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2020

Behavior of the cost of protection for the conservation of corn seed, through natural alternatives

Comportamiento del costo de protección para la conservación de semilla de maíz, mediante alternativas naturales

Comportamento do custo de proteção para a conservação de sementes de milho, através de alternativas naturais

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ABSTRACT

In the control and elimination of insect plague, as harmful as *Sitophilus oryzae*, vegetable powders of leaves and essential oils were used, produced from three botanical species of the *Myrtaceae* family; its application allowed to verify the effectiveness of these treatments in the control of this insectile species that affects the corn seed stored by local producers. During the application of these natural alternatives, the behavior of the insect was observed; parameters such as mortality, emergence and loss of weight of the grain were measured, which made it possible to establish *Callistemon citrinus (Curtis) Skeels* as the most promising species. The analysis of legislative documents and research carried out by other authors made it possible to calculate the production cost of vegetable powders and essential oils and on this basis, a price was proposed for the possible commercialization of the products. In this way, it was valued the increase generated by the use of these alternatives in the cost of the stored seed, which represents its protection cost. The objective of the research was to analyze the behavior of the protection cost for the conservation of stored corn seed, from natural alternatives in the local agro-livestock production. The comparison of the cost of protection showed the most economical alternative for the local producer and this cost was proposed as the fourth complementary parameter to be taken into account in the decision to use one alternative or another for the protection of stored corn seed.

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Keywords: essential oils; cost protection; vegetable powders; *Sitophilus oryzae*

RESUMEN

En el control y eliminación de plagas de insectos, tan dañina como el *Sitophilus oryzae*, se utilizaron polvos vegetales de hojas y aceites esenciales, producidos a partir de tres especies botánicas de la familia *Myrtaceae*; su aplicación permitió constatar la efectividad de estos tratamientos en el control de esta especie insectil que afecta la semilla de maíz almacenada por productores locales. Durante la aplicación de estas alternativas naturales, se observó el comportamiento del insecto; se midieron parámetros como la mortalidad, la emergencia y la pérdida de peso del grano, que posibilitaron establecer como la especie más prometedora al *Callistemon citrinus (Curtis) Skeels.* El análisis de documentos legislativos y de investigaciones realizadas por otros autores posibilitó el cálculo del costo de producción de los polvos vegetales y los aceites esenciales y sobre esta base, se propuso un precio para la posible comercialización de los productos. De esta forma, se valoró el incremento que genera el empleo de estas alternativas en el costo de la semilla almacenada, lo cual representa su costo de protección. El objetivo de la investigación fue analizar el comportamiento del costo de protección para la conservación de semilla de maíz almacenada, a partir de alternativas naturales en la producción agropecuaria local. La comparación del costo de protección mostró la alternativa más económica para el productor local y se propuso, además, este costo, como el cuarto parámetro complementario a tener en cuenta en la decisión de emplear una alternativa u otra para la protección de la semilla de maíz almacenada.

Palabras clave: aceites esenciales; costo protección; polvos vegetales; *Sitophilus oryzae*

RESUMO

No controlo e eliminação de pragas de insetos tão prejudiciais como Sitophilus oryzae, foram utilizados pós vegetais de folhas e óleos essenciais produzidos a partir de três espécies botânicas da família Myrtaceae; a sua aplicação permitiu verificar a eficácia destes tratamentos no controlo desta espécie de insetos que afetam as sementes de milho armazenadas pelos produtores locais. Durante a aplicação destas alternativas naturais, foi observado o comportamento do inseto; parâmetros como mortalidade, emergência e perda de peso dos grãos foram medidos; o que permitiu estabelecer Callistemon citrinus (Curtis) Skeels como a espécie mais promissora. A análise de documentos legislativos e pesquisas realizadas por outros autores, permitiu calcular o custo de produção dos pós vegetais e óleos essenciais; e com base nisso foi proposto um preço para a possível comercialização dos produtos, valorizando assim o aumento gerado pela utilização destas alternativas no custo das sementes armazenadas, o que representa o seu custo de proteção; o objetivo da pesquisa foi analisar o comportamento do custo de proteção para a conservação das sementes de milho armazenadas, a partir de alternativas naturais na produção agrícola local. A comparação do custo da proteção mostrou a alternativa mais económica para o produtor local; e este custo foi também proposto como o quarto parâmetro complementar a ter em conta na decisão de utilizar uma ou outra alternativa para a proteção das sementes de milho armazenadas.

Palavras-chave: óleos essenciais; custo da proteção; pós vegetais; *Sitophilus oryzae*

INTRODUCTION

The conservation of grains destined to seed represents one of the greatest concerns for local producers in Latin American countries. "The insect plagues that affect the grains, which are stored, are diverse according to the existing conditions in the corn. The losses caused by plagues range from 14% to 36%" (OMS, 2018).

