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Production and nutritional composition of edible mushrooms in consortia of lignocellulosic residues from in Amazon

Produção e composição nutricional de cogumelo comestível em consórcios de resíduos lignocelulósicos na Amazônia

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ABSTRACT
Edible mushrooms are healthy foods with high nutritional value. However, at the end of the bioprocess, a nutrient-rich compound called Spent mushroom substrate (SMS) is generated which can be disposed of incorrectly, causing environmental pollution. The reuse of SMS in the mushroom production chain has been an eco-friendly option for obtaining biomass at low cost. There is a lack of studies reporting on the use of SMS from the production of edible mushrooms in lignocellulosic waste available in the Amazon. In this context, the aim of this work was to investigate the reuse of SMS from mushroom species for new cultivation cycles in the growth of Pleurotus albidus. The production of this macrofungus was carried out in substrate mixtures made up of cupuaçu exocarp, açaí processing waste and SMS, supplemented with rice bran. The mushroom was grown for eight days in the absence of light at 25 °C and 80% humidity. After complete myceliation of the substrate and development of the primordium, the cultures were exposed to diffused light every 12 hours at 15 °C for three days. The mature basidiomata were then harvested and assessed for physical characteristics, productivity parameters and centesimal composition. In the ET2 cultures [cupuaçu exocarp + SMS + rice bran (450:400:150) g], significant values were obtained for biological efficiency (14.8%), productivity (2.3%) and production rate (0.49%). In ET2 [açaí waste + SMS + rice bran (500:400:100) g], significant values were determined for basidiomata (151 units), weight (151 g), stipe length (1.01 cm), protein (7.42%) and ash (10.39%). The addition of SMS to the substrate mixture is an innovative alternative for the production of P. albidus isolated from the Amazon.

Palavras-Chave
macrofungo
semente
exocarpo
açaí
fermentação

RESUMO
Os cogumelos comestíveis são alimentos saudáveis e possuem alto valor nutricional. Porém, ao final do bioprocesso é gerado um composto rico em nutrientes denominado Spent mushroom substrate (SMS) que pode ser descartado de forma incorreta, causando poluição ambiental. A reutilização do SMS na cadeia produtiva de cogumelos vem sendo uma opção ecoamigável para obtenção de biomassa, a baixo custo. Há carência de estudos reportando o uso de SMS oriundo da produção de cogumelos comestíveis em resíduos lignocelulósicos disponíveis na Amazônia. Neste contexto, este trabalho teve por objetivo investigar a reutilização de SMS de espécies de cogumelos para novos ciclos de cultivo no crescimento de Pleurotus albidus. A produção desse macrofungo foi realizada em misturas de substratos constituídas por exocarpo de cupuaçu, resíduos do processamento do açaí e SMS, suplementados com farelo de arroz. O cultivo do cogumelo foi realizado por oito dias, na ausência de luz a 25 °C, umidade ambiente de 80%. Após miceliação completa do substrato e desenvolvimento do primórdio, as culturas foram expostas à luz difusa a cada 12 horas a 15 °C, por três dias. Em seguida, os basidiomas maduros foram colhidos e avaliados quanto às características físicas, parâmetros de produtividade e composição centesimal. Nos cultivos em ET2 [exocarpo de cupuaçu + SMS + Farelo de Arroz (450:400:150) g] foram obtidos valores significativos de eficiência biológica (14,8%), produtividade (2,3%) e taxa de produção (0,49%). Em ET2 [resíduos de açaí + SMS + farelo de arroz (500:400:100) g] foram determinados valores expressivos de basidiomas (151 unidades), peso (151 g), comprimento do estipe (1,01 cm), proteínas (7,42%) e cinzas (10,39%). A adição de SMS na mistura de substratos é uma alternativa inovadora para a produção de P. albidus isolado da Amazônia

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Introduction

The production of edible mushrooms has proven to be a good business opportunity and continues to be an expanding sector worldwide (INDRATMI et al., 2024). Mushrooms are grown on a commercial scale, in many countries, and edible species constitute a reservoir of nutrients, such as proteins, carbohydrates, minerals, vitamins, amino acids and dietary fiber, with a reduced fat content. Some of these fungi also synthesize bioactive compounds with medicinal action, an attribute of functional foods (COELHO et al., 2022).

