Growth of different strains of *Pleurotus ostreatus* in lignocellulosic biomasses

**Crescimento de diferentes linhagens de *Pleurotus ostreatus* em biomassas lignocelulósicas**

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**ABSTRACT**

Agro-industrial waste has been widely applied in bioprocesses, among which fungiculture has been highlighted for its ability to transform waste into value-added products. Thus, this study observed two strains (474 and 572) of *Pleurotus ostreatus* when cultivated in residues of pineapple crown, açaí seeds and mixture of pineapple crowns and açaí seeds, and evaluated the colonization of the substrates, formation of structures and quantity of mushrooms produced. In all the substrates, it was possible to observe complete colonization, with the emergence of primordia up to 20 days. In the treatments with the 474 strain, only in the pineapple crown substrate were there three flushes of production, while in the açaí seeds and pineapple crowns and açaí seeds, there were only two flushes. As for strain 542, all treatments showed three flushes. The pineapple crown substrate provided greater production of basidiocarps (fresh mass) in strains 474 and 542. Therefore, the capacity of adaptation and development of *P. ostreatus* strains in different substrates was evidenced, since mushrooms were produced with characteristics similar to those reported in the literature.

**Keywords:** Basidiocarps; Oyster mushrooms; Agro-industrial residues.

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**RESUMO**

Os resíduos agroindustriais têm sido amplamente aplicados em bioprocessos, dentre os quais a fungicultura tem se destacado por sua capacidade de transformar resíduos em produtos de valor agregado. Assim, este estudo observou duas linhagens (474 e 572) de *Pleurotus ostreatus* quando cultivadas em resíduos de coroa de abacaxi, sementes de açaí e mistura de coroas de abacaxi e sementes de açaí, e avaliou a colonização dos substratos, formação de estruturas e quantidade de cogumelos produzidos. Em todos os substratos, foi possível observar colonização completa, com surgimento de primórdios até 20 dias. Nos tratamentos com a linhagem 474, apenas no substrato de coroa de abacaxi houve três fluxos de produção, enquanto no substrato de açaí e coroas de abacaxi e sementes de açaí, houve apenas dois fluxos. Quanto à linhagem 542, todos os tratamentos apresentaram três fluxos. O substrato de coroa de abacaxi proporcionou maior produção de basidiocarpos (massa fresca) nas linhagens 474 e 542. Portanto, evidenciou-se a capacidade de adaptação e desenvolvimento de linhagens de *P. ostreatus* em diferentes substratos, uma vez que foram produzidos cogumelos com características semelhantes às relatadas na literatura.

**Palavras-chave:** Basidiomas; Cogumelo ostra; Resíduos agroindustriais.

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INTRODUCTION

Lignocellulosic biomass is the most abundant, low-cost, renewable and energy-dense raw material. It is underutilized and often there is no adequate treatment for its final destination (VU et al., 2020). Lignocellulosic biomasses are residues from agricultural and/or industrial processes that have little or no sustainable way of using them, and they contribute to a huge fraction of the stream of urban solid waste, especially in underdeveloped countries (SADH; DUHAN; DURAN, 2018; OMRAN; BAEK, 2022). Thus, these bio-residues are an alternative for use as a carbon source and growth substrate for mushroom cultivation (ZAKIL et al., 2022).

Of the variety of microorganisms capable of degrading lignocellulosic material, white-rot fungi stand out, since they are widely reported for their ability to degrade various structures of plant cell walls (BARI et al., 2015). Pleurotus ostreatus (Jacq.:Fr.) Kumm., a white-rot basidiomycete fungus, also known as oyster mushroom, is one of the most popular edible mushrooms in Brazil and worldwide (SILVA et al., 2019; ZIED et al., 2019). This mushroom is flexible in terms of growing conditions, and is able to grow in a wide variety of substrates, different types of climates and in installations that do not require strict environmental control when compared to other species of mushrooms (CARRASCO-GONZÁLEZ et al., 2017; SARDAR et al., 2017).

In this sense, the objective of this study was to evaluate the development of two strains of Pleurotus ostreatus, when cultivated in pineapple crowns (PC), açaí seeds (AS), and a mixture of PC + AS, aiming at the valorization of different lignocellulosic biomasses as cultivation substrates for mushroom production.

