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Research Directions

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Recreating an Amazonian Ancestral Biodesign Technique

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Abstract

This study investigates an ancestral Biodesign technique associated with the fruits of the Amazonian tree *Crescentia cujete*. For centuries, Amazonian artisans have transformed these fruits into objects named cuias, which serve mainly as containers. Despite the continued practice of cuias production, a specific shaping technique discovered in historical accounts remains unknown and unused by contemporary artisans. The paper reports the recreation of this technique considering the ancestral ethos underpinning these traditions. A mixed-method approach has combined historical and museum research, direct interaction with trees in a bioeconomy context, and participatory observation of traditional artisans' production. The findings reveal the ancient practice of "Growing Design" with that tree and other practices that resonate with Biodesign, establishing a connection between this field and indigenous knowledge. This study highlights the underappreciation of indigenous objects and techniques, emphasizing the potential that emerges from understanding the alignment of certain ancestral wisdom with Biodesign principles, such as amplifying indigenous heritage and opening new possibilities in design.

Introduction

The late 20th and early 21st centuries witnessed the rise of numerous strategies that established a connection between product design and the natural world (Karana et al. 2010). This development arose from profound reflections within the design community regarding their role in the environmental crisis. Among these strategies is Biodesign, documented in 2012 by curator William Myers and defined by most scholars as the approach that integrates living organisms and their processes to generate alternative and "sustainable" materials or products, emphasizing environmental harmlessness (Camere & Karana, 2018; Collet, 2017; Diniz, 2023; Ertürkan et al. 2022; Karana, 2020; Myers, 2018).

Despite being perceived as contemporary, authors such as Ginsberg and Chieza (2018) argue that Biodesign has historical roots in practices such as the selective refinement of organisms, a concept deeply embedded in agriculture and animal husbandry. Acknowledging the possibility of Biodesign relating to ancient practices, and intending to find clear evidence of this connection in tangible objects, this study begins by associating traditional Amazonian objects with contemporary insights on Biodesign.

The cultural significance, fabrication process, and history of Cuias

Cuias (Figure 1), harvested from the *Crescentia cujete* tree (Figure 2) in the Amazon rainforest in Brazil, undergo an intricate artisanal process. These versatile objects serve various purposes, including food and drink containers, bathing tools, shovels, bags, cases, vases, and packaging (Bandoni, 2012). Their use is deeply rooted in the Brazilian indigenous tradition; they have become an integral part of the indigenous imaginary and have maintained their significance to this day (Gennari, 2011). From a design perspective, cuias exemplify objects with a low environmental footprint and a circular biological cycle, encapsulating Amazonian traditional ecological wisdom. In an era where ecological and regenerative principles are increasingly relevant in design, cuias serve as a noteworthy example deserving of further investigation.

Although cuias can be found serving as containers across various regions in Latin America, the artisanal techniques employed are significantly diverse. This study concentrates on the Amazonian region of Santarém, situated in northern Brazil, which has served as a prominent center for cuia production since ancient times and where the object is still intensely present. In that area, the Association of Riverside Craftswomen of Santarém (ASARISAN) played a pivotal role in securing recognition for the "Way of Making Cuias" as Brazilian Cultural Heritage in 2015.

Figure 1. Contemporary Amazonian cuias from the north of Brazil. *Source:* authors, 2024.

Figure 2. Amazonian *Crescentia cujete* or cuieira tree (left) and the fruit (right). *Source:* authors, 2022.

According to the documents utilized in cuia's heritage appreciation (Lima, 2015; Morais, 2015), the artisanal process involves harvesting mature cuia fruits, cutting them in half, removing the pulp, sun-drying the skins, sanding, and coating them with layers of natural resin. The painted cuias are then placed in a bed of sand and ashes sprinkled with human urine, which produces a black lacquered layer. The ornamentation is carved on this top layer, further enhancing cuia's appearance.

Moreover, cuias from the Santarém region have held the fascination of researchers for centuries, and the most comprehensive historical document regarding them is the naturalist Alexandre Rodrigues Ferreira's treatise *Memória sobre as Cuyas* (Memory about Cuias), from 1786 – it stands as the sole text from the Brazilian colonial period specifically dedicated to this object.

The present investigation focuses on a subset of cuia items, which can be called "cuia-de-gomos," (Figure 3) mentioned and collected by Ferreira in the Santarém region during the 18th century together with other items.[1] "Cuia-de-gomos" are no longer produced by contemporary cuia's craftswomen. The reasoning behind selecting these examples lies in their segmented shape and stable base, which implies human intervention in the cultivation of the fruit. This is akin to a current Biodesign technique referred to as "Growing Design," as we will expound next.

