Mix Sustentável

Compósitos de polipropileno reforçados com fibras de bagaço de cana e coroa de abacaxi

Sugarcane bagasse and pineapple crown fibers reinforced polypropylene composites

Compuestos de polipropileno reforzados con fibras de bagazo de caña de azúcar y corona de piña

Alan Frizzo Koltz[1]
Matheus Poletto[2]

[1] Engenharia Mecânica, Universidade de Caxias do Sul, Caxias do Sul, Rio Grande do Sul, Brasil
[2] Programa de Pós-Graduação em Engenharia de Processos e Tecnologias, Universidade de Caxias do Sul, Caxias do Sul, Rio Grande do Sul, Brasil

Correspondência para: mpolett1@ucs.br

Resumo: A utilização de materiais compósitos vem crescendo em diversos setores da indústria impulsionado pelo uso de fibras naturais. Neste estudo, foram desenvolvidos em extrusora duplarrosca, compósitos de polipropileno (PP) reforçados com 20% e 40% em massa de fibra do bagaço de cana-de-açúcar (SB) e coroa do abacaxi (PC). Através da microscopia eletrônica de varredura foi possível observar a morfologia das fibras, bem como sua dispersão. A resistência à tração e à flexão aumentaram 20% e 30%, respectivamente, utilizando 20% carga. No entanto, reduziram quando utilizado com 40%, possivelmente devido a fraca adesão fibra-matriz. O módulo de flexão aumentou com adição de carga em vir-

ARTIGO ORIGINAL - SEÇÃO CIENTÍFICA

Editor responsável pelo artigo: Lisiane Ilha Librelotto, Dr. Eng., Paulo Cesar Machado Ferroli, Dr. Eng.

Recebido em
26/11/2025
Aprovado em
26/12/2025
Publicado em
30/10/2026

PID
10.29183/2447-3073.MIX2026.v12.n4.248-262

Texto padrão da Licença
Este trabalho está licenciado com uma Licença Creative Commons - Atribuição 4.0 Internacional.

Declaração de Copyright
Autores mantém os direitos autorais e concedem à revista o direito de primeira publicação, com o trabalho simultaneamente licenciado sob a Licença Creative Commons Attribution que

tude do módulo das fibras ser superior ao da matriz. O módulo de tração dos compósitos com 40% de fibras PC foi 80% superior, quando comparado ao PP. O mesmo teor de carga de fibras de SB gerou aumento de 19% no módulo Young. A resistência ao impacto reduziu quando comparada ao PP. No entanto, aumento das propriedades mecânicas dos compósitos com o uso das fibras, sem aumentar a densidade, indica o potencial de utilização destes resíduos lignocelulósicos como reforço em materiais compósitos poliméricos.

Palavras-chave: Compósitos poliméricos; Fibras naturais; Materiais lignocelulósicos; Propriedades mecânicas; Morfologia.

Abstract: The use of composite materials has been growing in various industrial sectors, driven by the use of natural fibers. In this study, polypropylene (PP) composites reinforced with 20 wt% and 40 wt% of sugarcane bagasse (SB) and pineapple crown (PC) fibers were developed in a twin-screw extruder. Scanning electron microscopy allowed observation of fiber morphology and dispersion in the matrix. Tensile and flexural strength increased by 20% and 30%, respectively, using a 20 wt% of SB, while this increase reaches 40% and 20% when 20 wt% of PC were used. However, these properties decreased when a 40 wt% was used, possibly due to weak fiber-matrix adhesion. The composite flexural modulus increased with addition of filler because the fibers modulus was higher than matrix. The composite tensile modulus with 40 wt% PC fibers was 80% higher when compared to PP. The same filler content of SB fibers resulted in a 19% increase in Young's modulus. Impact strength decreased when compared to PP. However, the increase in composite mechanical properties with fibers addition, without significantly increasing composite density, indicates potential use of these lignocellulosic wastes as reinforcement in polymeric composite materials.

Keywords: Polymer composites; Natural fibers; Lignocellulosic materials; Mechanical properties; Morphology.

Resumen: El uso de materiales compuestos ha ido aumento en diversos sectores industriales, impulsado por uso de fibras naturales. En este estudio, se desarrollaron compuestos polipropileno (PP) reforzados con 20% y 40% masa de fibras de bagazo de caña de azúcar (SB) y corona de piña (PC) en extrusora de doble husillo. Microscopía electrónica de barrido permitió observar morfología de fibras y su dispersión en matriz. La resistencia a tracción y a flexión aumentaron 20% y 30%, respectivamente, utilizando un contenido de relleno del 20%. Sin embargo, disminuyeron cuando se utilizó un contenido del 40%, posiblemente

permite o compartilhamento do trabalho com reconhecimento da autoria e publicação inicial nesta revista.

Contribuição dos autores segundo a Taxonomia CRediT

Sigla dos autores: Autor 1: Alan Frizzo Koltz, AFK Autor 2: Matheus Poletto, MP AFK: conceptualization, formal analysis, investigation, methodology, visualization,editing, and writing – original draft. MP: project administration, resources, writing – review amp; editing, conceptualization and supervision.

Conflito de interesses

Declaração de conflitos de interesse.

Fonte de financiamento

Fonte de financiamento.

debido a débil adhesión fibra-matriz. Módulo de flexión aumentó con adición de relleno porque módulo de fibras era mayor que de matriz. Módulo de Young con 40% masa de fibras PC fue 80% superior al PP. El mismo contenido de relleno de fibras de SB produjo aumento del 19% en módulo Young. Resistencia al impacto disminuyó en comparación con PP. El aumento de propiedades mecánicas de compuestos con uso de fibras, sin un incremento significativo de densidad, indica potencial de estos residuos lignocelulósicos como refuerzo en materiales compuestos poliméricos.

