

## SUBSTRATO PÓS-COLHEITA DE COGUMELO DO SOL NA PRODUÇÃO DE CHICÓRIA

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**RESUMO:** Para o cultivo da chicória, existem diferentes substratos, combinações de matérias e proporções variadas, que auxiliam em seu desenvolvimento. O uso de matérias primas no preparo destes substratos varia de acordo com a sua disponibilidade na região e clima. Estes resíduos comumente são depositados em propriedades rurais, causando efeitos nocivos ao meio ambiente. Portanto, o presente trabalho visou estudar o aproveitamento de substrato pós-colheita de *Agaricus blazei* na produção de chicória, levados como critérios de avaliação, a massa fresca da chicória (planta inteira, incluindo raiz), altura da planta e número de folhas. Foram feitos três tratamentos, sendo T1 (100% de substrato tradicional), T2 (100% composto exaurido) e T3 (50% substrato tradicional e 50% composto exaurido), cada um com 10 repetições. Quanto os resultados, a média de massa fresca foi de 295,0 g, 493,7 g e 434,6 g para os tratamentos 1, 2 e 3, respectivamente. Em relação à altura de plantas, a média foi 16,9 cm, 22,2 cm, 20,1 cm para os tratamentos 1, 2 e 3, respectivamente. E número de folhas, obteve média de 23,6, 33,3 e 28,6 para os tratamentos 1, 2 e 3, respectivamente. Os melhores resultados foram obtidos com os substratos contendo composto exaurido de cogumelos, sendo superiores ao substrato convencional. Portanto, a utilização deste material até em mistura com o convencional, geram resultados satisfatórios, renda e produto com valor agregado.

**Palavras-chave:** hortaliças, resíduos, cogumelos.

## ROYAL SUN MUSHROOM SPENT MUSHROOM SUBSTRATE IN THE PRODUCTION OF CHICORY

**ABSTRACT:** For the cultivation of chicory, there are different substrates, combinations of materials and varied proportions, which assist in its development. The use of raw materials in the preparation of these substrates varies according to their availability in the region and climate. These residues are commonly deposited on rural properties, causing harmful effects to the environment. Therefore, this work aimed to study the use of *Agaricus blazei* spent mushroom substrate in the production of chicory, taken as evaluation criteria, the fresh mass of chicory (whole plant, including root), plant height and number of leaves. Three treatments were performed, T1 (100% traditional substrate), T2 (100% depleted compost) and T3 (50% traditional substrate and 50% depleted compost), each with 10 repetitions. As for the results, the average fresh weight was 295.0 g, 493.7 g and 434.6 g for treatments 1, 2 and 3, respectively. Regarding plant height, the average was 16.9 cm, 22.2 cm, 20.1 cm for treatments 1, 2 and 3, respectively. As for number of leaves, it was obtained an average of 23.6, 33.3 and 28.6 for treatments 1, 2 and 3, respectively. The best results were obtained with substrates containing exhausted mushroom compost, being superior to the conventional substrate. Therefore, the use of this material, even in mixture with the conventional one, generates satisfactory results, income and product with added value.

**Keywords:** vegetables, residues, mushrooms.

## 1 INTRODUCTION

Chicory is a plant from the *Asteraceae* family and originates from East India. It has been known and used in human food since ancient Greece, Rome, and Egypt, in cooked form or in salads. It is a source of vitamins B, C, D, and beta-carotene, contains calcium, phosphorus, and iron, and is rich in fiber (CARVALHO, 1988). It has stimulating properties for the liver and gallbladder; for this reason, it is considered a medicinal plant (BALBACH; BOARIM, 1992).

There are two clearly defined varieties: *Cichorium endivia* var. *latifolia* L., the smooth variety, and *Cichorium endivia* var. *crispa* L., which is the curly chicory characterized by its deeply lobed leaves (FILGUEIRA, 2000). It is a plant rich in vitamins, minerals, and proteins (MARTINS *et al.*, 2003). It has antipyretic, anti-inflammatory, and analgesic properties (VILLACHICA *et al.*, 1996).