Mushrooms have played a significant role in the culture and history of mankind, spanning various civilizations since ancient times. In recent years, the importance of these macrofungi goes beyond their importance as a food and extends into the domains of medicine and ecology (OMOWAYE-TAIWO et al., 2023; ADEWOLE, 2022). *Pleurotus ostreatus, Agaricus bisporus,* and *Lentinula edodes* are the most commercially cultivated mushroom species worldwide (BULAM et al., 2022; CETIN; ATTILA, 2024). In Brazil, the literature shows that *Agaricus bisporus, Agaricus brasiliensis* and *Pleurotus* species, among others, dominate production due to the discovery of their medicinal and culinary value (AKCAY et al., 2023; BARBOSA et al., 2023).

The cultivation of mushrooms allows the generation of food, in addition to being a model of exploitation of residual lignocellulosic biomass mediated by an efficient continuous flow process that can be carried out even in closed environments, requiring significantly smaller land areas than most other crops (MARTÍN et al., 2023). In recent decades, this activity has aroused the interest of entrepreneurs and scientists since mushrooms are organisms with the potential to contribute to agricultural production, research, pollution control, waste management, medicine, economy, whilst also being a source of protein (HAUKONGO et al., 2021; DE BRITO et al., 2023).

The diffusion of mushroom cultivation has occurred worldwide, a factor that has promoted a significant increase in production since 2010 (KUMLA et al., 2020). The technologies of cultivation of edible mushrooms involving the use of lignocellulosic residues are the result of agricultural production in Brazil, among which stand out substrates such as sugarcane, soy and corn (DE BRITO et al., 2023).

Data from scientific investigations carried out in the Amazon have shown that cupuaçu exocarp (*Theobroma grandiflorum* Willd ex-Spreng Schum) and residues from the processing of açai (*Euterpe oleracea* Mart) are also potential lignocellulosic residues that can be used in the production of *Lentinus citrinus* and *Pleurotus* species (SILVA NEVES, 2014; MACHADO, 2016; CASTILLO, 2018; BARBOSA et al., 2020).

Among the various processes used for growing edible mushrooms, the technique of using sterilized substrate in polyethylene bags allows one to grow quality products (ATILA, 2019; HAUKONGO et al., 2021; INDRATMI et al., 2024).

Solid state fermentation continues to be the main technology used for mushroom production, at a commercial level. It is a bioprocess that uses mixtures of lignocellulosic materials to supply nutritional deficiencies. From this process, at the end of fermentation, SMS (spent mushroom substrate) is produced, and it is a by-product of cultivation that contains residual nutrients that pollute the atmosphere and, if incorrectly disposed of as waste, there is a potential of ecosystem contamination. Therefore, further treatment and use of SMS are essential (KUMAR et al., 2021; RAVLIKOVSKY et al., 2024). Commonly, at the end of the fermentation process, after harvest, mushroom crop residues (SMS) are disposed of locally, either by spreading them on the ground or sending them to a landfill site. Waste prevention has top priority in order to manage them sustainably, thus reuse or recycling can be an effective way to handle this solid waste (OWAID et al., 2017).

In many countries, the substrates that remain after harvesting the mushrooms are often be discarded as waste and become environmental pollutants. As a solution, the feasibility of reuse as an ingredient for growing new mushrooms is recommended (ASRHAFI et al., 2014; OWAID et al., 2017; THAKUR et al., 2022; RAVLIKOVSKY et al., 2024). In addition to providing soil corrective effect, it acts as a bioremediation agent and a substrate for the production of other renewable energies, such as biogas, bioethanol, biohydrogen and biooil. (PHAN et al., 2012; BARBOSA et al., 2020; KUMAR et al., 2021).

Given the medicinal and nutritional importance of edible mushrooms, the need for treatment and the additional use of residues, this research presents the results for the reuse of post-cultivation residues (SMS from the production of *P. albidus* and conventional forest residues) for new crops of *P. albidus*.