Biodesign and "Growing Design"

Myers and other authors (Esat & Ahmed-Kristensen, 2018; Karana, 2020; Mironov et al. 2009) foreshadow Biodesign as a potential paradigm shift or a new frontier in design, as it challenges

[1]Ferreira did not name them, but he mentioned these cuias are segmented – in Portuguese, "de gomos" (Ferreira, 1933).

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Figure 3. "Cuia-de-gomos" collected by Ferreira in the 18th century. *Source:* Hartmann, 1991 (part of the collection of the Museum Maynense at Lisbon Science Academy).

industrial practices by substituting mechanized and digitized processes with biological and biomimetic ones, relying on organic materials and aligning with principles of ecology and regeneration. Biodesign transforms manufacturing processes and reshapes the relationships between humans and other species, suggesting profound changes in the design field (Bandoni et al. 2023; Camere & Karana, 2018; Ginsberg & Chieza, 2018).

The diverse Biodesign authors provide very different diagrams and terminologies to explain its techniques. This study mainly focuses on the term "Biofabrication"(Collet, 2017), interpreting it differently than its original context in the medical field (Mironov et al. 2009) or healthcare (Pavlovich et al. 2016). To avoid potential misunderstandings, we adopt the term "Growing Design" (Camere & Karana, 2017) as an equivalent to "Biofabrication" in this study.

"Growing Design" is a Biodesign technique where designers interfere with the shapes of the growing organisms to create objects: their appearance is transformed, and they acquire new qualities. In this role, the designer acts as a cultivator, guiding the morphological evolution of materials through collaboration with natural organisms, predominantly bacteria, fungi, or algae (Collet, 2021). Typically conducted in laboratories for the control of variables, such as temperature or light, "Growing Design" positions living organisms as active participants or partners in the design process, marking a significant step in engaging with nonhuman entities (Bandoni et al. 2023). Camere and Karana (2018) highlight that the "alive" and "unpredictable" nature of organisms fundamentally alters the understanding of materials, the creative process, and the methodologies adopted by designers. They also provide examples of "Growing Design" applied beyond laboratories, involving plant roots and plant fruits (e.g., gourds).[2]

The correspondences of "Growing Design" and indigenous techniques become evident upon examination of the "cuia-de-gomos" (Figure 3). This study is predicated on the notion that a relationship between Biodesign and indigenous knowledge can be demonstrated through a thorough comprehension of the ancient cuia example, where the recreation of the object and its technique would be essential.

[2]It is relevant to highlight that gourd molding is a historically known practice in ancient Chinese culture (Siebert, 2020). The study of gourd molding influenced this article's experiments (Bandoni et al. 2023).

The recreation of ancient practices

The concept of reconstructing historical artifacts using modern resources is not novel. Museum conservation and archaeology are the disciplines most adept at employing reconstruction techniques, while contemporary designers typically lack training in understanding antiquated manufacturing methods or rediscovering techniques that are no longer used. The insight into the original appearance of objects or artworks, the experience of spaces, or even the taste of ancient food is a valued result of the reconstruction of ancient practices and an appreciation of the meaning, function, and operation of a historical object.

It is essential to distinguish between restoration, which involves working with an existing object, and recreation, which entails constructing an object from scratch. A compelling illustration of recreation is the *panis quadratus*, a type of Roman bread found exceptionally preserved in excavations at Pompeii. This discovery has enabled archaeologists, scholars, and bakers worldwide to reconstruct this particular bread and propose various methods for its historical production. For instance, a recent study by Cardenas et al. (2023) utilized classic written sources detailing bread-making practices, archaeological material culture from Pompeii, and traditional bread-making knowledge still prevalent in the Mediterranean region. This shows that an interdisciplinary approach to bioarchaeological records facilitates a comprehensive analysis of the object and can suggest new avenues for research.

Historian Pamela Smith has made significant contributions in this field, drawing on her collaboration with a practicing silversmith and conservator to reconstruct casting techniques outlined in a detailed 16th-century manuscript. Smith (2012) asserts that reconstruction offers a unique opportunity to simultaneously engage as both participant and observer, resulting in a type of knowledge that cannot be obtained in another way:

> Reconstruction also has another benefit for historians of the early modern period (and perhaps of all periods), for we scholars, steeped in text-based sources and trained from an early age in reading, writing, and propositional knowledge, actually may fail to understand the greater part of human experience in the preindustrial world, when most learning and knowledge was experiential and acquired by observation. (2012, p. 13)

In this investigation, reconstruction was utilized to validate the feasibility of a particular object technique's production and to juxtapose it with contemporary design strategies. While some practitioners acknowledge the antiquity of Biodesign, examples