Stored corn grains are attacked by *Sitophilus zeamais Motschulsky*, known as the corn weevil. In Cuba, in carried out researches, it has also been possible to verify the presence of *Sitophilus oryzae*, or rice beetle, which "caused affectations in grains stored in Cienfuegos' metallic silos, where the infestation made impossible the human consumption of the grain" (Martínez Curbelo et al., 2015); also, it was identified "among the insects with more incidence in food stores of Sancti Spíritus province" (Ramos Hernández et al., 2016).

For the control of this plague, plaguicides are currently used that are classified as pyrethroids, "but it has been shown that *Sitophilus oryzae* shows resistance [...] depending on the concentration and time of exposure, to which is added the depreciation of the value of the product sprayed" (Daglish et al., 2014).

The control of this insectil species is difficult, but bioactive compounds, present in several botanical species, which contain insecticide properties, constitute alternatives to be taken into account in the control of the insect, by acting as repellents or inhibitors.

In the research "Ten species of *Myrtaceae* as an alternative for the control of *Sitophilus oryzae* in the seed of *Zea mays*, L", carried out in the Center of Study for Sustainable Agricultural Transformation (CETAS in Spanish) of the University of Cienfuegos, about the production and use of natural alternatives for the conservation of the corn seed stored in the local agro-livestock production, in Cienfuegos, it was found that the use of products such as vegetable powders from leaves and essential oils from botanical species make plague control possible, guarantee conservation, have the advantage of being degradable products and, in addition, cause a minimum impact on humans and the environment. In this study, it was evaluated the behavior of the parameters in both alternatives, related to mortality, insect emergence and loss of weight of the grain, which allowed identifying the species that provides greater benefit to the conservation of the seed.

The analysis of the production process of these products developed under specific laboratory conditions led to associating this process with the calculation and estimation of the production cost and, on this basis, proposing a price for the commercialization of the products obtained in order to value the increase generated by the use of these products in the cost of the stored seed, an increase that represents their protection cost. The objective of the research was to analyze the behavior of the protection cost for the conservation of stored corn seed, from natural alternatives in the local agro-livestock production.

The protection cost constitutes the complementary parameter that allows the local producer to decide which alternative to use in the conservation of the stored seed that will be used in the following productive cycle.

The methodology applied in this work, to develop the analyses corresponding to the production cost and the calculation of the selling price of the vegetable powders and essential oils, was taken from the research carried out by Ojito (2016), about the "Antifungal activity of Citrus spp, against *Alternaria solani Sor*, causal agent of early blight in *Solanum lycopersicum* L.", which also allowed to declare as protection cost the increase of the cost of the stored seed as a result of the application of the natural alternatives.

MATERIALS AND METHODS

In the research, the historical-logical method was used to specify criteria about the control of insect plagues, based on the use of two natural alternatives: vegetable powders and essential oil extracts. For this purpose, different botanical species with insecticide properties were used: *Pimenta dioica (*L*.) Merr, Callistemon citrinus (Curtis) Skeels and Syzygium malaccense (*L*.) Merr. & L.M. Perry* for the production of vegetable powders and for the production of essential oils, *Pimenta dioica (L.) Merr and Callistemon citrinus (Curtis) Skeels.*

The participant observation allowed to establish the behavior of the insects when applying the leaf vegetable powder at the concentration of 1% and 3% (m/m) and the essential oil at a proportion of 90 µL/L air; on the other hand, the measurement of the mortality at 15 days allowed to establish if the leaf vegetable powder and the essential oils of the species used were classified as promising, according to the referenced criteria; the measurement was also used to quantify the emergence of the insect and the loss of weight of the grain. The proportions used in the experiment allowed establishing the consumption norms to protect the corn seed used to sow a hectare.

The analysis of legislative documents and research carried out by other authors led to the current methodology used for the preparation of the Cost Sheet, in order to set the price of the vegetable powders and essential oils produced and, based on consumption standards, the cost of protection for the different alternatives and variants was calculated.

The analysis and the synthesis allowed to verify the effectiveness of the vegetable powder of leaves and of the essential oils of botanical species, applied to the corn seeds, infested with *Sitophilus oryzae*. The evaluation was carried out based on the parameters: mortality, insect emergence and loss of grain weight. The cost of protecting the stored corn seed was established as a complementary parameter, depending on the use of one or another alternative by the local producer.

RESULTS AND DISCUSSION

The development of the chemical industry, in the 1950s, brought with it the production of the plaguicides that made possible the productive increases in agriculture and in the quality of food. Currently, there is great concern about the negative effects that have generated them and, regarding this, the World Health

Organization (2018) states that "one third of the diseases present in the world have their origin in environmental pollution and proposes to address health risks from acute or chronic exposure to plaguicides".

Epidemiological studies indicate that exposure to plaguicides is largely associated with "gastric cancer, lung cancer, bladder cancer, and hematological diseases" (Paz Sanchez et al., 2019).