Materials and Methods

Mushrooms

Pleurotus albidus DPUA 1692 was the edible mushroom species investigated in this study. To obtain the filamentous phase of *P. albidus* DPUA 1692, conceded by the DPUA collection of cultures at the Federal University of Amazonas (UFAM), was grown on GYP agar [g/L (agar 15.0 glucose 20.0, yeast extract 5 g, peptone 15 g and distilled water 1,000 mL)], pH 6.5. The culture medium was sterilized at 121 ºC for 15 minutes. All cultures were prepared in triplicate in a Petri dish. During the growth of the mushrooms, the cultures were kept at 25 ºC for 8 days. The cultures were stored at 4 °C for subsequent preparation of viable ones and use in the experiments. The basidiomata were collected and counted individually. They were weighed on an analytical balance (0.001g precision). The width and length of the pileus and stipe were measured using a caliper.

Production of *P. albidus* spawn

The spawn was prepared according to MACHADO (2017) and FONSECA et al. (2015). The wheat grains were washed, pre-cooked for 15 minutes and supplemented with calcium carbonate 0.3% (w/v, wet basis). Each spawn was formulated with 100 g of pre-cooked grains, stored in 20.3 cm x 17.8 cm high-density polyethylene bags. The bags with the grains were sterilized at 121 °C for 15 minutes. After cooling, mycelial discs with a diameter of 3 mm were inoculated on the surface of the wheat grains after removal from the cultures in GYP. The cultures were kept at 28 °C, in the absence of light until complete myceliation of the grains.

Cultivation of *P. albidus* in lignocellulosic residues

The production of *P. albidus* was performed as cited by FONSECA et al. (2015) and BARBOSA et al. (2020). The mixture of lignocellulosic residues was composed of cupuaçu exocarp (*Theobroma grandiflorum* Willd ex-Spreng Schum) and residues from the processing of açai (*Euterpe oleracea* Mart) or post-cultivation residue (SMS), with the addition of calcium carbonate 0.3% (w/v, wet basis). The formulations in different concentrations, supplemented with rice bran, on a wet basis, are listed in Table 1.

Table 1. Experimental Trial for production of *P. albidus* with reuse of post-cultivation substrate (SMS) in different concentrations

Experiments	Substrate + Supplement	%
Standard 1	Cupuaçu exocarp + Rice bran	80:20
Standard 2	Açaí processing residues + Rice bran	80:20
Standard 3	SMS + Rice bran	80:20
ET1	Cupuaçu exocarp + SMS + Rice bran	40:40:20
ET2	Cupuaçu exocarp + SMS + Rice bran	45:40:15
ET3	Cupuaçu exocarp + SMS + Rice bran	50:40:10
ET4	Açaí processing residues + SMS + Rice bran	40:40:20
ET5	Açaí processing residues + SMS + Rice bran	45:40:15
ET6	Açaí processing residues + SMS + Rice bran	50:40:10

Abbreviations: ET: Experimental Test; SMS: Post-cultivation substrate. Source: Authors (2023).

The cultivation of the mushrooms was carried out for eight days, in the absence of light at 25 ºC, with 80% ambient humidity. After 72 hours, 2 cm perforations were made in the polyethylene bags and the cultures were kept in similar conditions until complete mycelialization of the substrate and development of the primordium. With the appearance of the primordium, the cultures were exposed to diffuse light every 12 hours at 15 ºC, for three days, until basidiomata formation. The mature basidiomata were harvested and stored in Styrofoam® trays wrapped in flexible PVC, with a capacity of 250 g of product for the nutritional composition analysis.

The calculations of productivity (P), biological efficiency (BE) and production rate (PR) were determined based on Equations 1 to 3. The loss of organic matter from the substrate (LOM) was determined based on the weight of non-dehydrated residues (Equation 4) (FONSECA *et al.,* 2015).

