DOI: 10.34658/9788366741751.30

COMPARISON OF THE FINENESS AND MECHANICAL PROPERTIES OF HEMP FIBER CONDITIONNED IN TWO DIFFERENT RELATIVE HUMIDITY ENVIRONMENTS

Aurélie Decker[1,2,3(*)], Adrien Tritter[3], Vivien Sarazin[3], Omar Harzallah[1,2], Jean-Yves Drean[1,2]

[1] Université de Haute-Alsace, LPMT UR 4365, F-68100 Mulhouse, France
[2] Université de Strasbourg, France
[3] SADEF, 30.rue de la Station, Aspach-le-Bas, France
[(*)] *Email:* aurelie.decker@uha.fr

ABSTRACT

Bast fiber, like hemp, has an affinity for water [1,2]. The moisture content of hemp fiber increased with the increasing of relative humidity [1]. The relative humidity changes the fiber properties [2,3] studied by LPMT (Laboratoire de Physique et de Mécanique Textile) in Mulhouse, France. A comparison of the fiber properties measured in two different relative humidity environments (30% and 60%) was studied. The fiber was placed between two specific cardstock frameworks with glue. The fineness was determined from the diameter measured with a projection microscope. Then, the tensile test was realised with MTS®, tensile testing instrument, to determine the breaking force, strain and stress and the Young's modulus. The hemp fiber was manually extracted from unretted stem. The cultivar used was Santhica 27 cultivated in the East of France [4] by SADEF, a plant nutrition expert.

The impact of the relative humidity environment on the fiber properties was not constant. The tensile tests realised in this study were not homogeneous. Dispersion of the results could be caused by bast fiber multi-scale. The selection caused more variability of fiber properties than the relative humidity for hemp fiber.

KEYWORDS

Hemp, fiber, mechanical properties, relative humidity, fineness.

MATERIALS AND METHODS

This study was about Santhica 27 (S27) hemp fiber cultivated in Guewenheim in the East of France by SADEF in 2018. Stems were harvested in June (developmental stage) noted S27(1), in July (flowering stage) noted S27(2) and in October (post-flowering stage) noted S27(3). The evolution of fineness and mechanical properties on four cultivars whose Santhica 27 during their cultivation was displayed during AUTEX2021 [4]. Then the unretted stems were manually defibrated. According NF T25-501-2 standard, the fiber were placed between two specific cardstock frameworks. A projection microscope was used to measure the fiber diameter with X20 lens as NF EN ISO 137 standard. Then the mechanical properties (NF T25-501-2) were measured by the MTS instrument with 1 mm.min-1 crosshead speed, a 10 N cell and a distance of 20 mm between clamps. The tensile stress-strain curve was classified in three types as Duval and al. [5] classification. So, the type 1 (T1) represented an elastic behaviour, the type 2 a plastic behaviour and the type 3 represented a no-linear visco-elastic behaviour of the curve. Tests were performed with two different relative humidity, around 30% and around 60%. The temperature was stable with 20°C. To compare the different relative humidity environment, ANOVA analysis was realised.

RESULTS AND DISCUSSION

According the relative humidity environment, the diameter changed lightly specially for S27(1) and S27(2) (Table 1). Moreover bast fiber (like hemp and flax) absorbed water [1], so the diameter conditioned at 30% relative humidity had to be thinner than a fiber conditioned a 60%. For S27(1), like Fig. 1, the diameter distribution was spread. Fibers selected at 30% moisture had a larger diameter range, especially in the high diameter range, unlike those selected at 60% moisture.

Table 1. Morphological and physical properties of hemp fiber according to the harvest time and the relative humidity environment.