It can be cultivated throughout the year in high-altitude regions, but sowing generally occurs in the autumn–winter (FILGUEIRA, 2003). Chicory production occurs best under mild temperatures, although some cultivars are tolerant to relatively high temperatures.

Proper substrate management and selection are important for obtaining high-quality seedlings (BACKES; KÄMPF, 1991). Substrates are usually produced by growers themselves, using different materials, in mixtures or pure, that are available in their regions. The most commonly used materials are carbonized/natural rice husk, vermiculite, mature coconut fiber/powder, tree bark, worm humus, soil, and organic compost, among others. Many studies have aimed to characterize and test these materials, as well as others with the potential to be used as substrates (CAÑIZARES *et al.*, 2002; NUNES, 2000; CARRIJO *et al.*, 2004).

Among the possible materials to be used as a substrate, one can mention the spent compost resulting from the mushroom cultivation process, such as *Agaricus bisporus*, cultivated in a mixture of composted materials

appropriate for its growth (COLAK, 2004; MINOTTO *et al.*, 2014), as well as \* *Pleurotus* \* sp., cultivated in sugarcane bagasse subjected to rapid composting and pasteurization (BONONI; CAPELARI; MAZIERO, 1995; DONINI *et al.*, 2006). Furthermore, Bioplant, a commercial substrate derived from a mixture of pine bark and coconut fiber, is widely used in the production of vegetable seedlings. However, different crops may vary in terms of porosity, water retention capacity, and aeration of a substrate. The same substrate is commonly used for all vegetables, which can affect productivity.

*et al.* (1999), *Agaricus blazei* is classified as a saprophytic fungus because it colonizes decomposing organic matter. The literature describes the efficiency of these mushrooms in decomposing various agricultural and agro-industrial residues, such as corn cobs, coffee husks and pulp, coconut husks and fiber, peanut shells, sugarcane bagasse, etc. (PEREIRA *et al.*, 2017), by taking advantage of their availability in each region. These residues are degraded by the fungus's enzymatic complex (DUPRAT *et al.*, 2015).

According to Jasińska (2018), the production of 1 kg of fresh mushrooms generates 5 kg of *spent mushroom substrate* (SMS) at the end of the process. This enormous amount of waste results in disposal problems. However, SMS contains the mycelium of cultivated species, as well as nutrient residues such as organic substances (N, P, and K), and can be used in agricultural and horticultural production.

Rinker (2017) added that SMS from *A. bisporus* can also be used in biotechnological processes, such as optimizing the distribution of zinc, cadmium and lead among soil fractions; decreasing zinc toxicity in the soil; degrading chlorophenols, polycyclic aromatic hydrocarbons or aromatic monomers; inhibiting nitrification; and biodegrading toxic waste, among others.

Considering that extensive areas of Brazil include soils with low fertility and that interest in the use of organic fertilization to

replace chemical fertilization is expanding, the use of postcultivation substrates from mushroom production can be an interesting alternative in agriculture. This would provide benefits both for mushroom producers in the country, as well as for farmers and consumers, and for the environment (RIBAS, 2006).

This study is justified by the opportunity to utilize an unused waste product—spent compost from the cultivation of *A. blazei*—to transform it into a substrate for the production of chicory from the species *C. endivia L.*, generating a potential source of local income, as well as a sustainable destination for these organic materials. The main problem to be solved is the removal of these wastes from the environment, as they generate pollution and degrade the local soil.

This study presents potential for sustainable vegetable cultivation, providing an opportunity for mushroom growers to utilize exhausted substrates. The conception of this study arose from the lack of literature on the

subject, as well as the cultivation characteristics of chicory, such as rapid germination and easy management. Therefore, the present study aimed to verify the viability of the use of postharvest substrates of *A. blazei* for chicory production.

## 2 MATERIALS AND METHODS

### 2.1 Experimental design

The experiment was conducted in the city of Barra Bonita, SP. The experimental design was completely randomized, corresponding to 3 types of cultivation substrates based on organic waste, one of which was a traditional substrate (soil and humus) and two alternative substrates, which were based on spent compost from *A. blazei* in different proportions (50% and 100%) (Table 1), each with 10 repetitions (substrate pots – 400 g), totaling 30 experimental units.