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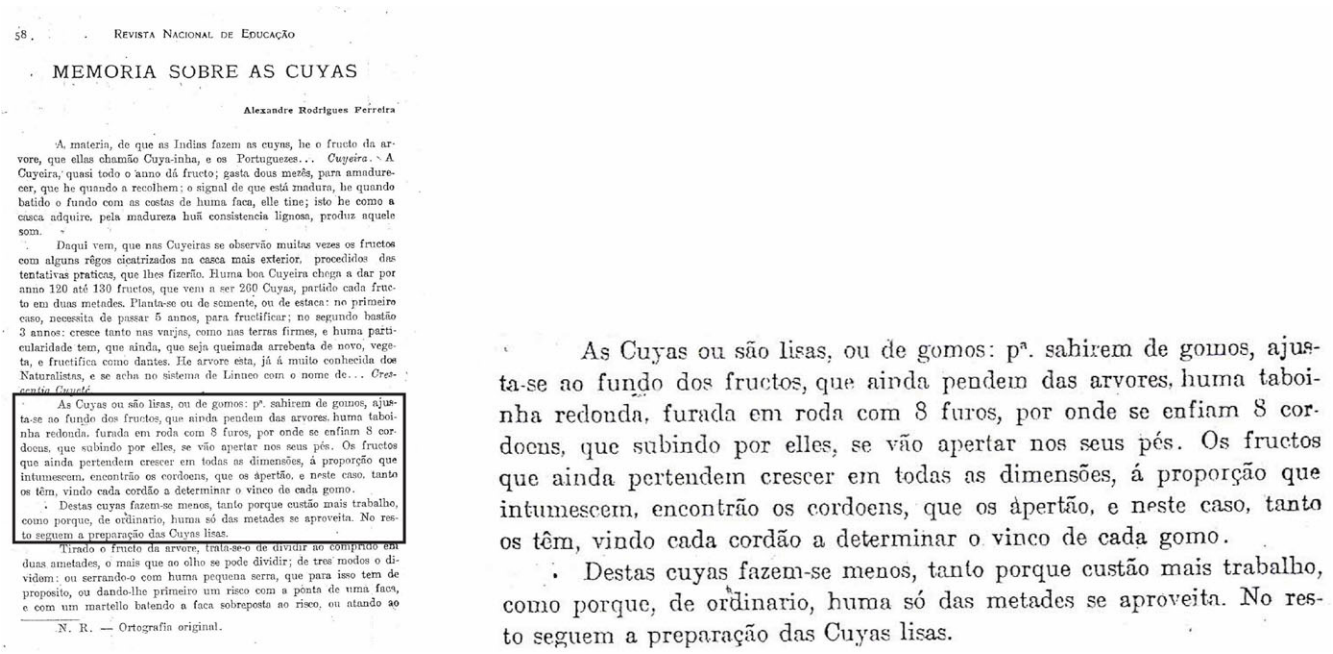

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MEMORIA SOBRE AS CUYAS

Alexandre Rodrigues Ferreira

A materia, de que as Indias fazem as cuyas, he o fructo da arvore, que ellas chamão Cuya-inha, e os Portuguezes... *Cuyeira*. A Cuyeira, quasi todo o anno dá fructo; gasta dous mezes, para amadurecer, que he quando a recolhem; o signal de que está madura, he quando batido o fundo com as costas de huma faca, elle tine; isto he como a casca adquire, pela madureza huã consistencia lignosa, produz aquele som.

Daqui vem, que nas Cuyeiras se observão muitas vezes os fructos com alguns rêgos cicatrizados na casca mais exterior, procedidos das tentativas praticas, que lhes fizerão. Huma boa Cuyeira chega a dar por anno 120 até 130 fructos, que vem a ser 260 Cuyas, partido cada fructo em duas metades. Planta-se ou de semente, ou de estaca: no primeiro caso, necessita de passar 5 annos, para fructificar; no segundo bastão 3 annos: cresce tanto nas varjas, como nas terras firmes, e huma particularidade tem, que ainda, que seja queimada arrebenta de novo, vegeta, e fructifica como dantes. He arvore esta, já á muito conhecida dos Naturalistas, e se acha no sistema de Linneo com o nome de... *Crescentia Cujeté*.

As Cuyas ou são lisas, ou de gomos: pª. sahirem de gomos, ajusta-se ao fundo dos fructos, que ainda pendem das arvores. huma taboinha redonda. furada em roda com 8 furos, por onde se enfiam 8 cordoens, que subindo por elles, se vão apertar nos seus pés. Os fructos que ainda pertendem crescer em todas as dimensões, á proporção que intumescem, encontrão os cordoens, que os apertão, e neste caso, tanto os têm, vindo cada cordão a determinar o vinco de cada gomo.

Destas cuyas fazem-se menos, tanto porque custão mais trabalho, como porque, de ordinario, huma só das metades se aproveita. No resto seguem a preparação das Cuyas lisas.