BIOLOGICAL EFFICIENCY (BE) =

$$\frac{Mushroom\ mass\ (wet\ basis)}{Substrate\ mass\ (dry\ basis)} x\ 100 \qquad \text{Eq.1}$$

PRODUTIVITY (P) =

$$\frac{Mushroom\ mass\ (dry\ basis)}{Substrate\ mass\ (dry\ basis)} x\ 100 \qquad \text{Eq.2}$$

PRODUCTION RATE (PR) =

$$\frac{Biological\ Efficiency\ (g)}{Total\ number\ of\ growing\ days} x\ 100 \qquad \text{Eq.3}$$

$$LOM = \frac{Weight\ of\ mycelial\ substrate\ (g)}{Initial\ weight\ of\ substrate\ (g)} x\ 100 \qquad \text{Eq.4}$$

Determination of the physicochemical characteristics of the biomass of *P. albidus*

The basidiomata of *P. albidus* were analyzed for moisture, lipids, protein, ash and carbohydrates. Moisture was determined by dehydration in a forced air circulation oven at 40 °C to obtain a constant weight, according to AOAC (2006). The protein fraction analysis was performed using the micro Kjeldahl method (AOAC, 2006), using the factor 4.38. Lipid quantification was performed using the Bligh and Dyer method (1959). The ash was determined by incineration of the material in a muffle furnace at 550-660 °C until a constant weight was obtained, according to AOAC (2006). Crude fiber was obtained through acid-base digestion, according to the Weende method, established by AOAC (2006). Total carbohydrates were estimated by difference (100 g - total grams of moisture, protein, lipids and ash) and total energy was calculated using the Atwater conversion factor, both recommended by NEPA (2006)

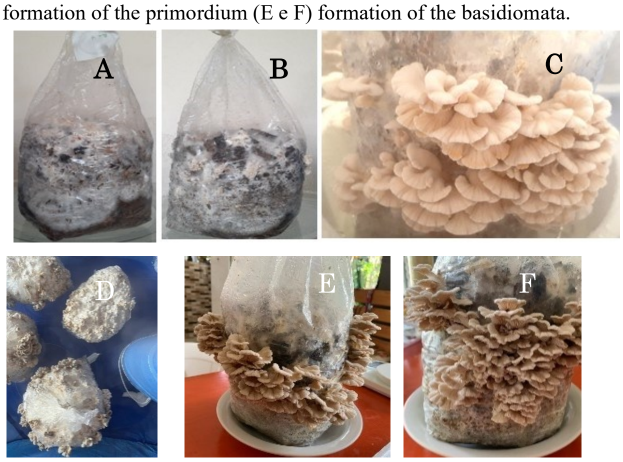
Statistical analysis

The results were submitted to statistical analysis using MiniTab, version 19.0. Descriptive tests (means), ANOVA and Tukey were used in the calculations, with 5% significance.

Results and Discussion

In this study, we investigated the production of *Pleurotus albidus*, a species of edible mushroom that colonizes ecosystems in the Amazon. The data obtained from the production of *P. albidus* are presented in Table 2. The results showed the development of P. albidus mycelial mass on all substrates; however, each substrate exhibited a characteristic development cycle. On average, the myceliation period for each substrate mixture was 14 days, while the development of the primordium to basidiomata formation took 13 days, and the basidiomata maturation period lasted 3 days.

Figure 1. Production of *P. albidus* in cupuaçu exocarp + SMS + rice bran and Açaí processing residues + SMS: (A e B) substrate myceliation; (D) formation of the primordium (E e F) formation of the basidiomata.



Souce: Authors (2023)

Table 2. Mean values of the characteristics and total yield of *P. albidus* grown in cupuaçu exocarp and in residues from the processing of açaí