**Table 1.** Experimental treatments proposed for this project.

Treatments <sup>1</sup>	Types of organic waste
1	100% traditional substrate (ST)
2	100% depleted <i>A. blazei</i> (CE) compound
3	50% ST + 50% CE

<sup>1</sup> Traditional substrate (soil (50%) and humus (50%)). Exhausted compost – Postharvest material from cultivated *A. blazei*, whose basic composition is a combination of sugarcane bagasse (50%) and grass (50%).

**Source:** Prepared by the authors

### 2.2 Variety of chicory

The chicory variety *C. endivia L.*, purchased from the Agropec Produtos Agropecuários e Pet Shop store in Barra Bonita, SP, was used. This variety was chosen because of its ease of adaptation to the climatic conditions of the city of Barra Bonita, SP, and its ability to achieve good productivity.

### 2.3 Substrate collection

The organic waste used in the formulation of the experimental substrates was collected from a rural property located on Macatuba Road, SP. This property produces mushrooms and vegetables. The traditional substrate is used in vegetable gardens, and the

spent compost from *A. blazei* has no destination, accumulating in green areas and potentially leading to the infestation of unwanted insects.

### 2.4 Preparation of experimental units

After collection, these residues were placed in 50 ml plastic pots, where 400 g of substrate was added according to the treatments in Table 1, with each treatment having 10 repetitions (pots). Five seeds were placed per pot. The pots were identified according to each treatment. Irrigation was performed manually via a hose.

## 2.5 Chicory Production

After the pots containing the substrates (soil and humus, exhausted compost from *A. blazei*) were individually weighed, they were placed on a bench located on a chicory-producing property in Barra Bonita, SP.

With the help of 50% shade cloth and some household materials, it was possible to create a favorable environment, with an average temperature between 23°C and 27°C, for the development of chicory seedlings.

The plants were planted on August 27, 2020, and the first leaves appeared 7 days later. The growth cycle was 90 days.

## 2.6 Transplanting and seedling development

After leaf development, approximately 20 days later, the seedlings were transplanted to a seedbed where according to the variety, the seedlings were spaced 20 to 30 cm apart in rows and 15 to 30 cm apart in plants. The plants were arranged in rows according to their substrate: one row with traditional substrate, another with exhausted compost of *A. blazei*, and another

with the mixture. Photographic records of the development of the transplanted plants were obtained.

## 2.7 Harvest

Harvesting begins when the oldest leaves reach 12--15 cm in length (MAKISHIMA, 1993). It was carried out manually on December 2, 2020.

## 2.8 Statistical analysis

For statistical analysis of the data obtained, Minuta 18.1 software was used. The variables were subjected to analysis of variance, and their means were compared via Tukey's test at a significance level of 5% (BOWER, 2000).

## 3 RESULTS AND DISCUSSION

According to visual analysis (Figure 1), plants grown in depleted *A. blazei* compost (Treatments 2 and 3 - Figures 1B and 1C, respectively) presented improved development.