The need to seek alternatives for the control and elimination of this insect species is a challenge; bioactive compounds present in several botanical species, which contain insecticidal properties, constitute options to be considered in the control of the insect, by acting as repellents and inhibitors. In this regard, research indicates that the use of leaf powders "from the species of *Tithonia diversifolia (Hemsl) A. Gray, Moringa oleifera (Lam*) and *Piper auritum Kunth* can have an effect [...] on *Sitophilus oryzae*" (Jiménez Álvarez et al, 2016) and also others, such as "*Justicia adhatoda L., Acorus calamus L., Sapindus mukorossi L., Azadirachta indica A. Juss*" (Khanal et al. 2019), have shown the possibilities of these compounds in the control of this insect. The use of essential oils from botanical species has been another alternative used. They are considered "potentially active on this insect" (Koutsaviti et al., 2018). "These oils constitute less toxic and ecological perspectives that allow for a reduction in losses caused by the plague" (Song et al., 2016).

The production and use of natural alternatives for the conservation of corn seed stored in local agro-livestock production began with the evaluation of botanical species with phyto- plaguicides activity for the synthesis of new types of insecticides, relatively safe for humans and their environment. To this end, botanical species from the *Myrtaceae* family were used, such as allspice, fat pepper or *Pimenta dioica (*L*.) Merr*, callistemon or *Callistemon citrinus (Curtis) Skeels, and malacca pomarrosa or Syzygium malaccense (L.) Merr. & L.M. Perry*, whose insecticide activity has been confirmed and from which, as a first alternative, the vegetable powder of the leaves was obtained and for the essential oil of botanical species, second alternative, only *allspice, fat pepper or Pimenta dioica (*L*.) Merr* and the *callistemon, or Callistemon citrinus (Curtis) Skeels* were used.

In the selection of plants for the production of vegetable powders and essential oils, the following characteristics were taken into account (Silva et al., 2002):

1. Being perennial
2. Be widely distributed and in large quantities in nature or can be cultivated
3. Use renewable plant organs (leaves, flowers or fruits)

The production of leaf vegetable powders and essential oils from botanical species was developed in two processes that are independent, as shown in figure 1, but that have in common their first phase, which began with the collection of the leaves of the species in the Botanical Garden of Cienfuegos, which were delivered free of charge to be transported to the laboratory where the processes were developed. This first part of the process was considered as the collection and transportation phase and corresponded to the assurance of the fundamental raw material that was used for these productions. At the end of the first phase of the process, the production of vegetable powders from leaves and essential oils from botanical species were separated, since they are two processes that go through their phases, in which expenses are incurred on a different basis.

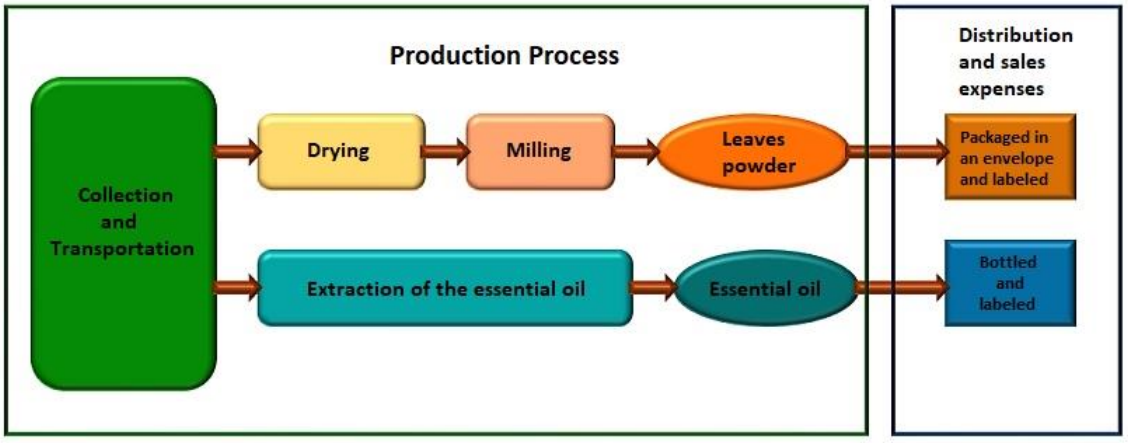

Fig. 1 - Production process of vegetable powders from leaves and essential oils from botanical species
Source: own elaboration

Leaf vegetable powders

Once the collected leaves were received at the laboratory, they were selected for processing. With this, the first part of the process was concluded and the second part of the process of production of vegetable powders from leaves began. The technician who processed them organized them in trays to dry them in the oven; at the end of the drying time, the trays with the dry leaves were removed from the oven, ready to be ground. That is why this second phase was recognized as Drying; the dry leaves were ground in the laboratory's grinder until they became powder, with particles of approximately 1 mm; this way, this third and final phase of the process was concluded, which was recognized as Milling. The powders obtained were weighed and 1 kg were packed in nylon envelopes, with the label where the characteristics of the product to be commercialized are detailed. This phase, which is independent of the production process, is the treatment given to the finished product and is known as Distribution and Sales.

In the first variant of this alternative, in this experiment, vegetable powders obtained from leaves, from different promising species, were applied only once to grains infested with *Sitophilus oryzae*, in a proportion of 1% (m/m), that is, 1 g to 99 g of corn; mortality was evaluated 15 days after the application and the best result was obtained (65.76%). With the use of vegetable powders obtained from *Pimenta dioica (L.) Merr*, a second evaluation was carried out later -at 30 days- and it was possible to appreciate that mortality reached 74.0%.

