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Biomaterial experimentation with bone residues for the manufacturing of Bone China porcelain

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Abstract: The reuse of raw materials is an important characteristic of Nature, which can contribute to the incorporation of discarded waste in a way that values its economic interest and thereby reduces waste intensity and its consequent environmental impact. Brazil, being a large producer of livestock, generates a significant amount of organic waste after production, such as bones. Bone China, a highly valued English porcelain known for its translucency and white color, allows for the creation of fine and delicate pieces due to the material's resilience. With a focus on sustainability and design inspired by nature, the use of bone powder in the development of biomaterials presents an opportunity to transform waste with no economic value into a new material to be explored in the design of more sustainable products. This work showcases the experimentation with bone remains from animals to create and prepare Bone China porcelain, adding value to what would otherwise be discarded. Starting from cattle bones, the material was cleaned and whitened with hydrogen peroxide before being heated in an oven until it turned into ash. This bone ash was then mixed with other essential raw materials, such as feldspar and kaolin, to create a basic mixture for Bone China porcelain. After testing various proportions, a composition is found that can be used to manufacture test models for further experimentation with the material. This study highlights the potential of valorizing waste from livestock production to develop materials with high added value, showing that sustainability and economic attributes cannot be separated when appreciating waste as a raw material.

Keywords: Bones - Biomaterials - Porcelain - Bone China - Ecodesign - Ceramics - Recycling - Production - Waste - Sustainability

[Resúmenes en castellano y en portugués en las páginas 58-59]

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1. Introduction

The Consumptions X Sustainability agenda has become recurrent in modern civilization, thanks to numerous awareness campaigns (Kiperstok, 2006), whereby human beings, despite constant surveillance, continue to produce a significant amount of disposable waste in a steadily increasing manner. According to Worrell and Reuter (2014), for instance, material consumption in the United States reaches 10 tons per person annually, growing at an average rate of five tons per year. In Brazil, according to the Brazilian Association of Public Cleaning and Special Waste Companies (ABRELPE, 2022), 81.8 million tons of Urban Solid Waste (USW) were generated in 2022 alone. This amounts to approximately 1 kg per day per inhabitant of the country, according to the Panorama of Solid Waste in Brazil report (ABRELPE, 2022). These figures demonstrate that even with waste collection policies in place, there is still an environmental impact caused by human presence, thus emphasizing the need to adopt sustainable policies and reduce material waste in order to minimize harm to the environment.

Although the term "waste" is often associated with something to be rejected and, therefore, not having a useful purpose, this concept has been revised in recent years (Cidade *et al.*, 2021). It is agreed that waste will only be, in fact, waste if it can no longer be reused or if its exploitation is no longer economically viable (Worrell; Reuter, 2014). Based on the current solid waste treatment system in developing countries like Brazil, there is a representative situation of this scenario, where waste is highly dependent on its valorization to be traded (Palombini; Cidade; De Jacques, 2017). From this perspective, sustainability relies on eco-efficiency for the incorporation of reused products, in a way that the balance of satisfaction and price remains equalized, thus decreasing waste intensity and ecological impact (Palombini; Cidade, 2022).

In addition to dry waste, there are organic and inorganic waste, which are extremely voluminous in Brazil. An example of this is the waste resulting from meat trading in agriculture, which is often overlooked. According to Miranda (2020), Brazilian livestock has established itself internationally in different cultures. According to data from the Brazilian Institute of Geography and Statistics (IBGE, 2024), Brazil has about 1.6 billion chickens and approximately 230 million heads of cattle. Specifically in terms of beef, the country is the world's largest exporter, accounting for about 27.7% in 2022, according to data from the Brazilian Association of Meat Exporting Industries (ABIEC, 2023).