MATERIAL AND METHODS

Biological Material

Two strains of Pleurotus ostreatus (474 and 542) were acquired from the Collection of Microorganisms of Agrosilvicultural Interest, from the Instituto Nacional de Pesquisas da Amazônia (INPA). Strain 474 corresponds to a P. ostreatus isolated in the Amazon and strain 542 corresponds to a commercial strain from mushroom producers in São Paulo. Açaí seed (Euterpe precatoria Mart) and pineapple crown (Ananas comosus) residues were acquired from street markets in the city of Manaus, AM, Brazil (3° 06’ 06” S, 60° 01’ 29” W). These materials were dried, crushed and stored in plastic bags at room temperature (±27 °C).

Mushroom cultivation

For the preparation of the spawns of each cultivation substrate, fungal mycelium discs from Petri dishes with potato-dextrose-agar (PDA) medium were transferred to flasks containing
78% pineapple crowns, 78% açaí seeds or pineapple crowns + açaí seeds (1:1 w/w), 20% of a mixture of bran (rice, wheat and corn in the proportion 60:20:20 w/w/w, respectively) and 2% of CaCO$_3$ (78:20:2 w/w/w), previously autoclaved at 121 ºC. After incubation of theses flasks (25 ºC) and growth of these fungi, 5% of the spawn was transferred to culture bags, prepared with the same formulation as the spawn, and incubated at 25 ºC, 90% humidity and a photoperiod of 12 hours after colonization (AGUIAR et al., 2022).

Evaluation of basidiocarp production

The strains of *P. ostreatus* (474 and 542) cultivated in substrates based on pineapple (PC), açaí seeds (AS) and in their mixture (PC + AS) were monitored daily for 120 days. The colonization of substrates, emission of primordia and basidiocarp formation were photographed throughout the cultivation. All basidiocarps were weighed and the fresh mass of all the mushrooms produced among the evaluated combinations (strains and substrates) was calculated to obtain the productive parameter.

RESULTS AND DISCUSSION

When cultivated on substrates based on pineapple, açaí seeds and pineapple + açaí seeds, the *P. ostreatus* strains (474 and 542) completed the total colonization of the substrates in between 15 and 18 days, showing vigorous and whitish mycelia, which is typical of *P. ostreatus*. Vigor did not differ between substrates, and all showed mycelium that were densely adhered to the substrate and had a cottony texture (Figure 1).

The length of time required for complete colonization of the cultivation bags varied among the mushroom strains and substrates evaluated, with colonization being faster in the pineapple substrate in relation to the other substrates tested. Overall, strain 542 colonized substrates faster than strain 474, with some replicates completing colonization in around 15 days.

Melanouri *et al.* (2022a; 2022b) cultivated *Pleurotus ostreatus* and *Pleurotus eryngii* in 10 different agro-industrial residues and observed the influence of the fungus x substrate interaction, and complete colonization was obtained between 16 and 38 days for *P. ostreatus* and 26 to 60 days for *P. eryngii*. This demonstrates the precocity of *P. ostreatus* regarding myceliation in relation to the other species, which is a desired characteristic in a commercial cultivation, since the production time is shorter. Koutrotsios *et al.* (2017) studied 16 strains of *P. ostreatus* under the same conditions, using pasteurized wheat straw as a substrate, and all of them completed colonization in 18 days, similar to the results obtained in the present work.
Figure 1 – Colonization of cultivation substrates by different Pleurotus ostreatus strains (474 and 542) when cultivated in residues of pineapple, açaí seeds and a mixture of pineapple + açaí seeds.

Photos: Lorena Vieira Bentolila de Aguiar

Kazige et al. (2022) evaluated Pleurotus ostreatus when cultivated in corn, bean and cassava residues and obtained better results when the fungus was cultivated in a substrate based on corn residues and combined with cow manure as an additive. This demonstrates the importance of studying waste available close to where production occurs and the reuse of waste from harvesting and processing in the production of mushrooms, which can increase economic gains. Otieno et al. (2022) formulated substrates based on fruit residues and wheat straw as a control for the production of P. ostreatus and P. eryngii and observed that the use of fruit residues presented higher production in relation to the control, in addition to obtaining mushrooms with a higher content of antioxidants and phenolic compounds, which demonstrates the potential and possibility of using fruit residues in fungiculture.