After 55 days of the infestation, the percentage of adult insect emergence and the percentage of grain weight loss in relation to the absolute control were evaluated; In the first one, it was considered 100% the number of emerged insects in the control and it was obtained that, with the application of vegetable powder of *Callistemon citrinus (Curtis) Skeels* species, the lowest results were achieved for this parameter; also, in the second one, it was registered the loss of weight of grains and the lowest result was obtained with the application of *Pimenta dioica (L.) Merr*, (Table 1).

The results reached at the concentration of 1% (m/m) with the species used caused a percentage of mortality, which coincides with what was referred to in the research "Extracts, vegetable and mineral powders for the control of corn and bean plagues in subsistence agriculture" by Lagunes (1994), cited by Torres et al. (2015), when they expressed that to classify a vegetable powder as promising for the control of plagues in stored products it must reach the concentration of 1% (m/m), values higher than 40% of mortality. These species are the most appropriate to achieve the obtaining of phyto-plaguicides, in a sustainable way. The use of *Syzygium malaccense* (L.) Merr. & L.M. Perry, which is an abundant species and is currently considered an invasive species.

Table 1 - Results of the application of plant powders at the concentration of 1 (m/m)

Parameters	**Time (Days)**	**Leaf vegetable powders (%)**		
		Pimienta dioca (L.) Merr	***Callistemon citrinus (Curtis Skeels)***	***Syzygium malaccense (L.) Merr. & L.M. Perry***
Mortality	15	65,76	64,67	43,33
	30	74,0	70,33	62,0
Insect Emergency	55	22,2	21,9	31,53
Weight loss in stored *Zea mays L. grains*	55-60	2,95	3,05	3,36

Source: Own elaboration

Local producers need to preserve the seed for three months or more; the results presented indicate that an application of 1% (m/m) of vegetable powder does not guarantee its total conservation, for which reason it is recommended that the third month, after having applied the vegetable powder, the stored seed be moved so that the applied powder covers the greatest amount of grains and a greater repellency is achieved. Another variant of this alternative is the application of vegetable powder at a concentration of up to 3% (m/m). With this, better results were obtained in the analyzed parameters for the three species.

In the second variant of this alternative, in this experiment, vegetable powders obtained from leaves were applied only once to the infested grains in a proportion of 3% (m/m), that is, 3 g to 97 g of corn. After 15 days, it was observed an increase of insect mortality, regarding the previous variant; the best results are obtained with the use of vegetable powders of *Pepper dioca (L.) Merr* with 70.0% and after 30 days, with 84.33%. On the other hand, this parameter is also increased for the species *Callistemon citrinus (Curtis) Skeels and Syzygium malaccense (L.) Merr. & L.M. Perry.*

The emergence parameter of the insect shows a very satisfactory behavior at 55 days for the three species and the best result is achieved with the vegetable powders of the *Pimienta dioca* (L.) Merr. Likewise, with the use of the vegetable powders of this species, the loss of weight of the grains is the least, although the *Callistemon citrinus (Curtis) Skeels* and the *Syzygium malaccense* (L.) Merr. & L.M. Perry show very good results (Table 2).

Table 2 - Results of the application of plant powders at a concentration of 3% (m/m)

Parameters	Time (Days)	Leaves vegetable powders (%)		
		Pimienta dioca (L.) Merr	***Callistemon citrinus (Curtis Skeels)***	***Syzygium malaccense (L.) Merr. & L.M. Perry***
Mortality	15	79,0	77,33	73,0
	30	84,33	84,0	75,33
Insect Emergency	55	3,6	4,06	5,04
Weight loss in stored *Zea mays L*. grains	55-60	2,1	2,96	3,49

Source: Own elaboration

Essential oils from botanical species

The production of essential oils began when the leaves collected in the laboratory were received, as explained above. Then, the second phase was carried out, which was defined, for this process, as the phase of Oil extraction; in this, the selected leaves were introduced in distilled water and submitted to a process of hydro distillation, from which the essential oil was obtained and, with this, the production process concluded. The oil obtained was packaged in bottles with labels; this phase, where the final product was packaged, is known as Distribution and Sales (Fig. 1).

The essential oil obtained from the different promising species was applied to the stored grain only once, in a proportion of 900 µL/L air; at 144 hours, an insect mortality of 94% was obtained with the essential oil of the species *Callistemon citrinus (Curtis) Skeels* (Table 3); there was no emergence of the insect and the loss is considered very low.

