INVESTIGATION OF THE BIOMECHANICAL PROPERTIES OF GOAT SKIN

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OUTLINE

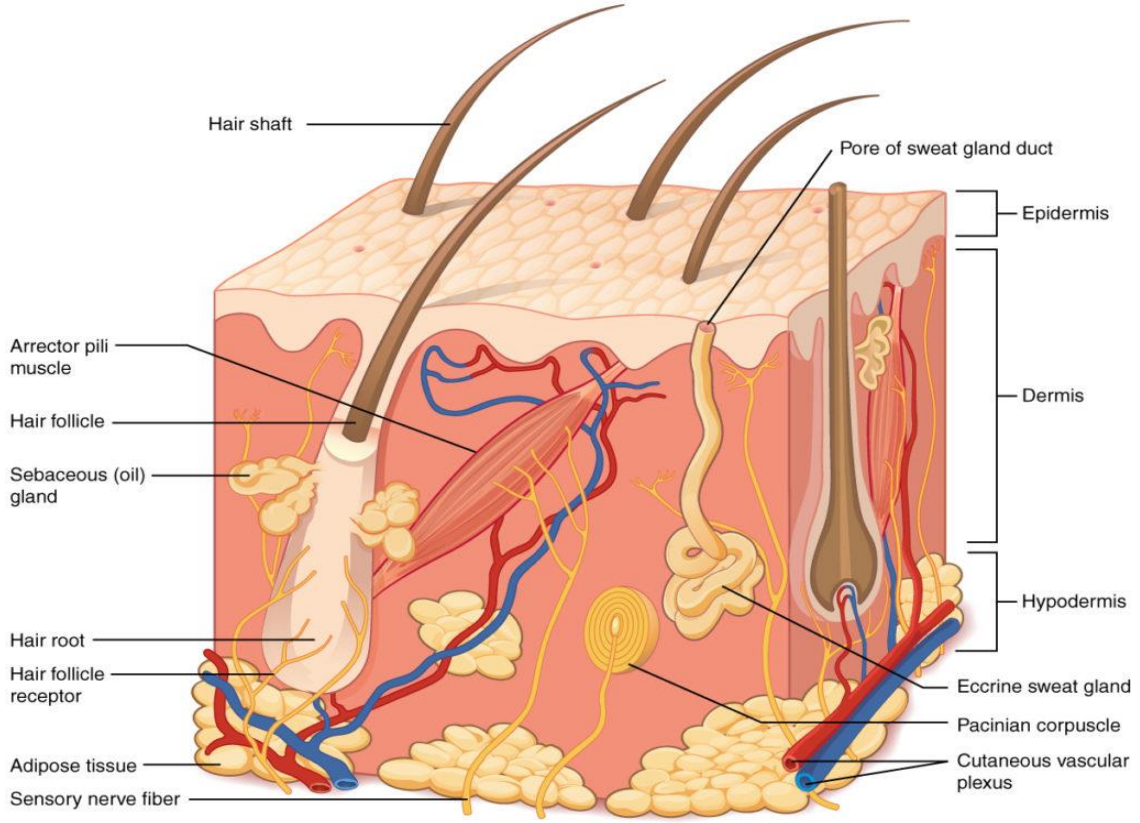
- **10th Asian-Pacific Conference on Biomechanics** (AP Biomech 2019)
- Chang Yung-Fa Foundation International Convention Center, Taipei, Taiwan
- November 1-3, 2019

OUTLINE

- Introduction
- Motivation and objective
- Methodology
- Sample preparation
- Histology imaging
- Mechanical testing
- Constitutive modelling
- Results
- Conclusion

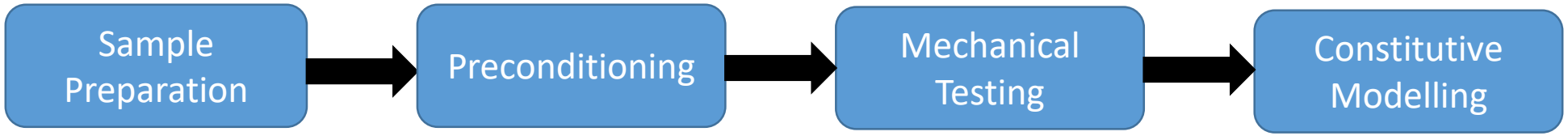
INTRODUCTION

- Largest organ by surface area in almost all of the animal species
- Interface between internal body and external environment
- Specialized to undergo various functions like secretion, protection, absorption
- Skin has a multilayered structure which can be considered as a composite with collagen fibers.