Variables	Number of Basidiomata	Weight (g)	Biological Efficiency (%)	Produtivity (%)	Loss of Organic Matter - LOM	Production Rate (%)	Cap Width	Cap length	Stem length
P1	76±0,4^{f}	83±0,4^{f}	8,31 ±0,4^{e}	1,30 ±0,4^{f}	126,15±1,75^{c}	0,27 ±0,4^{e}	3,55 ±0,4^{i}	2,45 ±0,4^{h}	0,63 ±0,4^{f}
P2	50±0,4^{h}	74±0,4^{h}	7,41 ±0,4^{g}	1,32 ±0,4^{e}	125,20±1,60^{c}	0,24 ±0,4^{h}	4,54 ±0,4^{c}	0,63 ±0,4^{i}	1,01 ±0,4^{c}
P3	85±0,4^{e}	98±0,4^{e}	9,81 ±0,4^{d}	1,52 ±0,4^{d}	135,50±7,80^{b}	0,32±0,4^{d}	4,52±0,4^{g}	2,32±0,4^{g}	0,61±0,4^{e}
ET1	50± 2,5^{g}	75± 38^{g}	7,53 ±2,2^{f}	1,20 ±1,9^{g}	125,25±4,15^{c}	0,25 ±8^{f}	3,73 ±0,8^{h}	2,91 ±0,4^{e}	0,32 ±0,3^{i}
ET2	112± 2,8^{b}	148 ± 54^{b}	14,80±3,1^{a}	2,33 ±2,1^{a}	151,70±0,70^{a}	0,49 ±14^{a}	4,01±0,8^{f}	3,01±0,6^{c}	0,51±0,4^{h}
ET3	90±0,4^{c}	103 ±0,4^{c}	10,31±0,4^{b}	1,52 ±0,4^{c}	151,70±1,70^{a}	0,34 ±0,4^{c}	4,32 ±0,4^{e}	2,92 ±0,4^{d}	1,23 ±0,4^{b}
ET4	88± 2,5^{d}	102 ± 38^{d}	10,21±2,2^{c}	1,81 ±1,9^{b}	126,85±0,35^{c}	0,34 ±8^{b}	6,23 ±0,8^{a}	3,51 ±0,4^{a}	0,62 ±0,3^{d}
ET5	38± 2,8^{i}	72 ± 54^{i}	7,23 ±3,1^{h}	1,11 ±2,1^{h}	148,86±0,54^{a}	0,24 ±14^{g}	4,23 ±0,8^{d}	2,52 ±0,6^{f}	0,52 ±0,4^{g}
ET6	120±0,4^{a}	151 ±0,4^{a}	5,11 ±0,4i	1,00 ±0,4^{i}	134,25±4,03^{c}	0,17 ±0,4^{i}	4,51 ±0,4^{b}	3,01 ±0,4^{b}	1,01 ±0,4^{a}

Source: Authors, 2023. Abbreviations: **P1**: Cupuaçu exocarp + Rice bran [800:200]; **P2:** Açaí processing residues + Rice bran [800:200]; **P3:** SMS + Rice bran [800:200]. **ET1:** Cupuaçu exocarp + SMS + Rice bran [(400:400:200)]; **ET2:** Cupuaçu exocarp + SMS + Rice bran [450:400:150]; **ET3**: Cupuaçu exocarp + SMS + Rice bran [500;400;100]; **ET4:** Açaí processing residues + SMS + Rice bran [g (400:400:200)]**; ET5:** Açaí processing residues + SMS + Rice bran [450:400:150]**; ET6:** Açaí processing residues + SMS + Rice bran [500;400;100]**;**
Means followed by the same letters in the columns did not differ from one another by the Tukey's test ($\rho < 0.05$).

Table 3. Centesimal composition of *P. albidus* basidiomata produced in the substrate mixture supported by cupuaçú exocarp or in residues from the processing of açaí

