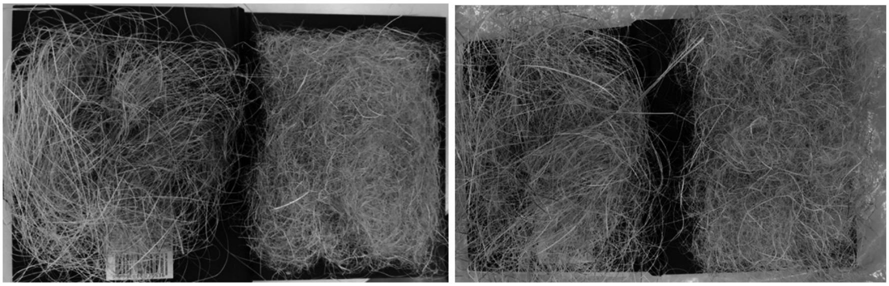

Figure 13. Non-treated (on the left) and treated (on the right) fibres before and after manual carding process.

Characterization of the Cordyline australis fibres
No significant differences were observed between the treated and non-treated fibres after conducting tests. However, the tenacity values obtained were much lower compared to other fibres like cotton, hemp or linen, which is an undesirable characteristic for the spinning process because it requires less force to break these fibres. The elongation at break value was also lower than the recommended 10% required for proper knitting (Sumihartati et al., 2021). The linear density showed that the fibres studied were thicker than other commercial fibres, but the values obtained were very heterogeneous, which could affect the homogeneity of the yarn (Sumihartati et al., 2021). Nevertheless, further studies are necessary to assess the reproducibility of these results since the three parameters showed high standard deviations.
The chemical composition evaluation of the fibres indicated that there were no chemical differences between treated and non-treated fibres, suggesting that the enzymatic treatment did not have any chemical impact on the fibres. However, regarding the colour difference and whiteness degree, the treated fibres appeared lighter in colour compared to the non-treated ones.

Spinning
The fibres were cut and prepared for spinning (Figure 14). This process proved to be challenging as the yarn broke frequently. The irregularity of the linear density of the yarn was attributed to the uneven distribution of *Cordyline australis* fibres in each section, causing them to slip between each other, due to the absence of inter-fibre linkage (Souza, 2018). To enhance the spinning process, a softener was used to decrease the fibres' roughness and improve inter-fibre linkage.

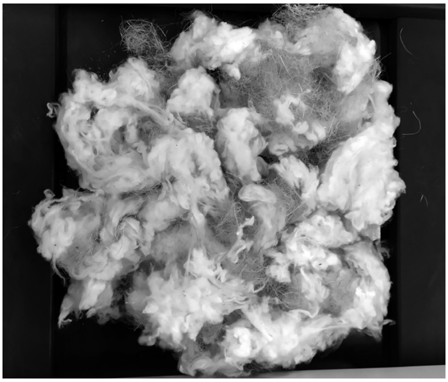

Figure 14. Blend of *Cordyline australis* and cotton fibres before the carding process.

The yarn made from *Cordyline australis* fibres presented a rougher texture and some loose fibres compared to the 100% cotton yarn (Figure 15). Analysis of the linear density showed that the yarn produced from treated fibres (without softening treatment) was thinner than the yarn made from non-treated fibres and 100% cotton yarn. This difference in linear density affected the spinning process, since the tenacity and elongation at break decrease with a lower linear density (Silva, 2019). The tenacity and elongation at break values of the *Cordyline australis* yarn were significantly lower than those of the cotton. However, the differences between *Cordyline australis* yarns were not significant.

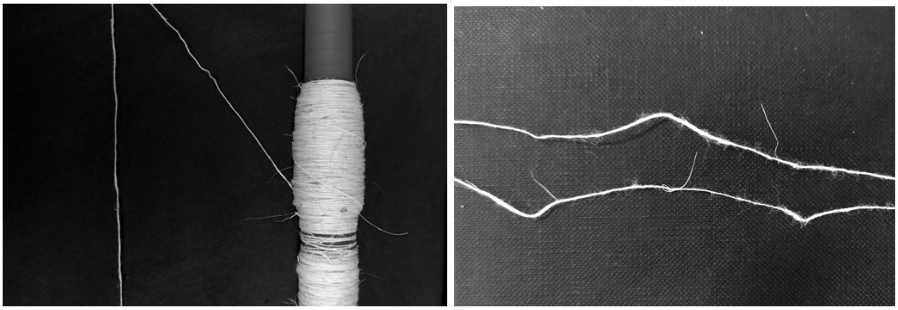

Figure 15. Yarn based on non-treated *Cordyline australis* fibres.

