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Synthesis of Hydrogel from Sugarcane Bagasse Extracted Cellulose

Reena Antony*, Alexia Varghese, Alfiya Raqeeb, Sushmita Roy

Department of Microbiology, Career College, Bhopal
Opposite to Dusshera Maidan, BHEL, Govindpura, Bhopal, Madhya Pradesh
Email ID : reenathomas2000@gmail.com, Telephone no.:9589712552
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ABSTRACT:

This study investigates the potential of bagasse-derived cellulose hydrogel as a sustainable biomaterial for wound healing applications. Bagasse, a byproduct of sugarcane processing, is rich in cellulose and offers a renewable and cost-effective source for hydrogel synthesis. The cellulose fibers extracted from bagasse were incorporated into a hydrogel matrix and characterized for various parameters including swelling capacity, viscosity, pH stability, spreadability, and gel strength. Comparative analysis with commonly used hydrogels such as alginate, aloe vera, collagen, and gelatin revealed that cellulose hydrogels exhibited superior properties, making them highly promising for biomedical applications. Notably, cellulose hydrogels showed enhanced spreadability, viscosity, and pH stability compared to their counterparts. The biodegradable nature of cellulose-based hydrogels not only addresses waste management concerns but also offers a sustainable alternative to synthetic materials. Additionally, the high cellulose content in bagasse enables these hydrogels to provide cooling and soothing effects, enhancing their therapeutic potential in wound healing. Overall, this research highlights the significance of bagasse-derived cellulose hydrogel as a versatile and eco-friendly biomaterial with promising applications in wound care and tissue engineering.

Keywords: Sugarcane bagasse, cellulose, hydrogel, swelling test, viscosity test.

1.Introduction:

Bagasse holds significant importance due to its potential as a renewable resource and its diverse range of applications. It is an abundant byproduct of sugarcane and sorghum processing, making it readily available for utilization. [1] Bagasse is particularly crucial for bioenergy production, serving as a feedstock for the generation of biofuels such as ethanol and biogas, thereby contributing to the reduction of greenhouse gas emissions and dependence on fossil fuels.[4] Additionally, bagasse can be used in pulp and paper manufacturing, providing an eco-friendly alternative to wood-based materials.[1] Moreover, research has explored its potential in the production of value-added products, including bioplastics and biochemicals, further highlighting its significance as a versatile raw material.[6] Cellulose is a complex polysaccharide found in the cell walls of plants, providing structural support and rigidity.[6] It is composed of linear chains of glucose molecules linked together by β-1,4-glycosidic bonds. Cellulose is one of the most abundant organic compounds on Earth and serves as a major component of plant biomass. Bagasse possesses several unique qualities that make it valuable for various applications:

1. *Renewable*: Bagasse is a renewable resource, as it is a byproduct of sugarcane or sorghum processing, making it abundant and sustainable.

2. *High cellulose content:* Bagasse is rich in cellulose, which makes it an excellent raw material for the production of biofuels, bioplastics, and biochemicals.

3. *Low cost*: As a byproduct of sugarcane or sorghum production, bagasse is often available at low or even zero cost, reducing the economic barriers to its utilization.

4. *Biodegradable*: Bagasse is biodegradable, making it an environmentally friendly alternative to synthetic materials in various applications, including packaging and disposable products.

5. *Versatile*: Bagasse can be used in various forms, such as pulp, fibers, or particles, making it suitable for a wide range of applications, including paper and board production, bioenergy generation, and as a feedstock for biorefineries.

