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Uptime optimization in a vertical dryer and its economic impact

Otimização do tempo de operação em um secador vertical e seu impacto econômico

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Resumo
O cacau na Bahia é tradicionalmente cultivado em sistemas agroflorestais que possibilitam a conservação da biodiversidade da Mata Atlântica via sistema de cultivo denominado de cabruca. A proposta deste artigo é apresentar o método para medir o tempo padrão de operação na secagem de cacau. A técnica do tempo padrão que é um recurso que permite analisar a capacidade produtiva de um processo levando-se em consideração uma série de aspectos presentes na rotina de trabalho, têm um grande impacto no tempo necessário para fabricação de um produto. Assim, investigamos a diferença do tempo de operação (tempo padrão) entre dois sistemas de secagem (barcaça e secador vertical) impactando na produtividade da lavoura e na viabilidade financeira no processo de secagem. O resultado encontrado do tempo padrão de operação da barcaça tradicional e do secador vertical de cacau, indica uma redução de 63,3% no tempo padrão de operação a favor do sistema vertical.
Palavras-chave: inovação. cacau. secador. tempo. operação.

Abstract
Cocoa in Bahia is traditionally cultivated in agroforestry systems that make it possible to conserve the biodiversity of the Atlantic Forest via a cultivation system called cabruca. The purpose of this article is to present the method to measure the standard operating time in cocoa drying. The standard time technique, which is a resource that allows analyzing the productive capacity of a process, considering a series of aspects present in the work routine have a great impact on the time required to manufacture a product. Thereby, we investigated the difference in operating time (standard time) between two drying systems (baarcaça and vertical dryer) impacting crop productivity and financial viability in the drying process. The result found for the standard operating time of the traditional barge and the vertical cocoa dryer indicates a 63.3% reduction in the standard operating time in favor of the vertical system.
Keywords: innovation. cocoa. dryer. time. operation.

1 Introduction.

Cocoa was introduced in southern Bahia in the mid-eighteenth century when cocoa seeds distributed throughout the region from small plantations in Camamu (BA) around 1802 formed the basis for the formation of the regional crop. However, the commercial planting of cocoa in the region began in the 1830s, when the crop effectively began to spread regionally and the adaptation of cultivation to the climate, soil and landscape of southern Bahia made the region the largest producer in the country, generating wealth, creating cities and forming a regional culture based on cocoa production (SALES et al., 2022).

Cocoa in Bahia is traditionally grown in agroforestry systems that shelter trees that shade the crop, reducing changes in temperature and humidity and enabling the conservation of part of the biodiversity of the Atlantic Forest, due to the predominant form of cultivation in the southern region of Bahia. called "Cabruca", providing the supply of other products combined with the crop such as fruits and resins that manage to protect the areas of cultivation from adverse ecological conditions (SALES; CÂNDIDA, 2016).

The cocoa bean drying process addressed in this research can be done naturally (using solar energy) or artificially (through combustion), the latter being a more aggressive way to the environment. The traditional drying system, used for years in cocoa plantations, uses the Barcaça, where the beans are spread over the ballast in a uniform layer that is constantly turned over with a wooden squeegee (SALES et al., 2021).

Drying using a vertical dryer is a vertical oven, consisting of a carbon steel structure surrounded by agricultural plastic (or acrylic), which must be filled with overlapping trays, each containing a layer of fresh cocoa beans. , able to circulate as much hot air as possible, with the aim of saving energy (used in drying by combustion), reducing manpower, reducing the area of the farm used for assembly, achieving greater control over the drying quality of the product, “serving as an ideal option or complement to traditional technology in the search for high quality almonds” (SALES et al., 2022).

In this sense, the research is justified in the use of the vertical cocoa dryer as an instrument to guarantee the quality and differentiation of almonds in productive chains and to reduce the cost of the drying processes for small and medium producers that have restricted performance due to limited investment and access to restricted production and distribution channels.

Considering the foregoing, the article focuses on the following question: How to develop the calculation of the standard time of the almond drying operation to guarantee quality and productivity in drying in the vertical cocoa dryer?

Under this perspective, the objective is to comparatively investigate the working time of the operator in drying almonds with the traditional dryer and the vertical dryer, as well as specifically to verify the standard time used for drying the cocoa beans in the vertical dryer and to analyze the impact of the optimization of the time in the productivity of the cocoa plantation for the producer, presenting methodology for the calculation of the standard operating time in the drying of almonds in the Vertical Dryer as an improvement of the patent of this equipment.

2 Cocoa dryers.

The drying of cocoa beans is a process of extreme importance for the storage of beans, as well as for their quality and commercialization, as it allows the reduction of the water content at adequate levels, maintaining the physiological and chemical quality, the good appearance and the quality almond nourishing (SALES; CÂNDIDA, 2016).

2.1 Traditional dryer – barcaça

The Barcaças have a structure with dimensions of 3m wide x 6m long, 8m wide x 8m long or 6 m wide x 12 m long, and height from the ground from 1 m, with turning to be carried out with a wooden squeegee, in order to promote the homogeneous drying and avoid agglomeration of the almonds. On the Barcaça, the cocoa is spread in layers of 3 to 6 mm thick, depending on the flow of the harvest and weather conditions, which is equivalent to a variable load of 25 kg to 40 kg of wet cocoa per square meter of Barcaça area (BEGIATO et al., 2009).