Knitting

Next, the yarns were knitted (Figure 16). The fibres that underwent the softening treatment presented better performance because they had fewer irregular areas, which could cause the yarn to slip from the needles and create holes in the knit (Figure 17). These areas were also more prone to breakage. The knit made with *Cordyline australis* fibres had a rougher texture compared to the 100% cotton structure.

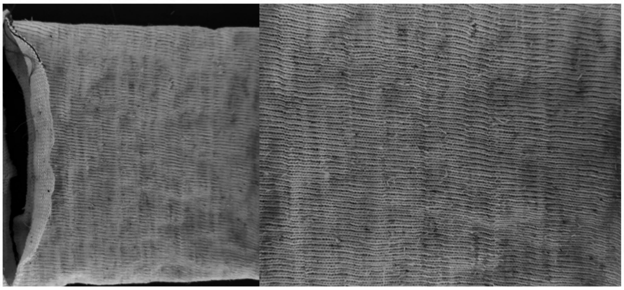

Figure 16. Knitted structure based on non-treated *Cordyline australis fibres*.

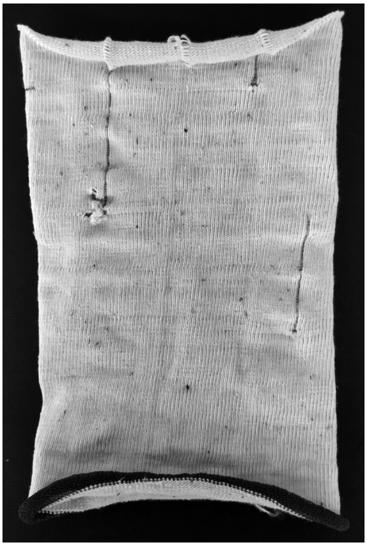

Figure 17. Holes in the knitted structure with the *Cordyline australis* fibres.

For the dying process, the knitted structures were first bleached and then dyed with a red dye (Figure 18).

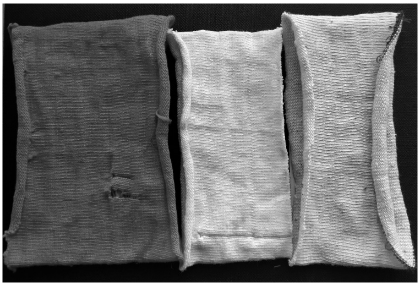

Figure 18. Cotton knitted structure with the original colour (on the left), bleached (at the centre) and dyed with a red dye (on the right).

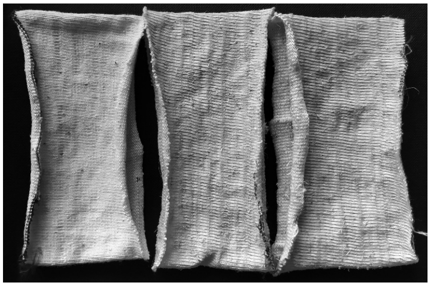

Figure 19. Original knitted structures of cotton (on the left), with treated fibres (at the centre) and non-treated fibres (on the right).

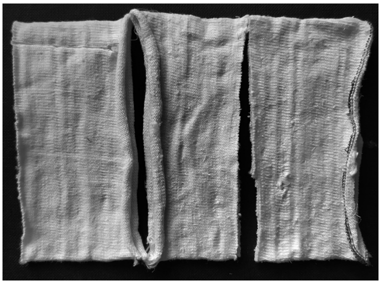

Figure 20. Bleached knitted structures of cotton (on the left), with treated fibres (at the centre) and non-treated fibres (on the right).

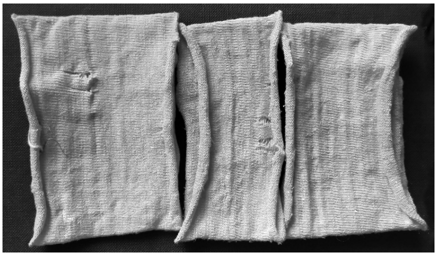

Figure 21. Dyed knitted structures of cotton (on the left), with treated fibres (at the centre) and non-treated fibres (on the right).