Palabras clave: Compuestos poliméricos; Fibras naturales; Materiales lignocelulósicos; Propiedades mecánicas; Morfologia.

Como citar: KOLTZ, Alan Frizzo; POLETTO, Matheus. Compósitos de polipropileno reforçados com fibras de bagaço de cana e coroa de abacaxi. **Mix Sustentável**, Florianópolis, v. 12, n. 4, p. 248-262, 2026. DOI: https://doi.org/10.29183/2447-3073.MIX2026.v12.n4.248-262.

1 INTRODUÇÃO

Population growth and technological advancements in recent decades have contributed to boosting the agro-industrial sector due to increased demand for food. Parallel to the growth in food production, there has also been an increase in the generation of waste and by-products from the agro-industrial sector (Lijó *et al.*, 2017) ,(Surendra *et al.*, 2016) ,(Venâncio; Silva, 2025) , (Silva; Belini, 2025).

Lignocellulosic fibers derived from agro-industrial wastes presented low cost and interesting mechanical properties, such as, tensile strength (Sayam, 2026) , (Santos *et al.*, 2025). Natural fibers are abundant, renewable, biodegradable and sustainable options to inorganic fibers, like glass fibers. These intrinsic characteristics making natural fibers highly suitable for high demand applications in several sectors, including construction and automotive industries, where both performance and environmental considerations are paramount (Santos *et al.*, 2025).

In the automotive industry, the pursuit for lightweight vehicles with high performance and efficiency is a constant challenge (Wagh; Malagi; Madgule, 2025). The search for light and mechanical strength materials hinders the development of polymer composite. Several works evaluated the potential use of natural fibers to reinforced polymer composites.

Kumar et al. (2022) used PC fibers as reinforcement into a maleic anhydride (MAH) grafted ethylene-propylene rubber (EPR) modified low-density polyethylene (LDPE). The highest tensile strength and Young modulus were obtained for composite consisting of 30 wt% PC (Kumar *et al.*, 2022). In addition, the highest flexural strength and flexural modulus were obtained for the same PC loading. Almeida et al. (2024) developed post-consumer high-density polyethylene composites reinforced with 2.5-20 wt% of SB treated with stearic acid. The authors observed that SB fibers improved the composite stiffness and tensile strength up to a content of 10% by mass . However, fiber-matrix adhesion was compromised, especially with higher fiber concentrations, such as 20 wt%. Arif Mahmud et al. (2025) evaluated the effect of SB fibers loading on the mechanical properties of chemically modified starch composite. The composite tensile properties were decreased with fiber loading up to 36 wt% of SB fibers. The authors attributed this decreased because there are no chemical bonds between fibers and matrix. Kumar et al. (2022) used PC fibers as reinforcement into a maleic anhydride (MAH) grafted ethylene-propylene rubber (EPR) modified low-density polyethylene (LDPE). The highest tensile strength and Young modulus were obtained for composite consisting of 30 wt% PC (Kumar *et al.*, 2022). In addition, the highest flexural strength and flexural modulus were obtained for the same PC loading. Almeida et al. (2024) developed post-consumer high-density polyethylene composites reinforced with 2.5-20 wt% of SB treated with stearic acid. The authors observed that SB fibers improved the composite stiffness and tensile strength up to a content of 10% by mass (Almeida *et al.*, 2024) . However, fiber-matrix adhesion was compromised, especially with higher fiber concentrations, such as 20 wt%. Arif Mahmud et al. (2025) evaluated the effect of SB fibers loading on the mechanical properties of chemically modified starch composite. The composite tensile properties were decreased with fiber loading up to 36 wt% of SB fibers. The authors attributed this decreased because there are no chemical bonds between fibers and matrix (Mahmud *et al.*, 2025).

Significant advancements have been made in lignocellulosic fiber reinforced polymer composites. Moreover, the potential use of some natural fibers from agro-industrial waste, such as PC and SB, in polymer composites has yet to be fully explored. The present work evaluated the usage of these both agro-industrial waste lignocellulosic fibers to developed polymer composites with an improvement in mechanical properties.

2 MATERIALS AND METHODS

Sugarcane bagasse (SB) was provided by the Casa Bucco distillery, located in Vale do Rio das Antas, Bento Gonçalves, RS. The pineapple crowns (PC) used in this study came from the waste of Agroindústria Produtos Coloniais Gabriel, located in Monte Belo do Sul, RS. The PP homopolymer was supplied by Braskem, grade H 103, with a melt flow index of 40g/10min (230°C/2.16 kg).

2.1 Composite preparation

The fibers were ground in a Primotecnica P1001 knife mill. After grinding sample was sieved (48 mesh) and the passing material was used to composite preparation. The particle size varies between 150-300 μm. PP and lignocellulosic wastes were previously dried in an oven at 80°C for 24 hours. Extrusion was carried out on a twin-screw extruder, model COR-20-32-LAB, co-rotational with L/D = 32 and D=20 mm, MH Equipamentos, using volumetric dosers. Composites with 20 wt% and 40 wt% of each lignocellulosic waste were prepared. The temperatures used in the different heating zones were: 120ºC, 160ºC, 175ºC, 185ºC, 190ºC, 170ºC, 185ºC, 190ºC, 190ºC and 190ºC (die temperature). The screw rotation speed was 200 rpm. The injection molding was performed on a equipment LHS 150-80, HimacoHidráulicos e Máquinas Ltda. The temperature profile used was 180ºC, 170°C and 170ºC in the three different heating zones. Specimens were prepared for mechanical tests, according to ASTM D638-14, ASTM D790-03 and ASTM D256-04 standards.