Natural drying on Barcaças has the advantage of being progressive and free of energy, but has the drawback of being time consuming and requiring a lot of manpower, particularly when carried out in the rainy season, something that is very common due to the harvest period in the region's rainy season (NASCIMENTO, 2010).

2.2 Vertical cocoa dryer

The vertical cocoa dryer (or vertical grain dryer) is a special vertically arranged greenhouse that had a patent granted by the INPI in 2021 under number BR 102015005977-9 B1 (SALES et al., 2021). The vertical dryer is filled with trays containing cocoa beans and in its lower part there is a system that allows the flow of these trays from top to bottom, consisting of a lever, two rotating side bars and another bar at the rear of the tower to provide the synchronization of movement.

The system consists of a greenhouse, the trays containing the fresh almonds enter the dryer from the top, and the trays containing dry almonds are removed from the bottom. This process facilitates handling and makes the operation more ergonomic, avoiding excessive wear and tear on the operator.

The vertical dryer reaches higher temperatures compared to traditional dryers (Barcaças), since its "skeleton" is surrounded by an agricultural plastic that has the function of significantly reducing heat loss to the external environment, in addition, obviously, to mitigate the convective effects, as the winds will not act directly on the trays and almonds. In this context, it can also be considered that the heat manages to stay longer inside the dryer, while the barge does not guarantee this effect. In addition, simplicity and efficiency were sought in order to reduce costs and simplify the manufacturing process. (SANTOS, 2014).

The vertical dryer is simple to operate and drastically reduces the problems caused by unhealthy conditions, in addition to the enormous reduction in the area needed for drying. (SANTOS, 2014). The use of artificial drying – including the vertical dryer – can facilitate handling and reduce the drying time of the almonds, and this method allows the use of larger volumes of product, including the use of forced ventilation to anticipate the process, reducing qualitative losses and quantitative (SANTOS et al., 2017), even contributing to the drying of the product in places where the harvest coincides with rainy periods (EFRAIM et al., 2010).

Therefore, in order to obtain the ideal drying of the cocoa beans, standard calculations can be verified to control the operating time, which, in addition to helping in the post-harvest processes and construction of equipment, can provide the drying time of the product and the energy expenditure, directly influencing the processing and price of the product (SANTOS, 2014). Figure 1 shows the prototype of the vertical dryer developed.

Figure 1 – Vertical cocoa dryer prototype.

3 Methodology.

A descriptive research strategy was adopted, which requires the investigator to provide a series of information about what he wants to research. This type of study intends to describe the facts and phenomena of a given reality (TRIVIÑOS, 1987).

As a method of analysis, a quantitative approach was used, which enables a better understanding of the problem in question. The data collection presents an empirical bibliographic review that made it possible to identify the impact of the implementation of a vertical cocoa bean dryer on the dynamics of regional cocoa farming, characterizing the productive interface of the cocoa culture and the economic development made possible by the implementation of a new technology, identifying the factors that explain the importance of implementing this innovation in the regional production mode.

This article covers as a study area the region of cocoa cultivation in the south of Bahia, belonging to the Economic Region of the South Coast of the state of Bahia. Presenting as a target audience the cocoa producers of Bahia, the associations of cocoa producers in Bahia, the cocoa milling industries, the chocolate industries and the teaching and research institutions in the region, which are concerned with the economic and regional technology.

3.1 Standard operation time.

In the area of Administration there are techniques to measure the time required to carry out a certain activity in order to measure the individual efficiency of the operator (employee), as structured by F. W. Taylor in the Theory of Scientific Management (LAUGENI et al., 2005).

The method used to analyze the standard operating time was similar to that indicated by MICHELINO (1964) and LAUGENI et al. (2005). Initially, a preliminary analysis of the work environment was carried out, identifying and characterizing the "cocoa drying" operation. Then, the operation as a whole was described (conditions, tools and work elements), and the operation was separated into elements, which according to LAUGENI et al. (2005), “has the purpose of verifying the working method that must be compatible with obtaining a precise measurement”. A hundredth hour stopwatch, observation sheets and a clipboard for observations were used, realizing that the simplicity of the materials used makes the technique advantageous over other possible ones.

LAUGENI et al. (2005) indicates several mathematical techniques for defining the cycle times to be timed, verifying the reliability of the measurements. For application and analysis of the technique, Excel 2016 was used, facilitating the performance of mathematical operations and obtaining greater efficiency in the results.

3.2 Timing.

Timing is one of the most used methods to measure work, mainly in industry and production areas. Despite considerable changes around the world since Taylor structured the Theory of Scientific Management and the study of times and motions to measure individual work efficiency, this methodology continues to be used to establish standards for production and for determining industrial costs (LAUGENI et al., 2005).

It is important to clarify that there are several study systems for measuring time. Here we use the standard time, which is a resource that allows analyzing the productive capacity of a process, considering a series of aspects present in the reality of a work routine that have a great impact on the time required to manufacture a product.