The emission of the first primordia of the strains 474 and 542 in the pineapple, açaí seed and pineapple + açaí seed substrates were observed up to 20 days after the start of cultivation. The first primordia appeared in the cultivation bags of strain 542. The primordia formed by both strains showed similar morphological characteristics, particularly the coloration in shades of light gray and a “pinhead” shape (Figure 2).
Figure 2 – Primordia formation by the different *Pleurotus ostreatus* strains (474 and 542), when cultivated in pineapple, açaí seed and mixture of pineapple + açaí seed residues.

Photos: Lorena Vieira Bentolila de Aguiar

Otieno *et al.* (2022), when cultivating *Pleurotus sajor-caju*, *P. ostreatus* and *P. eryngii* in substrates with residues from mango, pineapple, orange, avocado, watermelon and banana, observed variation in primordia emergence time according to mushroom species and substrate used. Primordia were obtained in a shorter time (11 days) when *P. ostreatus* was cultivated on orange peel and *P. sajor-caju* cultivated on wheat straw (control). However, the longest time was observed when cultivating *P. sajor-caju* in mango and avocado peel, and *P. eryngii* in mango peel. These authors associated longer time to primordia formation to the constitutive antifungal properties of the fruit residues. However, the development of basidiocarps was faster on fruit peel-based residues, thus demonstrating the adaptability of mushrooms.

Melanouri *et al.* (2022b) observed that *P. ostreatus* strains, in addition to colonizing substrates before *P. eryngii* strains, also presented a shorter time interval (19-36 days) between inoculation and the emergence of primordia, when compared to *P. eryngii* strains. The latter required 40-57 days for primordia formation, which varied according to substrate and strain tested. Additionally, both showed “pinhead” primordia.
Koutrotsios et al. (2017) observed that although their 16 strains of *P. ostreatus* completed the colonization of the substrate in the same time interval when cultivated in a substrate based on pasteurized wheat straw, they differed in relation to the time of emergence of the first primordia and formation of basidiocarps. For 5 of the 16 studied strains, the emergence of primordia was observed between 20 to 26 days from the beginning of cultivation, while other strains took from 28 to 71 to emit the first primordia. In addition, after the emergence of primordia, there was a significant variation in the total time for basidiocarp production, ranging from 12 to 44 days.

During development, strains 474 and 542 lost their gray color and the conical shape of the cap (“pinhead” shape), resulting in the classical oyster/shell shape. This is widely reported in the literature and usually takes 2 to 4 days to complete development. Other characteristics inherent to this species, such as a laterally located stipe, formation of taller cap and a shorter stipe, were also observed. Furthermore, the basidiocarps showed a color that changed from light gray, in the period of emergence of the primordia, to a whitish color, becoming lighter during the maturation process (Figure 3).

**Figure 3** – Mature basidiocarps of different *Pleurotus ostreatus* strains (474 and 542), when cultivated in pineapple, açaí, and a mixture of pineapple + açaí residues.

Photos: Lorena Vieira Bentolila de Aguiar
The name *Pleurotus* derives from the Latin “pleuro”, which means “formed laterally” or “in a lateral position”, and this designation is related to the position of the stipe in relation to the cap and the attachment of the stipe to the substrate/wood (TÉLLEZ-TÉLLEZ; DIAZ-GODINEZ, 2019). Both the scientific name “*Pleurotus ostreatus***” and the common name “oyster mushroom” refer to the shape of the cap (pileus), which resembles the bivalve of the same name (DEEPALAKSHMI; MIRUNALINI, 2014).

Morphologically, *P. ostreatus* basidiocarps have a wide, fan/oyster-shaped cap, measuring from 5 to 25 cm, which varies according to age/collection time. As for the color, they can vary from white to gray. In addition, the edge of the mushroom cap is curled when the basidiocarp is young, and presents a smooth and lobulated/wavy appearance (DEEPALAKSHMI; MIRUNALINI, 2014). All these characteristics were observed during the development of the two *Pleurotus* strains, with a small variation in shape according to the growth substrate (Figure 3). These characteristics have also been reported in the literature (MELANOURI et al., 2022b).