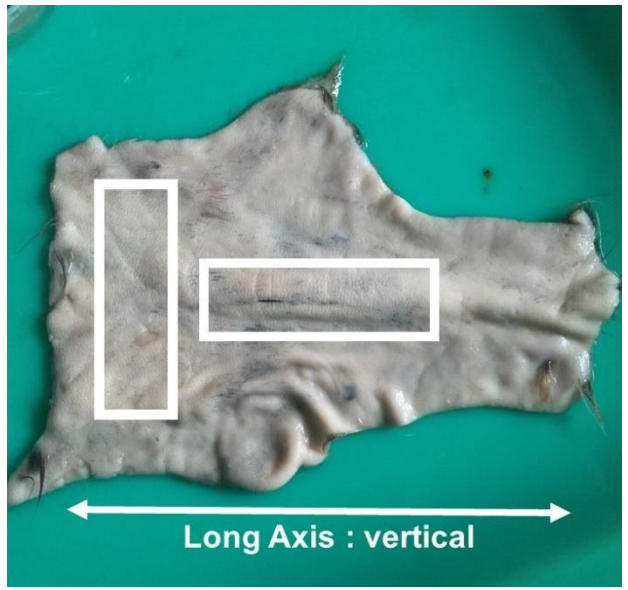


OBJECTIVE AND METHODOLOGY

- The goal of this work is to form a basis for the possibility of goat skin as a material for tissue engineering grafts by understanding its mechanical properties and the related microstructure



- Skin samples (n=7) of goat
- Rectangular specimens of 40mm length and 20mm width were excised in vertical and horizontal directions
- 7 specimens in Vertical (V) and 7 in horizontal (H) direction were obtained



MECHANICAL TESTING

- Specimens were loaded into Universal Testing Machine with a preload of 0.1N
- Preconditioning was done by applying 0.4N load at strain rate of 10mm/min for 4 cycles
- Uniaxial testing of each sample was at 10 mm/min

CONSTITUTIVE MODELLING

- Load vs extension data obtained from the mechanical testing
- ‘lsqnonlin’ function is used to fit the data with various hyper-elastic models.

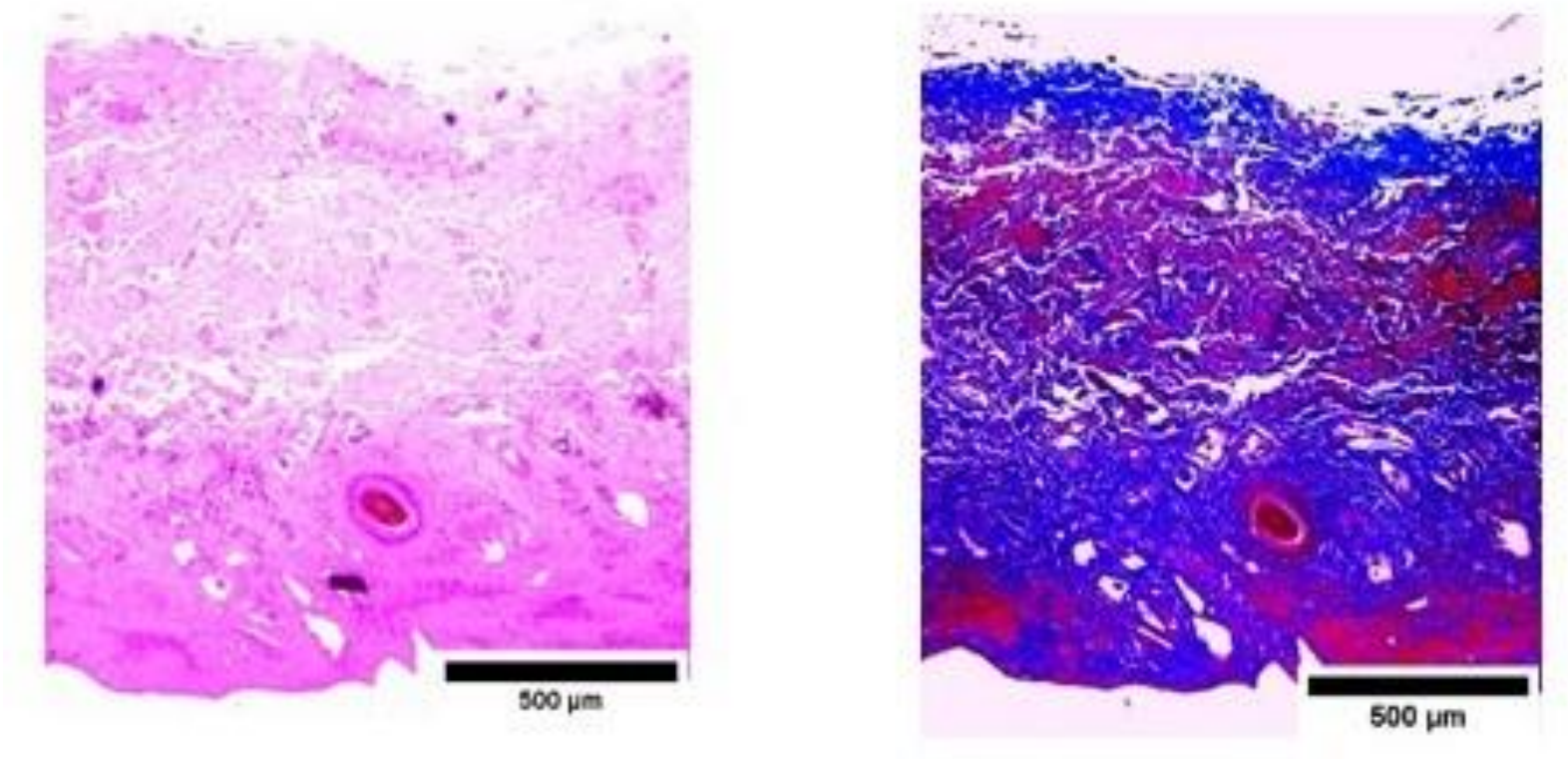
- Strain-energy function of following models were considered:

1. Ogden: $$W = \sum_{i=1}^{N} \frac{\mu_i}{\alpha_i} \left({\lambda_1}^{\alpha_i} + {\lambda_2}^{\alpha_i} + {\lambda_3}^{\alpha_i} - 3 \right)$$

2. Holzapfel-Gasser-Ogden: $$W = \frac{\mu}{2}(I_1 - 3) + \frac{k_1}{k_2}\left(e^{k_2 \left(I_4 - 1 \right)^2} - 1 \right)$$

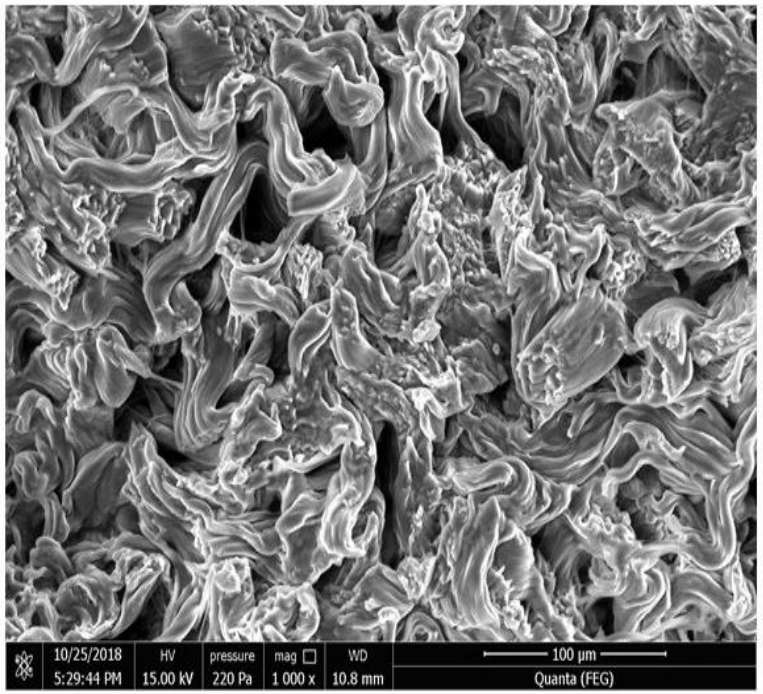
- The coefficient of determination (r^2) is taken as a basis to measure accuracy.

HISTOLOGY



Images of skin tissue sections with H & E and Massons trichrome stain. In the Massons trichrome stain collagen appears blue and muscle appears red.