Table 3 - Results of the application of essential oils of botanical species in the ratio of 900 µL/L air

Parameters	Time (Hours)	Essential oils of botanical species (%)	
		Pimienta dioca (L.) Merr	***Callistemon citrinus (Curtis Skeels)***
Mortality	144	51,0	94,0
Insect Emergency		1	0
Weight loss in stored *Zea mays L*. grains		0,01	0,02

Source: Own elaboration

Selection of the plant to be used

*Pimenta dioica (*L*.) Merr* is a plant that develops in the mountainous area of Santiago de Cuba; there is no tradition of cultivating this species in the central region, so it does not fulfill the characteristic of being widely distributed and in great amounts. In a conclusive way, a second option for seed protection by the local producer of the central region would be the use of vegetable powder and essential oil from *Callistemon citrinus (Curtis) Skeels*, which results obtained indicate that this species can be considered promising, since it is abundant in the country, it is perennial and the use of its leaves does not cause destruction in the plant; besides, the parameters obtained in both alternatives indicate that the protection of stored grains destined to seed is guaranteed.

Protection cost

In the process of protecting stored grains destined for seed, the local producer, in addition to having information about the effectiveness of treatments with vegetable powders and essential oils, according to the parameters presented, will be able to select which alternative he will use, but, in addition, to make this selection he must know how much it will cost, so a fourth parameter that complements this decision may be the cost of protection, which will be made up of the value of the products purchased by the local producer, which are applied to the stored seed. It is also possible to include the cost of labor in case it is contracted, although generally, in Cuba, it is the producer himself who carries out this activity, so the amount of this cost will depend on the value of the acquired products, which is calculated by multiplying the acquisition price by the acquired and applied quantity.

The doses applied to the corn grains in the experiment, mentioned above, made it possible to establish the quantities to be used to achieve the protection of the seed, led to the establishment of the following consumption standards:

- 1 kg of leaf vegetable powder should be used to protect 99 kg of corn seed
- 1 g of essential oil should be used to protect 0.8888 kg of corn seed

The price of the products of both alternatives was conformed from the established in the Resolution 20 of 2014 of the Ministry of Finance and Prices (2014) that establishes the methodology to use for the formation of prices in Cuba. For the selection of the method to be used, Article 17 of the Fourth Section was consulted, where it is established that "The wholesale prices of goods and services, which are not exported nor have presence of similar or substitutes in the internal market, are formed by methods of expenses". In order to calculate the profit for the formation of prices, Joint Resolution No. 1/2005 of the Ministry of Economy and Planning (MEP in Spanish) and the Ministry of Finance and Prices (MFP in Spanish) (2005) was consulted.

The expense method, according to the aforementioned article, indicates that prices are determined based on the necessary costs and expenses, to which a profit magnitude and the corresponding taxes are added, and therefore, can be summarized as follows:

$$Pep = C + G + U + T$$

Where:

Pep = price of the producing company

C = cost of production

G = expenses to be recognized in the price

U = utility

T = taxes and contributions to be defined

For the formation of the price, the Resolution, in its article 18, indicates that a Cost Sheet must be used, which must be prepared according to the instructions established by said resolution in its Annex No. 2. In said file, all the elements of the expression or formula presented in the resolution for the calculation of the price are conceived, since the calculation of the cost of production (C) constitutes the first element to be developed; for such purpose, it was necessary to quantify the expenses incurred in the different phases of the production process of the vegetable powders and the essential oils, which were grouped in the cost items:

- Raw materials and materials: this include acquired raw materials and transportation costs, among others
- Salary: includes salary and accrued vacation
- Other direct expenses: includes fuel consumed in transportation
- Costs associated with production: includes depreciation of laboratory equipment used in the production of leaf powders and essential oils and other costs

The Collection and Transportation phase is a common phase for both products; in it, the salary of the person in charge of selecting and collecting the leaves was incurred, as well as the fuel used for transportation; two cost items were identified: Salary and Other direct expenses: the cost calculated in this phase was 2,086 pesos.

In the production of leaf vegetable powders, in the Drying phase, expenses were incurred related to the electricity consumed by the stove and the salary of the laboratory technician who selected and organized the leaves into trays and placed them in the stove for drying. Two cost items were identified: Raw Materials and Materials and Salary, the calculated cost in this phase was 3, 49789 pesos and in the final phase, Milling, expenses were incurred related to the electricity consumed by the mill and the salary of the laboratory technician that grinds the dry sheets. Two cost items were identified: Raw Materials and Materials and Salary; the calculated cost in this phase was 1,236795 pesos.

During the production of the leaf vegetable powders, indirect expenses were incurred, related to the depreciation of equipment and other laboratory expenses, which were associated with the cost of production and with the distribution and sales of this product, in order to form a price. In accordance with Resolution 20 of 2014 of the MFP, Annex 3, which indicates that for such association the Maximum Coefficient of Indirect Expenses must be used, which was calculated by dividing the total value of

the aforementioned expenses by the amount planned for twelve (12) months of the salary of the workers directly linked to the production.

The calculation of the coefficient was made from the budget of the expenses for the concepts described above and the budgeted salary of the technician who worked in this process. An amount of 1.7991666 pesos was distributed for Expenses associated with production and 0.0001801 pesos for Distribution and Sales Expenses. This distribution made it possible to calculate the cost of production of this product for an amount of 8.6198516 pesos, which represented the magnitude of the resources needed in this process to reach 1 kg of leaf powder, made in very specific conditions in the laboratory where this production was carried out.