2.2 Composite characterization

The composite properties were evaluating by means of morphology, density and mechanical properties. Micrographs of lignocellulosic wastes and composites were obtained using a Tescan Mira3 scanning electron microscope with an acceleration voltage of 10 kV, on fractured samples previously coated with gold. Density determination was performed based on ASTM D792-13. Samples were weighed on analytical balance and subsequently immersed in ethanol and weighed again. Density was obtained by averaging three measurements for each sample. Samples for the tensile, bending, and impact tests were previously conditioned at a temperature of 23ºC and a relative humidity of 50% for 48 hours. Tensile test was performed on five specimens with a test speed of 5 mm.min-1, according to ASTM D638-14. Bending tests were performed according to

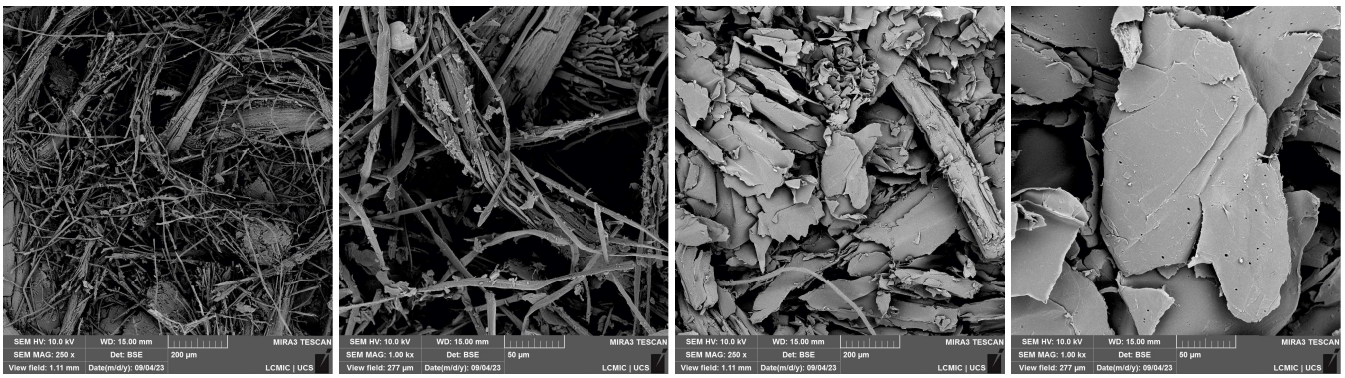
ASTM D790-03 on an EMIC DL3000 universal testing machine, on five specimens. Test speed used was 1.5 mm.min-1. The notching Izod impact strength tests were performed on a CEAST Resil 25 equipment with a 1J hammer, according to ASTM D256-04, on ten specimens. The results were analyzed using one-way ANOVA (p=0.05) and significant differences between groups were determined by Tukey test (α=0.05), by means of Excel software.

3 RESULTS AND DISCUSSION

3.1 SEM results

Figure 1 shows SEM micrographs of PC and SB fibers.

Figura 1 – SEM micrographs of PC (left) and SB (right) fibers with magnification of 250x and 1000x

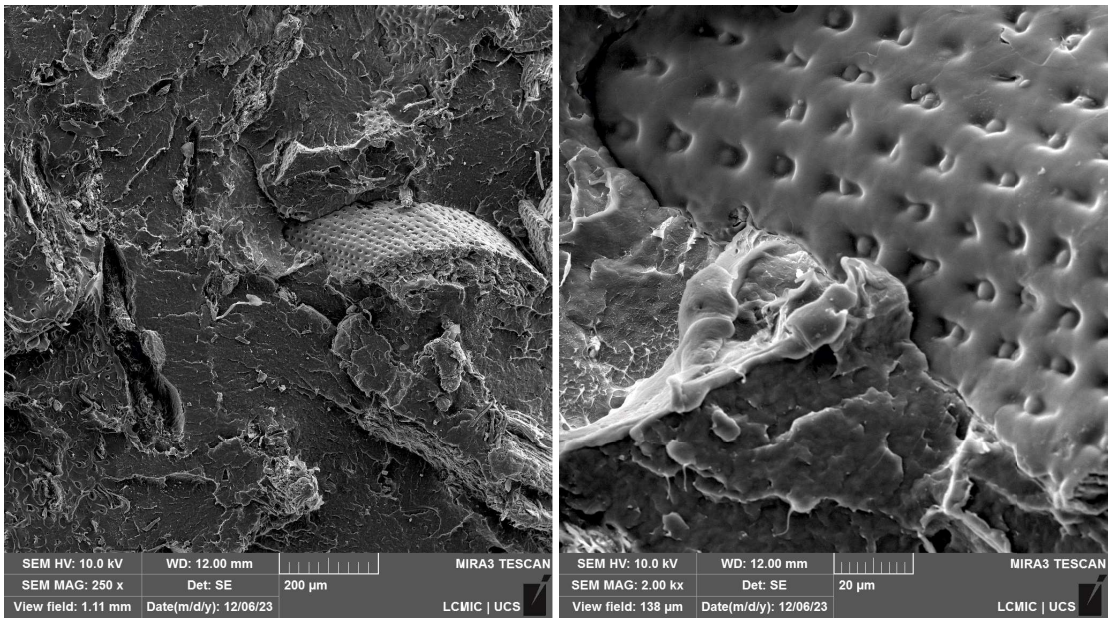


Source: Authors (2026).

