International Journal of Science and Research Archive
eISSN: 2582-8185 CODEN (USA): IJSRO2
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/
Research Journal Archive, INDIA

(RESEARCH ARTICLE)

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Effect of retting methods on molecular weight of *Agave atroverance* fibers

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International Journal of Science and Research Archive, 2023, 08(01), 038–042

Publication history: Received on 14 November 2022; revised on 24 December 2022; accepted on 26 December 2022

Article DOI: https://doi.org/10.30574/ijsra.2023.8.1.0325

Abstract

This study was undertaken to investigate the effect of retting method on the molecular weight of different portion of the *Agave atroverance* fiber (top, middle and bottom) extracted by different retting techniques. The raw fibers from *Agave atroverance* plant were retted by biological and chemical (degumming) retting methods. In biological retting method both the stagnant and boil water were utilized and in chemical retting method, the extracted fibres were treated with the 5% NaOH. *Agave atroverance* fiber is not purely cellulosic fiber. Percentage composition of different portion of the raw fiber was also determined. It contains α-cellulose, hemicellulose, nitrogenous matter, mineral matters and miscellaneous. The retted fibres were tested for determination of molecular weight. The percentage loss of molecular weight was found to be more in case of chemically retted fibres owing to the enhanced digestibility of lignocellulosic material by 4% sodium chlorite solution. Contrary to this, biological retting showed higher molecular weight due to the presence of higher cellulosic matter and removal of pectic substabces.

Keywords: *Agave atroverance*; Biological retting; Chemical retting; Molecular weight

1. Introduction

Due to the alarming rise of global warming issues and perishment of marine living organisms caused by accidentally swallowing nondegradable plastic products, awareness of plastic disposal issues (difficulties in recycling, environmental burden, and high recycle cost) had been heightened. As a result, bioplastics have gradually substituted conventional plastics in many applications [1, 2]. However, many users are still struggling to find suitable replacements as bioplastics have inconsistency and low performance profile. Therefore, reinforcement of natural fibres on plastics was reported to strengthen products with better/or maintaining biodegradability [3, 4].

Agave atroverance is a large succulent that forms a dense rosette of smooth dark green leaves with small dark brown marginal teeth and a terminal spine. It is a non-cultivated plant and the main source of sugars to produce "pulque", a traditional Mexican alcoholic fermented beverage produced from the sap known as "aguamiel" [5]. The agave plant takes at least eight years to reach the stage where it is suitable for use. Agaves have leaves 5-8 feet tall and 7-12 feet in diameter. It has a lifespan of 8-15 years, depending on species, growing conditions and climate [6]. There may be very good prospects for pulque fiber. When the Agave flower appears it can reach 10 m high and after that the Agave plant dies, because this flower consumes all the disposable sugars present. So it is necessary to emphasize the importance in making use of the produced Agave crops that nowadays does not have a real use, though it could be used to obtain considerable amounts of fermentable sugars, oligosaccharides, composite and diverse materials, in addition to the alcoholic beverages.

The widespread use of these fibers is fairly recent. As they are comprised of vascular systems, the cells are small and bound together by pectin's. The leaves are cut at the base, carried to the factory, rolled and the water squeezed out, and the other mushy tissues scraped away from the fibers. The fibers are then washed and hung out in the sun. They can be

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dyed directly. The fibers are too stiff to be used to make fabrics. They make better quality ropes than bast fibers however [7]. The present research was conducted to determine the percentage composition of different portion of *Agave atroverance* fiber and changes in the molecular weight of fiber by using different retting technique.

2. Material and methods

2.1. Collection of fiber

As a material for investigation *Agave atroverance* fiber was collected from the local area (Islamic University, Bangladesh) and also from Vadalia of Kushtia district. The middle portion of the fiber was selected for this investigation. The dirty materials were removed by treating 6.5 gm of soap-flake and 3.5 gm of soda per litre at 75°C for 30 minutes in a breaker in the ratio 1 gm of fiber per 50 ml of the solution. The fiber was then washed thoroughly with distilled water and dried in the open air. This gives fibers that are subjected for investigation. Figure-1 shows raw fiber which is obtained from the leaves of *Agave atroverance*. About 37 kg (average weight) of stem yields about 1 kg of good quality fiber; the yield is 2.5-3.5%.