Among a class of special materials for application in product development, there are the so-called Biomaterials. Considered as old as civilization itself, Biomaterials can be divided into conventional classes of metals, polymers, ceramics, and composites (Meyers; Chen, 2014). As an essential characteristic, biomaterials are derived from or originate from natural raw materials, which can be organic, such as cellulose, proteins, and waxes, or inorganic, such as calcium carbonate, silicates, or hydroxyapatite (Spear, 2018), with different industrial applications of interest (Gibson; Ashby; Harley, 2010). One way to apply waste from livestock, for example, is found in Bone China, a form of ceramic biomaterial based on bone ashes (Lefteri, 2014). Due to its high added value, the material can be considered as an option for valorizing waste that would otherwise be discarded and can be applied to different products.

Based on the possibilities of integrating waste with low-added value with the development of biomaterials, this work seeks, through the generation of technical-scientific subsidies, the possible reuse of livestock waste residues to create and prepare bone porcelain. An overview of the agricultural sector in Brazil is presented, followed by a brief explanation of animal-based ceramic biomaterials. Next, an experimentation and development process for bone porcelain for product design application is described, as a way to add value to something that would be a possible waste.

2. Biomaterials and Sustainability

2.1. Livestock farming in Brazil

Agribusiness is a sector that contributes significantly to both the Gross Domestic Product (GDP) of Brazil and its trade balance in terms of exports (Rodrigues; Marta-Costa, 2021), thus playing a fundamental role in the economy. This sector, representing over 20% of the

GDP and approximately 44% of total exports, demonstrates the strength of the Brazilian agricultural economy, according to Rodrigues and Marta-Costa (2021). Within this context, the beef trade and soy complex products are highlighted by the authors as areas of exceptional growth, driving Brazil's export values.
In raw data, Brazil has the second largest cattle herd in the world *(See Figure 1)*, second only to India, with 202 million heads *(See Figure 1A)*, representing 12.18% of the global herd (ABIEC, 2023). In particular, the export of beef, which generated a revenue of US$10.845 billion in 2023 according to the Brazilian Association of Meat Exporting Industries (ABRAFRIGO, 2024), illustrates the country's capacity in this sector. Rodrigues and Marta-Costa (2021), for example, emphasize how Brazil has positioned itself as a global leader in beef supply, reinforcing the position of Brazilian agribusiness in the national economy. According to data from the Ministry of Foreign Trade (Baliero, 2024), as of February 23, 2024, Brazil had exported 143.47 thousand tons of fresh beef. This volume not only surpassed the numbers from the same period in the previous year by 13.52% but also resulted in a significant revenue of US$651.34 million, indicating an increase of 6.16% compared to the previous year. Through this, the importance of Brazilian agribusiness becomes evident not only for the domestic economy but also for the global market supply.

Figure 1. Livestock farming in Brazil: (A) Cattle raising in Brazil is one of the largest in the world; (B) The process generates a substantial amount of waste, such as bone remnants (Source: (A) Flickr, License CC BY-NC-ND 2.0; (B) Picryl, License CC0 1.0.).

The expansion in Brazilian beef exports is part of a broader trend that encompasses other segments of livestock farming, such as chicken and pork meat production. Once again, Brazil stands out globally in these sectors, highlighting the success of its agricultural practices and, consequently, its greater responsibility in terms of closing the production cycle in a sustainable manner. The recent rise of Brazil as one of the global leaders in beef exports not only showcases its production capacity but also raises concerns about the waste derived from this production chain. For instance, according to data from the Brazilian Animal Recycling Association (ABRA, 2023), among the exports of non-edible animal products, bones account for only 9% of the total *(See Figure 1B)*, with a significant portion being used for the production of meals. Additionally, the growing international demand for other animal proteins also contributes to the acceleration of waste generation from bones, which could benefit from greater commercial value.