**Figure 1.** Development of transplanted plants and size differences between them.

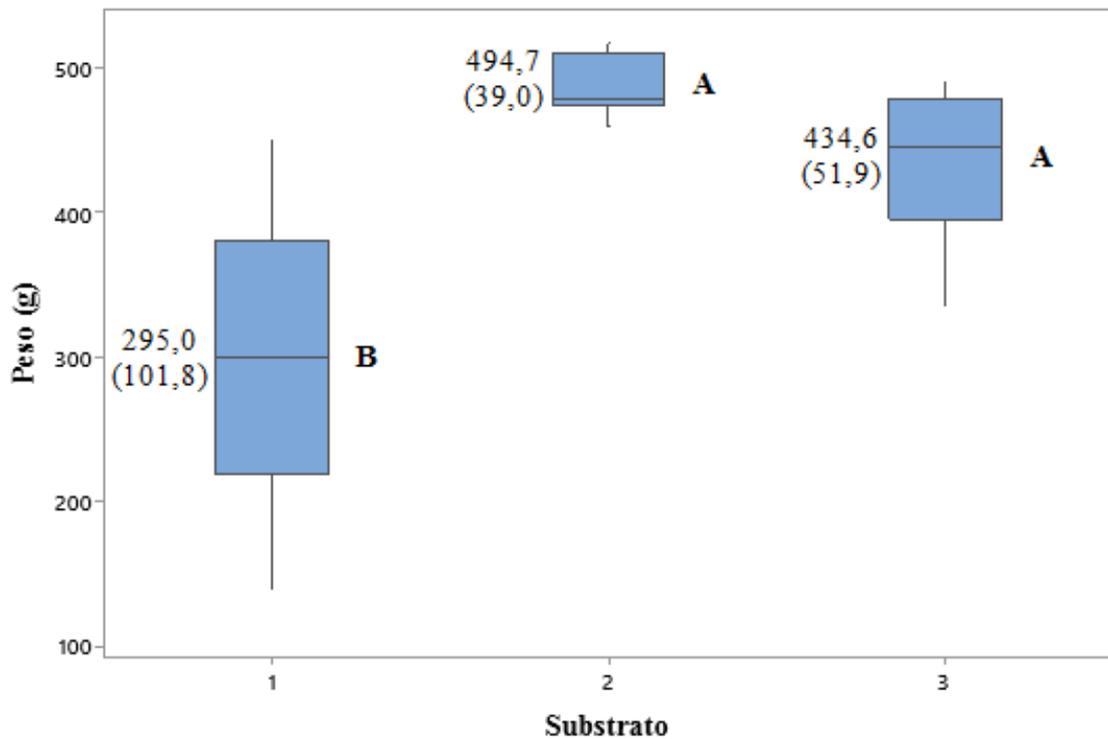


A. Plant in conventional substrate. B. Plants in spent compost substrate. C. Plants in mixed substrate.

Source: Prepared by the authors.

The average fresh weight (g) of chicory plants per treatment is shown in Figure 2.

**Figure 2.** Average fresh weight (g) of chicory plants by treatment. The standard deviations of the means are in parentheses.



Note: Substrates - 1: 100% traditional substrate; 2: 100% depleted *A. blazei* compost; 3: 50% traditional substrate + 50% depleted compost. Averages of 10 replicates. Different letters between treatments indicate a statistically significant difference ( $P < 0.05$ ).

**Source:** Prepared by the authors.

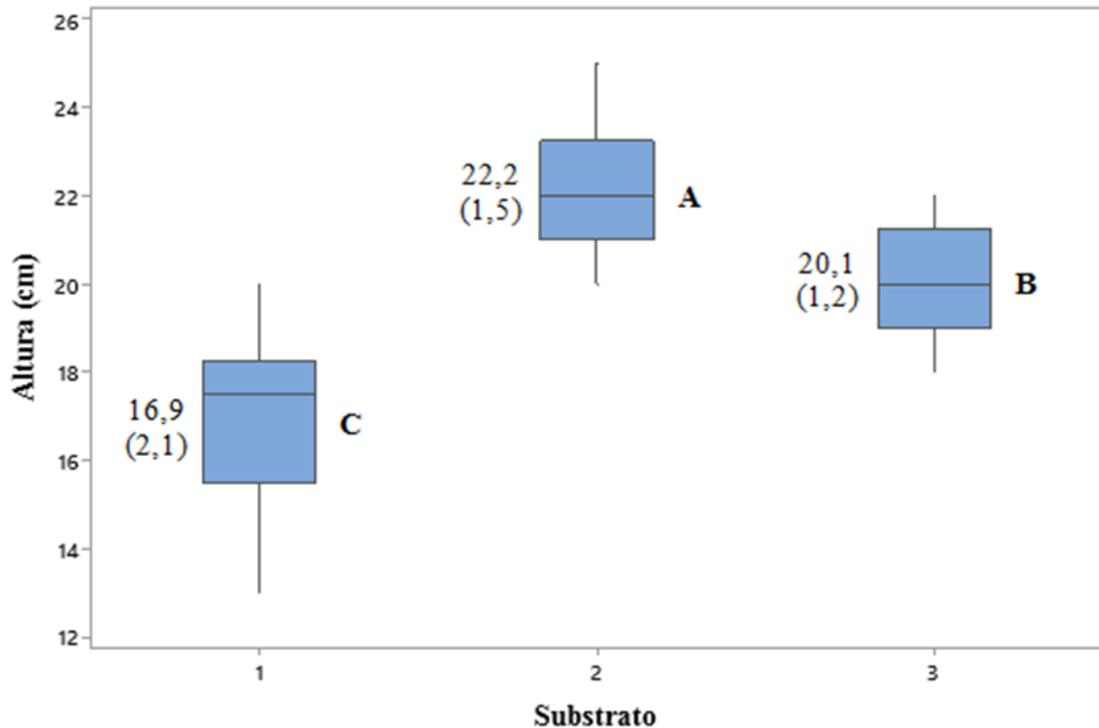
As shown in Figure 2, regarding the average fresh weight (g), there was a statistically significant difference between Substrates 2 and 3 (containing exhausted compost) and the conventional substrate. Compared with the conventionally used substrate (soil + humus), the exhausted mushroom compost resulted in an increase of up to 67% in plant weight (g).