Tirado o fructo da arvore, trata-se-o de dividir ao comprido em duas ametades, o mais que no olho se pode dividir; de tres modos o dividem: ou serrando-o com huma pequena serra, que para isso tem de proposito, ou dando-lhe primeiro um risco com a ponta de uma faca, e com um martello batendo a faca sobreposta ao risco, ou atando ao

N. R. — Ortografia original.

As Cuyas ou são lisas, ou de gomos: pª. sahirem de gomos, ajusta-se ao fundo dos fructos, que ainda pendem das arvores. huma taboinha redonda. furada em roda com 8 furos, por onde se enfiam 8 cordoens, que subindo por elles, se vão apertar nos seus pés. Os fructos que ainda pertendem crescer em todas as dimensões, á proporção que intumescem, encontrão os cordoens, que os apertão, e neste caso, tanto os têm, vindo cada cordão a determinar o vinco de cada gomo.

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Figure 4. Digital copy of the first page of *Memória sobre as Cuyas* (1786) in Revista Nacional de Educação, n.6, 1933. The highlighted part refers to the making process of "cuia-de-gomos.".

often do not stem from tangible objects; nevertheless, the present study could provide such evidence.

Methods

It is pertinent to note that all researchers involved in this study are Brazilian, with two having Amazonian roots and residing in the city of Belém during the research period. The other two lived in Lisbon, with one possessing prior experience in conducting research in the Amazon region, and both receiving support from European institutions. Importantly, none of the researchers are members of the artisan community selected as the subject of study, which demanded ethical consideration throughout the research process. Despite not having worked with cuias previously, all authors regard the significance of these objects as part of Brazilian traditions and identity.

The investigation employed a mixed-method approach, including historical, archival, and museum artifact research, the "Growing Design" experiments with cuias, and the observation of traditional craftswomen. The synthesis of these research methods culminated in a comprehensive examination of the traditional technique, opening up a discussion on the combination of ancestral knowledge and Biodesign principles.

The following subsections provide detailed insights into the different methods. The first section is about the historical research and the selection of references. The second is about the experimental process, initiated with a preliminary phase involving the interpretation of Ferreira's 18th-century text about cuias and the recreation of the ancient mold, followed by a phase wherein experiments were conducted. The phase of experiments was concomitant to the interaction with craftswomen.

Historical, archival, and museum artifact research

According to anthropologists and art historians (Carvalho, 2011; Hartmann, 1991; Martins, 2017; Puglieri & Maccarelli, 2023), documented references to cuias date back to the late 17th century. While several texts mention details regarding the decoration and painting techniques of cuias, the only source to mention a distinct typology of shapes is Ferreira's report *Memória sobre as Cuyas* from 1786. Therefore, this text serves as the primary source for our study. Ferreira's expedition, known as "*Viagem Philosophica*" (1783–1972), not only documented cuias but also various other indigenous techniques and objects, collecting pieces that were subsequently transported to Portugal (Hartmann, 1991).

We accessed the original text through a digital copy of a Brazilian publication from 1933 (Figure 4). It offers valuable insights into historical cuia production, detailing various characteristics that document their artisanal production, including materials, tools, and techniques (Ferreira, 1933). Notably, the mention of "cuia-de-gomos" appears on the first page, accompanied by a brief description of the technique observed by Ferreira. Despite the text being written in archaic Portuguese, it remains comprehensible today.

The cuia pieces collected by Ferreira are housed in the Museum Maynense at the Lisbon Science Academy and in the Coimbra Science Museum[3] (Hartmann, 1991). We observed the "cuia-de-gomos" specimens featured in Figure 3 in Lisbon; however, we were unable to handle them, measure or take photographs.

Recreating the ancient mold for the "cuia-de-gomos" experiment

The museum artifacts and the description by Ferreira played pivotal roles in recreating the "cuia-de-gomos" mold. As a starting point, the mold design should be light and exceedingly uncomplicated, employing plant-based materials and modifying the cuia's shape by implementing segments and a stable base.

[3]Presently, cuia collections in Brazil primarily comprise specimens from more recent periods, from the 19th and 20th centuries onward. Examples of such collections can be found at the Museum of Archaeology and Ethnology of the University of São Paulo, the Institute of Brazilian Studies at the University of São Paulo, and the Museu Goeldi in Belém. Although we visited the latter institution, we did not encounter any "cuia-de-gomos" or cuias with other variations in shape among their holdings.

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Table 1. Materials utilized in the "cuia-de-gomos" experiments

Number of tests	Mold base material (diameter: 80 mm, thickness: 5 mm)	String material/ thickness
5	Plywood	Jute 3.5 mm
5	Plywood	Cotton 4 mm
4	Plywood	Sisal 4 mm
4	Acrylics	Cotton 4 mm
2	Acrylics	Jute 3.5 mm

Ferreira's description of the "cuia-de-gomos" mold specifies using a circular wooden board featuring eight apertures affixed to the underside of the still-hanging fruits. Moreover, the description mentions cords threaded through these apertures, connecting them to the fruit.