2.2. Biomaterials

Ashby (2021) argues that the growth of human consumption is directly linked to increased pressure on our industrial system. In particular, the author notes that as more people consume, and the faster they do so, there is a greater demand for materials processed by the industrial system. This high demand, in turn, results in increased production of waste that is released back into the environment as garbage. This perspective offers a critical look at the cycle of consumption and disposal, highlighting the urgent need to rethink new industrial and consumption practices to mitigate adverse environmental impacts (Vezzoli; Manzini, 2008).

Currently, society has been debating sustainability and the creation of a holistic approach to restore the balance between nature, economy, and society. In this context, the dynamics between environmental, economic, and social aspects are altered, driven by rapid population and economic growth (Roosa, 2010) is situation leads to excessive use of natural resources and environmental degradation. It is essential, therefore, to adopt methods that promote resource reuse and drive innovation and creativity for environmental sustainability (Peters; Drewes, 2019).

Education is fundamental to achieving sustainable development, as Scott (2002) highlights, pointing to the need for a harmonious coexistence between humanity and the environment. This balance crucially depends on continuous learning about sustainable practices, including proper waste disposal, which allows for materials to be reintegrated into the life cycle, reducing environmental impact and promoting the conservation of natural resources.

The circular economy, as explored by Zago and Barros (2019), represents a methodology of great importance in the management of organic waste, aiming to reuse it as valuable resources, notably through composting. This approach not only addresses the urgent need for more sustainable waste management practices but also highlights the significant positive impact on the local economy, job creation, and minimization of environmental damage. The experience of Germany, a recognized leader in selective waste collection and recycling of organic waste, illustrates how such practices can foster sustainability while generating tangible economic and ecological benefits. The success of these initiatives in Germany and elsewhere highlights the vast potential of the circular economy, as discussed by Zago and Barros (2019), and suggests a promising direction for solving global environmental problems, encouraging the adoption of similar practices globally to improve sustainability and economic well-being.

In this context, Shen (1995) advocates for an integrated environmental management system that seeks sustainable solutions across various sectors, emphasizing the need for approaches that transcend disciplinary and sectoral boundaries to effectively address environmental issues. The environmental management approach requires a comprehensive and integrated perspective, recognizing the complexity of environmental challenges that are influenced not only by technological factors but also by a wide range of economic, social, physical, cultural, and political considerations.
On the other hand, according to Cubas *et al.* (2023), the evolution in materials science is paving the way for the adoption of more sustainable biomaterials. Gupte *et al.* (2021) underline the global transition to eco-friendly alternatives, highlighting nanocellulose as a potential substitute for fossil fuel-based plastics. In the field of healthcare, Wesolowski *et al.* (2020) mention that biology and ceramics intersect, especially in medicine, where ceramic materials are chosen for dental implants and heart valves due to their low rejection rate by the human body.
Eder, Amini, and Fratzl (2018) present a taxonomy of natural materials considered biological composites, which can be found based on their minimal constituent structures, including minerals, sugars, and proteins. The first group comprises those based on calcium carbonate, calcium phosphate, or siliceous materials, which are largely responsible for structural strength or rigidity in living beings, affecting their constitution, locomotion, and protection, among others (Eder; Amini; Fratzl, 2018). Specifically, calcium phosphate is the main component in bones, and it can be used in the development of biomaterials with various applications (Naqshbandi; Sopyan; Gunawan, 2013).

2.3. Bone China Porcelain

One of the main practical applications of calcium phosphate derived from bones is as one of the basic materials for the synthesis of Bone China *(See Figure 2)*. This type of porcelain is considered unique in terms of its appearance, being white, translucent, and highly glossy, and therefore highly valued and considered the most expensive tableware (Zhang *et al.*, 2016). Mechanically, the material has high hardness but also good overall strength for ceramic material, allowing it to be shaped into objects with thin and delicate sections, favoring its commercial value (Lefteri, 2014).
Historically, Bone China was primarily developed in the UK *(See Figure 2A)*, initiated by Thomas Frye, although its quality could not rival that of traditionally made porcelain (Zakaria; Haron, 2014). Therefore, the production only achieved success when its formulation was modified by Josiah Spode in the late 18th century, by combining a traditional porcelain recipe with bone ash (Nodeh *et al.*, 2015). From this point on, the composition that is still used today was established, containing 50wt% of bone ash, 25wt% of ground flux, and 25wt% of clay (Zhang *et al.*, 2016). The flux mainly corresponds to ground granite as it is a source of feldspar, as well as quartz, which contributes to the ceramic mixture fusing and appearing vitrified, favoring its translucency and overall strength *(See Figure 2B)*. For Bone China, Cornish Stone was initially used as the flux due to its low iron content, and the same principle was applied to the choice of white clay instead of red clay (Zakaria;