The basidiocarps were produced and collected for about 4 months (23rd to 113th day of cultivation). All treatments with strain 542 (pineapple, açaí seeds, pineapple + açaí seeds) resulted in three production flushes, while strain 474 showed three flushes only when cultivated in pineapple crowns (PC). As for the quantity of mushrooms produced, strain 542 produced the highest quantity of mushrooms based on the total fresh mass of basidiocarps, and was about 2.5 times higher than the production of strain 474 (Figure 4). Each flush corresponds to a continuous period of production of basidiomes, with the end of a flush being characterized as the moment when production of basidiomes stops (BERNARDI; MINOTTO; NASCIMENTO, 2008), and a new flush is when a new continuous basidiome production occurs.

**Figure 4** – Total fresh mass (g) of basidiocarps produced by two strains of *Pleurotus ostreatus* (474 and 542), when cultivated in pineapple crown (PC), açaí seed (AS), and a mixture of pineapple crown + açaí seed residues.
Naim *et al.* (2020) investigated the development of *P. ostreatus* in substrates based on wheat straw and residual substrates from oyster mushroom cultivation, supplemented with nano urea as a source of N (3 and 5 g per kg of substrate). The authors obtained three production flushes in most treatments, which suggests that the flushes are related to the nutritional variation of the substrates. They also observed that the supplementation with nano urea accelerated or delayed the formation of primordia in the second flush, with intervals that varied from 3 to 8 days.

Regarding the influence of the substrates on the cultivation of different *P. ostreatus* strains, the PC-based substrate stands out for having the highest productivity values, while strain 542 showed a production of around 2 times higher than strain 474 (Figure 4). The second substrate with the highest production of basidiocarps was the PC + AS mixture, which also had higher values for strain 542; about 3 times higher than strain 474 (Figure 4).

Melanouri *et al.* (2022a, 2022b) obtained different productivity results according to the substrate used. *P. ostreatus* showed higher production in substrates based on wood shavings, corncob, rice husks, and the combination of barley straw and oats. While the coffee residue, corncob, and bagasse from olive oil processing showed the highest production for *P. eryngii*. The corncob substrate was efficient regardless of the fungus used. Thus, corroborating the data present in this study, the PC substrate was also the most efficient, regardless of the strain tested.

Zakil *et al.* (2022) used agricultural residues of palm oil, sugarcane and corn in substrate formulations with varying residue concentrations in the cultivation of *P. ostreatus* and observed that the mixtures of residues resulted in a better adjustment of nitrogen and carbon concentrations. The change in the C/N ratio in the cultivation substrates resulted in higher productivity of mushrooms.

Given the above, for a successful cultivation, both the development of basidiocarps and productivity are important factors. It is known that naturally occurring strains can offer a variety of genotypes that are already adapted to local conditions of cultivation, which causes the mushrooms to present variations in shape, color, texture and aroma during production. Thus, the selection of suitable substrates in combination with strains can affect fungal efficiency as well as mushroom composition, appearance and quality (MELANOURI *et al*., 2022a).

Both the strains in this study showed developmental characteristics in accordance with those reported in the literature for the species *Pleurotus ostreatus*, which highlights the potential of using local strains (in this case strain 474) in fungiculture, and this should be further investigated in order to increase their productivity.
CONCLUSIONS

The northern region of Brazil generates residual biomass that is still underutilized. Given this scenario, it is essential to search for new alternatives that add value to biomass from agriculture and industrial processing, and fungiculture is an alternative for increasing income and reducing environmental impacts. Thus, *P. ostreatus* showed the ability to adapt to and develop in different substrates, presenting morphological characteristics similar to those reported in the literature, which demonstrates the potential for mushroom cultivation in the region.

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REFERENCES

AGUIAR, L. V. B.; GOUVÊA, P. R. S.; OLIVEIRA JÚNIOR, S. D.; SALES-CAMPOS, C.; CHEVREUIL, L. R. Production of commercial and Amazonian strains of *Pleurotus ostreatus* in plant waste. *Brazilian Journal of Development*, v. 8, n. 6, p. 47299-47321, 2022. Disponível em: <https://doi.org/10.34117/bjdv8n6-299>. Acesso em: jul. 2022.

