ISSN 2359-6562 (ONLINE) 2359-6562 (CD-ROM)

PRODUÇÃO BRASILEIRA DE *PELLETS* DE BIOMASSA AGROFLORESTAL

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RESUMO: A demanda mundial por *pellets* cresce exponencialmente. Isso ocorre porque são recursos energéticos associados à economia de baixo carbono e são utilizados por países que precisam reduzir suas emissões de gases do efeito estufa e atender aos acordos climáticos. Para explorar as oportunidades desse negócio é preciso oferecer informações ao mercado a respeito da capacidade de produção, quantidade de indústrias produtoras e quais materiais lignocelulósicos estão sendo compactados no formato de *pellets*. Esta pesquisa elaborou um mapa *on-line* dos produtores de *pellets* brasileiros, identificou os tipos de biomassas utilizadas como matérias-primas, verificou quem são os principais consumidores e apurou quanto foi produzido em 2020. Uma pesquisa com os produtores foi realizada, com aplicação de um formulário *on-line* do *Google Forms*, que obteve 100% de índice de resposta. Com esses dados foi elaborado um Mapa dos Produtores de *Pellets*. Os resultados revelaram cerca de 30 indústrias ativas, distribuídas em seis estados, que produziram cerca de 820 mil toneladas em 2020, fabricados com pinus, eucaliptos, acácia-negra, bagaço de cana-de-açúcar, casca de amendoim e casca de café. Os dados demonstram o crescimento do setor de *pellets* em diversas regiões brasileiras e a contribuição efetiva do país nas exportações desses biocombustíveis sólidos renováveis.

Palavras-chave: energia renovável, transição energética, COP26, agropellets, energia limpa.

BRAZILIAN PRODUCTION OF AGROFORESTRY BIOMASS *PELLETS*

ABSTRACT: The world demand for *pellets* grows exponentially. This is because they are energy resources associated with the low carbon economy and, in addition, they are used by countries that need to reduce their greenhouse gas emissions and comply with climate agreements. In order to explore the opportunities of this business, it is necessary to offer information to the market regarding the production capacity, number of producing industries and which lignocellulosic materials are being compacted in the form of *pellets*. This research produced an online map of Brazilian pellet producers, identified the types of biomass used as raw materials, verified who the main consumers are and found how much was produced in 2020. A survey with producers was carried out, with application of a Google Forms online form, which obtained a 100% response rate. Based on these data, a Map of Brazilian Pellet Producers was constructed. The results revealed about 30 active pelletizing industries, distributed in six states, which produced about 820 thousand tons of the product in 2020, made with pine, eucalyptus, black wattle, sugarcane bagasse, peanut husks and coffee husks. The data demonstrate the growth of the pellet sector in several regions of Brazil and the effective contribution of the country in the exports of these renewable solid biofuels.

Keywords: renewable energy, energy transition, COP26, agripellets, clean energy.

Recebido em 07/11/2021 e aprovado para publicação em 20/12/2021
DOI: http://dx.doi.org/10.17224/EnergAgric.2022v37n1p30-38

1 INTRODUCTION

Brazil is considered a global giant in terms of agroforestry biomass productivity and can be used as a raw material for biofuels (SIYAL *et al.*, 2021). Owing to its edaphoclimatic characteristics, which are favorable for the large-scale production of these plant biomasses, Brazil has the potential to take advantage of these energy resources, especially in matters related to *pellet production.* (SCATOLINO *et al.*, 2018). This market is considered a promising commercial opportunity with European countries that need to reduce their greenhouse gas emissions and meet the agreements signed since the Climate Conference (France, COP21) in 2015 (GARCIA *et al.*, 2018a).

This strong demand for renewable fuels in the global biomass *pellet market* continues to expand, with an estimated annual global production of 60 million tons by 2030 (MOREIRA *et al.*, 2021). However, with the consumption of this solid biofuel growing exponentially worldwide, these authors predict a shortage of lignocellulosic residues used by the pelletizing industry. Therefore, making better use of agroforestry residues and compacting them into *pellets* could be a way to increase the energy value of these plant biomasses.