Efficiency and standard times in production are influenced by the flow and material used in the work, chosen process, technology used and work characteristics, and the greater the human intervention in production, the greater the difficulty of correctly measuring times due to individual differences in production. every worker (LAUGENI et al., 2005). In this regard, carrying out a study of standard production and/or operating times is important data to establish standards for production programs, allowing the planning and effective use of resources and evaluation of work performance; provide data to determine costs; and provides data for balancing production structures by comparing and analyzing process and production capacity (LAUGENI et al., 2005).

The success of the time study is the systematic analysis of the work with criteria that make it possible to achieve improvements by facilitating the solution of problems

3.3 Method and equipment for time study.

The method chosen from the data available for the measurement uses the following equipment for the study of times: Chronometer with hundredth hour; Observation sheet; observation clipboard.

The measured standard times serve as a reference to evaluate the production performance, dividing the operation into elements, where the trained worker will execute the process to record and record all the data necessary to carry out the work (such as process design and place of work) (LAUGENI et al., 2005).

After defining the standard operating time on the cocoa barge, with data obtained from the Leão de Ouro farm, a hypothetical analysis of operating efficiency was carried out using he vertical cocoa bean dryer without motor and with motor to also assess the possibility of equipment automation. As the dryer is still a prototype, the simulations were carried out by reproducing the movements in the developed model.

3.4 Cycles.

The correct determination of the number of Cycles to be timed is deduced from the expression of the confidence interval of the mean sampling distribution of a distributed variable, as shown in the following equation (LAUGENI et al., 2005):

$$N = \left(\frac{Z\,R}{E_r d_2 \bar{X}}\right)^2 \qquad (1)$$

where:

N = number of cycles to be clocked,
R = sample amplitude,
$\mathbf{d_2}$ = coefficient as a function of the number of preliminary timings,
$\bar{\mathbf{x}}$ = sample mean (average),
$\mathbf{E_r}$ = relative error, and
Z = normal distribution table.

To use equation (1) four previous measurements were performed, obtaining the mean $\bar{x}$ and the amplitude **R**. The relative error $\mathbf{E_r}$ uses values ranging between 5% and 10% with probability between 90% and 95% (LAUGENI et al., 2005).

In this study, we adopted a reliability of 90%, with a relative error of 10%, which represents a Z probability coefficient of 1.65, seen in Table 1:

Table 1 – Probability of normal distribution.

Probability	90%	91%	92%	93%	94%	95%	96%	97%	98%	99%
Z	1.65	1.70	1.75	1.81	1.88	1.96	2.05	2.17	2.33	2.58

In addition to applying a timing coefficient d_2 of 2.059, since we performed 4 preliminary timings N_i for each analyzed element, as shown in Table 2.

Table 2 – Coefficient d_2 for the number of initial measurements

N_i	2	3	4	5	6	7	8	9	10
d_2	1.128	1.693	2.059	2.326	2.534	2.704	2.847	2.970	3.078

These coefficients are presented by LAUGENI (LAUGENI et al., 2005) and we use it to calculate equation (1). The amplitude R and the average $\bar{X}$ that are obtained from the observation of the operator's handling in the two drying systems discussed remain pending.

3.5 Operator speed.

Based on the analysis of the operator's activity, the speed $\boldsymbol{v}$ (or operator rhythm) was subjectively determined by the timekeeper, taking as reference the so-called normal operating speed, which is assigned a value of 1.00 (or 100%) (MICHELINO, 1964).

In this sense, if $\boldsymbol{v} = 1$, the velocity is normal. If $\boldsymbol{v} < 1$, the speed is slow. If $\boldsymbol{v} > 1$, the speed is accelerated (MICHELINO, 1964). In the evaluation carried out in this study, the timekeeper judged that the operator has $\boldsymbol{v} < 1$, due to the working conditions, such as exposure to the sun and the fatigue caused by the movements of the work process in the traditional drying in Barcaça.

In the drying process using the Vertical Dryer, the timekeeper judged that the operator has $\boldsymbol{v} = 1$, due to the working conditions in the Vertical Dryer, which are more ergonomically appropriate in relation to the traditional Barcaça.

From the timekeeper's assessment for this study, the velocity $\boldsymbol{v}$ is deduced as follows:

$$V = \begin{cases} 0{,}95 \; para \; Barcaça \; tradicional \\ 1{,}00 \; para \; Secador \; vertical. \end{cases} \quad (2)$$

3.6 Tolerances.

Tolerances are concessions or permissions, so that employees can satisfy and meet certain needs. Tolerances can be personal, for fatigue and for waiting. Personal tolerances correspond to interruptions to meet physiological needs (drinking water, drinking coffee, going to the bathroom, etc.). This type of tolerance is in the range of 2% to 5% of the full working day. Tolerance for fatigue concerns the energy recovery time of the worker as a function of the environmental conditions at work.

In this study, several factors were observed that contributed to the poor performance of the operator: work exposed to the sun, smoke, physical fatigue (size of the load), incorrect posture, and personal needs (including not being close to drinking fountains and restrooms). The literature considers that the time for personal needs should vary between 10 and 25 minutes per 8-hour shift (LAUGENI et al., 2005).