BARI, E.; NAZARNEZHAD, N.; KAZEMI, S. M.; Ghanbary, M. A. G.; MOHEBBY, B.; SCHMIDT, O.; CLAUSEN, C. A. Comparison between degradation capabilities of the white rot fungi *Pleurotus ostreatus* and *Trametes versicolor* in beech wood. *International Biodeterioration Biodegradation*, v. 104, p. 231 - 237, 2015. Disponível em: <https://doi.org/10.1016/j.ibiod.2015.03.033>. Acesso em: jul. 2022.

BERNARDI, E.; MINOTTO, E.; NASCIMENTO, J. S. Aproveitamento de resíduo de curtume como suplemento no cultivo de *Pleurotus ostreatus*. *Arquivos do Instituto Biológico*, v. 75, n. 2, p. 243-246, 2008. Disponível em: <https://doi.org/10.1590/1808-1657v75p2432008>. Acesso em: jul. 2022.

CARRASCO-GONZÁLEZ, J. A.; SERNA-SALDÍVAR, S. O.; GUTIÉRREZ-URIBE, J. A. Nutritional composition and nutraceutical properties of the *Pleurotus* fruiting bodies: potential use as food ingredient. *Journal of Food Composition and Analysis*, v. 58, p. 69-81, 2017. Disponível em: <https://doi.org/10.1016/j.jfca.2017.01.016>. Acesso em: jul. 2022.
DEEPALAKSHMI, K.; MIRUNALINI, S. *Pleurotus ostreatus*: an oyster mushroom with nutritional and medicinal properties. *Journal of Biochemistry and Technology*, v. 5, n. 2, p. 718-726, 2014. Disponível em: <https://jbiochemtech.com/storage/models/article/NG23jvirki6MsPU83nHuA6CbEMW8XcYx1abn0BuLtqBOKsnuWPknkyi9rj5/pleurotus-ostreatus-an-oyster-mushroom-with-nutritional-and-medical-properties.pdf>. Acesso em: jul. 2022.

KAZIGE, O. K.; CHUMA, G. B.; LUSAMBYA, A. S.; MONDO, J. M.; BALEZI, A. Z.; MAPATANO, S.; MUSHAGALUSA, G. N. Valorizing staple crop residues through mushroom production to improve food security in eastern Democratic Republic of Congo. *Journal of Agriculture and Food Research*, v. 8, p. 100285, 2022. Disponível em: <https://doi.org/10.1016/j.jafr.2022.100285>. Acesso em: jul. 2022.

KOUTROTSIOS, G.; KALOGEROPOULOS, N.; STATHOPOULOS, P.; KALIORA, A.; ZERVAKIS, G. I. Bioactive compounds and antioxidant activity exhibit high intraspecific variability in *Pleurotus ostreatus* mushrooms and correlate well with cultivation performance parameters. *World Journal of Microbiology and Biotechnology*, v. 33, p. 98, 2017. Disponível em: <https://doi.org/10.1007/s11274-017-2262-1>. Acesso em: jul. 2022.

MELANOURI, E. M.; DEDOUSI, M.; DIAMANTOPOULOU, P - a. Cultivating *Pleurotus ostreatus* and *Pleurotus eryngii* mushroom strains on agro-industrial residues in solid-state fermentation. Part I: Screening for growth, endoglucanase, laccase and biomass production in the colonization phase. *Carbon Resources Conversion*, v. 5, p. 61 - 70, 2022a. Disponível em: <https://doi.org/10.1016/j.crcon.2021.12.004>. Acesso em: jul. 2022.

MELANOURI, E. M.; DEDOUSI, M.; DIAMANTOPOULOU, P - b. Cultivating *Pleurotus ostreatus* and *Pleurotus eryngii* mushroom strains on agro-industrial residues in solid-state fermentation. Part II: Effect on productivity and quality of carposomes. *Carbon Resources Conversion*, v. 5, p. 52 - 60, 2022b. Disponível em: <https://doi.org/10.1016/j.crcon.2021.12.005>. Acesso em: jul. 2022.