Haron, 2014). Therefore, the lower the content of these contaminants, the whiter and more valuable the final piece will be.

Figure 2. Bone China Porcelain: (A) Hitkari Fine Bone China teacup; (B) Bone China, Minton & Co, Stoke on Trent, England, about 1897. Source: (A) Flickr, CC BY 2.0; (B) (Source: Wikimedia Commons, CC BY-SA 3.0).

In addition to the composition of the formulation used in the production of Bone China, other factors greatly influence its final quality. Due to the presence of calcium carbonate derived from bone ash, a major flux in this porcelain, its firing phase is limited and should be carried out in the range of 1250°C to avoid issues such as porosity or color changes (Nodeh *et al*., 2015). In fact, according to Nodeh *et al.* (2015), for the calcination, or obtaining of bone ash, organic materials are burned, leaving mainly the main components, requiring attention to the temperatures used. Another important aspect is the particle size distribution of the mixture, contributing to better adherence (and strength) of the material if the formulation is made with smaller particles (Zhang *et al*., 2016).
With various applications, from tableware (such as plates, bowls, pitchers, cups, and glasses), decorative objects (such as sculptures, vases, and figurines), and lighting fixtures, many products can benefit from the physical and aesthetic characteristics of Bone China (Zakaria; Haron, 2014). By utilizing by-products from the livestock industry, such as bones, it is possible to transform low-value material into high-value-added products, applying principles of sustainable design practices, as described by the circular economy. In this regard, this study explores the development of a basic ceramic body of Bone China aiming for its application in product design.

3. Materials and Methods

Before detailing the specific stages of the Bone China porcelain creation process, it is important to highlight that the methodology described below was consistently applied to a raw material source: cow bones. The initial objective was to explore the physical and aesthetic properties resulting from the use of bones in the final product. To this end, this raw material went through preparation stages - from selection, cleaning, and bleaching to firing and pulverization - before being mixed with the other ceramic components (kaolin and feldspar). This approach ensured that any differences observed in the properties of the obtained porcelain could be directly attributed to the bone raw material source, providing a solid basis for analysis.

3.1. Material Preparation

Selection of bone material: The process *(See Figure 3)* began with the selection of bovine bones, specifically from the hind leg region of the cow, known as the shank bone *(See Figure 3A)*. This choice was based on the superior physical resistance displayed by bovine bones compared to other bones, such as poultry bones, for example. Additionally, bovine bones offer an advantage in the cleaning process, as they are easier to clean due to their larger surface area and require a smaller quantity of bones to produce the same amount of powder.

Preliminary Cleaning: The initial stage involved manual cleaning of the bones to remove impurities such as cartilage, fat, and meat *(See Figure 3B)*. This phase is essential to ensure the quality of the bone material, positively influencing the final characteristics of the porcelain.