Variables (%)	Moisture	Lipids	Proteín	Ash	Fiber	Carbohydrates	Caloric Value (Kcal)
P1	9,16±0,02^{a}	2,54±0,08^{d}	2,71±0,06^{i}	3,75±0,03^{g}	2,92±0,4^{e}	78,95±0,4^{d}	361±0,03^{d}
P2	5,52±0,02^{g}	3,13±0,06^{c}	4,59±0,08^{e}	9,03±0,03^{c}	3,74±0,08^{a}	74,73±0,4^{i}	357±0,03^{f}
P3	8,55±0,3^{e}	2,08±0,04^{f}	6,82±0,07^{b}	4,11±0,4^{e}	3,20±0,08^{c}	75,51±0,03^{h}	359±0,07^{e}
ET1	8,28±0,03^{f}	0,42±0,5^{i}	3,43±0,04^{f}	3,28±0,03^{i}	2,01±0,5^{i}	82,64±0,02^{a}	355±0,06^{g}
ET2	8,65±0,02^{d}	2,08±0,03^{e}	3,12±0,05^{h}	3,68±0,06^{h}	2,62±0,4^{g}	79,89±0,3^{c}	361±0,03^{c}
ET3	9,06±0,05^{c}	1,03±0,4^{h}	3,33±0,03^{g}	3,79±0,08^{f}	2,40±0,08^{h}	80,42±0,5^{b}	353±0,02^{h}
ET4	3,39±0,03^{h}	4,44±0,04^{a}	6,43±0,5^{d}	8,67±0,03^{d}	2,99±0,5^{d}	77,07±0,02^{f}	374±0,06^{a}
ET5	3,29±0,02^{i}	3,44±0,05^{b}	6,47±0,03^{c}	9,50±0,06^{b}	3,69±0,03^{b}	77,30±0,3^{e}	366±0,03^{b}
ET6	9,06±0,05^{b}	1,76±0,03^{g}	7,42±0,4^{a}	10,39±0,08^{a}	2,72±0,4^{f}	76,61±0,5^{g}	351±0,02^{i}

Source: Authors, 2023. Abbreviations: **P1**: Cupuaçu exocarp + Rice bran [800:200]; **P2:** Açaí processing residues + Rice bran [800:200]; **P3:** SMS + Rice bran [800:200]. **ET1:** Cupuaçu exocarp + SMS + Rice bran [(400:400:200)]; **ET2:** Cupuaçu exocarp + SMS + Rice bran [450:400:150]; **ET3**: Cupuaçu exocarp + SMS + Rice bran [500;400;100]; **ET4:** Açaí processing residues + SMS + Rice bran [g (400:400:200)]**; ET5:** Açaí processing residues + SMS + Rice bran [450:400:150]**; ET6:** Açaí processing residues + SMS + Rice bran [500;400;100]**;**
Means followed by the same letters in the columns did not differ from one another by the Tukey's test ($\rho < 0.05$).

The number of basidiomata varied among the substrate mixtures, with ET5 (açaí processing residue [45] + SMS [40] + rice bran [15]) demonstrating a lower number of basidiomata (68.33%) compared to the significant number (120 basidiomata) observed in ET6 (açaí processing residue [50] + SMS [40] + rice bran [10]).

In the ET5 substrate (açaí processing residue [45] + SMS [40] + rice bran [15]), lower biomass (52.32%) was observed compared to the significant value (151 g) determined in ET6 (açaí processing residue [50] + SMS [40] + rice bran [10]). The results presented in Table 2 demonstrate that P. albidus achieved significant values for Biological Efficiency, Productivity, and Production Rate (148%, 23%; 0.49%) when produced on ET2 (cupuaçu exocarp [45] + SMS [40] + rice bran [15]). It can be inferred that the addition of SMS to the substrate mixture contributed positively to the development of P. albidus under the evaluated cultivation conditions, reducing production costs and enhancing sustainability by utilizing clean technologies for food production.

Regarding the loss of organic matter, significant values were determined in ET2, ET3, and ET5, respectively. The basidiomata of P. albidus exhibited different shapes, with significant characteristics observed (cap width, cap length, and stem length) when grown on açaí processing residues and cupuaçu exocarp with SMS. A smaller size was recorded in the other substrates (Table 3). In substrate mixtures, the dimensions of the basidiomata were significant in ET4 (açaí processing residue [40] + SMS [40] + rice bran [20]) and ET6 (açaí processing residue [50] + SMS [40] + rice bran [10]).