Pellet production in South America has shown surprising growth, especially in Brazil and Chile, where it increased by more than 385% in 2017 (CALDERÓN; GAUTHIER; JOSSART, 2018). In fact, *pellet* production in Brazil has increased in recent years. From 2015 to 2018, it increased from 75,000 to 507,000 tons of the product (GARCIA, 2018; GARCIA *et al*., 2018b); therefore, the growth in that period was 676%. These authors reported that Brazil is always one of the main players in this segment of agro-industrial biomass for energy; therefore, reliable statistical data on this renewable energy market segment are needed to meet the new demands of the low-carbon economy.

Therefore, this study is important for exploring the opportunities of this business (production and marketing). Furthermore, this research aims to provide the market with information regarding production, the number of industries, consumer markets, and lignocellulosic materials being used for *pellet production*. With the intense demand for low-carbon energy, strengthened at COP26 (Glasgow, Scotland), and on the basis of the georeferenced information in this article, entrepreneurs, equipment developers, and *pellet consumers* will have more confidence in the market to invest in this solid biofuel.

pellet producers, identify the raw materials, the main consumers, and calculate the Brazilian production of this solid biofuel in 2019 and 2020.

2 MATERIALS AND METHODS

2.1 Survey Forms

pellet producers, a questionnaire developed via the Google Forms online tool was used. *This resource was* chosen for its ease of distribution, completion, and data analysis. Furthermore, this method of data collection offers other benefits: low cost (because it is free), ease of use (because it does not require specific knowledge), and a user-friendly interface (because it is similar to common applications).

An invitation containing a link to the questionnaire was sent via email to all *pellet producers* in Brazil. To prevent the form from being modified, deleted, or inadvertently shared, editing was permitted only to the user who created it. All the questions required mandatory answers, so the form could be returned only with all the answers completed. The questions were of two different types: (a) text type, for open-ended essay questions; (b) multiple choice, to select only one of the presented options.

The field research was conducted between February and April 2020 and began with sending a link to the form to *pellet-producing companies* in Brazil. The form has three questions about the *pellet market* in Brazil: (1) it asks for basic information from companies; (2) it asks what *pellet production* was in 2019 and 2020; and (3) it asks what raw material is used in *pellet production*.

2.2 Using the Google Maps tool

To create the 2020 Map of Brazilian Pellet Producers, the free Google Maps platform was used. This service, launched in 2005, allows the creation of personalized and diverse maps, with the possibility of later sharing them with other users. The program's interface is simple and provides free access to map and satellite information, allowing for the concept of spatial location and distance between places. This application was chosen because it is a free, open-source platform that is highly integrated with *smartphones* and does not require any additional software to run, as everything is built through the online application.

2.3 Data analysis

The data analysis was performed via simple descriptive statistics via Microsoft Office 365 Excel® software. The comparison of the data obtained with previous information from the literature allowed the achievement of the proposed objectives, with statistical inferences from the pellet industries surveyed.

3 RESULTS AND DISCUSSION

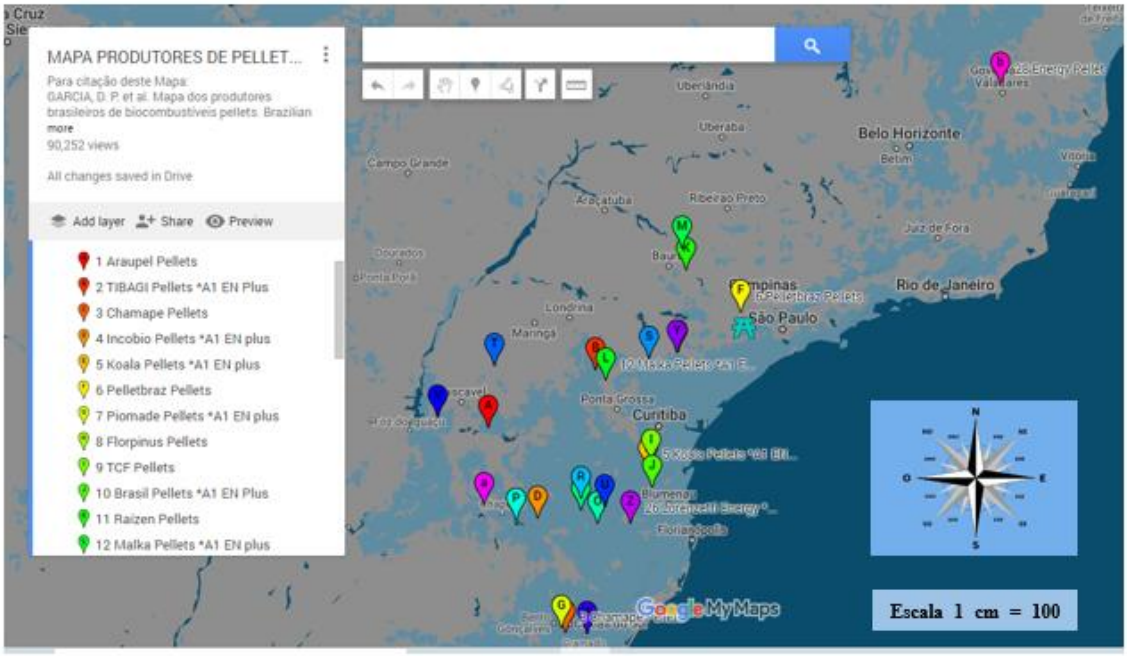
Among the thirty companies registered as manufacturers of solid biofuel, only one did not respond to the questions, but its main information was subsequently obtained via a cell phone and the WhatsApp® application. Thus, given the method of applying the questionnaire and the dispersion of the industries across the various regions of Brazil, a satisfactory response rate of 100% was obtained, meaning that basic production data were collected from all industries.