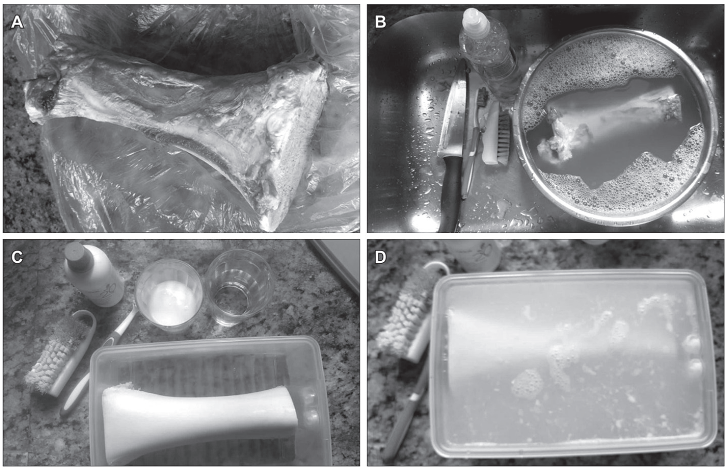

Figure 3.
Material Preparation: (a) Selection of the bone material; (b) Preliminary cleaning and degreasing; (c) Material after cleaning and degreasing; (d) Bleaching.

Degreasing: Degreasing was performed by immersing the bones in a solution of hot water with detergent. This method facilitated the removal of any organic residues still present on the bones *(See Figure 3C)*. The solution was left to rest for 12 hours, allowing for effective and thorough cleaning of the material.

Bleaching: Subsequently, the bones underwent a bleaching process to achieve the desired porcelain-like coloration. The solution used consisted of 20% hydrogen peroxide and warm water in a 50:50 ratio *(See Figure 3D)*. The bones were submerged in this mixture and left in a closed container for 12 hours, resulting in a white bone material, ideal for porcelain manufacturing.

3.2. Firing and Grinding

Firing: After the bleaching process, the bones were subjected to a firing process *(See Figure 4)* at a temperature of 1000°C for 12 hours. This procedure aimed to remove any remaining organic material and thoroughly dry the bones, resulting in a completely white, hard, brittle material, free from contaminants and fully dehydrated - fundamental characteristics for the subsequent pulverization step *(See Figure 4A and B)*.

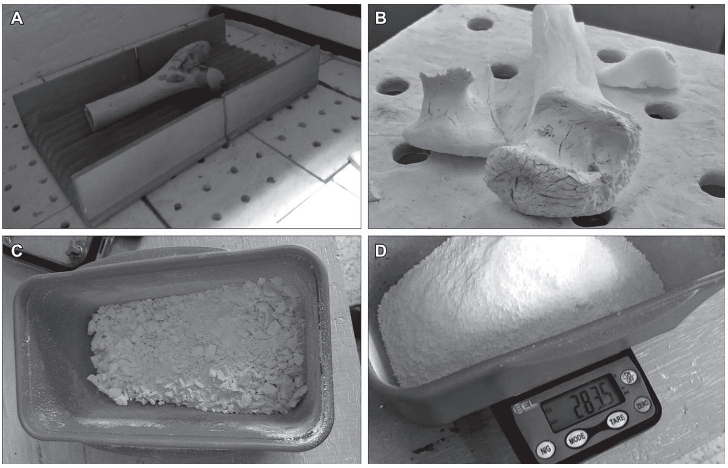

Figure 4.
Firing and Grinding: (A) and (B) Bone after firing; (C) and (D) Grinding process.

Grinding: A blender was chosen for the process of grinding and pulverization of bones *(See Figure 4C)*. This decision was based on the efficiency and speed at which the blender was able to reduce the bones to a fine powder *(See Figure 4D)*. Safety was prioritized during this process, with the use of Personal Protective Equipment (PPE) to prevent the inhalation of bone dust. A sieve was also used to assist in the uniformity of the particle size of the ground material.

3.3. Mixing of Solid Components

Preparation of Ceramic Mixture: After obtaining the bone powder through grinding and pulverization, the process of mixing the constituent materials of Bone China porcelain began *(See Figure 5)*. The required components –bone powder, feldspar, and kaolin– were combined in a specific traditional ratio of 50% bone powder, 25% feldspar, and 25% kaolin (Feng; Tian; Ji, 2022). This ratio was measured on an analytical balance, and each component was separated into individual containers, with a total of 100 grams for each mixture, ensuring consistency in proportions: 50 grams of bone powder, 25 grams of feldspar, and 25 grams of kaolin.