In these substrates, ET5 (açaí processing residue [45] + SMS [40] + rice bran [15]) also showed lower biomass (52.32%) when compared to the significant value (151g) observed in ET6 (açaí processing residue [50] + SMS [40] + rice bran [10]). The results presented in Table 2 demonstrate that P. albidus achieved significant values for Biological Efficiency, Productivity, and Production Rate (148%, 23%; 0.49%) when produced in ET2 (cupuaçu exocarp [45] + SMS [40] + rice bran [15]). It can be inferred that the addition of SMS to the substrate mixture contributed positively to the development of P. albidus under the evaluated cultivation conditions, reducing production costs and promoting sustainability through the use of clean technologies for this food production.

Several techniques can be used for mushroom cultivation to produce high-quality products. However, the use of sterilized substrates in polyethylene bags and the utilization of regionally available organic materials facilitate mushroom production, supporting strategies for commercial purposes (INDRATMI et al., 2024). Research has demonstrated the effectiveness of cupuaçu exocarp and other organic substrates available in various ecosystems of the Amazon, which are viable for mushroom growth and bioactive compound production

(COELHO et al., 2022; PIMENTA et al., 2021). Additionally, the data provided by Souza et al. (2021) showed that the biomass of mushrooms produced on these substrates exhibited nutritional characteristics that can enhance food products due to their significant fiber content (14.23%), protein (8.61%), and minerals (5.26%).

The results presented in Table 3 show that the addition of SMS to the substrate mixture using cupuaçu exocarp or açaí processing residue for P. albidus production resulted in the growth and production of basidiomata (Figure 1) with relevant nutritional characteristics. In these substrates, on a dry basis, the nutrient content of P. albidus biomass varied according to the concentration and composition of the substrate mixtures.

Among the mixtures listed in Table 3, those containing açaí processing residue predominated in the biomass of P. albidus, with significant lipid content (4.44%), protein (7.42%), ash (10.39%), and carbohydrates (77.30%). In the cupuaçu exocarp, only the carbohydrate content (82.64%) was significant. Among the mixtures with SMS and rice bran or without SMS, significant moisture content (91.6%) and fiber (3.74%) were observed, respectively. This variation in centesimal composition may be related to the composition of the substrates used for the cultivation of P. albidus (LACERDA, 2021; RODRIGUES; OKURA, 2022). Besides influencing the nutritional content, appropriate substrates for mushroom cultivation impact production costs, cultivation time, biological efficiency, and yield (HAUKONGO et al., 2021).

Considering the above, edible mushrooms can be consumed fresh or as supplements with other foods, given their relevant protein content and low lipid content compared to animal protein and other vegetable sources. Their use in diets may help prevent cardiovascular diseases, type 2 diabetes (DM2), and other chronic diseases (CRISPIM, 2023).

According to the Brazilian Food Composition Table (TBCA, 2013), 100g of beef contains, on average, 15g of protein, while the mushrooms studied showed an average of 7g of protein per 100g. Since the cultivation method is sustainable, owing to the reintroduction of SMS in the production chain for new crops, the principles of the circular economy are evident when evaluating this bioprocess. The basidiomata also present an optimal amount of protein when compared to conventional production cycles without the addition of SMS (PIMENTA, 2021; MACHADO, 2017).

Mushrooms are food products that contribute nutrients to diets, including proteins, vitamins, minerals, fibers, and more. In the Amazonian ecosystems, various mushroom species colonize different organic substrates, providing viable products that foster economic development, either as food or in other industrial sectors, especially pharmaceuticals, for producing bioactive compounds. Therefore, new production strategies and adaptations for native edible mushroom species are essential activities, contributing to the generation of knowledge, meeting nutritional and health demands, and creating new employment and income opportunities for local populations. Supporting this context, Kirsch (2016) demonstrated that P. albidus biomass can be used as food or as a supplement for developing new food products, offering positive health effects for the population

Conclusion

The results showed the development of the mycelial mass and basidiomes of *Pleurotus albidus* in all the substrates evaluated; however, the characteristics of the residues (cupuaçu exocarp and residues from açaí processing with or without addition of SMS) influence the development cycle of the mushroom. Nutritionally, the low fat content and high protein content constitute the biomass from the mushrooms developed in formulations containing residues from the processing of açai mixed with SMS. Furthermore, the technological process used for *in vitro* growth of *P. albidus* is viable for production of this species of edible mushroom.

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