The experiments were carried out as part of the "Cuia Colab" startup project, within a bioeconomy innovation initiative in the Amazon region promoted by SEBRAE, a Brazilian governmental institution related to the support of small entrepreneurs.

To commence the experiment, six *Crescentia cujete* trees located within the campus of Pará Federal University in Belém, Amazon, were selected to be part of the experiment. From July 2022 to May 2023, a total of 20 tests aimed at recreating the "cuia-de-gomos" were conducted, along with other experiments related to "Growing Design" (mentioned in Bandoni et al. 2023). Each test was numbered and tracked, with detailed notes and photographs digitally organized (accessible in the supplementary materials section).

We then conducted measurements on mature fruits to establish their average size, focusing on both the width and length of the fruit sphere (average dimensions were W: 51.3 cm/L: 50.75 cm). To fabricate the molds, we utilized these proportions as a reference, producing boards through laser-cutting techniques measuring 80 mm in diameter and 5 mm in thickness (Figure 5). The boards featured six apertures, aligning with the observed "cuia-de-gomos." Additionally, we explored alternative materials, testing both plywood and acrylic boards.

Regarding the cords, we employed jute strings with a thickness of 3.5 mm, with additional tests using 4.0 mm thick cotton and sisal ropes (see Table 1). We estimated the use of approximately 1.15 m of thread per experiment.

Before experimenting with the prototypes on the tree fruits, various methods for assembling and affixing molds to growing fruits were assessed (Figure 5), as the molds had to be attached to the fruits in situ.

The observation of cuia craftswomen

Participatory observation and informal interviews were conducted during three days in August 2022 with cuia artisans from the ASARISAN in their riverine community in Santarém, Brazil. Our ethnographic research protocols included informed consent as required by the local Brazilian institution SisGen.[4] The translated document is available in the Supplementary Materials section, together with a certificate from SisGen.

[4]The SisGen – National System for the Management of Genetic Heritage and Associated Traditional Knowledge – is a Brazilian online system where researches must be registered. For investigations on traditional knowledge, the website requests details such as the knowledge in question, the name of the contact person, their address, etc. The researcher must attach a written or spoken document from the contact person authorizing the work.

Three artisans demonstrated all the phases of the traditional cuia production process (Figure 6). The observation helped to identify aspects not emphasized in the literature review, such as the artisans' use of organic tools (fish scales, fish tongue, rough leaves) for sanding cuias.

We explained and presented our research to the craftswomen, showing the images of cuias from the 18th century and also some of our experiments and recreated molds. It is important to highlight that the experiments were conducted in the city of Belém and not close to the artisan's community.

Results and analyses

Literature and museum artifact research

While the manufacturing process of cuias has undergone minimal changes since their initial documentation, a notable disparity in decoration becomes evident when examining older specimens. Historical accounts mention the use of natural pigments derived from plants, such as yellow, red, and blue, in cuia's ornamentation (Gennari, 2011). However, organic colors other than black and shape manipulation are no longer used in current production practices – they can only be found in ancient museum pieces.

About the "cuia-de-gomos," Ferreira wrote that these objects were created by indigenous women who encircled the developing fruit with strings and a wooden base (1933). He mentions that as the fruit grows, it encounters the strings that press the fruit, determining the marks of each segment. Finally, he also observes that "cuia-de-gomos" were less commonly produced compared to other types due to the additional labor involved.

Ferreira's description confirms that the "cuia-de-gomos" technique, employed by indigenous people in Brazil with *Crescentia cujete* trees during the 18th century, is analogous to what is considered "Growing Design" in Biodesign today. Similarly, the painting of cuias, which includes the application of a resin that is transformed into a black lacquer through a reaction provoked by urine, also suggests a connection between these materials and processes to recent Biodesign and Biomaterials practices. The same applies to the extinct process of coloring cuias with red, yellow, and blue: the presence of these colors observed in items aged more than 200 years proves that the organic pigments are resistant and deserve an inquiry.

Experiment results

After a few attempts, once the "cuia-de-gomos" mold was assembled correctly to the tree, it remarkably began shaping the cuia within just four days, demonstrating the moldability of cuias and the potential for "Growing Design" with cuieira trees. However, by the end of the experiments, only 4 out of the 20 tests successfully produced molded cuias (Table 2). Challenges arose due to mature fruit not molding (five cases), mold breakage (four cases), and fruit falloff (five cases). As the trees were in public spaces, we had two cases where the fruit or mold disappeared. Notably, the first successfully molded "cuia-de-gomos" was harvested prematurely and withered shortly after.

