2020 IULTCS Young Leather Scientist Grant

Identification: YLSG2020_Megha Mehta

☑Basic Research ☐ Machinery/Equipment ☐ Environmental/Sustainability

1) Applicant Information

Name	Megha Mehta
Organization	NZ Leather and Shoe Research Association (LASRA)
Address	PO Box 8049
City/State	Palmerston North
Country	New Zealand

Advisor Information

Name	Rafea Naffa
Organization	NZ Leather and Shoe Research Association (LASRA)

Title: Investigating the structural differences of hides, skins and leather throughout the different processing stages.

Introduction:

As skins and hides are the raw material processed to produce leather, chemical and physical changes take place that affect the strength and other physical properties of the material. These structural changes are due to series of chemical and enzymatic treatments that alters the composition of original skin that removes few chemical components from the native skin and/or add some cross-linking agents [1]. This brings alteration in the collagen network which is not yet fully understood and forms the basis of investigation [3]. During the stages of leather processing many of the non-collagenous proteins are removed, these processes which include removing the hair, removal of non-collagenous material and opening up of the collagen fibres influence the final properties of the leather including its quality [2]. These processes have been thoroughly investigated in hide and skins from early leather processing stages using several destructive microscopic and analytical approaches of different macromolecules including proteins, lipids, carbohydrates and carotenoids, etc. to study change throughout the leather processing stages however non-destructive approaches have not been fully utilised. Raman and Attenuated Total Reflectance - Fourier Transform InfraRed (ATR-FTIR) is used to identify the alterations in the collagen with processing from fresh raw skin after removal from the carcass to dry crust leather [4].

Raman spectroscopy and ATR-FTIR can be used for non-invasive probing of chemical and biological samples. Both non-destructive techniques are fast, require minimal sample preparation, and have high specificity and sensitivity [5]. Raman spectroscopy has the advantage of a very weak water signal so minimal interference from water in biological samples, not causing any damage to the sample and allowing in-situ detection possible [6]. Sample preparation is relatively simple as compared to other analytical techniques, such as high-performance liquid chromatography (HPLC) and colorimetric methods [7]. Finding the variations in the initial leather processing steps reduces the costs of down-stream processing as well improving the leather quality. Therefore, the label-free and non-destructive techniques are highly attractive tool for understanding the structural variations. To evaluate the performance of results, univariate and multivariate statistical analysis [6,8] can be used to transform the big data set to a concise and useful piece of information.

The large-scale study of understanding the skin or hide and change in the arrangements of collagen fibrils after undergoing chemical treatments such as use of strong salt solutions, large changes in pH and enzymatic treatments to remove non-collagenous skin components and then new cross links formed helps in understanding the link between the macromolecules and structure [3]. Going over the whole chain of processing will help us in improving the conditions, finding the outliers and removing them without losing the quality. Raman and

ATR-FTIR will be used to study the skin and leather to gain better understanding of the leather processing regimes. Investigating in-depth structural profile of skins or hides during early processing stages will give us a better idea to get find the problem and resolve it before reaching the final stage that not only will save time but also minimise the cost incurred in carrying out the entire leather manufacturing process.

Objectives:

The main objective is the utilisation of two non-destructive approaches non-destructive technique – Raman and ATR-FTIR spectroscopy to investigate the structural profiles of hides or skins throughout the stages of leather processing. This will enable us to investigate the changes that take place in the microstructure of leather through the different stages of processing from skin/hide to leather. The structural basis of these changes at the level of collagen cross-links is poorly understood and has the potential of this investigation. This will involve:

- Identify and quantify proteins, lipids, amino acids, carotenoids, etc. in the different stages for leather processing using Raman and ATR-FTIR in conjunction with chemometrics (statistical analysis).
- Compare these macromolecules or any other chemical found in the different stages of leather processing.

Methods:

The major advantage of Raman and ATR-FTIR is minimal or no sample preparation. Collecting the skins or hides from the initial to the final processing stage, slicing the skins/hides using a Leica CM1850UV Cryostat and placed on a microscope slide for Raman and ATR-FTIR analysis.

Hypothesis/Expected Results:

It is expected that there will be significant changes in the cross-links in the process of removing in the liming and bating stages and then adding new cross-links at the pre-tanned and wet blue stages which is responsible for stabilising the collagen network structure. Monitoring the changes will be useful for developing the final physical characteristic of leather.

Research benefit for the local or global leather industry:

Investigating the structural profile of skins and hides throughout the early processing stages using non-destructive techniques will give us a greater understanding of how the different macromolecules and chemicals affect the quality of leather, particularly in response to some defects. This is the first time where Raman and ATR-FTIR will be used on large-scale in leather to investigate the effect of proteins, lipids and other molecules on leather properties. The introduction of these non-destructive techniques into leather science at wide level could potentially have a large transformative effect on the entire leather industry by bridging the gap between our understanding of leather structure and its biological content.

Literature:

1. Covington, A.D. and Covington, T., *Tanning Chemistry: The Science of Leather*. 2009: Royal Society of Chemistry.
2. Mann, B.R. and McMillan, M.M., *The Chemistry of the Leather Industry.* NZ Institute of Chemistry, 2017: p. 1-17.
3. Naffa R, Maidment C, Ahn M, Ingham B, Hinkley S, Norris G. Molecular and structural insights into skin collagen reveals several factors that influence its architecture. *International journal of biological macromolecules.* 2019;128:509-20.
4. Martinez MG, Bullock AJ, MacNeil S, Rehman IU. Characterisation of structural changes in collagen with Raman spectroscopy. *Applied Spectroscopy Reviews*. 2019;54(6):509-42.
5. Larkin P. Infrared and Raman spectroscopy: principles and spectral interpretation. Amsterdam: Elsevier; 2017.
6. Kumar S, Verma T, Mukherjee R, Ariese F, Somasundaram K, Umapathy S. Raman and infra-red microspectroscopy: towards quantitative evaluation for clinical research by ratiometric analysis. *Chemical Society Reviews.* 2016;45(7):1879-900.
7. Naffa R, Holmes G, Ahn M, Harding D, Norris G. Liquid chromatography-electrospray ionization mass spectrometry for the simultaneous quantitation of collagen and elastin crosslinks. *Journal of Chromatography A.* 2016; 1478:60-7.
8. Ahmed R, Lau C, editors. Bone mineralization and collagen formation observed with principal component analysis of Raman scattering from healing calvarial defects. Proceedings of the SPIE BiOS conference of Imaging, Manipulation, and Analysis of Biomolecules, Cells, and Tissues XVII; 2019: *International Society for Optics and Photonics*; 2019;10881.