Marques *et al.* (2014) evaluated the effects of using different proportions of *A.*

*subrufescens* SMS on the growth of lettuce seedlings. The authors reported that the best results were obtained in substrates containing 45% SMS, with the average plant mass in the conventional substrate being 180 g, whereas for substrates containing SMS, the value reached 233.45 g/plant.

Figure 3 shows the average height (cm) of chicory plants by treatment.

**Figure 3.** Average height (cm) of chicory plants by treatment. The standard deviations of the means are in parentheses.



Note: Substrates - 1: 100% traditional substrate; 2: 100% depleted *A. blazei* compost; 3: 50% traditional substrate + 50% depleted compost. Averages of 10 replicates. Different letters between treatments indicate a statistically significant difference ( $P < 0.05$ ).

**Source:** Prepared by the authors.

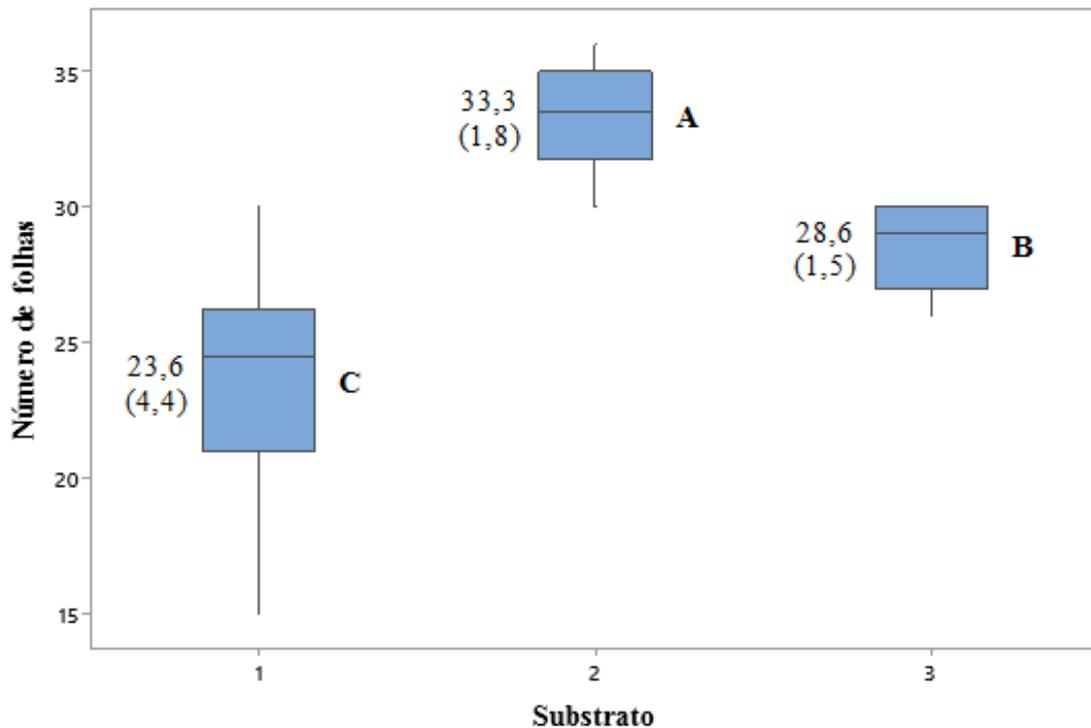
All the treatments differed statistically from each other. Substrate 2 resulted in plants with an average height of 22.2 cm, which was greater than that in the other treatments. Substrate 3 produced plants with an average height of 20.1 cm, which was lower than that of Substrate 2 but higher than that of Substrate 1, which resulted in plants with an average height of 16.9 cm.