The factor $\boldsymbol{F_T}$ (Tolerance Factor) is given by the equation:

$$F_T = \frac{1}{1-p} \quad (3)$$

where $\boldsymbol{p}$ is the ratio between the total time stopped due to permits and the working day, that is (LAUGENI et al., 2005):

$$p = \frac{total\ interval\ time}{workday\ time} \quad (4)$$

3.7 Standard operation time.

To determine the Standard Operation Time, once the valid measurements have been obtained (in the case of this study, 4 measurements were considered for each element of the operation, both for traditional drying on barges and for Drying in Vertical Dryers), follow the steps:

• Calculate timed time $\boldsymbol{T_C}$; adding the $\bar{x}_n$ averages of the timed times of the elements of the operation in which the process was decomposed:

$$T_C = \sum_{i=1}^{n} \bar{X}_i \quad (5)$$

• Calculate normal time $\boldsymbol{T_N}$; multiplying the clocked time $\boldsymbol{T_C}$ by the speed applied to the process; presented in the equation:

$$T_N = T_C \times V \quad (6)$$

• And finally, calculate the Standard Time $\boldsymbol{T_P}$; multiplying the normal time $\boldsymbol{T_N}$ by the process tolerance factor $\boldsymbol{F_T}$; given by the equation:

$$T_P = T_N \times F_T \quad (7)$$

3.8 Division of the drying operation into elements.

The analyzed operation is cocoa drying, which aims to reduce the cocoa moisture to 7 to 8%, using the barge (traditional dryer) and the vertical dryer for cocoa beans.

This operation can be divided into elements, which according toLAUGENI et al. (2005), has the purpose of verifying the work method and must be compatible with obtaining the precise measurement of timing in each stage of the process.

3.9 Elements of the traditional Barcaça drying operation.

The drying process using the traditional barge is the most used in the cocoa plantation in the south of Bahia, very important for the production process in the regional agricultural properties. Chart 3 shows the operating elements of the traditional Barcaça:

Table 3 – Barcaça operating elements.

BARCAÇA	**ELEMENTS**
1	Catch the roll
2	Open the Barcaça
3	Turn the seeds with a roller
4	Turn the seeds over with your feet

It is observed that these activities do not favor the health of the worker, because in addition to being exposed to the sun, this work causes pain in the joints of the feet, according to the testimony of the Barcaça operator himself.

3.10 Elements of drying operation with vertical dryer.

The drying process using the Vertical Dryer starts with the insertion of innovative equipment in the cocoa plantation, enabling improvement in the production process and drying quality, mainly in the small properties of the regional plantation. Chart 4 presents the operating elements of the vertical cocoa bean dryer.

Table 4 - Elements of the operation of the Vertical Dryer.

VERTICAL DRYER	ELEMENTS
1	Open lever
2	Tray removal
3	Bagging
4	Tray feeding
5	Place trays on platform
6	Climb the ladder
7	Feed the tower
8	Down the ladder

Each vertical dryer tray has a capacity of approximately 24 kg of almonds. In a tower height of 2 m, we can fill 40 stacked trays, totaling 960 kg of cocoa, occupying very little horizontal space (1m x 1m), with a sensible use of space. The grain dryer holds 50% less cocoa than the barcaça, but saves 98% of the space occupied.

4 Results and discussions.

The objective of this analysis is to compare the performance of the operator if he works with the traditional barge or with the vertical cocoa dryer. In order to make a proper comparison, only one operator was considered working in the drying process, as it happens in the current condition in barcaças from properties in the region, where there is only one barcaça operator responsible for the operation.

4.1 Operation using the traditional barcaça

For this quantitative approach, the determination of cycle times was carried out and initially proceeded with 4 timed measurements for each of the pre-selected elements for the traditional Barcaça, as shown in Table 5:

Table 5 – Barcaça observation times (sec.).

Observation Sheet	1 (seg.)	2 (seg.)	3 (seg.)	4 (seg.)	Average Times ($\bar{x}$)	Sample Amplitude
1. Catch the roll	43,36	49,27	41,52	44,72	44,72	7,75
2. Open the Barcaça	35,14	41,08	37,56	38,23	38,01	5,94
3. Revolve with the roller	1242,37	1126,42	1219,63	1177,24	1191,42	115,95
4. Revolve with your feet	220,85	207,21	172,75	168,36	192,29	52,49

With these measures, Equation 1 was used, as presented in chapter 4, to find the results for the number of Barcaça Cycles. Table 6 shows data for the caculation of N in the element “Catch the roll”:

Table 6 – Data for the calculation of *N* – element “Catch the roll”.

Element data “Catch the roll”

$\bar{x}$	R	Z	E_r	d_2
44.72	7.75	1.65	0.1	2.0590

Therefore, we have a number of cycles N = 1,93 for the element "Catch the roll". This result tells us that in order for the sample to be reliable in terms of the presented parameters, it must be measured at least twice for the element "Catch the roll". As four measurements were performed, it follows that the measurement is reliable. The same procedure was carried out for the other elements and the same conclusion is verified through the values of N. Therefore, for the other elements the calculations for the number of cycles N present, values that are in an interval **(**0.61; 4.79**)** according to the calculation performed for each element.