The second element developed, according to the formula, are the expenses to be recognized in the price (G); among them, there are the distribution and sales expenses, which were associated with the expenses for packaging and labeling, as well as the expenses incurred in the packaging of the product which are the following: materials for the packaging (envelopes and labels) salary of the technician who weighed the leaf powder and the allocation of indirect expenses made; these expenses amounted to 0.3141001 pesos for 1 kg of leaf powder.

The third element of the formula is the profit (U); for this, it was proceeded as established in Joint Resolution 1 of 2005, of the MEP and the MFP, in its sole Annex, where it is indicated that "A maximum of twenty percent (20%) of elaboration costs is set as General Utility Regulations to form prices" (Ministry of Economy and Planning & Ministry of Finance and Prices, 2005) and also clarifies that the elaboration cost is the total production cost, minus the material consumption.

The profit mass obtained was 1, 1477363 pesos and represented 13.32% of the total production cost, that is, approximately 13% that constitutes the Profit Norm to be applied.

The fourth element calculated was constituted by the taxes (T) and for this purpose, the tax rates were applied to the taxable base which, in this case, was made up of the cost item Salary and salary expenses corresponding to the packaging of leaf powders, the tax rates used, as established in the State Budget Law for 2020: 12.5% for the Social Security Contribution, 5% for the Tax on the Use of the Labor Force and 1.5% for Social Security Expenses.

The sum of the total production cost of distribution and sales expenses, taxes and the calculated profit mass resulted in a price of 10, 6676167 pesos, for 1 kg of leaf vegetable powders, as shown in table 4.

Table 4 - Summary of the cost sheet for the leaf vegetable powder alternative

CARD FOR PRICES OR TARIFFS	
Product: Vegetable powder from leaves of botanical species	
Production level: 1 kilogram	**UM: Peso**
CONCEPTS	**TOTAL**
Raw materials, materials and direct inputs	2,88117
Salaries	3,08351
Other direct expenses	0,856
Costs associated with production	1,79917
TOTAL COST	8,61985
Distribution and sales expenses	0,3141
Social Security Contribution	0,38548
Short-term social security expenses	0,04626
Tax on the use of the workforce	0,15419
TOTAL EXPENDITURE	0,90003
Useful regulations to be applied	13,32 %
Profitable mass	1,1477363
PRICE or TARIFF	10,6676167

Source: Own elaboration

The production of essential oils began when the leaves collected in the laboratory were received, as explained above, at a cost of 2,086 pesos; then the final phase of oil extraction was carried out, in which the costs of distilled water, electricity consumed by the electric blanket and the salary of the laboratory technician who carried out and supervised the process were incurred; two cost items were identified: Raw Materials and Materials and Salaries; the cost of this phase is 5,21625 pesos.

In this process, indirect expenses associated only with production were considered, which refer to other laboratory expenses, so they were related to the item, Expenses associated with production for 0,003 pesos; depreciation was not considered because the equipment used for the hydro distillation of the oil was totally depreciated, although it was in perfect condition.

The first element that was calculated -the total calculated production cost (C)- was 7,30525 pesos and represented the magnitude of the resources needed in this process to reach 1 g of essential oil of botanical species and that, as in the production of leaf powder, was done under very specific conditions of the laboratory where this experience was carried out.

The second element developed, the expenses to be recognized in the price (G), among them, appear the Distribution and sales expenses, which were associated with the expenses for packaging and labeling and the expenses incurred in the packaging of the product which are the following: materials for the packaging (bottles, caps and

labels) and salary of the technician who bottled the oil obtained; these expenses amount to 0.83392 pesos for 1 g of essential oil of botanical species.

As a third element with the same procedure, the profit (U) was calculated; for this, the material consumption was also deducted and the elaboration cost was conformed; the Profit Regulation to be applied was calculated, which was 12.48%, that is, approximately 12% and the Profit Mass was 0.91205 pesos.

The fourth element calculated was the taxes (T), which are presented in Table 5, so the sum of the total production cost of distribution and sales expenses, taxes, short-term social security expenses and the profit mass calculated resulted in a price of 9.754518 pesos for 1 g of essential oil of botanical species, as presented below.

Table 5 - Summary of the cost sheet for alternative essential oils of botanical species

CARD FOR PRICES OR TARIFFS	
Product: Essential oil of botanical species	
Level production: 1 gram	**UM: Peso**
CONCEPTS	**TOTAL**
Raw materials, materials and direct inputs	2,745
Salaries	370,125
Other direct expenses	0,856
Costs associated with production	0,003
TOTAL COST	730,525
Distribution and sales expenses	0,83392
Social Security Contribution	0,46269625
Short-term social security expenses	0,5552355
Work	0,1850785
TOTAL EXPENSES	15,372183
Utility regulations to be applied (approximate)	12,48 %
Profitable mass	0,91205
PRICE or TARIFF	97,545183