As can be seen in Figure 1 PC lignocellulosic waste presented a fibrillary shape with filamentary structures that are elongated and have a high length-to-diameter ratio. Mucilage from pineapple leaves still presented after grinding together with bundle of fibers. PC fibers presented variations in their transversal section from flat to square. Additionally, the surface of the fibers presented dimensional variations along their length and superficial roughness, which could serve as mechanical anchoring points in polymeric matrices (Neto *et al.*, 2015). Twist and bent points in the fibers were observed, which may indicate fiber mechanical strength and flexibility to withstand tensions during the injection and extrusion molding processes flows without break (Neto *et al.*, 2015). Others authors, also found similar structures for fibers obtained from Ananas genus (Neto *et al.*, 2015) (Taipina; Ferrarezi; Gonçalves, 2012) , (Huda *et al.*, 2008). On the other hand, SB lignocellulosic waste are formed mainly by plate-like particles, as shown in Figure 1, with some filamentary structures. According to Sanches et al. (2010), SB is composed of a heterogeneous set of particles composed of grains and fibers, with sizes ranging from 1 to 25 mm, but with an average size of approximately 2 mm. The particle size of bagasse depends mainly on the type of equipment used in sugarcane processing and, to a lesser extent, on the sugarcane variety (Sanchez *et al.*, 2010). As can be seen in Figure 2 the twin-screw extrusion process resul-

ted in a homogeneous distribution of 20 wt% of PC fibers in polymer matrix, since it is not possible observe fiber accumulation. Figure 2 also shown fiber matrix interface. The fiber does not present layers of polymer covering its surface, so it is possible that a weak fiber matrix adhesion might occurs. Lignocellulosic fibers are high hydrophilic materials, while PP is a hydrophobic matrix. In this way, is expected that a weak adhesion between fiber and matrix can occur at the interface mainly due to the presence of some hydrophobic extractives in natural fibers surface (Jan *et al.*, 2026).

Figura 2 – SEM micrographs of composites with 20 wt% of PC fibers with magnification of 250x (left) and 2000x (right).



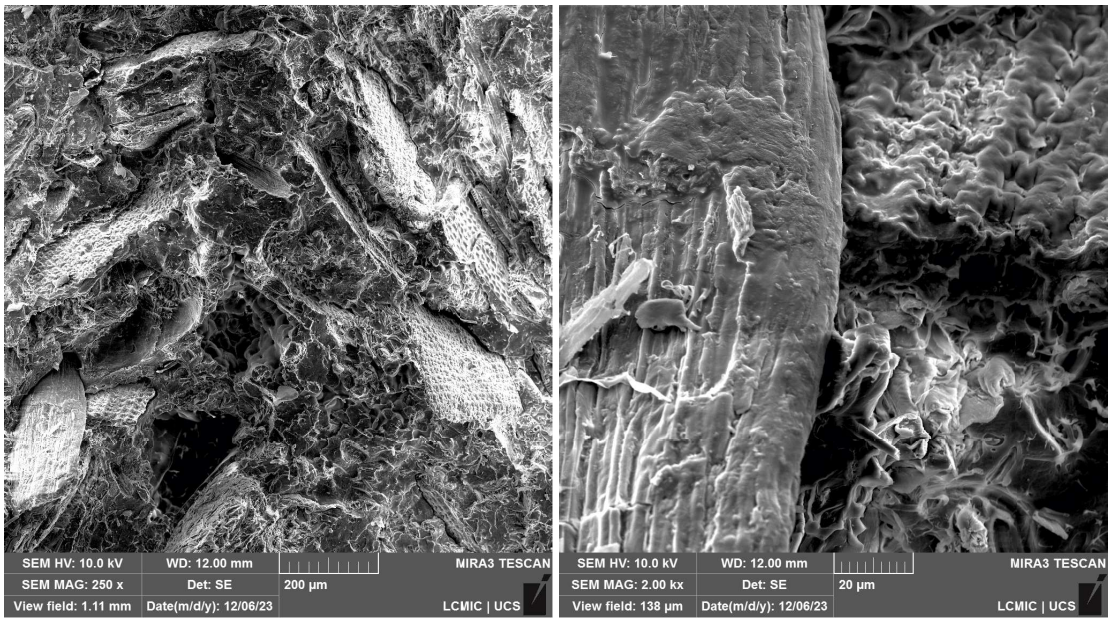
Source: Authors (2026).

Figure 3 shown the SEM micrographs of composites with 40 wt% of PC fibers. It can be observed in Figure 3 that composite showed fiber dispersion and homogeneity between polymer matrix and PC fibers. As can also be seen in Figure 3 the PC fiber remains smooth, without the presence of polymer layers on the fiber surface, which may result in weak adhesion. As a result, a smaller amount of energy is transferred from matrix to fiber, which may result in composites with brittle behavior (Hussain *et al.*, 2024).

The morphological behavior of composites reinforced with 20 wt% of SB fibers are shown in Figure 4. It is possible observe in Figure 4 voids in matrix due the SB fiber pullout. As explained earlier, the weak interfacial adhesion between hydrophobic matrix and hydrophilic fibers may promote fiber pullout. Figure 4 also shown in detail the interface region. The SB fiber is not covered by matrix, as also previously observed for PC fiber, and a poor interfacial adhesion between fiber and matrix occurred. Figure 5 shows the morphology of composite reinforced with 40 wt% of SB fibers. The same characteristics of composites with 20 wt% SB is observed.

Fiber pullout and poor fiber matrix interfacial adhesion governs composite morphology with 40 wt% of SB fibers. The fibers were evenly dispersed in polymer matrix even with 40 wt%. The increase amount

Figura 3 – SEM micrographs of composites with 40 wt% of PC fibers with magnification of 250x (left) and 2000x (right).



