

## 2025 IULTCS Young Leather Scientist Grant

**Identification: YLSG\_2026\_Nima Pourrasoul Sardroudi**

**COMPLETE APPLICATION FORM (click application area)**

Basic Research    Environmental/Sustainability    Machinery/Testing

### 1) Applicant Information

Name	Nima POURRASOUL SARDROUDI
Date of Birth	15/06/1995
Organization	Ege University, Leather Engineering Department
Address	Ege University, Engineering Faculty, Leather Engineering Department, 35100, Bornova
City/State	Izmir
Country	Türkiye
Email Address	nima.pourrasoul@gmail.com
Phone Number	+90 545 822 57 07
Education (list)	Bachelor (2013-2017): Ege University, Leather Engineering Department
	Master (2017-2021): Ege University, Leather Engineering Department
	Master (2024-2025): University of Lleida, Leather Engineering
	PhD (2021-current): Ege University, Leather Engineering Department
If student, graduating year	2027
If employed, starting date	-

### Advisor Information

Name	Prof. Dr. Arife Candaş Adıgüzel Zengin
Organization	Ege University, Engineering Faculty, Leather Engineering Department
Email Address	<a href="mailto:candas.zengin@ege.edu.tr">candas.zengin@ege.edu.tr</a> ; <a href="mailto:adiguzelcandas@gmail.com">adiguzelcandas@gmail.com</a>

By submitting this application, I commit to develop the project as outlined in the attached Research Project Plan and to complete a written report by February 28, 2027 with the following items:

- 1) Introduction
- 2) Materials and Methods
- 3) Results and Discussion
- 4) Conclusion
- 5) Suggestion for Future Work
- 6) References

## 2) Research Project Plan

### **Title:** Algal Biopolymer-Based Films as Green Alternatives for Leather Surface Coating Applications

#### **Introduction:**

The Industrial Revolution increased production and population growth, leading to environmental challenges such as biodiversity loss, global warming, and climate change (Tomislav, 2018). In response, initiatives like sustainability, circular economy and bioeconomy have emerged to promote sustainable resource use and reduce waste through regenerative and renewable systems (McCormick and Kautto, 2013). Although the leather industry fits these principles by using renewable by-products from the meat sector, the finishing process of the industry relies on non-biodegradable petroleum-based film formers (Tamilselvi et al., 2019).

The decline of fossil resources has led to a growing interest in bio-based film formers (Wang et al., 2019). In this context, polysaccharides and proteins, especially algal polysaccharides, provide renewability, biodegradability, and strong film-forming capabilities (Patel et al., 2023; Thiviya et al., 2023). Carrageenan, extracted from red seaweeds, is widely used in edible films, biomedical applications, and electrolytes (Farhan and Hani, 2017; Cunha and Grenha, 2016). However, the inadequate mechanical and barrier properties necessitate reinforcement, and the incorporation of proteins such as soy and whey isolates has demonstrated promising enhancements (Łupina et al., 2019; Azevedo et al., 2015). In addition, plasticizers like glycerol and sorbitol are also essential for increasing the flexibility of carrageenan-based biofilms (Rhim & Ng, 2007).

Research on carrageenan–protein blend films remain scarce and has largely centered on their use in food packaging applications (Sogut et al., 2019; Yavari Maroufi et al., 2023). In the leather sector, algal polysaccharide applications remain limited to retanning modifications (Nalyanya et al., 2020), and no studies to date have investigated the use of carrageenan-based biofilms as surface coatings. Therefore, this study examines carrageenan/soy and carrageenan/whey biofilms as sustainable coating materials for leather. After characterizing the mechanical, thermal, and barrier properties of the biofilms, the selected blends were applied to chromium-free wet-white leather and evaluated in terms of tensile strength, thermal behavior, water vapor permeability, color properties, fastness characteristics, and organoleptic performance.

#### **Objectives:**

The main objective of the study is to develop sustainable, biodegradable alternatives to petroleum-based film formers used in leather finishing, which pose long-term environmental concerns.

To achieve this aim, the study investigates the polysaccharide–protein-based biopolymers as potential eco-friendly film formers, focusing specifically on carrageenan (C) blended with soy protein isolate (S) and whey protein isolate (W). The research intends to prepare 27 distinct blend ratios to analyze and compare their physical, mechanical, thermal, and surface properties, including tensile strength, water vapor permeability, water contact angle, FTIR characteristics, TGA, and DSC behavior, in order to identify the most promising formulations.

The second objective of the study is to assess the practical suitability of the optimal biofilm formulations (2%C, 2%C\_0.2W, and 2%C\_0.7S) by evaluating their performance when applied to

chromium-free wet-white leather for use in leather finishing applications. This involves analyzing changes in mechanical properties, permeability, color characteristics, color fastness, organoleptic properties, and surface morphology (SEM). Ultimately, the study aims to demonstrate the potential of polysaccharide–protein biofilms as viable, sustainable, and high-performance alternatives to conventional petroleum-based coatings in the leather industry.

## **Methods:**

The methodology has started with the preparation of 27 different carrageenan–protein blend films, utilizing carrageenan (C) as the polysaccharide source and soy (S) and whey protein isolates (W) as the protein components. These formulations were cast into films and subjected to a comprehensive set of analyses to determine their physical and functional behaviors. Mechanical properties, water vapor permeability, and water contact angle were tested to evaluate strength and barrier performance, while Fourier Transform Infrared Spectroscopy (FTIR), Thermogravimetric Analysis (TGA), and Differential Scanning Calorimetry (DSC) were used to assess chemical interactions and thermal stability (Rhim & Ng, 2007). Through these analyses, three optimal formulations—2%C, 2%C\_0.2W, and 2%C\_0.7S—were identified based on their superior overall performance.