These unique qualities contribute to the attractiveness of bagasse as a renewable and sustainable resource for addressing challenges related to energy, waste management, and the transition to a bio-based economy. A hydrogel is a three-dimensional network of hydrophilic polymer chains capable of absorbing and retaining large amounts of water or biological fluids while maintaining their structural integrity [peppas1996hydrogels]. These materials have diverse applications due to their unique properties, including high water content, biocompatibility, and tunable mechanical properties. Certainly, here are the properties of hydrogels:

1. *Swelling Capacity:* Hydrogels have the ability to absorb and retain large amounts of water or biological fluids without losing their structural integrity.[5]

2. *Biocompatibility*:Many hydrogel materials are biocompatible, meaning they are compatible with living tissues and do not elicit significant immune responses or toxicity.[5,2]

3. *Mechanical Properties:*The mechanical properties of hydrogels, such as stiffness and elasticity, can be tailored by adjusting parameters like polymer concentration, crosslinking density, and molecular weight.[5]

4. *Permeability*: Hydrogels often exhibit selective permeability to solutes and molecules, allowing for controlled release of drugs or nutrients in various applications.[5]

5. *Responsive Behavior:*Some hydrogels exhibit stimuli-responsive behavior, undergoing reversible changes in swelling, porosity, or other properties in response to environmental cues like pH, temperature, or light.[5]

2. Methodology:

2.1 Collection of sugarcane bagasse:

Sugarcane bagasse was collected from fruit shops and bought to the laboratory with air tight packaging. Then the bagasse was washed with water and air dried at room temperature. Once it is air dried it is dried in hot air oven at 50°C for 5 hours.

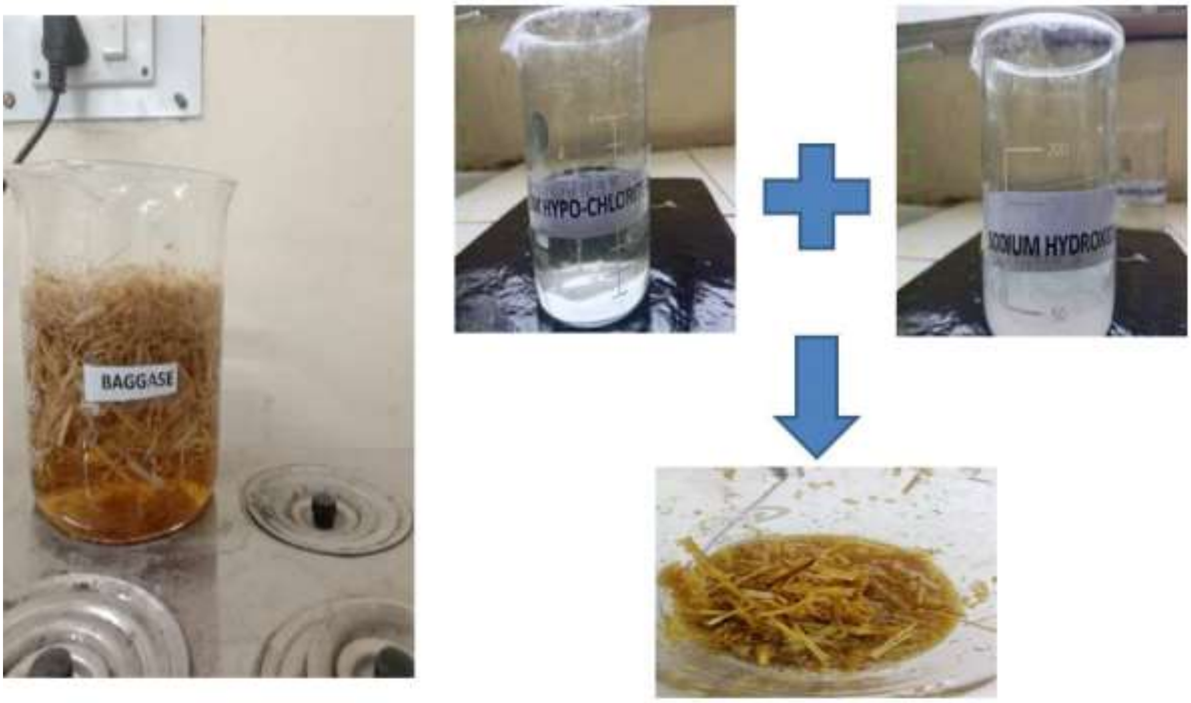
Processing of Baggase from sugarcane for cellulose extraction