Failures taught us to diagnose the precise maturation moment to add the mold to the fruit and the string tension that should be created in the mold assemblage. Successful experiments (Figure 7) took about 1.5–4 months to harvest, and we learned this time can be shortened by removing the mold as soon as the shape is formed. The influence of the materials utilized are not conclusive, with jute being possibly the most suitable string for the experiment.

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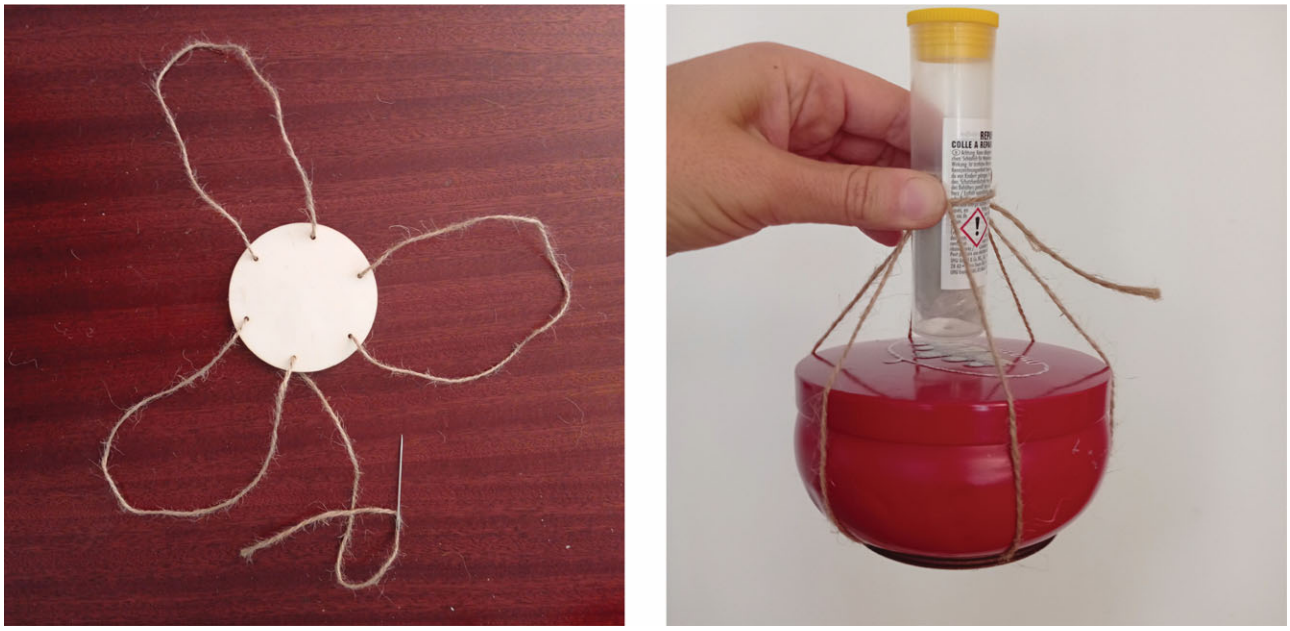

Figure 5. (left) An interpretation of the "cuia-de-gomos" mold with a plywood base – 8 cm diameter and 5 mm thickness – with 6 apertures and a 3.5 mm jute string; (right) a simulation of the mold's assemblage to the tree. *Source:* authors, 2022.

Figure 6. Artisans working on the cuia process in the Aritapera region of Santarém, Brazil. *Source:* authors, 2022.

The interpretation of the 18th-century description enabled the reconstruction and testing of a remarkably simple and ecological mold. It allowed the rematerialization of an ancient cuia typology that no longer existed (Figure 8). The resulting molded cuias exhibit visible changes in terms of object stability and ornamentation, mirroring the characteristics observed in museum pieces.

We emphasize that the ancient mold, different from other molds tested during the project "Cuia Colab" (Figure 9), instead of dominating or forcing the material, shows a precise balance, a negotiation among shapes, and a dialog between humans and plants, as Lohmann (2018) describes with her most effective experiments with algae or as mentioned by Mancuso (2019) when asserting that trees invite us to take part in their conversations. All researchers experienced a range of emotions connected with the trees, including enthusiasm, disappointment, guilt, care, worry, and surprise, acknowledging them as active agents in the process (Bandoni et al. 2023).