It should be noted that even the revolver element with the feet presenting N above four, it was decided to use four timing measurements since the other elements presented a value of N well below four, which guaranteed us security for the adoption of four timings in the sample time taken. Figure 2 shows the result of the number of cycles per Barcaça element.

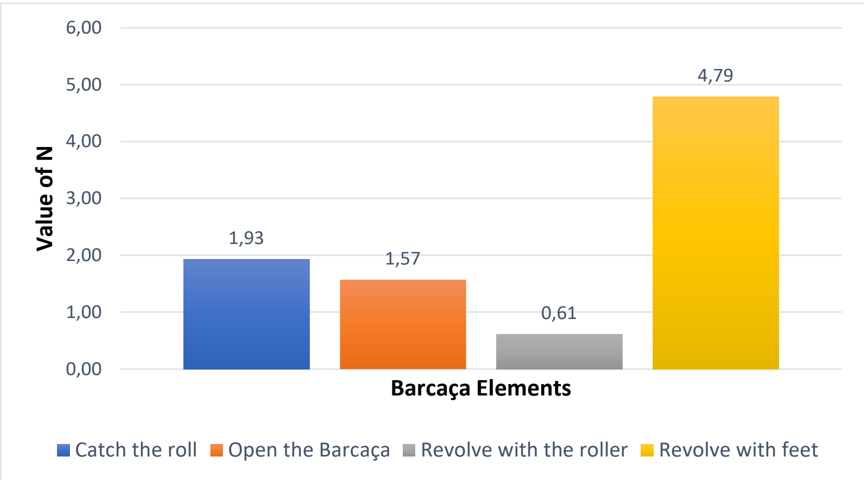

Figure 2 - Number of barcaça cycles.

In the traditional barcaça drying process, it was adopted that the speed v = 0.95 - close to normal, but a little slow due to the conditions to which the operator is exposed, for Barcaça operation.

The tolerance fator F_T was determined using Equation 3, already presented, considering that in an 8-hour journey (480 min.), the operator had a total of 15 minutes for a snack, 10 minutes to drink water and go to the bathroom and 30 minutes for lunch. Applying Equation 4, p = 0.11; which results in the tolerance factor F_T = 1.13.

With the 4 recordings registered, the measured time T_C was calculated, using Equation 5, we have that T_C = 8,384.99 seconds. equivalent to 139.74 minutes.

Note that during the working period the operator revolved six times with the roller and with his feet, so the average times observed in these actions were multiplied by 6 (operating elements described).

For the calculation of the normal time T_N, we apply Equation 6 where we have T_N = 132.75 min, and finally we have the calculation of the standard time T_P, applying Equation 7, where T_P = 150 min. Standard time of Barcaça T_P is 150 min equivalent to approximately 2 hours and 30 minutes.

4.2 Operation in the vertical cocoa dryer.

The vertical dryer is an innovative piece of equipment developed to provide an option to improve the drying operation, especially for small and medium-sized producers who need to efficiently use the available space on the property. Table 7 shows the timed measurements for the action of each element in the sample.

Table 7 – Vertical Dryer observation times.

Observation Sheet	1° (seg.)	2° (seg.)	3° (seg.)	4° (seg.)	Average Times ($\bar{x}$)	Sample Amplitude
1 - Open Lever	2,89	2,87	2,61	2,76	2,78	0,28
2 - Removal of the tray	3,15	2,99	3,02	3,39	3,14	0,40
3 - Bagging	2,89	2,87	2,61	2,76	2,78	0,28
4 - Feeding the trays	21,39	22,04	19,83	21,09	21,08	2,21
5 - Place the tray on the platform	22,72	24,83	25,37	25,61	24,63	2,89
6 - Climb the stairs	9,90	9,28	9,36	9,60	9,53	0,62
7 - Feed the tower	3,15	2,99	3,02	3,39	3,14	0,40
8 - Down the stairs	5,68	6,21	6,34	6,40	6,16	0,72

With the declared variables, it is easy to calculate the number of cycle times to be timed for the dryer elements. It was found that all N values were less than or equal to 4. Therefore, it was concluded that 4 timed measurements were sufficient for the applied case.

Using the same procedures for taking data, shows in Table 8 for the element "Open lever", we have:

Table 8 - Data for the calculation of *N* – element "Open lever".

Element data "Open lever"

$\bar{x}$	R	Z	E_r	d_2
2.785	0.28	1.65	0.05	2.0590

We then obtain from Equation 1 the calculation of the number of cycles where for the Element "Open lever": N = 2.60

For the other elements, the calculations for the number of cycles N present values that are in an interval **(**1.09; 4.17**)** according to the calculation made for each element.

It should be noted that even the elements "Removal of the tray" and "Feed the tower" presenting a value of N slightly above 4, it was decided to use 4 measurements of timing, since the other elements presented a value of N below 4, which guaranteed us security for the adoption of 4 measurements in the sample time taken. Figure 3 shows the result of the number of cycles per Barcaça element.