Source: Authors (2026).

of voids in composite materials may cause a loss of mechanical strength, reducing the material lifetime under fatigue, often resulting in catastrophic failure. A well-bonded interface is crucial for transferring stress from matrix to fibers, which strengthens the overall composite (Dhamodharan; Subramaniyan, 2026). When this bonding is compromised, the fibers can break more easily, contributing to composite failure (Dhamodharan; Subramaniyan, 2026).

3.2 Density values

The density values of PP and composites are shown in Figure 6. It can be observed that with increasing filler content, all polymer composites showed an increase in density compared to PP. Lignocellulosic materials have a higher density than PP, which may explain the increase in the density of the composite with the addition of filler. The PC40 sample showed a highest density value. The value obtained for PC40 was 1.0 g/cm³, while the density of PP is 0.9 g/cm³, an 11% increase in the density value. Ornaghi et al. (2010) observed that the density values are higher for composites with a higher fiber content, since fibers have a higher density than polymer matrix (Ornaghi; Zattera; Amico, 2015). Statistical analysis showed that the addition of 20 wt% of PC or SB and 40 wt% of SB did not represented a significant increase in density values when compared to PP. This results is interesting, since the increasing in lignocellulosic fiber content may provide an increase in composite mechanical properties without cause an increase in density adding mechanical performance to composite material without making it denser. Bonelli et al. (2005) emphasize that composite mechanical

Figura 4 – SEM micrographs of composites with 20 wt% of SB fibers with magnification of 250x (left) and 2000x (right).



Source: Authors (2026).

properties depend on several factors, such as fiber dispersion in polymer matrix, interaction between fiber and matrix, as well as volume and type of fibers used (Bonelli *et al.*, 2005).

3.3 Mechanical properties

The tensile properties of PP and composites developed with PC and SB fibers are presented in Table 1 .

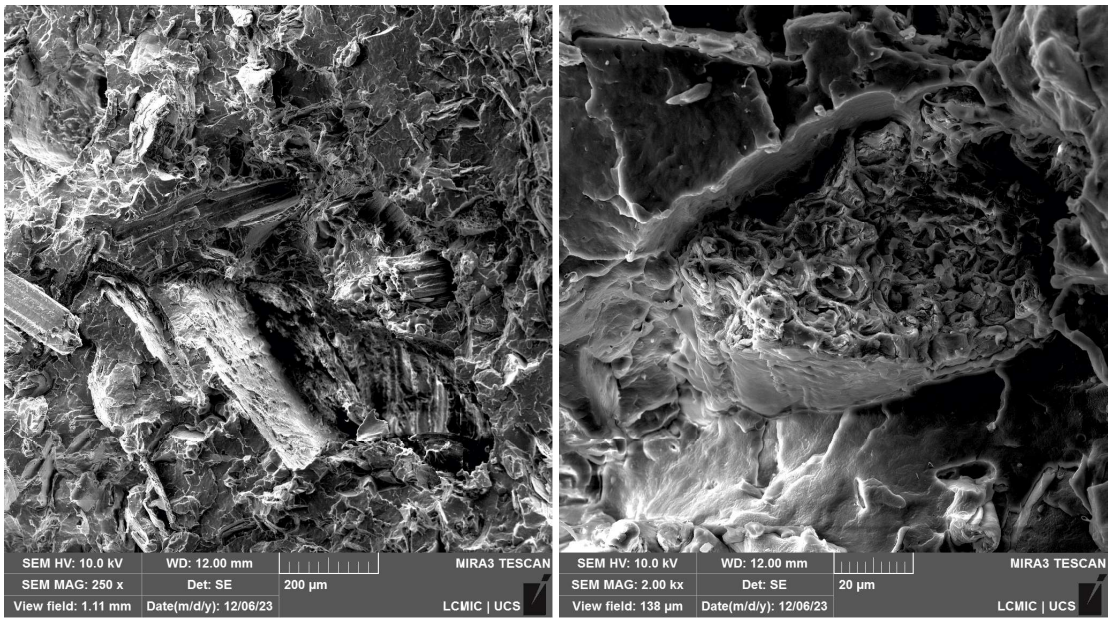
Tabela 1 – PP and composite tensile properties

Sample	Elongation at break (%)	Tensile strength(MPa)	Tensile modulus (MPa)
PP	14.2 ± 0.7a	20.0 ± 0.5a	377.4 ± 44.1a
PC20	12.0 ± 0.9a	28.1 ± 0.8d	614.3 ± 64.0b
PC40	7.4 ± 0.3b	23.1± 0.4b,c	695.3 ± 60.9b
SB20	8.7 ± 1.8b	23.9 ± 1.5b	626.0 ± 46.9b
SB40	12.2 ± 0.7a	21.4 ± 1.1a,c	449.4 ± 54.3a

Source: Authors (2026).

The incorporation of fibers, in general, reduces composite elongation at break. The fibers act by restricting polymer chains mobility of PP (Ornaghi; Zattera; Amico, 2015). PC40 and SB20 composites are more brittle than other composites evaluated. The composites also showed greater tensile strength when compared to PP. In addition, the lower the mass content of fibers in composites, the greater the tensile strength. This is due