The colour coordinates were established by comparing the knitted structures made with *Cordyline australis* fibres (original, bleached and dyed) with those of 100% cotton. The results of the colour difference analysis revealed that the original knitted structures (Figure 19) appeared darker due to the green-yellow colouration of the leaf fibres, which influenced the brightness of the structure. As anticipated, this effect was not observed in the 100% cotton structures. Moreover, there was no substantial difference in colour coordinates between the knitted structures made from treated and non-treated fibres, suggesting that the enzymatic treatment did not significantly affect the fibres' colour.

The bleached knitted structures (Figure 20) showed comparable outcomes to those made from 100% cotton, indicating that *Cordyline australis* fibres responded well to the bleaching process. The dyed knitted structures depicted in Figure 21, exhibited slightly darker tones in the fibres-based knits, indicating their ability to absorb colourants efficiently, demonstrating promising results.

Conclusions

This study has facilitated the development and characterization of yarns and knitted structures with fibres obtained from *Cordyline australis* leaves. The results demonstrated the potential of these fibres as a viable natural substitute for the textile and clothing industry. Nonetheless, more research is required to achieve fibres with appropriate properties for the spinning process.

Acknowledgments

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Resumen: La industria textil es una de las industrias más contaminantes del mundo. Las fibras sintéticas representan más del 60% de todas las fibras consumidas por esta industria, lo que unido al elevado consumo energético conduce a una elevada huella ecológica en la producción textil. Por ello, es importante promover la economía circular en el ciclo de vida de los productos textiles como forma de reducir el consumo de materias primas de origen fósil, así como incrementar el uso de fibras naturales. En este trabajo se exploró el potencial de las hojas de *Cordyline australis* para aplicación textil. En la extracción de las fibras se realizó un pretratamiento hidrotermal seguido de un tratamiento enzimático con celulasas. Postreramente, las fibras de *Cordyline australis* se mezclaron con fibras de algodón virgen para producir hilo textil y una estructura tejida (malla). Las mallas fueron teñidas, caracterizadas y comparadas con las mismas estructuras en 100% algodón. Aunque estas fibras aún se encuentran en las primeras etapas de desarrollo han mostrado un alto potencial para su uso como fibras textiles naturales alternativas, con enormes ventajas en el punto de visión de la sostenibilidad de los productos textiles donde se incorporan.

Palabras clave: fibras textiles sostenibles - biomateriales alternativos - fibras Cordyline australis - fibras de algodón - degumming - hilado - tejido e teñido

Resumo: A indústria têxtil é uma das indústrias mais poluentes no mundo. As fibras sintéticas representam mais de 60% de todas as fibras consumidas por esta indústria, o que, juntamente com o elevado consumo energético, acarreta uma elevada pegada ecológica na produção de têxteis. Como tal, é importante promover a economia circular no ciclo de vida dos produtos têxteis como forma de diminuir o consumo de matérias-primas de origem fóssil, bem como aumentar a utilização de fibras naturais. Neste trabalho foi explorado o potencial das folhas de fiteira (Cordyline australis) para aplicação têxtil. Na extração das fibras das folhas foi realizado um pré-tratamento hidrotérmico seguido de um tratamento enzimático com celulases. Posteriormente, as fibras de fiteira foram misturadas com fibras de algodão virgem, para produção de fio têxtil e de uma estrutura tricotada (malha). As malhas foram tingidas, caracterizadas e comparadas com as mesmas estruturas em 100% de algodão. Apesar destas fibras ainda se encontrarem nos primeiros estádios de desenvolvimento, demonstraram um elevado potencial para utilização como fibras têxteis naturais alternativas, com enormes vantagens do ponto de vista da sustentabilidade dos produtos têxteis onde venham a ser incorporadas.

Palavras-chave: fibras têxteis sustentáveis - biomateriais alternativos - fibras de Cordyline australis - fibras de algodão - degumming - fiação - tricotagem e tingimento

[Las traducciones de los abstracts fueron supervisadas por su autor]