Sugarcane Bagasse   Crushed into powdered form   Bagasse after drying

2.2 Isolation of cellulose from bagasse:

Dried sugarcane bagasse was boiled in water for 4 hours. Then it is allowed to soak in 4% sodium hydroxide solution for 4 hours followed by treating with 4% sodium hypochlorite and 2% sodium hydroxide solution for 4 hours at 100°C. Then it is washed with distilled water. The final product was dried at room temperature for 2 days.[3]

Treatment of Baggase from sugarcane for cellulose extraction



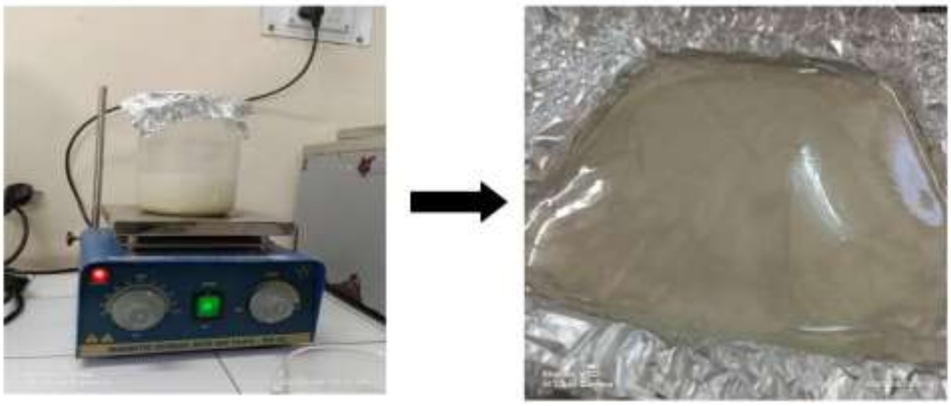
Bagasse kept for boiling in water for 4 hours

Treatment of processed Sugarcane bagasse with the solution of sodium hydroxide and sodium hypochlorite

2.3 Synthesis of cellulose hydrogel:

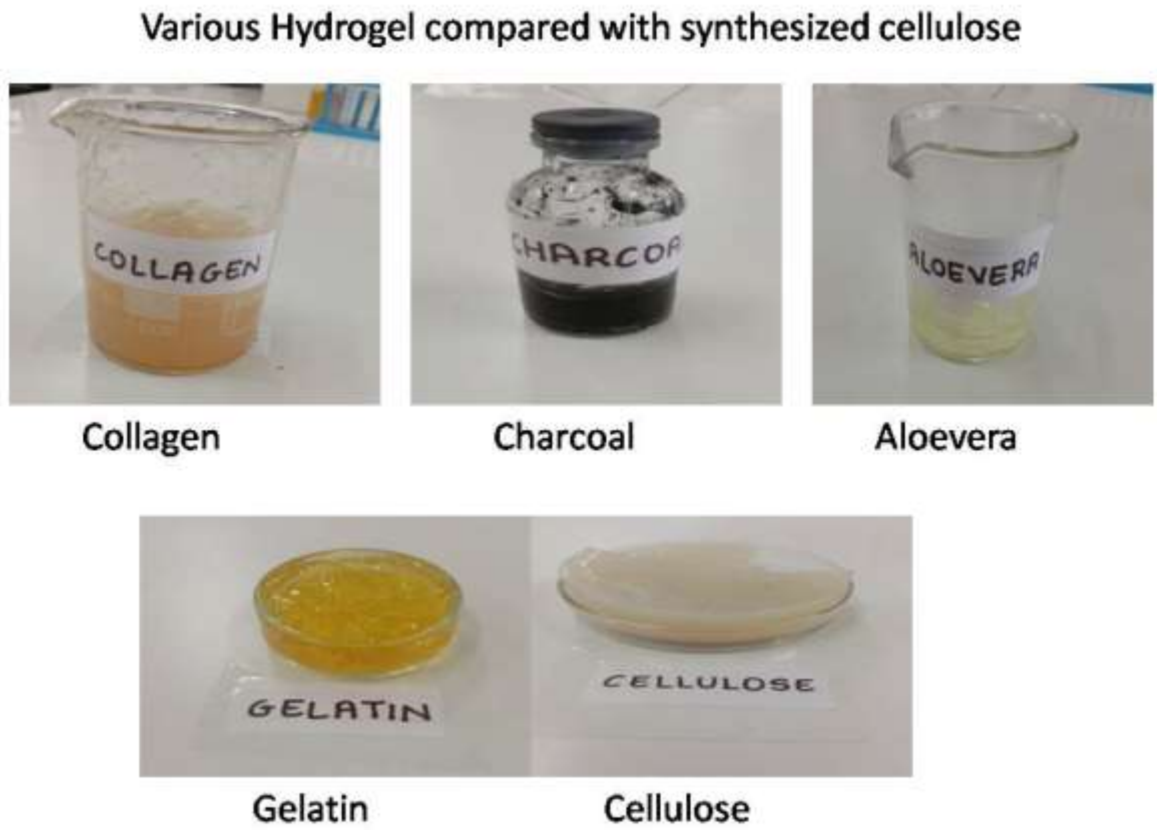
For Preparation of cellulose hydrogel 9.87 g of zinc chloride and 0.2 g calcium chloride are dissolved in 3.63 g of distilled water at 65°C for 15 minutes. Meanwhile, 0.45 g of cellulose fiber is mixed with 1.05 g of deionized water to produce cellulose suspension. After that zinc chloride and calcium chloride solution was poured into the cellulose suspension and stirred for 45 minutes.[8] To the prepared solution add 3.2 g of gelatin powder and autoclave the resulting solution at 121°C for 15 minutes. Then pour it is plate of desired shape.