On the basis of the analysis of the responses from the questionnaires, it is possible to make inferences of interest about the production and market of *pellets* in Brazil and achieve the objectives outlined for this study. The basic information from the companies requested in the questionnaire served as the basis for the creation of the map of Brazilian pellet producers shown in Figure 1. Using the interactive resources of Google Maps, the company's address was located, and a colored marker was added next to its trade name, along with its physical address, telephone number, and email. This objective action facilitated contact between consumers and producers of solid biofuels and encouraged the use of this renewable and clean biofuel.

The idea behind creating the online map was to facilitate the purchase of pellets by consumers throughout Brazil, as it allows them to locate the nearest factory to buy the product. Furthermore, the map contributes to expanding domestic consumption and promotes awareness of the advantages of using pellets, increasing the demand for these solid biofuels. Low consumption and a lack of knowledge about product characteristics are market problems identified as the most relevant factors contributing to the slow development of the domestic pellet market in the country (GARCIA *et al.*, 2018a; GARCIA; CARASCHI; VENTORIM, 2017).

The Brazilian Pellet Producers Map, updated on November 1, 2021, is available online (encurtador.com.br/qMRZ8), accessible via smartphones, and its interactivity is enhanced through routes that can be created to discover the distance to the nearest pellet factory. It is a tool that contributes to the development of the domestic market because it presents all producers of the biofuel to consumers and developers of pellet-powered equipment. This will guarantee customers a continuous supply of the product in various regions of the country from multiple suppliers.

Figure 1. Map of Pellet Producers [Updated 1/11/2021].

