a constant fraction and variable deterioration rate, considering that the inventory change in each period is transformed by a specific deterioration (11, 12).

In addition, research has been carried out to increase the level of analysis of the variables involved in a system with perishable items. Among these, are inveontory models with periods of backorders, payment policies to suppliers, optimal price policy, multi-level within the supply chain, inflation, multi-warehouses, multi-product and uncertainty parameters (11,12).

For scenarios where products with highly perishable nature are handled; defined according to a short life span; inventory management proposes a model called "The newspaper salesman problem", whose technical name is single period inventory model. The problem of the newspaper seller, consists in that the seller receives from suppliers the amount ordered by a single time, in such a way that if the level demanded by the customers of the seller is greater than the available units, the newspapers seller leaves to perceive the gain on the sale of the missing units, on the other hand, if the newspapers seller acquires more of the defendants units, then there will be not sold units, incurring in losses, taking into account that such product at the end of the life span, loses its value (15).

To determine the optimal inventory policy, it is necessary to understand the demand nature and the behavior, either by establishing the possible values of the random demand, with their respective frequency or know the demand probability distribution function. In addition, it is necessary to know the cost associated with the generation of excess and the cost associated with the unmet demand by not having the required inventory, which covers both the loss of profit as the penalty for customer non satisfaction (13, 14).

2.2. Features in strawberry production

The strawberry, whose scientific name is Fragaria vesca; a species belonging to the family rosacea, specifically to the genus Fragaria; presents high consumption worldwide, thanks to its organoleptic features, such as aroma, color and acidity, as well as a high content of vitamins A, C, B1 and B2. The strawberry plant, has a perenniel character, forming new stems on a constant basis. Its growth depends on climatic conditions such as light and temperature, it is estimated that proper altitude suitable for production is set between 1300 and 2000 m. Germination is usually given in deep loam soils or sandy loam soils, maintaining a pH between 6 and 7 units, with regard to their granulometry, establishes a requirement of 5% MO, 15% limestone, 20% clay and 50% sand. Must be placed in the first 15 cm from the ground. Currently the production process takes place in open fields or in macro tunnels. In addition, prior to the production process, must be carried out the disinfection stage, to mitigate the presence of fungi, mites, herbs, vermin and insects (17, 18).

The productive system defined through macro tunnels, has been implemented in technified production systems, providing benefits such as the reduction in the leachate generation from the fertilizers, as well as in the investment made in pesticides and the control of temperature levels. It consists in the implementation of compartments with a width between 70 and 80 cm, height 20 cm. In each of the compartments are built two rows, separated 40 cm between them. Subsequently, the beds should be covered with black polyethylene, whose thickness varies between 0.2 to 0.4 mm; establishing an insulation from the ground. The open field production, presents a great disadvantage, taking into account the fact that the crop has biotic limitations, therefore it is exposed to pests, mites and larvae. In addition, in relation to the abiotic constraints, adverse weather, wind, frost and high rainfall (19, 21).

The strawberry production process is defined with respect to the crop establishment, with a planning horizon of 2 years divided into operation stages. The first stage called vegetative, has a duration of 4 to 6 months, according to the type of Fragaria to cultivate; which includes the development of planted seedlings. The second stage referred to as productive, whose approximate duration is 7 months in the colombian field, corresponds to the production of the false fruit collection, where it is indicated that per plant planted, it will generate an average of 1.4 kg of strawberries, for the total of the first productive period, generating fruits every 3 days on average, where each fruit has a lifespan between 5 and 9 days, according to the conditions of handling and management in the crop. The first productive session is taken as the highest-performance; where during the first 3 months 60% of the production is generated, during the 2 months after the 25% and in the final 2 months the 15% of the production. Subsequently the third stage corresponds to the pruning and renewal of the crop; with an average duration of 2 months; that is included as a required step in the crop maintenance, which allows to check the plants conditions, the cleaning and removal of plants not required, the pest control and to check on the status of irrigation systems and macro tunnels. The fourth stage, corresponds to the second session of production; its duration is 7 months in the same way; where the average production per plant decreased to 0.6 kg of strawberries per plant sown, while maintaining the same percentage behavior with respect to the first stage. Finally there is a pruning and renewal for the end of the crop useful period (3,22).

To conserve and control humidity levels, irrigation systems are used, which are classified in two groups, sprinkler or drip irrigation. The sprinkler system, presents the advantage of precision in the water dosage, however, the water consumption is greater than in the drip system. Strawberries harvesting, in the production stages is complemented with a temporary storage in cameras at low temperatures, maximizing the conservation of the same. It is necessary to emphasize that, in accordance to the market to which the product is going to be exported, the parameters of the selection process are established, taking into account that usually are associated with size, conservation level and color (23).