Treatment of cellulose extracted to form Hydrogel



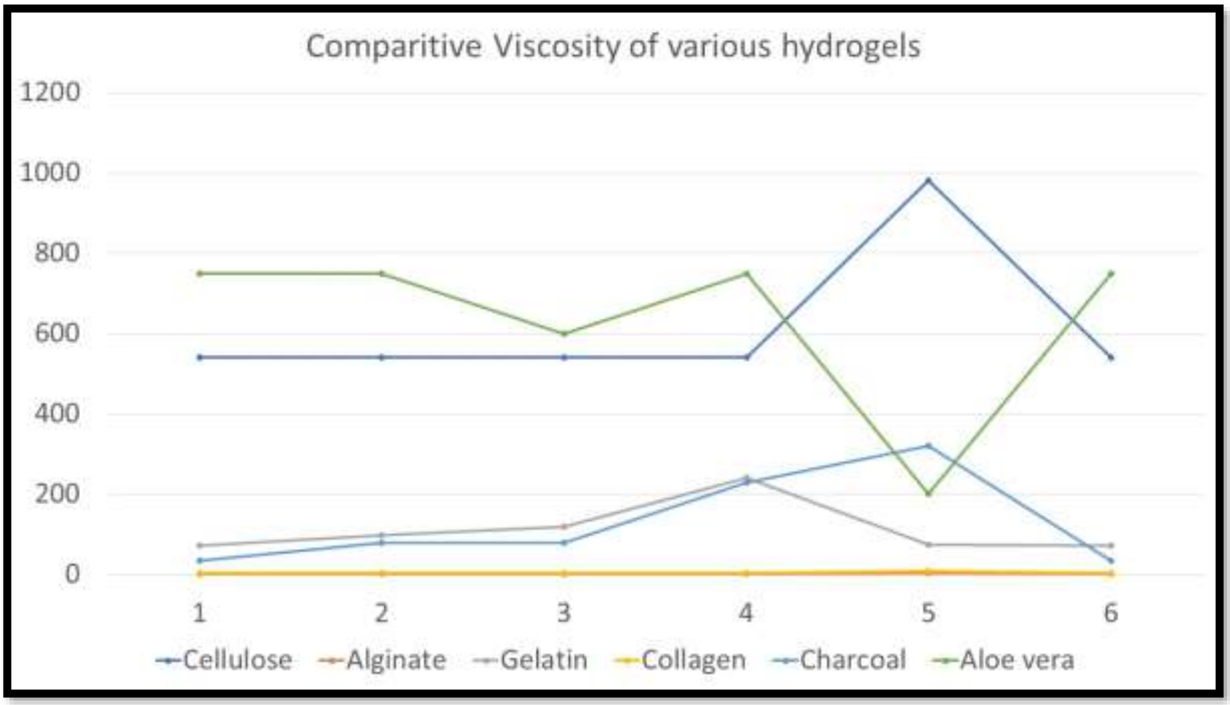
3. Results:

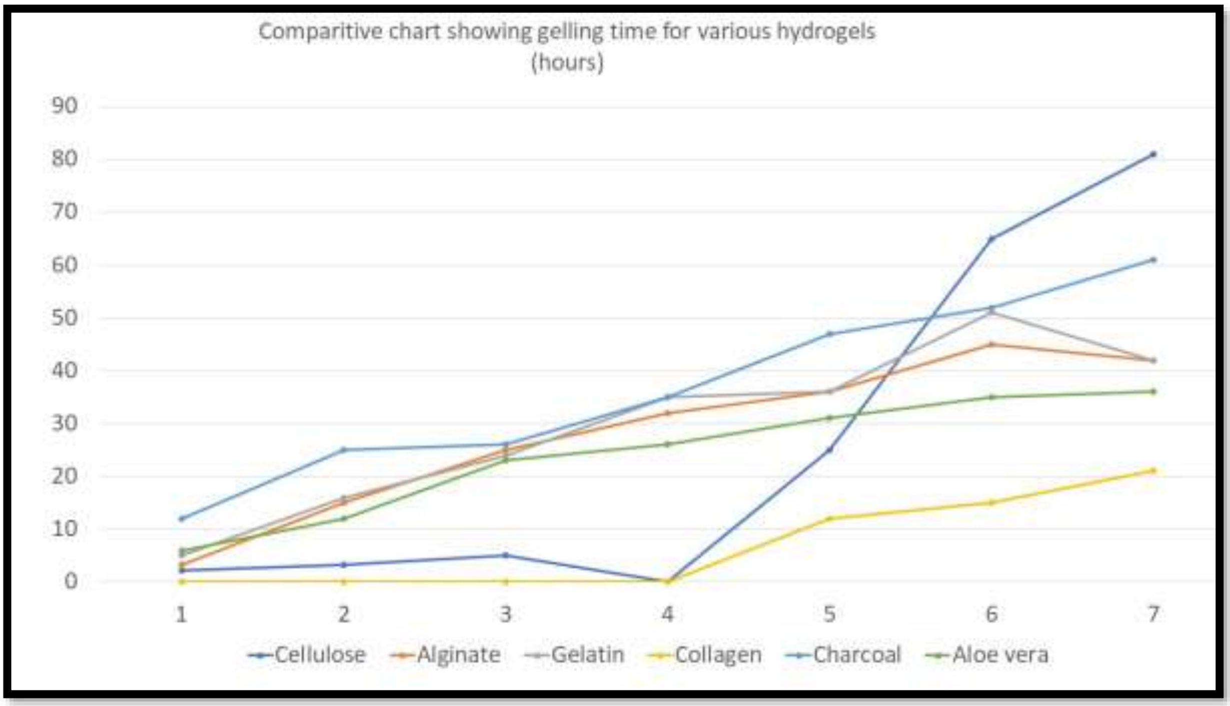
The synthesized cellulose underwent comparative analysis with various hydrogel types, evaluating parameters such as viscosity, pH, swelling capacity, gelling ability etc.