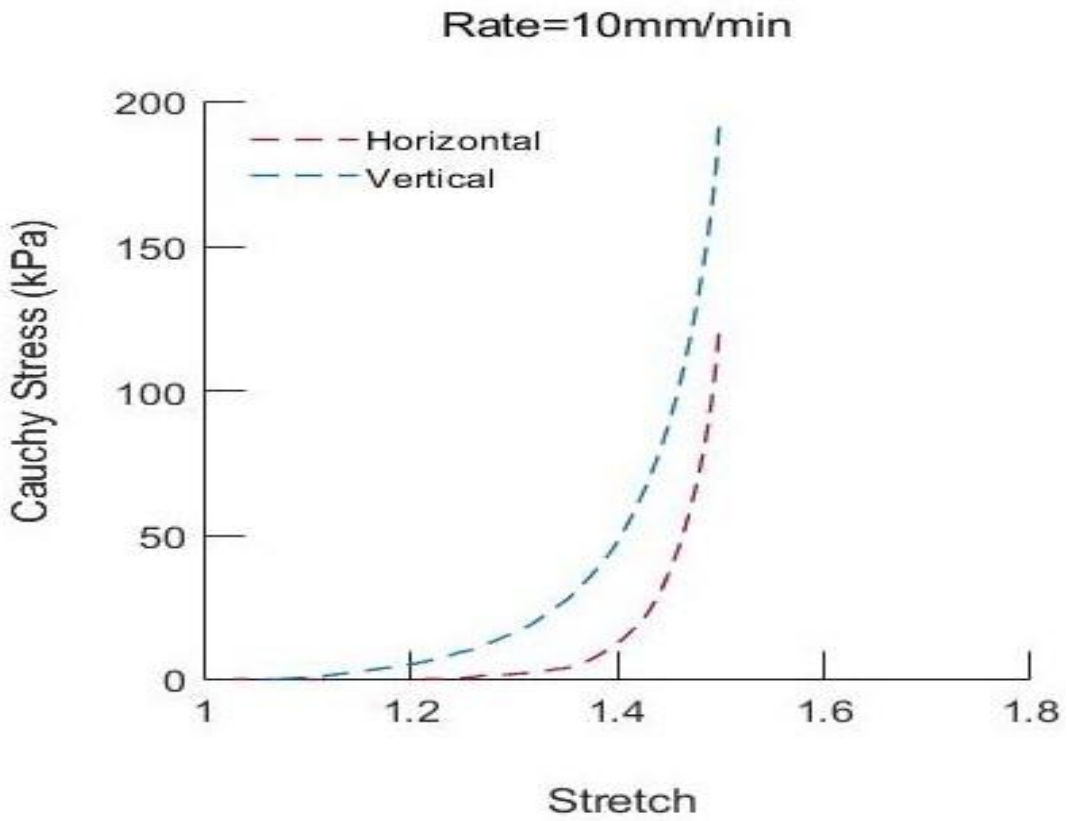
SEM IMAGING



SEM images of skin cross section

RESULTS

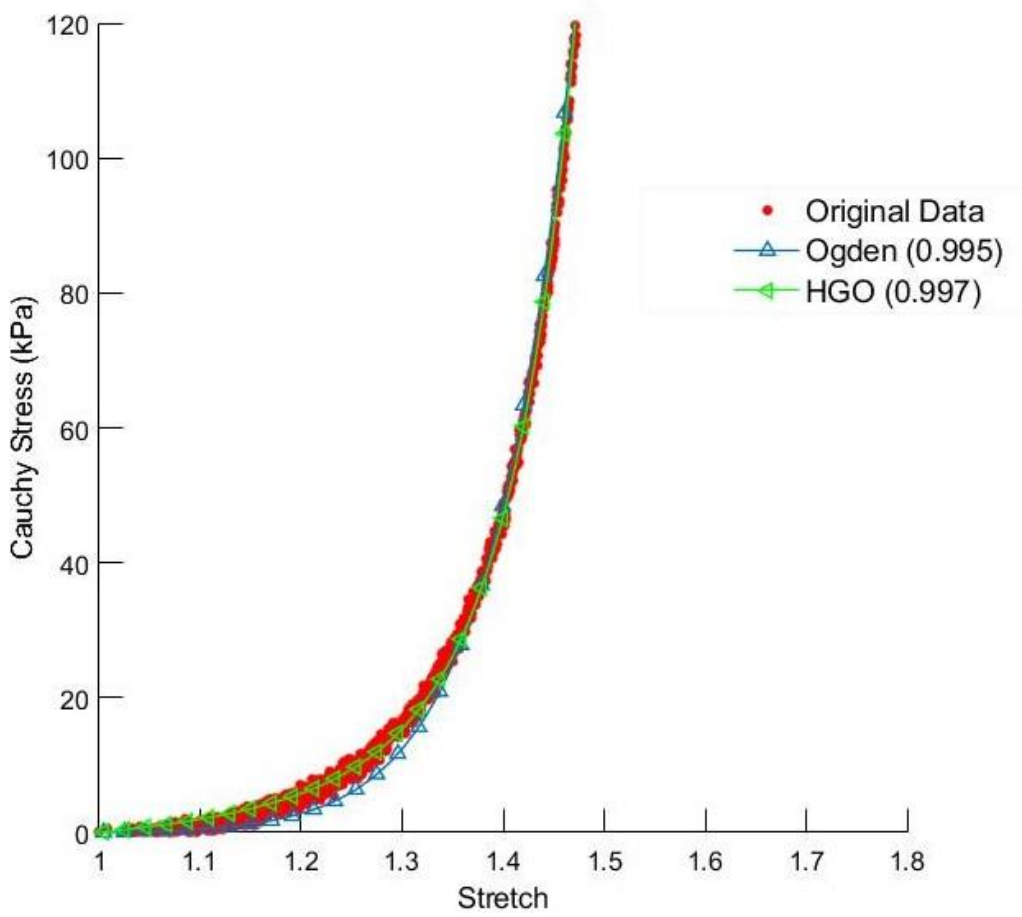
- All the samples showed non-linear behaviour, with linear behaviour up to stretch value of 1.3
- The anisotropic response is clearly captured with stiffer response in vertical direction than in horizontal direction