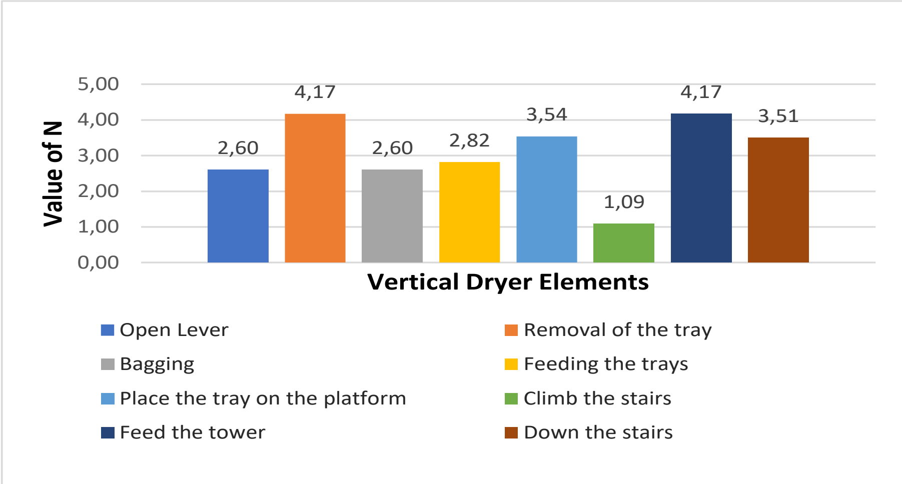

Figure 3 – Number of vertical dryer cycles.

Since this is an experimental measurement, it is assumed that $\boldsymbol{V} = 1$, that is, normal speed, since the timekeeper judged that the operator has $\boldsymbol{V} = 1$, due to the fact that working with the Vertical Dryer presents more ergonomically appropriate conditions in relation to the traditional Barcaça.

The tolerances are the same for the barge, considering that the time for personal needs must vary between 10 and 25 minutes per 8-hour shift. Therefore, the tolerance fator $\boldsymbol{F_T}$ in Equation 3 is the same as for the Barcaça.

Once valid timings have been obtained for each element of the operation, the Standard Operation Time $\boldsymbol{T_P}$ is calculated.

In the data sequence, we have $\boldsymbol{p}$ = 0.11; $\boldsymbol{F_T}$ = 1.13; e $\boldsymbol{T_C}$ = 2,930 seg.

Note that the $\boldsymbol{T_C}$ was multiplied by 40 due to the vertical dryer having 40 trays and the times recorded refer to the operation of 01 tray. Thus, $\boldsymbol{T_C}$ = 2,930 seg. the equivalent of 48.83 min.

Considering $\boldsymbol{v}$ = 1, and applying Equation 6, we obtain $\boldsymbol{T_N}$ = 48.83 min. With these data inserted in equation 7, the standard operating time for the vertical dryer $\boldsymbol{T_P}$ = 55 min is obtained.

Comparing the result of the standard time of the vertical dryer of approximately 55 min with the standard time previously obtained using traditional Barcaças for drying cocoa, of 150 min (approximately 2 hours 30 minutes), in percentage, there will be a significant reduction of approximately 63.3 % of operating time, which demonstrates how much the rural producer and the industry can gain productivity in time using the vertical dryer for cocoa beans.

4.3 Operation in the motorized vertical cocoa dryer.

The operation necessary to run the dryer depends on an ergonomic action, which is to move the lever to remove the tray that will probably be under the action of the sun. Thereby, this topic works with the insertion of an engine, either electric or pneumatic, responsible for this movement.

So the condition was used that the elements "Open lever" and "Removal of the tray" are replaced by an electric motor.

Figure 4 shows the result of the number of cycles for the Vertical Dryer when the two elements are removed and replaced by an electric or pneumatic motor.

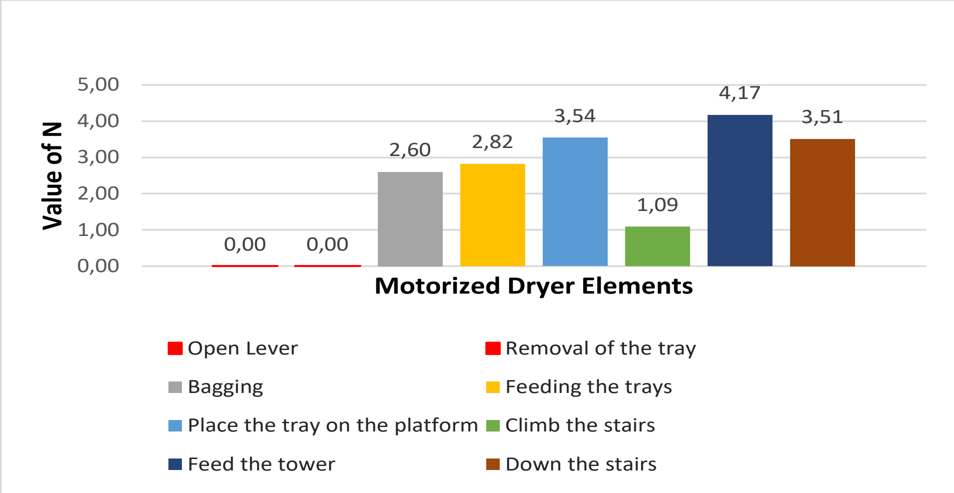

Figure 4 – Number of dryer cycles with motor.