Comparison of cellulose hydrogels with already available hydrogels:

Hydrogels	**Gelling time**	**pH**	**Spreadability**	**Gel strength**	**Viscosity**
Cellulose	2 hr 15 min	7.2	2-4 cm	12- 69 MPa	540 cps
Alginate	3 hrs 30 min	7.4	5-7 cm	8- 57 MPa	1.4 cps
Gelatin	3 hrs to 5 hrs	4.8	3.6 cm	30- 300 MPa	71.8 cps
Collagen	280 seconds	6.9	0.05 cm	100- 200 MPa	3.84 cps
Charcoal	72 hrs	5.5	8 cm	10- 40 MPa	35 cps
Aloe vera	6 hrs	4.5	8.40 cm	12- 60 MPa	750 cps


Comparitive Viscosity of various hydrogels
1200
1000
800
600
400
200
0
1
2
3
4
5
6
Cellulose
Alginate
Gelatin
Collagen
Charcoal
Aloe vera


Comparitive chart showing gelling time for various hydrogels
(hours)
90
80
70
60
50
40
30
20
10
0
1
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5
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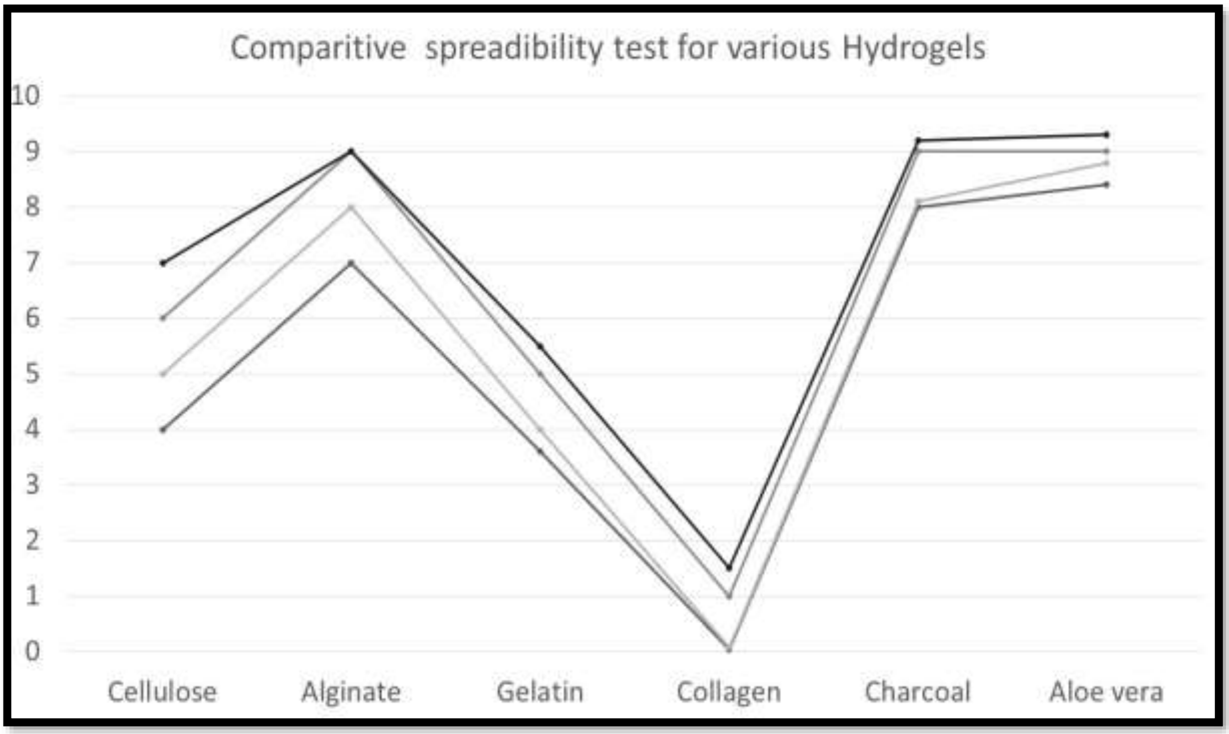
7
Cellulose
Alginate
Gelatin
Collagen
Charcoal
Aloe vera