Stress-stretch plot of representative sample

- We calculated elastic modulus at two different regions of the plot.

	Horizontal		Vertical	
	E_L (kPa)	E_H(kPa)	E_L (kPa)	E_H(kPa)
Average	0.24 $\pm$0.32	24.23$\pm$20.78	0.21$\pm$0.32	19.26$\pm$11.71



Plots of all models fitted with original data

Model name	Parameters	Horizontal Direction	r^2	Vertical Direction	r^2
Ogden	$\mu_1(kPa)$	0.02±0.06	0.919–0.999	0.01±0.02	0.995–0.999
	$\alpha_1(-)$	51.78±17.65		40.56±11.58	
HGO	μ(−)	0.33±0.51		8.28E-12±1.38E-11	
	$k_1(kPa)$	2.02±5.27	0.944–0.999	0.58±0.88	0.991–0.999
	$k_2(-)$	4.79±1.89		3.53±1.06	

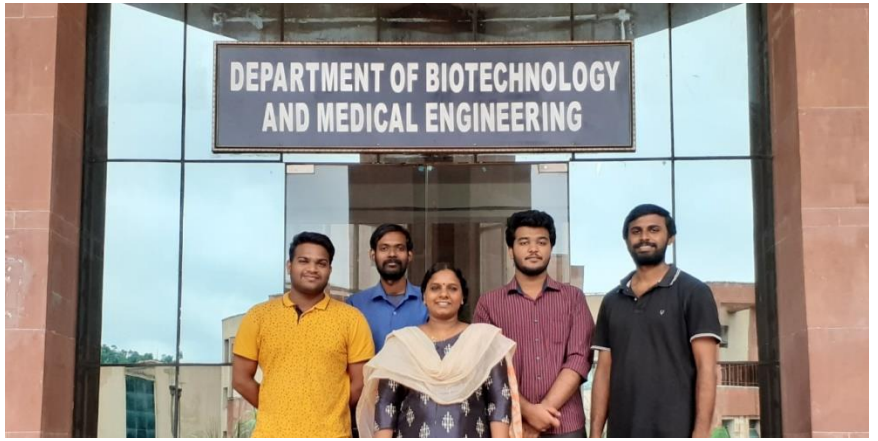
Parameter values along both directions. Here μ, μ_1 and k_1 are in kPa, while α_1 and k_2 are dimensionless parameters. r^2 represents the coefficient of determination.

CONCLUSION

- Goat skin exhibit non-linear and anisotropic behavior
- Microscopic studies also show the presence of collagen fibers which determine the anisotropic behavior
- Constitutive models like Ogden and HGO fitted the experimental data accurately
- The model parameters obtained can be combined with finite element modeling and with simulations for studying skin behavior during mechanical impact, damage and treatment.

ACKNOWLEDGMENTS

- The authors would like to acknowledge the Department of Biotechnology and Medical Engineering, NIT Rourkela for the financial support to carry out this research.



THANK YOU!