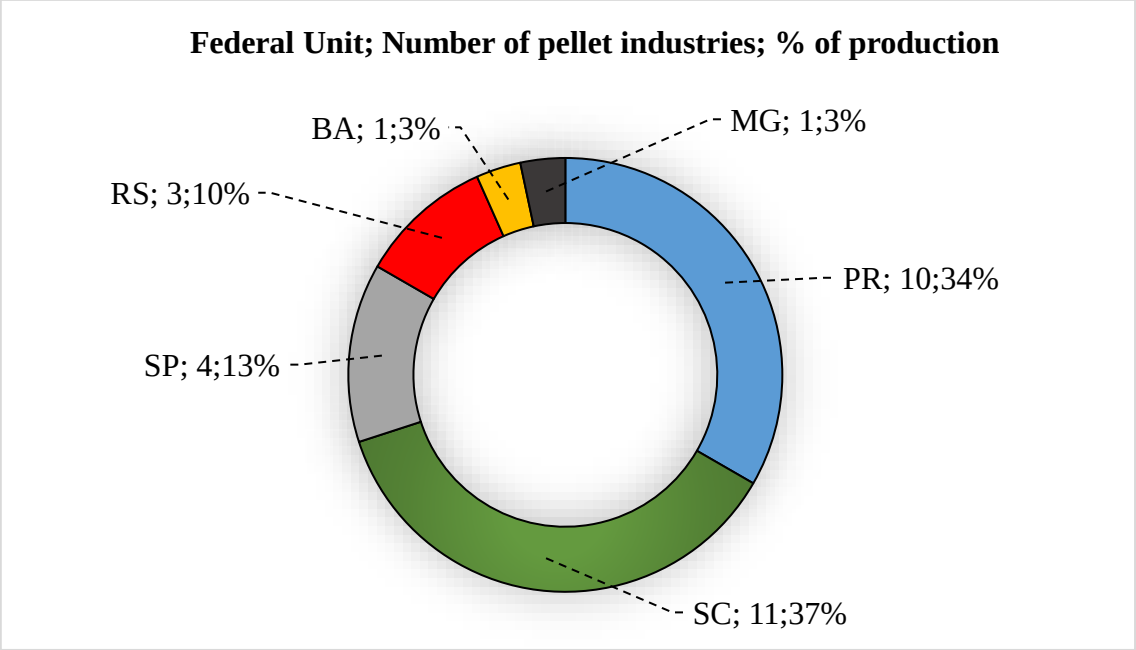


Source: Garcia *et al.* (2018a).

Evidence of its usefulness in the pellet market is the number of views it has received since its creation. It has reached over 90,000 views (as shown in the upper left corner of Figure 1) since it was first launched in January 2015.

On the basis of research data, Brazil has 30 agroforestry biomass pellet industries (Figure 2), distributed across the South, Southeast, and Northeast Regions, with the majority located in the state of Santa Catarina, owing to the high availability of residual raw material from the region's timber industries (GARCIA; CARASCHI; VENTORIM, 2017). These data are higher than those reported by these authors, who indicated the existence of approximately 13 manufacturing companies in the country in 2016. Therefore, there was a significant increase in the number of pellet manufacturers during this period. These authors reported that the expansion of this market, both in Brazil and worldwide, is explained by the growing demand for low-carbon energy sources that replace fossil fuels (oil, coal, and natural gas), as these sources emit greenhouse gases that contribute to global warming.

Figure 2. Evolution by state of agroforestry biomass *pellet production.*



Source: Survey data

Furthermore, at the 2021 United Nations Climate Change Conference (COP26), the much-needed energy transition was once again highlighted, and wood pellets adequately meet this global need for clean and renewable energy, replacing natural gas (from industry) and coal (from thermal power plants). Therefore, with commitments to reduce carbon dioxide (CO_2) emissions into the atmosphere, the demand for energy pellets may increase (SIYAL *et al.*, 2021).

In terms of the production of agroforestry biomass pellets in Brazil, production increased approximately 11-fold from 2016--2020, as shown in Table 1. This sharp increase in production is justified by the larger volume of wood pellets destined for export. In 2016, 51.71% of production was supplied to the external market, mainly in Europe, for use in residential heating. By 2020, approximately 88% of Brazilian pellet production was destined for the external market, mainly for consumption by large thermoelectric power plants in the United Kingdom and Japan but also by residential consumers in Europe, who use them for internal heating. This increase in pellet exports was favored by the exchange rate. In Brazil, the small share of production consumed in the domestic market (12%) is directed toward the generation of thermal energy in commercial and industrial areas, especially for heating poultry farms, hotels, hospitals, pizzerias, and bakeries (GARCIA; CARASCHI; VENTORIM, 2017).

However, despite the growth in production, Brazil's share of the international market is insignificant, representing less than 2.0% of the total produced worldwide, according to Garcia *et al.* (2018a).

Table 1. Evolution of lignocellulosic biomass *pellet production* in Brazil.

Year	Production (tons per year)	Source (Magazine)	Bibliographic References
2015	75,000	Wood Science	Garcia *et al*. (2017)
2016	135,350	The Role	Garcia (2017)
2017	470,000	Biosystems Engineering	Garcia *et al*. (2018a)
2018	507,000	B. Forest	Garcia (2018)
2019	700,000	This work	
2020	820,000		

Source: Survey data

According to information obtained from online forms (Table 2), 25 pellet production units use pine waste from the timber industry as the main raw material in the pelletizing process. One company in Jaú/SP reported using sugarcane bagasse, whereas another industry in Rio Grande/RS stated that it uses black wattle wood (Acacia) (mearnsii). On the other hand, a manufacturer from Varginha/MG confirmed that they produce pellets using coffee husks, and a producer from São Carlos/SP uses peanut husks to produce pellets both for generating energy and as roughage for feeding beef cattle.