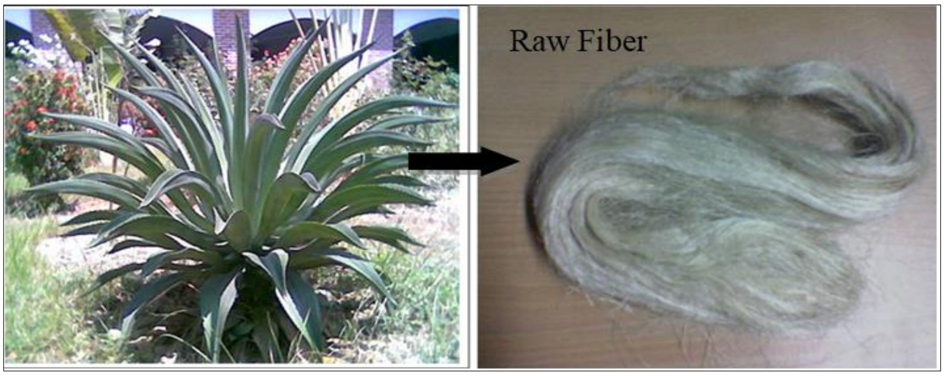

Figure 1 *Agave atroverance* plant and raw fiber

2.2. Retting

Retting is a natural microbial process and it is also involves the degradation of non-fibrous matter which acts as glue between the fibers in woody plant parts and fibers without damaging the fiber cellulose. This process allows easy separation of individual fiber strands and the woody core. Since retting is a biological process, it requires both moisture and a warm temperature for microbial action to occur [8]. Retting of *Agave atroverance* fiber was done by biological and chemical to study the effect of extraction on molecular weight of fibre. The retting was done in the month of September at a temperature and relative humidity in range of 30°C - 37°C and 75% - 85%, respectively.

2.2.1. Biological retting

Most bast fibers are cemented to the adjacent cells inside the stem or leaves with pectin, which can be extracted by retting processes. Retting is sometimes termed degumming. The retting of fibers were done by immersing *Agave atroverance* plant leaves under water (rivers, ponds, or tanks) for 2 to 3 weeks, during which the pectinous substances that bind the fiber with other plant tissues are softened and degraded by micro-organisms [9].

2.2.2. Boil Retting

Boiling is a chemical process of retting for removing non-cellulosic material attached to fibers to release individual fibers. In this process *Agave atroverance* plant leaves were immersed in water and boiled for about 4-5 hours. During boiling the pectinous substances that bind the fiber with other plant tissues are softened and the fibers are separated from other plant tissues.

2.2.3. Chemical Treatment

The extracted water retted and boiled *Agave atroverance* fibers were chemically treated with 0.4% sodium chlorite. It is more efficient and can produce clean and consistent long and smooth surface fibers. Sodium chlorite ($NaClO_2$) solution of strength 4 gm/liter was prepared and its pH was regulated to 4 by adding 0.2M CH_3COOH solution from a burette and the pH change was observed directly with a pH meter (STICK-TYPE pH-Meter). For each gram of pulque fiber 80 ml of the liquor was taken and bleaching was conducted at temperature 80-90°C for 120 minutes. Prior to start bleaching 1 ml of buffer solution of acetic acid and sodium acetate of pH-4 was added for 10 ml of the liquor to maintain the constant pH throughout the process. After the completation of bleaching, the fiber was washed well with distilled water, immersed in 0.2% sodium meta-bisulphite solution for 15 minutes in the ratio 1 gm fiber per 20 ml of metabisulphite solution. Finally washed well, dried in an open air.

3. Results and discussion

From table-1, it is evident that the composition of *Agave atroverance* fiber that the main constituents are α-cellulose (72%), hemicellulose (11%) and lignin (6%) and the rest are very minor in proportions so giving very little influence to the structure of *Agave atroverance* fiber.