So, the consequence is that, with the two actions replaced by a machine, the operator does not need to wait for the action to be completed to continue carrying out his work. Therefore, these elements are suppressed as shown in Table 9, presenting a more harmonious timed operation time than that of the vertical dryer that does not use automation in the equipment.

Table 9 – Dryer observation times with motor (sec.).

Observation Sheet	1° (seg.)	2° (seg.)	3° (seg.)	4° (seg.)	Average Times ($\bar{x}$)	Sample Amplitude
1 - Bagging	2,89	2,87	2,61	2,76	2,78	0,28
2 - Feeding the trays	21,39	22,04	19,83	21,09	21,08	2,21
3 - Place the tray on the platform	22,72	24,83	25,37	25,61	24,63	2,89
4 - Climb the stairs	9,90	9,28	9,36	9,60	9,53	0,62
5 - Feed the tower	3,15	2,99	3,02	3,39	3,14	0,40
6 - Down the stairs	5,68	6,21	6,34	6,40	6,16	0,72

The fatal change for this removal will be in the results of the clocked time, normal time and the standard operating time. In this sense, it follows that the values found for "N" remain reliable.

Once the valid timings were obtained, the Standard Time T_P was calculated, applying the Equations already presented:

Therefore, the value of p = 0.11 was found from Equation 4. In this way, the F_T tolerance factor of Equation 3 is the same as for the Barcaça and the Motorless Dryer, F_T =1.13.

So, the T_C was found applying equation 5, where T_C = 2,693.2 sec. equivalent to 44.89 min.

From the application of Equation 6, the T_N was calculated with v = 1; and consequently T_N = 44.89 min.

With these data inserted in Equation 7, we obtain the Standard operating time for the vertical dryer with motor, which is T_P = 50.72 min., approximately 51 min. Considering the result for the Standard operating time T_P for the automated vertical dryer with motor equivalent to 51 min.

Standard time without using a motor is approximately 55 min. Using an engine, the time was reduced to approximately 51 min. Therefore, there is a reduction of approximately 8% of the standard operation time when using the motor, compared to the hypothesis using the dryer without motor.

Comparing this hypothesis with the traditional use of the Barcaça, in which the Standard Time is 150 min., when changing the use of the barge to the vertical cocoa dryer technology having an electric or pneumatic motor, the time reduction will be approximately 66%.

Figure 5 shows the comparison for the standard time in the three models of equipment covered in this research.

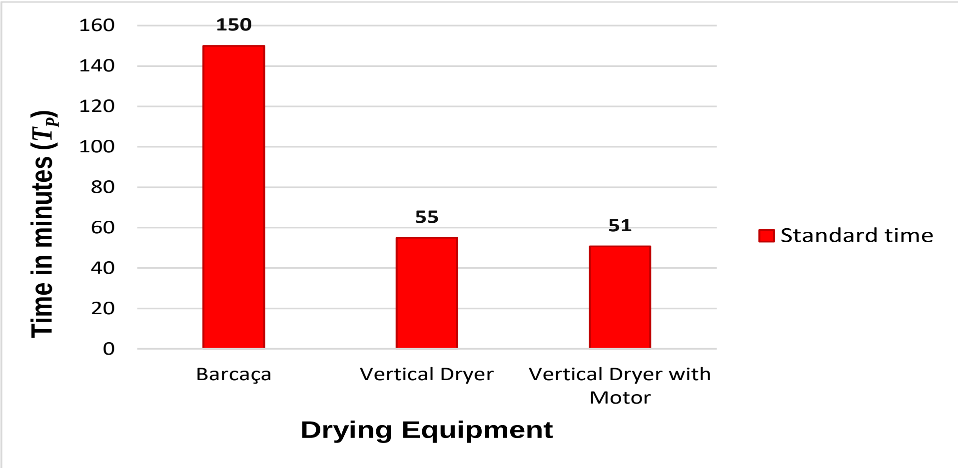

Figure 5 – Comparison between standard time of each equipment.

Despite the use of an engine reducing the effort of the worker, avoiding occupational diseases, heavy work, among other ergonomic effects, the increase in the cost of the equipment is a problem, especially considering its use in small rural properties of family agriculture. Even so, it is important to note that increasing automation decreases the incidence of errors, since a human being can cause accidents in the operation, a fact that would not occur using equipment with a higher level of automation. It is important to demonstrate this option for possible commercial production in series, which would reduce the final cost of the equipment for the producer.

5 Economic viability of the vertical cocoa dryer.

The reduction in operating time has a direct impact on the reduction in drying time, and in addition to operating time, the capacity of the dryers is of substantial importance in comparing the productivity between the vertical dryer and the Barcaça.

The possibility of using innovative equipment such as the vertical dryer conditions sustainability in the production of the cocoa crop, ensuring productivity and cost reduction that provide a competitive price, which are conditions for access to consumer markets that better remunerate regional cocoa.