NAIM, L.; ALSANAD, M. A.; SEBAALY, Z. E.; SHABAN, N.; FAYSSAL, S. A.; SASSINE, Y. N. Variation of *Pleurotus ostreatus* (Jacq. Ex Fr.) P. Kumm. (1871) performance subjected to different doses and timings of nano-urea. *Saudi Journal of Biological Sciences*, v. 27, p. 1573 - 1579, 2020. Disponível em: <https://doi.org/10.1016/j.sjbs.2020.03.019>. Acesso em: jul. 2022.

OMRAN, B. A.; BAEK, K. H. Valorization of agro-industrial biowaste to green nanomaterials for wastewater treatment: Approaching green chemistry and circular economy principles. *Journal of Environmental Management*, v. 311, p. 114806, 2022. Disponível em: <https://doi.org/10.1016/j.jenvman.2022.114806>. Acesso em: jul. 2022.

OTIENO, O. D.; MULAA, F. J.; OBIERO, G.; MIDIWO, J. Utilization of fruit waste substrates in mushroom production and manipulation of chemical composition. *Biocatalysis and Agricultural Biotechnology*, v. 39, p. 102250, 2022. Disponível em: <https://doi.org/10.1016/j.bcab.2021.102250>. Acesso em: jul. 2022.
SADH, P. K.; DUHAN, S.; DUHAN, J. S. Agro-industrial wastes and their utilization using solid state fermentation: a review. *Bioresourc Bioprocessing*, v. 5, p. 1, 2018. Disponível em: <https://doi.org/10.1186/s40643-017-0187-z>. Acesso em: jul. 2022.

SARDAR, H.; ALI, M. A.; ANJUM, M. A.; NAWAZ, F.; HUSSAIN, S.; NAZ, S.; KARIMI, S. M. Agro-industrial residues influence mineral elements accumulation and nutritional composition of king oyster mushroom (*Pleurotus eryngii*). *Scientia Horticulturae*, v. 225, p. 327 - 334, 2017. Disponível em: <https://doi.org/10.1016/j.scienta.2017.07.010>. Acesso em: jul. 2022.

SILVA, I. F.; LUZ, J. M. R.; OLIVEIRA, S. F.; QUEIROZ, J. H.; KASUYA, M. C. M. High-yield cellulase and LiP production after SSF of agricultural wastes by *Pleurotus ostreatus* using different surfactants. *Biocatalysis and Agricultural Biotechnology*, v. 22, p. 101428, 2019. Disponível em: <https://doi.org/10.1016/j.bcab.2019.101428>. Acesso em: jul. 2022.

TÉLLEZ-TÉLLEZ, M.; DIAZ-GODINEZ, G. Omic Tools to Study Enzyme Production from Fungi in the *Pleurotus* genus. *Bioresourc*, v. 14, n. 1, p. 2420-2457, 2019. Disponível em: <https://bioreources.cnr.ncsu.edu/resources/omic-tools-to-study-enzyme-production-from-fungi-in-the-pleurotus-genus/>. Acesso em: jul. 2022.

VU, H. P.; NGUYEN, L. N.; VU, M. T.; JOHIR, M. A. H.; MCLAUGHLAN, R.; NGHIEM, L. D. A comprehensive review on the framework to valorise lignocellulosic biomass as biorefinery feedstocks. *Science of The Total Environment*, v. 743, p. 140630, 2020. Disponível em: <https://doi.org/10.1016/j.scitotenv.2020.140630>. Acesso em: jul. 2022.

ZAKIL, F. A.; XUAN, L. H.; ZAMAN, N.; ALAN, N. I.; SALAHUTHEEN, N. A. A.; SUEB, M. S. M.; ISHA, R. Growth performance and mineral analysis of *Pleurotus ostreatus* from various agricultural wastes mixed with rubber tree sawdust in Malaysia. *Bioresource Technology Reports*, v. 17, p. 100873, 2022. Disponível em: <https://doi.org/10.1016/j.biteb.2021.100873>. Acesso em: jul. 2022.

ZIED, D. C.; PARDO-GIMÉNEZ, A.; OLIVEIRA, G. A.; CARRASCO, J.; ZERAIK, M. L. Study of waste products as supplements in the production and quality of *Pleurotus ostreatus* var. Florida. *Indian Journal Microbiology*, v. 59 p. 328 - 335, 2019. Disponível em: <http://dx.doi.org/10.1007/s12088-019-00805-1>. Acesso em: jul. 2022.

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