Sample	Relative humidity	Diameter [µm]	Breaking force [N]	Strain [MPa]	Breaking stress [%]	Young's modulus [GPa]
S27 (1)	30%	107.8 ±12.1 a	1.3 ±0.2 a	198.4 ±41.8 a	1.9 ±0.2 b	8.9 ±1.8 a
	60%	84.9 ±9.0 b	1.1 ±0.2 a	225.2 ±43.0 a	2.8 ±0.2 a	7.6 ±1.4 a
S27 (2)	30%	88.2 ±9.0 a	1.6 ±0.3 a	275.6 ±48.4 a	1.9 ±0.3 b	12.4 ±1.6 a
	60%	71.7 ±6.7 b	1.2 ±0.2 a	300.3 ±44.7 a	2.6 ±0.3 a	11.8 ±1.5 a
S27 (3)	30%	66.8 ±7.1 a	1.9 ±0.4 a	535.9 ±71.2 a	2.6 ±0.2 a	19.0 ±2.4 a
	60%	61.1 ±6.7 a	1.3 ±0.3 b	455.4 ±79.9 a	2.9 ±0.3 a	15.7 ±3.0 a

a and b corresponding to comparison of relative humidity environment for each harvest time in the same row (ANOVA)

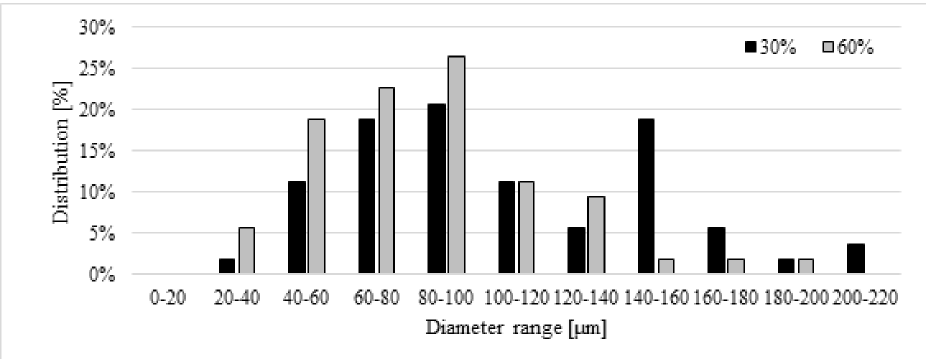

Figure 1. Diameter distribution [%] for Santhica 27 harvested in June (S27(1)) according the relative humidity environment.

The difference in breaking force between the two relative humidity environments was noteworthy for S27(3) as ANOVA analysis (Table 1). For a moisture of 60%, the fiber seemed less strong in force than a moisture of 30%. The relation between 30% and 60% was from 1.21 (S27(1)) to 1.45 (S27(3)).

For S27(1) and S27(2), the stress between a moisture of 30% and of 60% was significantly different with a relation of 0.69 (S27(1)) and 0.75 (S27(2)). Placet and al. [3] confirmed than the hemp elementary fiber stress increased with the relative humidity increased.

Finally, whatever the harvested time, the differences in strain and in Young's modulus were not significant according ANOVA analysis. Contrary to the Placet and al. [3] study, which the strain and the Young's modulus of elementary fiber increased when the relative humidity increasing. For flax and nettle ultimate fiber, according to Davies and Bruce's study [2], there is a relationship between the stiffness modulus and the environmental relative humidity.

According the strain-stress curve classification (Fig. 2) used by Placet and al. [3], the type 1, elastic behaviour, decreased between the relative humidity of 30% and 60% for S27(2) and S27(3) like the study of Placet and al. [3]. So with a weak relative humidity, the fiber had an elastic behaviour. The type 3, a no-linear visco-elastic behaviour, increased as Placet and al. [3], for S27(1) and S27(3). To conclude the strain-stress curve seemed change between the relative humidity 30% and 60%.

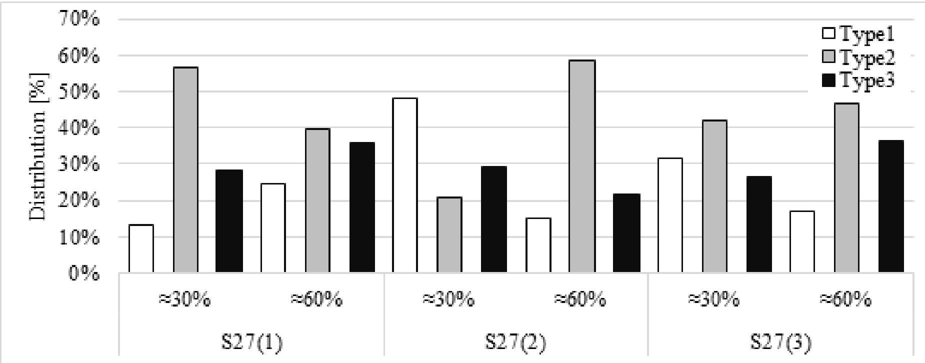

Figure 2. Distribution of typical tensile strain-stress curves of hemp fiber according the relative humidity and the harvest time. Type 1 represents the elastics behaviour, type 2 represents the plastic behaviour and type 3 represents the no-linear visco-elastic behaviour of the curve.