2.3. Six Sigma

The Six Sigma, is regarded as a systematic method that allows to set a strategic improvement of processes and products, based on scientific and statistical methods; which main objective is the reduction of defects related to quality and that are perceptible by the customer. According to this, the most known methodology in Six Sigma is DMA-

IC, represented as a quality strategy defined in five stages. In the stage Define, it seeks to identify the needs and requirements of the process to be improved, with the purpose of establishing the objectives and the traceability system that will be developed, which corresponds to the Measure stage. Subsequently, in the Analyze stage, the factors and causes present in the survey process are identified. According to this, the adjusments design and implementation are performed, corresponding to the Improvement stage; to finally carry out the verification of the obtained results and analyze its correlation with the objectives initially established, representing the Control stage (24, 25).

Furthermore, the concept of Six Sigma quality involves ensuring that the variation of the quality characteristics presents a defect rate of 0,002 ppm (parts per million), world-renowned or associated with a zero defects process. Many features depend on specific attributes of occurrence and taking into account that there is a Group of Six Sigma Metrics, centralized in the indicator defects per million opportunities of error - DPMO. It is understood by unit to the part or product which is elaborated in a process, and it is considered for quality evaluation, as well as sets as an opportunity for error to any section of a unit that is measurable or verifiable in conformity or non-conformity. A defect is associated with the non-conformities or deviations in the units. Taking into account these elements, the indicators or metrics are defined, set forth as defects per unit - DPU; used to determine the level of quality in a process, without taking into account the opportunities for error; Defects per opportunity - DPO; which takes into account the complexity of the unit according to the error chances; and finally, the DPMO; corresponding to the multiplication of DPO by a million; which provides the desired pattern, taking into account that the world-class goal involves having a maximum of 3.4 DPMO. The sigma level depends directly on and referred to the probability that a unit is free of defects, calculated with respect to the DPU. (26)

3. Methods and materials

The study derived from the research Project ING_ ING_1915, the Faculty of Engineering of the Militar Nueva Granada University, was carried out with the objective of designing a inventory management model in a strawberry crop, based on a perishable ítems inventory model, known as the single period inventory model and the implementation of 6 sigma metrics for the consideration and control of the level of waste and the limitations of the crop productive capacity. This model was established on the basis of secondary information sources, as well as sections of previous research, the research project mentioned above.

The model design is based on the single period model formulation; considering a probability function with a theoretical nature, in relation to the demand occurrences in the last few seasons; whose parameters and equations are presented below:

Notation and input parameters in the single period inventory model

D =Demand for the period described with probability function

f (D)=Density function of demand with respect to probability function

b=Underage cost per unit

Co=Overage cost per unit

Q=Optimal order quantity*

F(Q)=Critical ratio related to optimal order quantity*

F' (Q)=Cumulative probability function*

The model contemplates the definition of critical ratio; presented in equation 1; that is defined as the ratio of the underage cost per unit, with respect to the total cost defined by the underage cost per unit and the overage cost per unit, which is defined as a ratio.

$$F'^{(Q^*)} = \frac{b}{b + Co} \quad (1)$$

Subsequently, it is necessary to estimate the cumulative probability function, given as the definite integral between the minimum value of the distribution and Q* given as incognita, of the density function of the probability distribution that is associated to the demand, represented in equation 2.

$$F^{I}(Q^{*}) = \int_{a}^{Q^{*}} f(D)dD \quad (2)$$

When clearing Q* with regard to the critical ratio and the integral resulting from the cumulative probability function, it is possible to define the value of the optimal order amount.

Similarly, the model will depend on the calculation of the sigma sin the process, taking into account the Six Sigma Metrics. The DPU indicator represents the equation 3, the equation 4 represents the DPO, the equation 5 represents the indicator DPMO and the equations 6, 7 and 8 represents the calculation of the number of sigma.

$$DPU = \frac{Number\ of\ defects}{Total\ number\ of\ product\ units} \quad (3)$$

$$DPO = \frac{Number\ of\ defects}{(number\ of\ units * number\ of\ defect\ oppotunities\ per\ unit)} \quad (4)$$

$$DPMO = DPO * 1000000\ Defects\ per\ million\ opportunities \quad (5)$$

$$Z_C = Z_Y + 1{,}5 \quad (6)$$

$$Y = e^{-DPU} \quad (7)$$

$$P(Z < Z_Y) = Y \quad (8)$$

Taking into account the conditions previously described, the following is the description of the model designed.