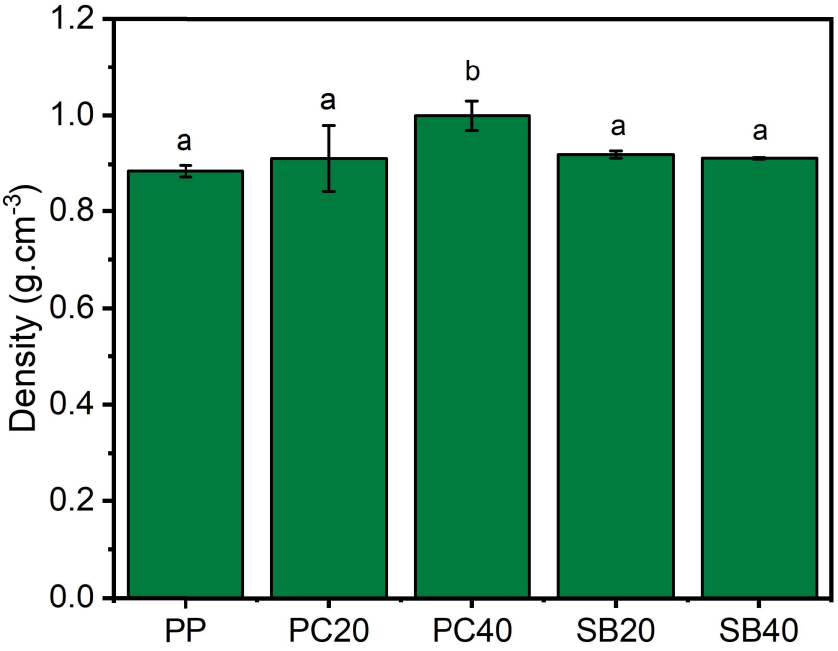
Figura 5 – SEM micrographs of composites with 40 wt% of SB fibers with magnification of 250x (left) and 2000x (right).



Source: Authors (2026).

to the weak adhesion that occurs between fibers and matrix. With the increase in filler content, it was possible to identify a decrease in tensile strength and an increase in tensile modulus. PC20 composite sample exhibit the highest tensile strength. The tensile strength for PC20 is 40% higher than PP. This may be associated with the fiber morphology showed in Figure 1. PC lignocellulosic waste presented a filamentary structures composed by filament bundles that may support more energy during tensile test that the plate-like particles of SB. The tensile strength increase for SB20 was only 20% , when compared to the polymer matrix. Dhamodharan and Subramaniyan (2026) observed the same behavior when jute fiber reinforced polymer composites. According to the authors, the primary contribution of jute fiber is its ability to efficiently transfer load within the composite (Dhamodharan; Subramaniyan, 2026). When subjected to external forces, composite matrix transfers stress to jute fibers, which have higher tensile strength. As a result, an improving in the overall composite tensile properties were obtained. Composites presented a tensile modulus higher than PP. This occurs because natural fibers are more rigid than matrix. Poletto et al. (2016), observed a similar behavior when evaluated the effect of cellulose fiber loading in a polymer matrix. The authors observed that the addition of 10 wt% and 20 wt% of cellulose fibers in a polymer matrix increased flexural strength when compared to the matrix . However, the property decreased when 30 wt% were used. Higher cellulose contents can result in fiber agglomeration and thus, a decrease (Poletto, 2016) in flexural strength. Conversely, an increase in the flexural modulus was observed with fiber loading, and this behavior may be related to the fact that cellulose fibers have a higher modulus than the matrix polymer (Poletto, 2016). The use of 40 wt% of PC fibers resulted in an increase of approximately 80% in the composite elastic modulus, when compared to PP. However, the same filler content, but using SB fibers, generated an increase of approximately 19%. This reduction may be related to the degradation of SB

Figura 6 – Mean density values for PP and composites with fibers studied.



Means followed by the same letter are not significantly different.
Source: Authors (2026).

fibers due to the processing temperature observed mainly during the injection stage of the specimens for the tensile test. Wearn et al. (2020) emphasize that an increase in fiber content can further increase the interface region between the composite components, potentially reducing tensile strength. Therefore, the greater the volume of fibers, the more difficult it is to achieve homogeneous distribution between the materials within the polymer matrix, which can interfere with stress transfer from the matrix to fiber reinforcement (Wearn; Montagna; Passador, 2020). Table 2 presented the results for flexural strain, flexural strength, and flexural modulus for PP and composites reinforced with PC and SB fibers.

Tabela 2 – Flexural properties obtained for PP and composites studied

Sample	Flexural strain(%)	Flexural strength (MPa)	Flexural modulus (MPa)
PP	7.4 ± 0.3a	29.1 ± 2,8a	885.1 ± 73.8a
PC20	6.5 ± 0.5b	35.4 ± 1.0b	1354.6 ± 46.7b
PC40	4.4 ± 0.4c	34.2± 0.8b	1918.7 ± 55.9c
SB20	5.7 ± 0.2d	38.4 ± 1.1b	1589.1 ± 119.3d
SB40	4.4 ± 0.3c	35.5 ± 1.2b	2126.1 ± 123.8c

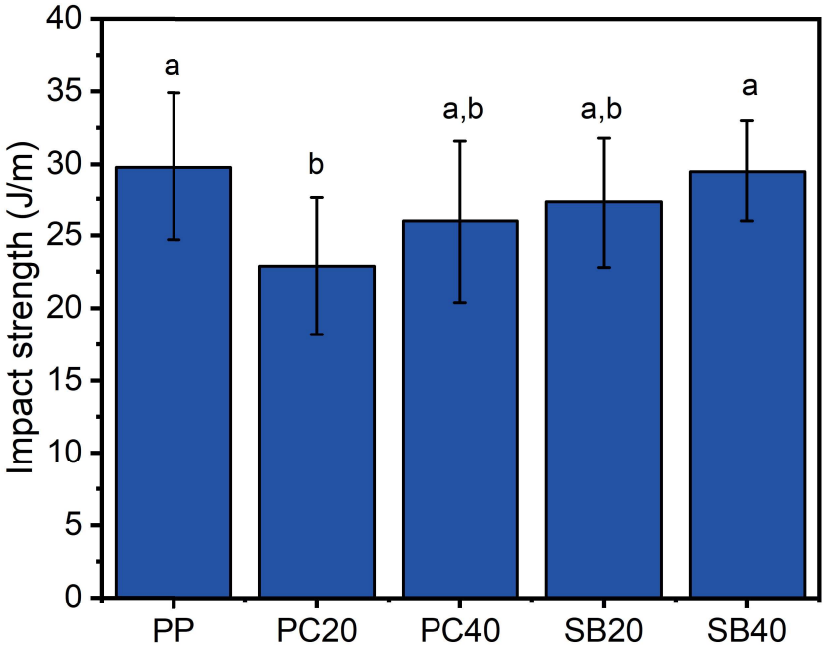
Source: Authors (2026).