The choice of raw material for pellet production is related to the availability of residual agroforestry biomass near the industrial plant. Pine sawn timber residues, which are used by more than 83% of Brazilian producers, are byproducts of the timber industry in the region where the factories are located. The low bulk density and high moisture content of these lignocellulosic materials translate into high transportation costs, making the project unfeasible if the material is more than 200 km away from the pelletizing plant (GARCIA *et al.*, 2018b).

Table 2. Number of industries and pellet production in Brazil in 2020.

Agroforestry Biomass	Number of Industries	Production (t/year)	% of Brazilian Production
Pine wood	25	463,452	56.52
Black acacia wood	1	250,000	30.49
Sugarcane bagasse	1	80,000	9.76
Eucalyptus wood	1	25,000	3.05
Peanut shell	1	1.048	0.13
Coffee husk	1	500	0.06
TOTAL	30	820,000	100.00

Source: Survey data

Although the enormous amount of eucalyptus waste generated by the timber industry is acknowledged, it is not the preferred choice of producers for pellet production because this forest biomass is denser and harder than pine is, causing excessive wear on pelletizing dies and increasing production costs (GARCIA *et al.*, 2017).

Brazil has a wide variety of plant biomass sources that can be compacted into *pellets* for energy purposes. There are reports in the literature of eucalyptus tip pellets (PINTO *et al.*, 2015), residual biomass pellets from the 2nd generation bioethanol production process from sugarcane bagasse (MOREIRA *et al.*, 2020), soybean processing residue pellets *(SCATOLINO et al.*, 2018), coffee farming residue pellets *(FARIA et al.*, 2016), bamboo pellets (SETTE JÚNIOR *et al.*, 2016), elephant grass pellets (GARCIA *et al.*, 2019), and even

mixtures of lignocellulosic materials, which aim to facilitate the densification process and minimize mechanical wear on the perforated pelleting die (GARCIA *et al.*, 2017; SANTANA *et al.*, 2021). However, these laboratory studies seek to understand the most relevant characteristics of these raw materials for energy use, but this does not yet involve industrial-scale production.

As shown in Table 2, approximately 90% of Brazilian pellet production uses forest biomass (wood). Although Brazil produces more than 100 million tons of agroforestry residues annually from a wide variety of species (BONASSA *et al.*, 2018), with the potential to be compacted into pellets and briquettes (sugarcane bagasse, rice husk, peanut husk, and corn straw, for example), most of them generally have high ash contents (FARIA *et al.*, 2016; GARCIA *et al.*, 2018b). This quantity of residual mineral elements from combustion is an important characteristic that should be evaluated in energy pellets, especially for obtaining certification and meeting international marketing standards.

For future prospects for this market, the following stand out: (1) the likely growth in production and exports to meet the demands for low-carbon energy (ratified at COP26), (2) overcoming sectoral limitations related to logistical issues, and (3) the use of the newly created Brazilian pellet quality standards, NBR 13013-1 (ABNT, 2022), by all national manufacturers, as well as the expansion of regulations to other biomasses such as sugarcane bagasse, coffee husks, and peanut husks.

4 CONCLUSIONS

This research focused on quantifying Brazilian biofuel production in *pellet form*. On the basis of the analysis of producer responses, the following conclusions were drawn:

- Brazil has 30 active industries that produce biomass pellets. agroforestry;
- Six types of raw materials are used by Brazilian pellet producers: pine, eucalyptus, black wattle, sugarcane bagasse, coffee husks, and peanut shells;
- In 2020, Brazil produced 820,000 tons of biofuel pellets, the majority (90%) of which were pine sawdust;
- The export market accounts for 88% of Brazilian pellet production;
- The largest consumers of pellets produced in Brazil are thermal power plants in the United Kingdom and Japan.

5 ACKNOWLEDGEMENTS

The authors express their sincere gratitude to CNPq and CAPES for granting scholarships, which are fundamental to promoting research in Brazil.

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