Artisan observation's results

The observation revealed the remarkable artisans' practice of leaving no waste during cuia's production. The nonessential parts

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Table 2. Results of the "cuia-de-gomos" experiments

	Mold base	Type of string	Duration	Conclusion note
1	Wood	Sisal 3.5 mm	8 days	Did not mold
2	Wood	Jute 4 mm	22 days	Success (but withered after harvest)
3	Wood	Jute 4 mm	5 days	Fruit fell
4	Wood	Jute 4 mm	7 days	Did not mold
5	Acrylics	Jute 4 mm	43 days	Success
6	Wood	Jute 4 mm	8 days	Fruit fell
7	Wood	Sisal 3.5 mm	21 days	Fruit fell
8	Wood	Sisal 3.5 mm	8 days	Did not mold
9	Wood	Jute 4 mm	116 days	Success
10	Acrylics	Jute 4 mm	6 days	Mold broken
11	Wood	Sisal 3.5 mm	4 days	Fruit fell
12	Wood	Cotton 4 mm	10 days	Mold disappeared
13	Wood	Cotton 4 mm	150 days	Success
14	Wood	Cotton 4 mm	23 days	Fruit fell
15	Acrylics	Cotton 4 mm	7 days	Mold broken
16	Acrylics	Cotton 4 mm	22 days	Did not mold
17	Acrylics	Cotton 4 mm	14 days	Fruit disappeared
18	Wood	Cotton 4 mm	14 days	Mold broken
19	Wood	Cotton 4 mm	92 days	Did not mold
20	Acrylics	Cotton 4 mm	21 days	Mold broken

of cuias and organic tools were allowed to fall to the ground beneath the workplace, where they would decompose and enrich the garden where cuieira trees live. This cyclical use of resources underscores the importance of the cuia-making tradition not only as a cultural expression but also as an ecological practice with a natural close loop.

The cuia-making knowledge is transmitted orally and through practice from mothers to daughters. The measurement of time and materials during the process is not precise from a design perspective, and this could hinder the opportunity for improvement and repeatability. However, from a different perspective, it reveals new and alternative ways of working and thinking. Artisans rely on their expertise, so measurements are not an issue.

For example, understanding when cuias are ready to harvest was central to our experiments. When asked, "How long cuias take to mature?" each artisan provided a different estimate, ranging from one to two months. However, when asked, "When do you know a cuia is ready to harvest?" artisans indicated three techniques for choosing mature cuias: they can examine the cuia color, which should present some dark spots; they can scratch the cuia's surface off to see if it does not come out easily; and they can knock the fruit with a knife and "listen to it," knowing the different sounds that a mature and green cuia produce. This tacit knowledge directly influenced our experiments.

An important aspect to note is that the artisans self-identify as riverine rather than indigenous.[5] This group was unable to ascertain precisely when the tradition of crafting cuias started within their families, nor are they aware of indigenous groups employing similar techniques for cuia production. Nonetheless, they recognize the inherent connection between cuias and indigenous heritage. Upon being presented with images of "cuia-de-gomos," they expressed unfamiliarity with molded cuias, indicating that the recreated mold and our experimental tests were novel to them. Additionally, they acknowledged awareness of the use of various colors in traditional cuias but lacked certainty regarding their origins and production methods. This underscores the loss of many techniques associated with cuias.

Discussion and conclusion

Ancestral Biodesign

As mentioned, Ginsberg and Chieza (2018) suggested that Biodesign could be an ancient practice, considering the 10,000-year-old tradition of refining crops or cattle through selective breeding. In this study, the connection between Biodesign and ancient practices becomes evident through an object. The example of the "cuia-de-gomos" research and recreation experiments expands the usual boundaries of this emerging field.

The indigenous technology present in "cuia-de-gomos" undeniably challenges the prevailing notion that biotechnology and design are modern disciplines exclusively practiced by engineers in a laboratory setting (Hénaff, 2023). Reviving an almost-forgotten technique with an ancient form allows us to refresh design possibilities and explore novel materialities that align more effectively with the ecological requirements of the present era.

Anthropologist Arturo Escobar describes ancestrality as a "living memory directly connected to the ability to envision a different future" (2018, p. 71), in the sense that even though representing a community's history and enduring customs, it is not a rigid link to the past. Consequently, safeguarding ancestrality has become a significant responsibility of our current era, achievable through various approaches, including design. By building upon indigenous heritage and preserving its memory through practical applications, we can shape the future by drawing inspiration from our historical roots. As indigenous philosopher Aílton Krenak declares, "(. . .) if there is a future to be considered, that future is ancestral, because it was already here" (2022, p. 11).

We believe that the recreation of the traditional "cuia-de-gomos" solution renewed and strengthened today's cuia-related traditions, presenting a dynamic and intertwining of the past with the future. It emphasizes the interplay between traditional practices within the design domain and, specifically, the contemporary Biodesign trend, often associated with biotechnology and innovation, with little recognition of these significant roots.