Source: Own elaboration

The price calculated for both developed productions, under laboratory conditions, led to the establishment of a cost for the protection of the corn seed stored by local producers, which should be considered as a reference or estimate, since if some of the production conditions varied, the price calculated for the products would be modified and, consequently, the cost of protection; however, this cost made it possible to analyze the impact it has on the cost of the protected seed. This analysis took into account the following conditions:

a. According to information from the Ministry of Agriculture, the consumption standard for planting one hectare of corn is 25 kg of seed
b. The conservation period, when applying the alternatives, is 3 months and only one application of the selected product was made
c. The seed was valued at an average production cost of 3.95 pesos per kilogram and it was considered that the seed is audited

Therefore, it is assumed that the cost of the stored seed needed to plant one hectare is:

- *Cost of seed stored for sowing = Consumption Standard* x *Acquisition cost of the audited seed*
- *Cost of seed stored for sowing = 25 kg x 3,95 pesos = 98,75 pesos*

For the use of the leaf vegetable powder as an alternative for the protection of the seed, the following analysis was made:

Variant 1. Application of leaf vegetable powders at a concentration of 1 % (m/m)

- 1 kg of vegetable powder is used to protect 99 kg of corn seed
- 0.25 kg of vegetable powder is used to protect 25 kg of corn seed

Therefore, the protection of 25 kg of corn seed required 0.25 kg of leaf vegetable powder which, valued at the estimated selling price of 10, 66761667 pesos, resulted in an approximate protection cost to the farmer of 2.66 pesos, so the cost of the protected seed amounted to 101.41 pesos.

Variant 2. Application of leaf vegetable powders at the concentration of 3 % (m/m)

- 3 kg of vegetable powder is used to protect 100 kg of corn seed
- 0.75 kg of vegetable powder is used to protect 25 kg of corn seed

To protect 25 kg of corn seed, 0.75 kg of leaf vegetable powder was needed which, valued at the estimated selling price of 10,66761667 pesos, resulted in an approximate protection cost to the farmer of 8.00 pesos, that is, the cost of the protected seed was 106.75 pesos.

With the use of essential oils as an alternative for the protection of the seed, the following analysis was made:

- 1 g of essential oil is used to protect 0.8888 kg of corn seed
- 28. 125 g of essential oil are used to protect 25 kg of corn seed

For the protection of 25 kg of corn seed, 28,125 g of essential oil were needed, valued at the sale price, estimated at 9.7545183 pesos; this resulted in a cost of protection to the farmer of 274.35 pesos, so the cost of the protected seed amounted to 374.17 pesos, as shown in table 6.

Table 6 - Behavior of the protection cost estimated for the conservation of 25 kg of supervised corn seed, necessary for the sowing of 1 ha

Natural protection alternative	Cost of stored seed (Pesos)	Protection costs (Pesos)	Cost of protected seed (Pesos)	Increased cost of seed for protection
Leaf vegetable powders (concentration 1 %)	98,75	2,67	101,42	2,6 %
Leaf vegetable powders (concentration 3 %)	98,75	8,00	106,75	7,5 %
Essential oil of botanical species	98,75	274,35	373,10	73,5 %

Source: Own elaboration

The comparison of the protection costs indicated that the most economical alternative for the local producer is the use of plant powders since, when applied in its two concentration variants -at 1 and 3 % (m/m)- the cost of the protected supervised seed increases only by 2.6 and 7.5 %, respectively; however, the use of essential oil generates an increase in the cost of the protected seed of 73.5 %, which represents a protection cost of 274.35 pesos.

The decision to use one alternative or another for the protection of the seed must be based on the benefits provided by each one of these, and for this purpose, the parameters obtained when applying the plant powders and the essential oil must be consulted; the behavior of mortality, of the insect's emergence and the loss of weight of the grain must be evaluated, and as a complementary parameter, the cost of protection.

In the results of the present research, it was possible to verify that the vegetable powders and essential oils allowed to control the plague of stored grains with efficiency, in order to preserve the seed to guarantee the following productive cycles. Both alternatives are safer from the agroecological point of view for the human being and compatible with the integrated management of plagues for the control of the insect; they have a low production cost and the behavior of the protection cost indicates that they are economically accessible for local producers; in addition, they can substitute imported chemical products, used in the conservation of the seed by the local producers and their production is a contribution to the establishment of a sustainable agriculture.

The use of leaf powders and essential oils for the protection of corn seed is a proposal that can be applied to local producers in different areas of the country.