Table 1 Percentage composition of different portion of *Agave atroverance* fiber

Constituents	***Agave atroverance* Fiber Amounts (percentage dry basis)**		
	Middle portion	**Bottom portion**	**Top portion**
α-cellulose	72%	63.00%	70.60%
Hemicellulose	11%	17.50%	15.05%
Lignin	6%	11.01%	5.22%
Fatty & waxy matter	2%	3.20%	1.87%
Pectic matter	4%	1.31%	3.10%
Aqueous extract	2%	1.90%	1.40%
Miscellaneous	3%	2.08%	2.76%
Total	100%	100%	100%

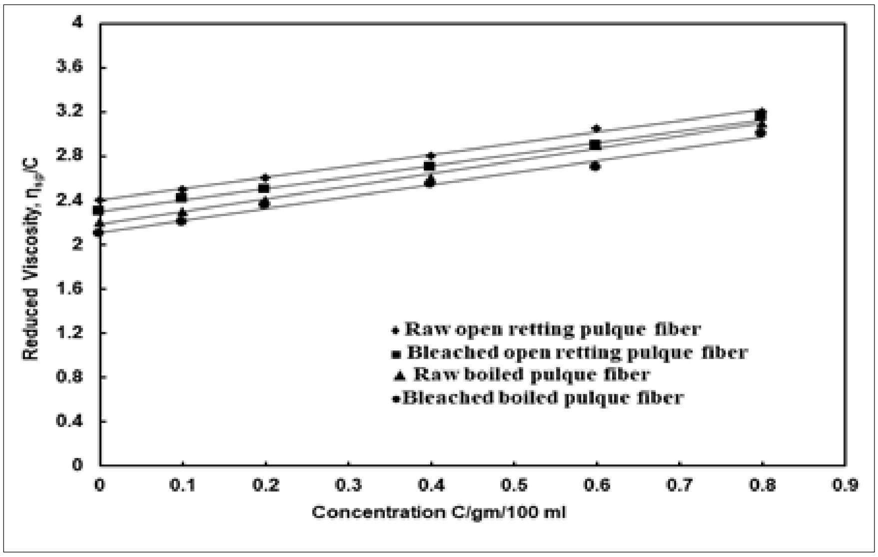

Figure 2 Molecular weight determination of top portion of raw and bleached *Agave atroverance* fiber

From table-1 we can also concluded that the middle portion of *Agave atroverance* fiber contain more *α*-cellulose and low lignin and hemicellulose content. We know that lignin is the main constituents, which is responsible for yellowing of jute fiber. So, the yellowing of *Agave atroverance* fiber occurs more readily in the bottom portion than in the middle and top portion.

According to the method described in the materials and methods section fiber solution in phosphoric acid were prepared with raw, boiled and bleached *Agave atroverance* fiber (middle, bottom and top portion). Flow times of these fiber solutions were measured at different concentrations. From the results values of relative viscosity, η_{sp}/C were calculated. The intercept of straight line in plot of η_{sp}/C vs C gave the intrinsic viscosity [η] of fiber.

From Figure 2-4, as it is evident that the molecular weight of *Agave atroverance* fiber is higher for open rettted *Agave atroverance* fiber than boiled and bleached fiber.