The substantial difference in productivity comes from the greater efficiency of the tower compared to Barbaça in terms of the drying process (LIMA; SALES, 2015). In addition, the occupation space is optimized, allowing that for the same area, 72 m^2, it is possible to install 6 towers while only 1 Barcaça can be installed, in this way the load capacity of the tower system is 3 times greater, and with drying time up to 4 times shorter (AMIGO et al., 2018).

In a Barcaça with a fixed area of 72 m^2, equivalent to the ballast of the barge, its maximum load is 120.24 arrobas of almonds (soft cocoa) reduced after drying by 50% to approximately 60 arrobas. The average drying time in the barge system is 12 days (MARTINS et al.,2012), presenting a monthly production (30 days) of approximately 150 arrobas of dry cocoa (CODEVASF, 2009).

In the same area of 72 m^2, it is possible to install up to 6 (six) vertical drying towers, individually with a maximum capacity of 60.12 arrobas of almonds (soft cocoa), approximately 30 arrobas of dry cocoa per tower after drying. In this way, in a system with 6 towers, the maximum load is 360.72 arrobas (soft cocoa) and approximately 180 arrobas of dry cocoa, occupying the same space destined for a traditional Barcaça.

As the drying time in the vertical dryer is approximately 3 (three) days, the monthly production capacity (30 days) of a tower is 300 arrobas and of the set with 6 towers is 1800 arrobas of dry cocoa. Figure 6 shows the comparison of the monthly production capacity between the equipments.

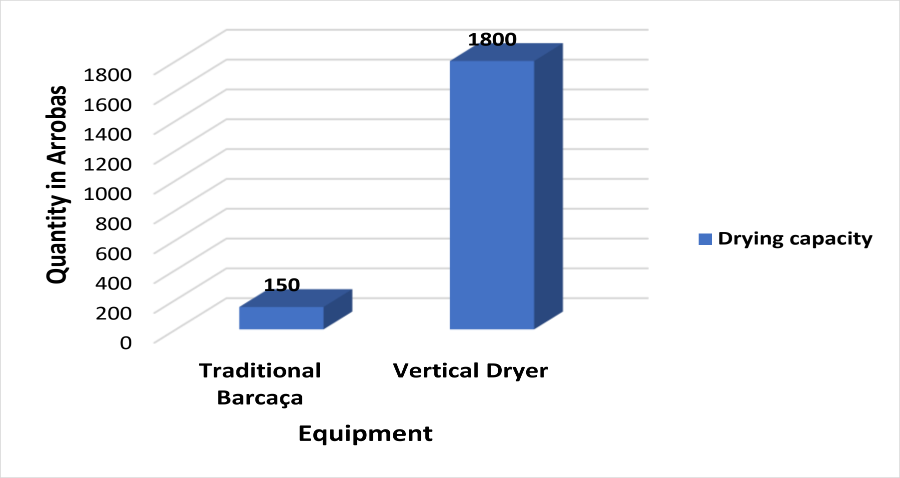

Figure 6 – Comparison of monthly production capacity.

The substantial difference in productivity comes from the greater efficiency in operating time and, consequently, in the drying process of the tower compared to the barge. In addition, the occupation space is optimized, this allows that for the same area, 72 m² occupied by only 1 barge, it is possible to install a system of 6 (six) towers of the vertical dryer, with the load capacity of the tower system 3 (three) times greater, and with drying time 4 (four) times shorter.

In this regard, it is important to note that the improvement in productivity and, consequently, better profitability for producers, promotes an improvement in the quality of life, emphasizing that the better temporal use of production factors and the greater profit per unit of production area, reduce the vulnerability of the crop and enable satisfactory profitability for the producer and the adoption of innovative technologies in regional production units (GOMES et al., 2015).

6 Final considerations

In the south of Bahia, especially in the cultivation of cocoa, the drying process is still developed in the traditional model, using horizontal dryers - barges - which require a lot of space and manpower, and depend a lot on the operator's manipulation to achieve a good result. drying quality that allows quality almonds and differentiated flavor.

In view of this, several producers and service providers seek technological innovations as strategic assets that allow for a significant reduction in operating time. Furthermore, the reduction of used space, improvement in ergonomic terms, use of clean energy and improvement in the operation cycle (standard time), enables economic growth and productive development of the regional crop.

The focus of this paper was standard time. This method allows companies to faithfully determine their production capacity, it is also through standard time that it becomes possible to balance production lines, identify bottlenecks, determine manufacturing costs, assist in the preparation of budgets, identify opportunities for improvement, among others.

We adapted the standard time technique to the drying system. The result found for the standard operating time of the traditional barge with the vertical cocoa dryer, shows a 63.3% reduction in the standard operating time in favor of the vertical system. Therefore, the vertical dryer impacts on the reduction of production costs, which justifies its financial viability, resulting in a strategic option as an aid to the development of regional farming.

This work presents a calculation method that allows quantitatively verifying the performance of the vertical dryer in improving the productivity of the regional crop and presents an analysis of the performance of the equipment in drying cocoa beans in relation to traditional equipment, enabling better economic results for the local product.

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