3.1 Notation and parameters

Below is the first section of the model that corresponds to the definition of notation and parameters to be used, by adjusting the terms and conditions of the single period inventory model with the characteristics of the strawberry crop and six sigma metrics, looking to establish a specific model for production planning and control is such kind of environment.

D_t=Demand for the period t

Cd_t=Available harvesting capacity in the period t

Ce_t=Expected harvesting capacity in the period t

Pe_t=% of waste in the period t

Me_t=Waste in kg of strawberry in the period t

b=Underage cost per kg of strawberry

Co_t=Expected overage cost per kg of strawberry in the period t

f(C)=Density function of harvesting capacity

Q_t^*=Optimal order quantity of harvesting in kg of straberry in the period t

$F(Q_t^*)$=Critical ratio for harvesting in the period t

$F^I(Q_t^*)$=cumulative probability function for harvesting in the period t

σ_t=Sigma level of harvesting process in the period t

3.2. Description and logic of the model

From the notation and the parameters presented, the model logic is described below, starting with the period t=1 and their replicas. The inventory model is applicable to the months, which apply only to production stages. It is assumed that the available harvesting capacity for each period will correspond to the expected capacity of the month, divided into production sections of 3 days. The first part corresponds to th identification of percentage of waste; equation 9; associated with the kg of strawberry that were removed from the crop, prior to harvesting in the period.

$$Pe_t = \frac{Me_t}{Ce_t} * 100 \quad (9)$$

The amount of waste identified, in addition will be used to relate the Six Sigma metric, corresponding to the calculation of the sigma level; associated with a cumulative standard normal distribution, for the harvesting process in the period. The modification is presented in equations 10 and 11.

$$\sigma_t = Z_Y + 1{,}5 \tag{10}$$

$$Y = e^{-\left(\frac{Me_t}{Ce_t}\right)} \tag{11}$$

Identify the sigma level in the harvesting process, will be used as a control indicator for the crop, from this the assumption that if the sigma level in a period is less than or equal to 1 sigma, a cleaning to the crop should be carried out, whose duration will be 5 days, implying that in the next period no harvesting takes place; considering that the harvest is done every 3 days; is defined in equation 12. In addition, from the cleaning set, it is assumed that the next feasible harvesting period will have a percentage of waste of 1%.

$$If\ \ \sigma_t \leq 1, Ce_{t+1} = 0\ \ and\ \ Pe_{t+2} = 1 \tag{12}$$

If the sigma level associated to waste is strictly greater than 1, defines the available harvesting capacity, as the expected capacity less the amount of waste identified. The demand for consumption of strawberry in a crop, during the production stages, generally is associated with a probabilistic character, based on 2 types of consumption, direct orders and pre sale. The assumption that demand will be met only during harvesting periods is established. From this, the underage cost per unit will be defined, associated with the relationship between the amount of kg of strawberry to harvest required to meet the demand, considering that all strawberry collected that is not used to cover the demand will be considered a useful waste. This is presented in equation 13.

$$Co_t = \begin{cases} If\ D_t < Cd_t, Co_t = b * \left(\frac{D_t}{Cd_t} - 100\right) \\ If\ D_t \geq Cd_t, Co_t = 0 \end{cases} \tag{13}$$

The critical ratio for the period, in this case, shall be defined as the recommended harvest proportion, related to the available capacity identified; given in the equation 14.

$$F(Q_t^*) = \frac{b}{b + Co_t} \tag{14}$$

The cumulative probability function; equation 16; in this case will be given as the definite integral between the minimum value of the distribution, assumed as 0; taking into account the possibility to not generating harvest; and the optimal amount of collection for the period, given as incognita, of a density function of harvesting capacity; equation 15; for which in this case is defined that its behavior is uniform with minimum value 0 and maximum value the available capacity of the period.

$$f(C) = \frac{1}{Ce_t - a} \tag{15}$$

$$F^I(Q_t^*) = \int_a^{Q_t^*} f(C)dC \tag{16}$$

The critical ratio and the cumulative probability function proposed, will be used to define the optimal amount of collection, the leftover stock whose life span life will be of 5 days and the percentage of covered demand in the period.

4. Results

From the modeling raised, a theoretical verification test to check the operation is performed. Table 1 shows the parameters defined for the case.