In the second phase, the selected films were applied to chromium-free wet-white goat leather to evaluate their practical suitability as sustainable coating materials. The coated leathers were tested for tensile strength, elongation at break, and water vapor permeability, along with spectrophotometric color measurements and color fastness to water spotting, following assessment approaches seen in leather and biopolymer studies (Sogut et al., 2019). Additional evaluations, including organoleptic assessment and Scanning Electron Microscopy (SEM), were performed to examine surface appearance, coating homogeneity, and microstructural changes. This structured methodology enabled a systematic comparison of bio-based coating performance and demonstrated the potential of polysaccharide–protein films for leather finishing applications.

## **Hypothesis/Expected Results:**

This research is expected to demonstrate the potential of carrageenan-based biofilms reinforced with soy and whey protein isolates as a successful replacement of petroleum-based film formers in leather finishing. It is anticipated that certain C/S and C/W blend ratios (specifically those already identified as optimal during preliminary characterization) will exhibit improved mechanical strength, better flexibility, enhanced thermal stability, and more favorable barrier properties compared to pure carrageenan films. These optimal formulations are also expected to show balanced water vapor permeability and higher water contact angles, indicating better film integrity and reduced hydrophilicity.

The selected biofilm coatings, when applied to chromium-free wet-white leathers, are intended to form uniform, stable, and adherent surface layers that enhance both the mechanical properties and aesthetic qualities of the leather. Enhancements are expected in tensile strength, elongation, and color uniformity, along with acceptable water-spotting color fastness. SEM analyses are anticipated to validate the formation of a smooth, continuous coating devoid of defects, whereas organoleptic evaluations should indicate that the coated leathers maintain desirable softness and handle.

Overall, the study is anticipated to demonstrate that polysaccharide–protein blend biofilms offer a sustainable, biodegradable, and high-performance alternative to conventional petroleum-based finishing materials in the leather industry.

## **Research benefit for the local or global leather industry**

This research provides the leather industry with a sustainable, biodegradable, and high-performance alternative to petroleum-based surface coatings, supporting both environmental responsibility and improved product quality on a local and global scale.

### **Literature:**

- Azevedo, V. M., Dias, M. V., Borges, S. V., Costa, A. L. R., Silva, E. K., Medeiros, É. A. A., & Soares, N. D. F. F. (2015). Development of whey protein isolate bio-nanocomposites: effect of montmorillonite and citric acid on structural, thermal, morphological and mechanical properties. *Food Hydrocolloids*, 48, 179-188.
- Cunha, L., & Grenha, A. (2016). Sulfated seaweed polysaccharides as multifunctional materials in drug delivery applications. *Marine drugs*, 14(3), 42.
- Farhan, A., & Hani, N. M. (2017). Characterization of edible packaging films based on semi-refined kappa-carrageenan plasticized with glycerol and sorbitol. *Food Hydrocolloids*, 64, 48-58.
- Łupina, K., Kowalczyk, D., Zięba, E., Kazimierczak, W., Mężyńska, M., Basiura-Cembala, M., and Wiącek, A. E. (2019). Edible films made from blends of gelatin and polysaccharide-based emulsifiers-A comparative study. *Food Hydrocolloids*, 96, 555-567.
- Maroufi, L. Y., Shahabi, N., Fallah, A. A., Mahmoudi, E., Al-Musawi, M. H., & Ghorbani, M. (2023). Soy protein isolate/kappa-carrageenan/cellulose nanofibrils composite film incorporated with zenian essential oil-loaded MOFs for food packaging. *International Journal of Biological Macromolecules*, 250, 126176.
- Nalyanya, K. M., Rop, R. K., Onyuka, A., Birech, Z., & Kamau, P. (2020). Mitigating the Formation of Hexavalent Chromium in Leather by Using Aloe Barbadensis Miller Mixed with Carrageenan.
- McCormick, K., & Kautto, N. (2013). The bioeconomy in Europe: An overview. *Sustainability*, 5(6), 2589-2608.
- Patel, A. K., Vadrade, A. P., Singhanian, R. R., Michaud, P., Pandey, A., Chen, S. J., ... & Dong, C. D. (2023). Algal polysaccharides: current status and future prospects. *Phytochemistry Reviews*, 22(4), 1167-1196.
- Rhim, J. W., and Ng, P. K. (2007). Natural biopolymer-based nanocomposite films for packaging applications, *Critical reviews in food science and nutrition*, 47(4), 411-433.
- Sogut, E., Balqis, A. I., Hanani, Z. N., & Seydim, A. C. (2019). The properties of  $\kappa$ -carrageenan and whey protein isolate blended films containing pomegranate seed oil. *Polymer testing*, 77, 105886.
- Tamilselvi, A., Jayakumar, G. C., Charan, K. S., Sahu, B., Deepa, P. R., Kanth, S. V., & Kanagaraj, J. (2019). Extraction of cellulose from renewable resources and its application in leather finishing. *Journal of Cleaner Production*, 230, 694-699.
- Thiviya, P., Gamage, A., Liyanapathirana, A., Makehelwala, M., Dassanayake, R. S., Manamperi, A., ... & Madhujith, T. (2023). Algal polysaccharides: Structure, preparation and applications in food packaging. *Food Chemistry*, 405, 134903.
- Tomislav, K. (2018). The concept of sustainable development: From its beginning to the contemporary issues. *Zagreb International Review of Economics & Business*, 21(1), 67-94.
- Wang, R., Wang, H., Pengjie, L., Yao, Y., & Ji, W. (2020). Structure and Properties of a Novel Collagen-Soy Protein Isolate Film via Self-Assembly: A Comparative Study. *Journal of the Society of Leather Technologists and Chemists*, 104(1), 25-32.