The properties of fiber measured at 30% of moisture seemed more disperse than the properties measured at 60% of moisture. Generally, the strain and the Young's modulus decreased with the diameter increasing, in particularly for the 30% of moisture (Fig. 3). The stress of fiber conditioned at 60% of moisture seemed higher.

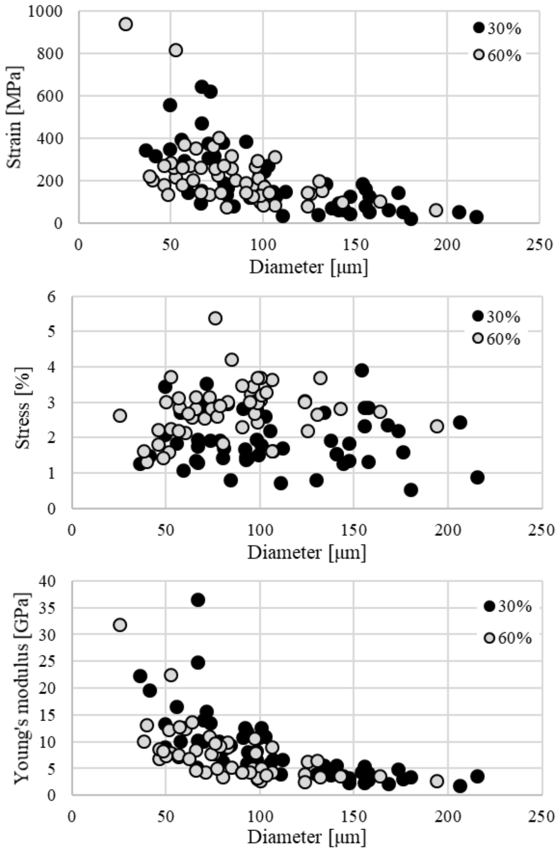

Figure 3. Mechanical properties (Stain, Stress and Young's modulus) for Santhica S27 (1) according the relative humidity environment.

CONCLUSION

According the ANOVA analysis, there were some significant difference between fibers conditioned at a moisture of 30% and of 60% in specially for the diameter, the breaking force and stress. Moreover, the Young's modulus and the strain did not seem to be influenced by the relative humidity environment. The difference in diameter could also come during the fiber selection influencing the breaking force and stress.

So, the bast fiber selection would cause more variation than the moisture condition.

REFERENCES

[1] Jiang Y., Lawrence M., Hussain A., Ansell M., Walker P., *Comparative moisture and heat sorption properties of fibre and shiv derived from hemp and flax*, Cellulose 2019, vol. 26 no 2, pp. 823–843. https://doi.org/10.1007/s10570-018-2145-0.

[2] Davies G.C., Bruce D.M., *Effect of Environmental Relative Humidity and Damage on the Tensile Properties of Flax and Nettle Fibers*, Textile Research Journal 1998, vol. 68, no 9, pp. 623–629. https://doi.org/10.1177/004051759806800901.

[3] Placet V., Cisse O., Boubakar M.L., *Influence of environmental relative humidity on the tensile and rotational behaviour of hemp fibres*, Journal of Materials Science 2012, vol. 47, no 7, pp. 3435–3446. https://doi.org/10.1007/s10853-011-6191-3.

[4] Decker A., Tritter A., Drean J.Y., Harzallah O., *Evolution of the fineness and mechanical properties on four hemp cultivars during their cultivation*, AUTEX2021, Guimarães, Portugal, 2021.

[5] Duval, A., Bourmaud A., Augier L., Baley C., *Influence of the sampling area of the stem on the mechanical properties of hemp fibers*, Materials Letters 2011, vol. 65, no 4, pp. 797–800 https://doi.org/10.1016/j.matlet.2010.11.053.