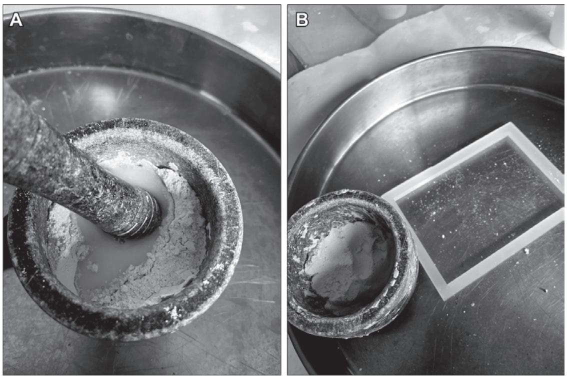

Figure 5. Material Mixing: (A) Mixing of the components in a mortar; (B) Preparation for material compression.

Determination of the Ideal Water Percentage: The subsequent step focused on identifying the ideal water percentage to add to the dry mixture in order to achieve the appropriate consistency for shaping. Water additions at proportions of 10%, 20%, 30%, 40%, and 50% were experimented with, and the mixture was mixed with a mortar until a homogeneous consistency was obtained *(See Figure 5A)*.

3.4. Compression

After evaluating the ideal water proportion in the mixture, the next step involved selecting a suitable container to perform the material compression process, aiming to shape it into uniform sheets. This procedure ensures standardization of the samples in terms of shape and composition –feldspar, kaolin, and bone meal– subjected to the same temperature profile during firing. To delimit the edges of the material and facilitate subsequent compression, a simple rectangular mold was chosen, which could be compacted to observe the behavior of the material in these experimental tests. After designing the mold, it was fabricated with PMMA (polymethyl methacrylate, or acrylic) and laser-cut *(See Figure 5B)*. This method allowed for the creation of uniform samples, essential for accurate evaluation of the effects of water content variation on the final properties of the ceramic product.

3.5. Drying

The next step of the experiment involved drying the mixture, which was carried out immediately after molding the sheets. For this purpose, the samples were placed on a ceramic surface and subjected to a controlled temperature of 40°C for 6 hours in a muffle-type kiln with a digital controller JC45013 (JUNG Tecnologia para Processos Térmicos, Blumenau, SC, Brazil). This preliminary dehydration procedure before firing is critical to ensure the removal of excess water from the material, mitigating the risk of structural damage, such as porcelain fracture, during firing.

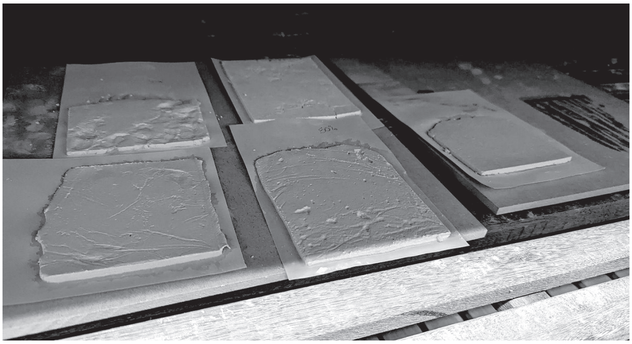

Figure 6.
Drying Process of the Pieces in the Kiln.

During the drying process, the ceramic material loses water and naturally shrinks. According to Groover (2012), an excessive amount of water in the ceramic material during firing can cause internal stresses that result in structural failures due to the expansion of steam, which is 1600 times the volume of the original water, creating immense internal pressure. Therefore, the clay must be completely dry before firing to reduce the risk of cracking.