[5]As journalist Eliane Brum explains (2021), Amazonian riverine communities are the most "invisible peoples of the Forest" (p. 81), as they are not part of indigenous groups that precede colonialist invasion nor the quilombolas who were brought from Africa. They descent from groups that were mostly attracted to work in the forest and became part of it through the years, "they are a victory of the forest who made them part of it" (p. 95). Today, many riverine peoples and their practices are recognized as traditional communities. As such, they can be considered a "complex form of resistance" (p.79).

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Figure 7. A successful experiment from assembling the recreated mold (left) to the change of shape (right). *Source:* authors, 2022.

Figure 8. Molded "cuia-de-gomos" hanging on the tree (left) and after being harvested and dried (right). *Source:* authors, 2022.

Learning from artisans, collaborating with a tree

This research underscores the importance of acknowledging the legitimacy and amplifying the voices of communities that guard traditional ecological knowledge, which is essential in reevaluating current design approaches.

The observed craftswomen's skills and ancestral knowledge reflect ecological consciousness and encompass a range of nonconventional practices that present valuable insights to contemporary designers: the collaboration between women and trees, intergenerational knowledge transfer, attention and care to detail, and use of organic materials and tools. Nevertheless, a challenge exists in systematizing or translating their vernacular technology, given that they are rooted in principles distinct from those employed in scientific conventions. It prompts a thought-provoking question: Can designers and other professionals genuinely integrate this unique mode of knowledge and craftsmanship? What ethical considerations surround such endeavors?

Another challenge faced by this study relates to working with a plant and accepting their agency. For that matter, it was important to access works and concepts from the botanic field related to the Amazon forest. Experts mention a dynamic process of coevolution

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Figure 9. "Cuia-de-gomos" after being painted black by the artisans (left) and other "Growing Design" tests made with cuias (right). *Source:* authors, 2022.

in this region, where humans, vegetation, and animals have engaged in a profound and reciprocal coexistence (Furquim, 2020) – the Amazon forest is more akin to a garden than to a pristine environment (Neves & Castriota, 2023). The coevolutionary process relates to the interference of species in each other's evolution, going beyond the idea of "domestication" of a species. According to botanist Priscila Moreira (2020), who focuses on the *Crescentia cujete* tree in her studies, given its long-term collaboration with women, the cuieira trees are continuously coevolving and reciprocating with humans: humans influence the life of cuieiras, and they influence humans.

Therefore, when examining partner species such as the cuieira tree, we should no longer view them solely as a fount of resources or frameworks that meet ecological requirements, as anthropologist Anna Tsing (2022) suggests. Instead, we should regard them as active contributors to shaping processes and allies in advancing design – we can collaborate with them and coevolve together. This approach signifies a departure from conventional industry practices in Biodesign, emphasizing the value of nurturing interspecies relationships and benefiting the entire ecosystem (Bandoni et al. 2023).

Colonialism and design

Nego Bispo, a quilombola thinker from Brazil, says that to colonize "is to subjugate, humiliate, destroy, and enslave the trajectories of people with a cultural matrix – an original matrix different from one's own"(Bispo dos Santos, 2023). Throughout the study, many colonization signs were present: the remaining "cuia-de-gomos" items are inside a museum in Portugal with restricted access; there was a tendency of judging the craftswomen's way of working from a design perspective and also the tendency of admitting the trees as "manufacturing tools." It is clear that the researchers did the study coming from a Euro-centered design perspective, however, being conscious of that led us to constantly review our methods and goals.

Furthermore, the literature about cuias central to this research mainly came from Anthropology and Biology, without references from the design field. The limited attention given to the studied subject reflects a constrained viewpoint in the design discipline today. Even in countries where indigenous influences are prevalent, design remains closely tied to an industrial paradigm, and indigenous objects and techniques are often overlooked within narratives of progress (Watson, 2019).

Even though the purpose of this paper is to show clear evidence of Biodesign present in an ancient indigenous practice – highlighting that Biodesign is an integral component of traditional ecological knowledge and not the proclivity of Western science, it is important to mention that to name the old technique "Biodesign" can also be a way of colonizing it, which is not our intention. At present, we may refer to the analyzed technique as "Ancestral Biodesign," but maybe a new and more appropriate terminology should emerge.

All of this implicates an emerging area that relates traditional knowledge and Western science. As Kimmerer (2015) states, "traditional ecological knowledge, the physical and spiritual framework, can guide science, create an ethical habitat for coexistence and mutual flourishing (. . .), and envision a time when the intellectual monoculture of science will be replaced with a polyculture of complementary knowledge" (p. 139).

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/btd.2024.13.

Data availability statement. The authors confirm that the data supporting the findings of this study are available within the article or its supplementary materials.

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Author contribution. A.B. coordinated the study, interacted with the artisans, and cowrote the draft. L.C. organized and conducted the experiments. M.C. supported the experiments and produced images. C.P. reviewed the article critically. All authors gave final approval for the publication.

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Competing interests. The authors declare none.

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