The composites flexural strain decreased when fibers were added to PP. The fibers may act restricting

polymer chains mobility, increasing composite stiffness, which in turn reduces the material deformation (Madgule *et al.*, 2023) , (Poletto, 2016). The composite flexural strength increased when 20 wt% of lignocellulosic fibers was added, but tends to decrease when the mass content increased to 40%. This drop in flexural strength may be associated with poor adhesion between the nonpolar PP and polar lignocellulosic fibers, directly affecting the composite mechanical properties (Dhamodharan; Subramaniyan, 2026), (Madgule *et al.*, 2023). However, the results of statistical analysis revealed that there is no significant difference in flexural strength when both type of fibers and filler loading. The composites flexural modulus is higher than polymer matrix. This behavior occurred due to the increase in mass content of PC and SB fibers, since as comment earlier, the fiber modulus is higher than matrix. The addition of 40 wt% of fibers generated an increase of approximately 115% and 140% in composite flexural modulus with use of PC and SB fibers, respectively, when compared to PP. The fibrous reinforcement promote by PC fiber provides greater resistance to bending and deformation, leading to improved modulus of elasticity and higher load-bearing capacity (Dhamodharan; Subramaniyan, 2026). Luz et al. (2006) observed that composites reinforced with 20 wt% cellulosic fiber exhibit higher flexural modulus than matrix, with an approximate increase of 66% when compared to PP (Luz; Gonçalves; Jr, 2006). Figure 7 shows results obtained for composite impact strength. It can be observed that fibers addition reduced PC20 composite impact strength. This sample presented the more brittle behavior in tensile test. So, it is expected lower energy absorption during impact tests. The reduction in impact strength is associated with the weak interfacial adhesion between fibers and PP matrix, as shown in Figure 2. The absence of a strong interface prevents the transfer of energy absorbed by the polymer matrix to the reinforced fibers, which leads to polymer cracking and lower impact strength (Jan *et al.*, 2026).

According to Pires (2012), one of the difficulties in obtaining composites with the expected mechanical properties and dimensional stability is the lack of adhesion between fibers and matrix. The difference in polarity between natural fibers, which are hydrophilic, and PP, which is hydrophobic, is responsible for the lack of adhesion (Pires *et al.*, 2012). This results in an important role for the fiber-matrix interface. However, if the interactions between phases are weak, it is unlikely that composite mechanical properties will increase. On the other hand, larger particles tend to create uneven distributions within the composite. So, stress concentrators areas were formed and reduced the composite impact strength (Jan *et al.*, 2026). Larger particles have a smaller surface area relative to their volume, resulting in less effective bonding with the PP matrix. This weak bonding reduces the composite ability to absorb and dissipate impact energy effectively (Jan *et al.*, 2026). The statistical analysis results showed that no significant differences in impact strength were obtained with the addition of 40 wt% of PC or SB fibers, when compared to PP. The result indicates that even with the trend of decreasing in tensile and flexural composite properties with filler loading, the impact strength is less affected. Thus, a balance between strength and ductility is maintained in composite material even with a high filler content. This is an important result when these composite will be used in applications that demand mechanical strength and ductility, such as vehicle bumpers. Therefore, these composites could be also used in applied in automotive interior components like door panels and dashboards, where moderate strength and flexibility are required (Dhamodharan; Subramaniyan, 2026) , (Wagh; Malagi; Madgule, 2025).

Figura 7 – Impact strength of PC and SB composites studied



Means followed by the same letter are not significantly different.
Source: Authors (2026).

4 CONCLUSION

The utilization of two industrial waste based on lignocellulosic fibers in polymer composites was evaluated in this work. The SEM results show that PC and SB fibers were dispersed in polymer matrix after twin-screw extrusion and injection molding processes. However, the adhesion of these hydrophilic natural fibers to hydrophobic PP matrix is weak. The addition of 40 wt% of natural fibers studied did not deeply change composite density, but are more suitable to increase the mechanical properties. In general, the fibrillary shape of PC fibers prove to be more suitable to increase the mechanical properties evaluated than SB plate-like particles. Therefore, both natural fibers tested were options to develop polymer composites reintroducing high value-added wastes in new industrial cycles, contributing for circular economy and sustainability.

5 ACKNOWLEDGMENTS

The authors thank University of Caxias do Sul for technical support. M. Poletto also thank Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), grant number 304647/2022-5.

REFERÊNCIAS

Almeida, S. da S. *et al.* Post-consumer high-density polyethylene matrix reinforced by sugarcane bagasse fibers treated in stearic acid solution. **Journal of Materials Research and Technology**, Elsevier, v. 31, p. 3749–3759, 2024.

Bonelli, C. M. *et al.* Comportamento térmico, mecânico e morfológico de compósitos de polietileno de alta densidade reciclado com fibra de piaçava. **Polímeros**, SciELO Brasil, v. 15, n. 4, p. 256–260, 2005.