3.6. Firing

Finally, after the drying stage, the material was subjected to a progressive firing cycle of 12 hours in the same kiln, where the temperature started at 40°C and gradually increased until reaching 1250°C.

4. Experimental results

In general, the main variable to be manipulated initially in the experiment was the amount of water used in the mixture of solid components for the preparation of the experimental samples. Thus, it was observed that a 10% water mixture resulted in a sandy consistency with little cohesion, which would be inadequate for modeling without the use of industrial pressing equipment. With 20% water, the mixture remained moist and sand-like, still insufficient in terms of bonding. In both cases, it is evident that the clay (kaolin) present in the dry mixture requires a sufficient amount of water to fulfill its role as a plasticizer in the ceramic mass, aiming to facilitate the shaping and construction of a piece. Being insufficient, the ceramic mass cannot be sustained or used manually, as per the experimental design.

For samples with the addition of 30% water, manipulation improved, but the mixture was still relatively solid. Increasing to 40% water, the mixture became excessively liquid, losing the desired malleability for piece formation. Therefore, the decision was made not to proceed with the 50% water ratio. Instead, a balance between the 30% and 40% proportions was sought, resulting in the choice of 35% water. This proportion offered an ideal consistency with appropriate bonding and ease of shaping, being used in the remaining experimental process.

After the drying process, the samples with high water percentages were observed to break, except for the 35% water sample, which maintained its integrity. This observation reinforces the conclusion that 35% is among the ideal water proportions for the mixture of feldspar, kaolin, and bone ash, resulting in a material that can be both easily shaped and dried without cracks or other defects. It should be noted that this percentage only applies to a more manual manufacturing process, as executed in this experimental project.

After firing, the samples with water percentages of 20%, 30%, 35%, and 40% were observed to each have distinct characteristics. The 20% water sample, due to being too dry, was unable to maintain a stable structure, not activating the plasticity of the clay as necessary. Both the 30% and 40% samples exhibited internal fractures resulting from both the insufficient activation of the clay (too dry) and excess moisture (too wet), respectively. Despite being fired, both could not be handled, being very fragile and extremely brittle, making it difficult to manipulate the finished piece. Finally, it was observed that the 35% water content resulted in a fired piece with sufficient strength for manipulation, in addition to exhibiting one of the main characteristic properties of Bone China porcelain, its translucency, resistance, and hardness *(See Figure 7)*.

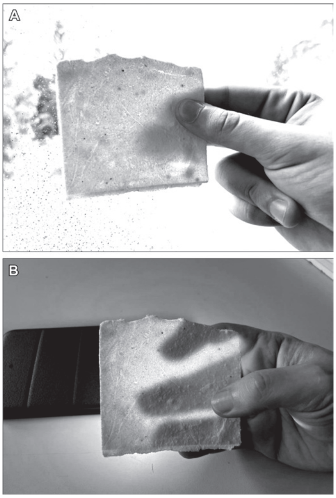

Figure 7.
Experimental Results: Translucency of the piece over (A) daylight and (B) a flashlight.

5. Final Considerations

The development of biomaterials is an important means of reusing organic waste that has little or no added value but is often wasted despite its large production, leading to environmental, economic, and social impact. This study presented an experimental process for creating a bone ash-based porcelain known as Bone China, which has the highest added value among ceramic materials. In particular, a primarily manual process was conducted to facilitate replication.
The main difficulties encountered were related to determining the percentage of water required in the steps of (i) plastic mixing of the ceramic material, (ii) molding of the experimental pieces, (iii) drying, and (iv) firing. After the tests were conducted, it was found that a water percentage of 35% in the mixture of dry components was considered ideal for the proposed objectives, allowing the creation of a Bone China ceramic piece with characteristics that reflect its highest value properties: translucency and strength.