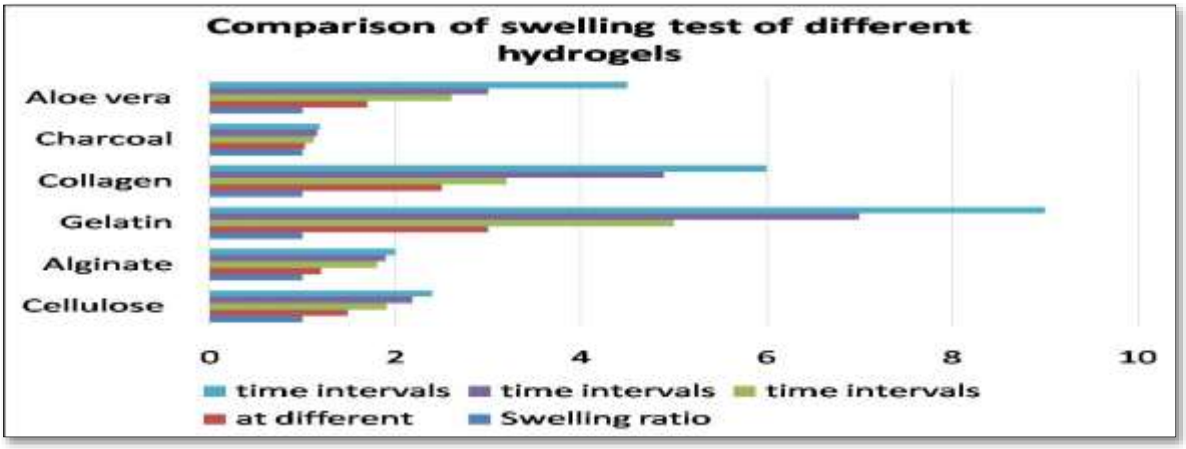
Cellulose Hydrogel synthesized:

Swelling test: Swelling rate is most important characteristic of hydrogel, to determine swelling rate study of swelling capacity versus time of hydrogel sample should be obtained by free absorbency capacity measurement at successive time interval.

Swelling test on Hydrogel synthesized

3.4 Comparison of hydrogels on basis of swelling test at different time duration:

Hydrogels	Swelling ratio at different time intervals				
	0.5 hrs	1 hr	2 hr	3 hr	4 hr
Cellulose	1	1.49	1.91	2.19	2.4
Alginate	1	1.2	1.8	1.9	2
Gelatin	1	3	5	7	9
Collagen	1	2.5	3.2	4.9	6
Charcoal	1	1.02	1.12	1.16	1.19
Aloe vera	1	1.7	2.6	3	4.5



3.2 Viscosity test: Viscosity is the ability of material to resist deformation in response to stress that is it is the ability of hydrogel to respond to changes occurred which is done by U – tube viscometer.

Viscosity of cellulose suspension at different concentrations

Viscosity test for 5% cellulose suspension					
Vol.(ml)	5	10	15	20	25
Time(sec)	386	400	420	480	540
Viscosity test for 10% cellulose suspension					
Vol.(ml)	5	10	15	20	25
Time(sec)	420	480	540	600	660
Viscosity test for 15% cellulose suspension					
Vol.(ml)	5	10	15	20	25
Time(sec)	540	690	780	902	1200

U- tube viscometer

Conclusion

This research explores cellulose hydrogels derived from bagasse as sustainable wound healing solutions. Bagasse, a sugarcane processing byproduct abundant in cellulose, offers a renewable resource for hydrogel synthesis. Through experiments, cellulose fibers from bagasse were integrated into hydrogel matrices, undergoing comprehensive characterization. Comparative analysis with common hydrogel materials like alginate, aloe vera, collagen, and gelatin revealed cellulose hydrogels' superior properties, including enhanced spreadability, viscosity, and pH stability. These findings highlight cellulose hydrogels' promise for biomedical applications, particularly wound healing. Their biodegradability addresses waste management and offers a sustainable alternative to synthetic materials. Additionally, the cooling and soothing effects attributed to bagasse's high cellulose content enhance cellulose hydrogels' therapeutic potential. This study underscores the significance of bagasse-derived cellulose hydrogels as eco-friendly biomaterials poised to advance wound care and tissue engineering. Among various hydrogels examined, cellulose hydrogels demonstrate superior characteristics, emphasizing cellulose's versatility and relevance in addressing healthcare challenges.

Acknowledgement

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