Dhamodharan, S.; Subramaniyan, G. G. Influence of resin composition on mechanical properties of eco-friendly jute-mesquite gum and pop composites. **Journal of Reinforced Plastics and Composites**, SAGE Publications Sage UK: London, England, v. 45, n. 7-8, p. 1781–1798, 2026.

Huda, M. S. *et al.* Effect of chemical modifications of the pineapple leaf fiber surfaces on the interfacial and mechanical properties of laminated biocomposites. **Composite Interfaces**, Taylor & Francis, v. 15, n. 2-3, p. 169–191, 2008.

Hussain, A. *et al.* Industrial approach to circularity of polymer composites: Processing, characterization, mechanical testing, and wear regression. **Journal of Reinforced Plastics and Composites**, SAGE Publications Sage UK: London, England, v. 43, n. 7-8, p. 456–472, 2024.

Jan, Q. M. U. *et al.* Sustainable recycling of polypropylene waste: Characterization and statistical analysis of wood husk-pp composite. **Journal of Reinforced Plastics and Composites**, SAGE Publications Sage UK: London, England, v. 45, n. 7-8, p. 1916–1933, 2026.

Kumar, J. *et al.* Development of eco-friendly bio-composite by reinforcing pineapple fruit waste crown fiber to ethylene-propylene rubber modified polyethylene. **Polymer Composites**, Wiley Online Library, v. 43, n. 11, p. 8259–8273, 2022.

Lijó, L. *et al.* The environmental effect of substituting energy crops for food waste as feedstock for biogas production. **Energy**, Elsevier, v. 137, p. 1130–1143, 2017.

Luz, S. M. d.; Gonçalves, A. R.; Jr, A. P. D. Microestrutura e propriedades mecânicas de compósitos de polipropileno reforçado com celulose de bagaço e palha de cana. **Matéria (rio de Janeiro)**, SciELO Brasil, v. 11, p. 101–110, 2006.

Madgule, M. *et al.* Experimental investigation on mechanical properties of novel polymer hybrid composite with reinforcement of banana fiber and sugarcane bagasse powder. **Advances in Mechanical Engineering**, SAGE Publications Sage UK: London, England, v. 15, n. 10, p. 16878132231203810, 2023.

Mahmud, M. A. *et al.* Chemical characterization and tensile properties of a sugarcane bagasse-chemically modified starch composite structure developed for packaging purposes. **Results in Materials**, Elsevier, v. 25, p. 100634, 2025.

Neto, A. R. S. *et al.* Comparative study of 12 pineapple leaf fiber varieties for use as mechanical reinforcement in polymer composites. **Industrial Crops and Products**, Elsevier, v. 64, p. 68–78, 2015.

Ornaghi, H. L.; Zattera, A. J.; Amico, S. C. Dynamic mechanical properties and correlation with dynamic fragility of sisal reinforced composites. **Polymer Composites**, Wiley Online Library, v. 36, n. 1, p. 161–166, 2015.

Pires, E. N. *et al.* Efeito do tratamento alcalino de fibras de juta no comportamento mecânico de compósitos de matriz epóxi. **Polímeros**, SciELO Brasil, v. 22, n. 4, p. 339–344, 2012.

Poletto, M. Polystyrene cellulose fiber composites: effect of the processing conditions on mechanical and dynamic mechanical properties. **Matéria (Rio de Janeiro)**, SciELO Brasil, v. 21, n. 03, p. 552–559, 2016.

Sanchez, E. M. *et al.* Compósito de resina de poliéster insaturado com bagaço de cana-de-açúcar: influência do tratamento das fibras nas propriedades. **Polímeros**, SciELO Brasil, v. 20, n. 3, p. 194–200, 2010.

Santos, C. M. *et al.* Natural fibers as a conscious choice for a greener future. **Discover Polymers**, Springer, v. 2, n. 1, p. 22, 2025.

Sayam, S. Natural fibers in sustainable materials: Extraction technologies, fiber modification, and performance–sustainability relationships. **RSC advances**, The Royal Society of Chemistry, v. 16, n. 12, p. 10495–10537, 2026.

Silva, I. C. R.; Belini, U. L. Piaçava como produto de maior valor agregado: Perspectivas para o design: Piassava as a product with greater added valeu: Perspectives for design. **MIX Sustentável**, v. 11, n. 2, p. 189–204, 2025.

Surendra, K. *et al.* Bioconversion of organic wastes into biodiesel and animal feed via insect farming. **Renewable energy**, Elsevier, v. 98, p. 197–202, 2016.

Taipina, M. de O.; Ferrarezi, M. M. F.; Gonçalves, M. d. C. Morphological evolution of curauá fibers under acid hydrolysis. **Cellulose**, Springer, v. 19, n. 4, p. 1199–1207, 2012.

Venâncio, M.; Silva, J. D. da. Technical-environmental feasibility of wood-plastic composites production: A theoretical approach: Viabilidade técnico-ambiental da produção de compósitos madeira plástico: Abordagem teórica. **MIX Sustentável**, v. 11, n. 4, p. 208–219, 2025.

Wagh, J. P.; Malagi, R. R.; Madgule, M. Investigative studies on natural fiber reinforced composites for automotive bumper beam applications. **Journal of Reinforced Plastics and Composites**, SAGE Publications Sage UK: London, England, v. 44, n. 23-24, p. 2524–2534, 2025.

Wearn, Y. N.; Montagna, L. S.; Passador, F. R. Compósitos de fibra de coco/ldpe: efeito do tratamento superficial das fibras de coco em compósitos verdes. **Matéria (Rio de Janeiro)**, SciELO Brasil, v. 25, n. 1, p. e–12548, 2020.