Although the application of refining processes for organic materials derived from agriculture, such as bone ash, can be laborious and time-consuming, with a yield that may be considered low, it is noteworthy how easily a valueless waste can be transformed into a raw material with high added value applications. Lastly, it is intended to encourage further studies and experimental practices to incorporate such materials into the production of new design products, aiming to reuse rejected materials and emphasizing the sustainable aspect that biomaterials can provide.

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Resumen: La reutilización de materias primas es una característica importante de la Naturaleza, que puede contribuir a la incorporación de residuos desechados de forma que se valore su interés económico y se reduzca así la intensidad de los residuos y su consiguiente impacto ambiental. Brasil, al ser un gran productor de ganado, genera una importante cantidad de residuos orgánicos tras la producción, como los huesos. Bone China, una porcelana inglesa muy apreciada y conocida por su translucidez y color blanco, permite crear piezas finas y delicadas gracias a la resistencia del material. Con un enfoque en la sostenibilidad y el diseño inspirado en la naturaleza, el uso de polvo de hueso en el desarrollo de biomateriales presenta una oportunidad para transformar residuos sin valor económico en un nuevo material a explorar en el diseño de productos más sostenibles. Este trabajo muestra la experimentación con restos óseos de animales para crear y preparar porcelana Bone China, añadiendo valor a lo que de otro modo sería desechado. Partiendo de huesos de ganado, el material se limpió y blanqueó con peróxido de hidrógeno antes de calentarlo en un horno hasta que se convirtió en ceniza. A continuación, esta ceniza de hueso se mezclaba con otras materias primas esenciales, como feldespato y caolín, para crear una mezcla básica para la porcelana Bone China. Tras probar varias proporciones, se encuentra una composición que puede utilizarse para fabricar modelos de prueba para seguir experimentando con el material. Este estudio pone de manifiesto el potencial de valorización de los residuos de la producción ganadera para desarrollar materiales de alto valor añadido, demostrando que la sostenibilidad y los atributos económicos no pueden separarse a la hora de apreciar los residuos como materia prima.

Palabras clave: Huesos - Biomateriales - Porcelana - China de huesos - Ecodiseño - Cerámica - Reciclaje - Producción - Residuos - Sostenibilidad.

Resumo: A reutilização de matérias-primas é uma característica importante da natureza, que pode contribuir para a incorporação de resíduos descartados de forma a valorizar seu interesse econômico e, assim, reduzir a intensidade de resíduos e seu consequente impacto ambiental. O Brasil, por ser um grande produtor de gado, gera uma quantidade significativa de resíduos orgânicos após a produção, como os ossos. A Bone China, porcelana inglesa altamente valorizada, conhecida por sua translucidez e cor branca, permite a criação de peças finas e delicadas devido à resiliência do material. Com foco na sustentabilidade e no design inspirado na natureza, o uso de pó de osso no desenvolvimento de biomateriais apresenta uma oportunidade de transformar resíduos sem valor econômico em um novo material a ser explorado no design de produtos mais sustentáveis. Este trabalho mostra a experimentação com restos de ossos de animais para criar e preparar a porcelana Bone China, agregando valor ao que, de outra forma, seria descartado. A partir de ossos de gado, o material foi limpo e branqueado com peróxido de hidrogênio antes de ser aquecido em um forno até se transformar em cinzas. Essa cinza de osso foi então misturada com outras matérias-primas essenciais, como feldspato e caulim, para criar uma mistura básica para a porcelana Bone China. Depois de testar várias proporções, foi encontrada uma composição que pode ser usada para fabricar modelos de teste para experimentos adicionais com o material. Este estudo destaca o potencial de valorização dos resíduos da produção pecuária para o desenvolvimento de materiais com alto valor agregado, mostrando que a sustentabilidade e os atributos econômicos não podem ser separados quando se trata de valorizar os resíduos como matéria-prima.

Palavras-chave: Ossos - Biomateriais - Porcelana - Bone China - Ecodesign - Cerâmica - Reciclagem - Produção - Resíduos - Sustentabilidade

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