Table 1. *Parameters for the model.*

Expected production capacity - Month 1 (kg)	Expected production capacity - 3 days (kg)
13,440	1,344
b (underage cost/kg)	2,200

Source: Authors.

On the basis of the parameters, the inventory model is executed, whose results are shown in tables 2 and 3, taking into account that a demand vector was simulated, with a normal behavior with an average of 1,000 kg and a deviation of 500 kg.

Table 2. *Definition of available capacity and level of sigma.*

Day	Expected capacity of harvesting in kg of strawberry	% Of Waste	Waste in Kg of strawberry	Calculation of sigma	Sigma level for harvesting	Available capacity for harvesting in kg of strawberry
1						
2						
3	1,344.00	61%	819.84	1.61	1.00	524.16
4						
5						
6	-	0%	-	-	-	-
7						
8						
9	1,344.00	1%	13.44	3.83	3.00	1,330.56
10						
11						
12	1,344.00	3%	40.32	3.39	3.00	1,303.68
13						
14						
15	1,344.00	2%	26.88	3.56	3.00	1,317.12
16						
17						
18	1,344.00	18%	241.92	2.48	2.00	1,102.08
19						
20						
21	1,344.00	12%	161.28	2.71	2.00	1,182.72
22						
23						
24	1,344.00	34%	456.96	2.06	2.00	887.04
25						
26						
27	1,344.00	26%	349.44	2.24	2.00	994.56
28						
29						
30	1,344.00	51%	685.44	1.75	1.00	658.56

Source: Authors.

Table 3. Definition of demand coverage.

Day	Available capacity for harvesting in kg of strawberry	Demand in kg	Overage cost proportion	Overage cost value per kg	Critical Ratio	Q* of harvest-ing in kg	Leftover Stock in kg (max 5 days)	% Of demand coverage
1								
2								
3	524.16	653.00	-	$ -	100%	524.16	-	80%
4								
5								
6	-	-	-	$ -	0%	-	-	0%
7								
8								
9	1,330.56	1,043.00	0.28	$ 606.55	78%	1,043.00	287.56	100%
10								
11								
12	1,303.68	1,185.00	0.10	$ 220.33	91%	1,185.00	118.68	100%
13								
14								
15	1,317.12	585.00	1.25	$2,753.27	44%	585.00	732.12	100%
16								
17								
18	1,102.08	1,305.00	-	$ -	100%	1,102.08	-	84%
19								
20								
21	1,182.72	514.00	1.30	$2,862.23	43%	514.00	668.72	100%
22								
23								
24	887.04	919.00	-	$ -	100%	887.04	-	97%
25								
26								
27	994.56	778.00	0.28	$ 612.38	78%	778.00	216.56	100%
28								
29								
30	658.56	785.00	-	$ -	100%	658.56	-	84%

Source: Authors.

It is evident, that the model on a theoretical level is functional allowing to establish an inventory management system for the crop in a planning period of a month, with a harvesting process every 3 days, demonstrating the correct planning, on the basis of established criteria of amount of waste, related to Sigma level, ensuring that on reaching the level 1, the crop must be renewed. On the basis of the assumptions for the control of the amount of waste generated, the sigma level on harvesting period, verifying the expected and available productive capacities, as well as the recommended amount of harvest and the additional stock available on the percentage of demand coverage, it is possible to identify the functionality in the simulation.

5. Conclusions

It is noted that the application of this article, covered the design of a model for inventory management in a strawberry crop, based on a perishable ítems inventory model, known as the single period inventory model and the implementation of 6 sigma metrics for the consideration and control of the level of waste and the limitations of the productive capacity of the crop. The model on a theoretical level is functional, allowing to evidence in a planning period of a month; for a simulated demand with normal behavior with an average of 1,000 kg and a deviation of 500 kg per day; that the model allows to adequately establish the recommended optimal amount of collection; linking expected harvesting capacity regarding actual available capacity; as well as the amount of waste in the crop in a given period, allowing to establish controls on the crop, taking into account the quality factor of six sigma and its application as an indicator of occurrences of waste, which allows to guarantee in a theoretical level the planning and crop renewal periods. Likewise, it is possible to quantify the percentage of coverage and the additional stock that is not used for coverage, allowing the grower to have an overview of the additional sales potential or possible additional losses, taking into account that strawberry life span, corresponds to an average of five days in normal conditions. It is reiterated that this development, represents a section of the research Project ING_INV_1915. It is noted that in the future we expect to deploy the inventory model in a real-world scenario, in order to make adjustments, for the probable behavior of the waste and its respective financial analysis.

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