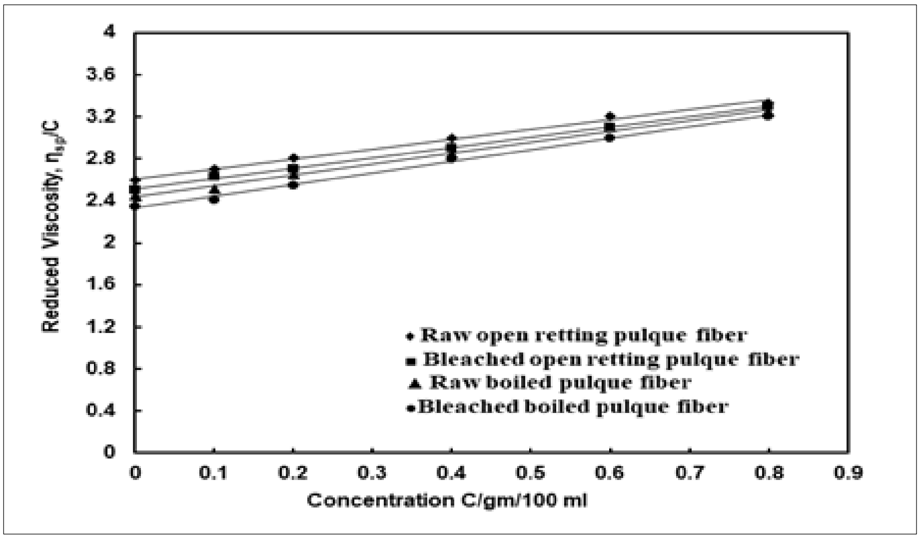

Figure 3 Molecular weight determination of middle portion of raw and bleached *Agave atroverance* fiber

We have also seen that the middle portion of *Agave atroverance* have greater molecular weight than that of bottom and top portion of *Agave atroverance* fibers because the middle portion of *Agave atroverance* fibers have higher content of α-cellulose than botom and top portion. The properties of the fiber largely depend on α-cellulose because it is the main constituent of *Agave atroverance* fiber . So, the pulque fiber has more tensile strength, fastness properties. The fiber retted in more than 4% sodium chlorite solution and boiling the tensile strength was decreased. Water seems to be the most suitable technique to extract high quality fibers, while boiling and chemical treatment is expensive, time consuming and complex; thus it cannot be applied in the rural areas.

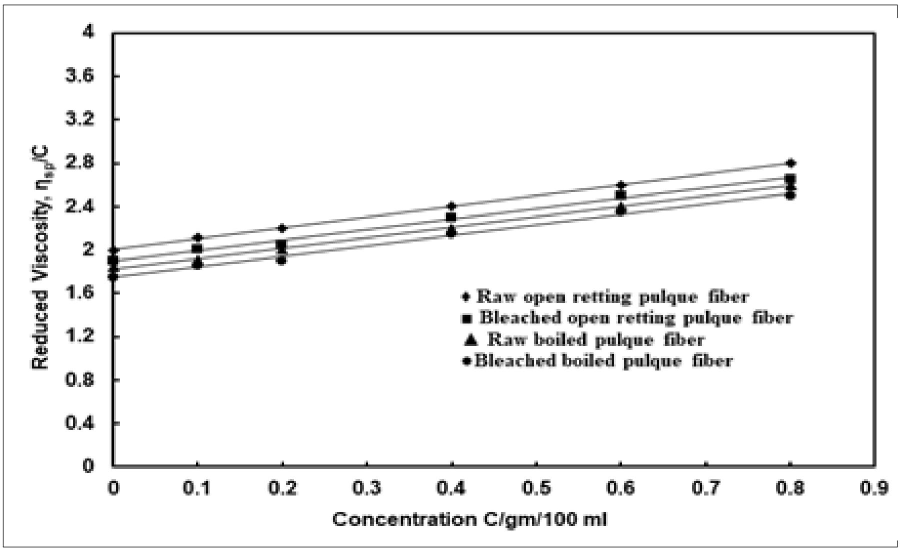

Figure 4 Molecular weight determination of bottom portion of raw and bleached *Agave atroverance* fiber

4. Conclusion

Global trends towards sustainable development have brought natural, renewable, biodegradable raw material. For this reason, there is a need to search for the extraction method to remove the non-fibrous components and completely free the fibres from other impurities. Out of the two retting methods biological retting fibers exhibited better properties in terms of constituents and molecular weight. The weight loss was also comparatively lower than the fibres obtained from chemical retting. Hence, the properties exhibited by fibres extracted from biologically were considered good for technical textile used therefore stagnant water was considered as ideal medium of retting. It can be concluded that the quality of the fibre depend on the manner of the retting conditions, therefore it is an essential to choose appropriate retting method according to the ultimate use of fibres in different industrial applications as a potential source of fibres for technical textiles.

Compliance with ethical standards

Acknowledgments

The authors are grateful to the Department of Applied Chemistry and Chemical Engineering, Islamic University, Kuhtia, Bangladesh.

Disclosure of conflict of interest

The authors declare that no conflict of interest exists.

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