In the study by Abreu (2019), which evaluated the use of SMS from *A. subrufescens*

and *P. ostreatus* for lettuce and arugula cultivation, the conventional substrate provided lettuce seedlings with an average height of 14.63 cm and arugula seedlings of 22.98 cm, whereas the addition of SMS resulted in an increase of up to 54% in the average height of plants of both species.

The average number of leaves per chicory plant per treatment is shown in Figure 4.

**Figure 4.** Average number of leaves on chicory plants per treatment. The standard deviations of the means are in parentheses.



Note: Substrates - 1: 100% traditional substrate; 2: 100% depleted *A. blazei* compost; 3: 50% traditional substrate + 50% depleted compost. Averages of 10 replicates. Different letters between treatments indicate a statistically significant difference ( $P < 0.05$ ).

**Source:** Prepared by the authors.

A statistically significant difference was observed between all the treatments with respect to the number of leaves (Figure 4). Substrate 2 obtained values 41% higher than those of Substrate 1, and Substrate 3, although inferior to Substrate 2, resulted in 21% more leaves than did Substrate 1.

According to the SMS evaluation of *A. subrufescens* and *P. ostreatus* for lettuce and arugula cultivation by Abreu (2019), the average number of plant leaves increased by up to 62% with the addition of spent mushroom compost.

In the study by Lopes (2014), the use of SMS from the mushroom *A. subrufescens* for the production of tomato seedlings was evaluated, revealing a negative impact on the root length, mass, and shoot size of the plants as the amount of SMS used increased. However, seedlings grown with substrates containing SMS presented a greater number of fruits.

The use of SMS from *A. bisporus* (champignon) is also an alternative for

cultivating peppers of the species *Capsicum annuum* L., reducing the production costs of this plant and producing high-quality seedlings (ABREU *et al.*, 2020).

SMS (soil-streamed mixed media) is rich in nitrogen and carbon, with nitrogen contents ranging from 0.4% to 13.7% and C:N ratios ranging from 9 to 15:1, which favor plant growth and development (ROY *et al.*, 2015). Furthermore, it possesses characteristics such as high water content, nutrient content, and low density, making this substrate a suitable option for vegetable production (MAHER *et al.*, 2000). The literature suggests potential uses for reusing SMS, including agricultural organic compost, seedling substrates, animal feed, fuel, and bioremediation of contaminated soils (ZHANG; ZENG-QIANG; ZHI-GUO, 2012).

According to Siqueira *et al.* (2011), in addition to several advantages in terms of physical-chemical properties, SMS is rich in microorganisms, which can promote plant growth and provide a phytosanitary balance for crops by enabling some of these

microorganisms to induce resistance in plants against some pathogens.

Therefore, the correct choice of alternative substrates can provide an opportunity for cultivating the vegetables proposed in this research, in addition to being a sustainable destination for spent mushroom compost and a possible source of local income.

#### 4 CONCLUSIONS

Among the substrates tested (based on exhausted compost and soil and humus), the substrate with the most satisfactory results was Substrate 2 (100% exhausted compost), in terms of the number of leaves, average plant height (cm) and average fresh weight (g). Substrate 3 (50% traditional substrate + 50% exhausted compost) also showed statistically superior results to those of the conventional substrate.

Therefore, spent *Agaricus blazei* compost can be used as a substitute for conventional substrates for growing chicory.

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