REFERENCES

Daglish, G. J., Nayak, M. K., & Pavic, H. (2014). Phosphine resistance in Sitophilus oryzae (L.) from eastern Australia: Inheritance, fitness and prevalence. *Journal of Stored Products Research*, *59*, 237-244. https://doi.org/10.1016/j.jspr.2014.03.007

Jiménez Álvarez, L., Arias Vega, A., & Valdés Herrera, R. (2016). Tithonia diversifolia, Moringa oleifera y Piper auritum: Alternativas para el control de Sitophilus oryzae. *Revista Centro Agrícola*, *43*(3), 56-62. http://cagricola.uclv.edu.cu/index.php/es/volumen-43-2016/numero-3-2016/805-tithonia-diversifolia-moringa-oleifera-y-piper-auritum-alternativas-para-el-control-de-sitophilus-oryzae

Khanal, S., Adhikari, A., Tiwari, A., Singh, N. B., & Subedi, R. (2019). Efficiency of botanical extract against maize weevil Sitophilus zeamais (Motschulsky, 1855) (Coleoptera: Curculionidae). *World News of Natural Sciences*, *24*, 1-8. http://psjd.icm.edu.pl/psjd/element/bwmeta1.element.psjd-b6fe39f4-3d2e-47d9-ba03-5a0f5aeae72c

Koutsaviti, A., Antonopoulou, V., Vlassi, A., Antonatos, S., Michaelakis, A., Papachristos, D. P., & Tzakou, O. (2018). Chemical composition and fumigant activity of essential oils from six plant families against Sitophilus oryzae (Col: Curculionidae). *Journal of Pest Science*, *91*(2), 873-886. https://doi.org/10.1007/s10340-017-0934-0

Martínez Curbelo, G., Feitó Cespón, M., Covas Varela, D., & Barrera Garcia, A. (2015). Control de la temperatura para la prevención de plagas poscosecha en la conservación de granos. *Revista Científica Ingeniería y Desarrollo*, *33*(2), 216-237. http://rcientificas.uninorte.edu.co/index.php/ingenieria/article/view/6281

Ministerio de Economía y Planificación, & Ministerio de Finanzas y Precios. (2005). *Resolución Conjunta No. 1 Establece determinado por ciento de utilidad, como un componente máximo de los precios mayoristas, tarifas y márgenes comerciales* (Resolución Conjunta No. 1). Gaceta Oficial de la República de Cuba. https://www.gacetaoficial.gob.cu/es/resolucion-conjunta-1-de-2005-de-ministerio-de-economia-y-planificacion-ministerio-de-finanzas-y

Ministerio de Finanzas y Precios. (2014). *Metodología general para la formación y modificación de precios mayoristas, tarifas técnico productivas y tasas de margen comercial* (Resolución 20). Gaceta Oficial de la República de Cuba, Edición Extraordinaria No. 12. https://www.gacetaoficial.gob.cu/es/resoluci%C3%B3n-20-de-2014-de-ministerio-de-finanzas-y-precios

Ojito Ramos, K. (2016). *Actividad antifúngica de extractos de hojas de Citrus spp. Frente a Alternaria solani Sor., agente causal del tizón temprano en Solanum*

lycopersicum L. [Tesis de Doctorado]. Universidad Central «Martha Abreu» de Las Villas.

OMS. (2018). *¿La herencia de un mundo sostenible? Atlas sobre salud infantil y medio ambiente*. Organización Mundial de la Salud. https://apps.who.int/iris/handle/10665/260496

Paz Sánchez, C. E., Martínez Mora, S. F., Paz Illescas, C. E., & Acosta Gaibor, M. P. (2019). Uso de plaguicidas y su consecuencia en la leucemia linfoide y mieloide en trabajadores agrícolas. *Mikarimin. Revista Científica Multidisciplinaria*, *5*(1), 37-56. http://45.238.216.13/ojs/index.php/mikarimin/article/view/1382

Ramos Hernández, J. M., Rodríguez Toledo, Y. F., & Palmero López, M. (2016). La Fauna de insectos y ácaros asociados a almacenes de alimentos en la provincia de Sancti Spíritus. *Fitosanidad*, *20*(1), 13-19. http://www.fitosanidad.cu/index.php/fitosanidad/article/view/605

Silva, G., Lagunes, A., Rodríguez, C., & Rodríguez, D. (2002). Insecticidas vegetales: Una vieja y nueva alternativa para el manejo de plagas. *Manejo Integrado de Plagas y Agroecología*, (66), 4-12. https://biblat.unam.mx/es/revista/manejo-integrado-de-plagas-y-agroecologia/articulo/insecticidas-vegetales-una-vieja-y-nueva-alternativa-para-el-manejo-de-plagas

Song, J.-E., Kim, J.-M., Lee, N.-H., Yang, J.-Y., & Lee, H.-S. (2016). Acaricidal and insecticidal activities of essential oils against a stored-food mite and stored-grain insects. *Journal of Food Protection*, *79*(1), 174-178. https://doi.org/10.4315/0362-028X.JFP-15-109

Torres, C., Silva, G., Tapia, M., Rodríguez, J. C., Urbina, A., Figueroa, I., Lagunes, A., Santillán Ortega, C., Robles Bermúdez, A., & Aguilar Medel, S. (2015). Propiedades insecticidas del polvo de Laurelia sempervirens L. para el control de Sitophilus zeamais Motschulsky (Coleoptera: Curculionidae). *Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas*, *14*(1), 48-59. https://www.redalyc.org/articulo.oa?id=85632845006

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Authors declare not to have any conflict of interest.

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The authors have participated in the writing of the paper and the analysis of the documents.