

# Security and Health in the Tanning Process of Paiche (*Arapaima Gigas*) Skin with Quebracho Extract (*Schinopsis Balansae*) and Mimosa (*Acacia Dealbata*) for the Environmentally Industrial Use Sustainable

Christiaan E. Moreno<sup>b</sup>, Grese Hanampa<sup>a</sup>, Zanhly L. Valencia-Reyes<sup>b,\*</sup>, Fiorella V. Güere<sup>b</sup>, Alex S. Armas-Blancas<sup>b</sup>, Alejandro Mena<sup>b</sup>, Hellen F. Blancas<sup>c</sup>, Giner E. Díaz<sup>d</sup>, Sixto S. Mendoza<sup>e</sup>, Guillermo L. Vilchez<sup>a</sup>

<sup>a</sup>Universidad Nacional Tecnológica de Lima Sur, Sector 3 Grupo 1A 03, Av. Central, Villa EL Salvador, Lima 15834, Perú

<sup>b</sup>Universidad Nacional Mayor de San Marcos, Ciudad Universitaria, Lima 15081, Perú

<sup>c</sup>Universidad Nacional de Educación Enrique Guzmán y Valle, Lurigancho-Chosica 15472, Perú

<sup>d</sup>Universidad Pontificia de Cataluña, España

<sup>e</sup>Universidad César Vallejo, Av. Alfredo Mendiola 6232, Los Olivos 15314, Perú

[zvalenciar@unmsm.edu.pe](mailto:zvalenciar@unmsm.edu.pe)

Raising paiche in the Peruvian Amazon it produces enough raw material to produce leather skins, but because of his use limited, these skins They present a pollution problem. In its research study, the importance of using both mechanical procedures as chemicals to obtain high quality leather. To bring about the process, they were used in different concentrations of quebracho and mimosa. Paiche skin leather resulting was resistant and moldable, with a bending resistance capacity that exceeded 30,000 bends without deformation, thus providing greater tear resistance T1 (146.23 N) and T5 (143.12 N), and greater traction in T4 (16.62 N/mm<sup>2</sup>). Furthermore, the leather had ashes less than 1 %, humidity less than 9%, and chromium oxide content by below 1.5%. It was also treated the effluent generated during the process getting values acceptable pH, conductivity and COD. The study I consider the legislation existing in the country to guarantee the protection and safety of workers during the management of paiche skin tanning, considering the use of chromium oxide as a high risk for the health of workers, the regulations are still insufficient and the protection and security of the workers.

## 1. Introduction

The tanning of hides has historically posed high risks both to human health and the environment due to the use of hazardous chemicals, such as chromium (III) and chromium (VI), which are widely used in conventional tanning processes (Mazzi, 2023). As concerns about environmental impacts and sustainability have grown, research has started exploring safer and less polluting alternatives, such as the use of plant-based extracts. The use of quebracho and mimosa in the tanning industry is an example of an ecologically sustainable solution that reduces the use of toxic chemical compounds (Mohammadi et al., 2024). In Peru, the tanning industry has undergone significant changes in recent years due to the implementation of new technologies aimed at reducing environmental impact. Recent studies have shown that plant-based extracts, such as quebracho and mimosa, are viable options for achieving a cleaner and more efficient tanning process (Fouzi et al., 2024). These extracts not only reduce reliance on synthetic chemicals but also allow for the utilization of natural resources available in the Amazon region, contributing to both the local economy and ecosystem conservation. The use of paiche skin for leather production represents a significant step toward sustainability in the fishing and tanning industries. Traditionally, paiche skin has been discarded, creating a solid waste problem that affects local ecosystems (Cruz & Huerta-Mercado, 2015).

The development of technologies that enable the use of this byproduct in the leather industry not only offers environmental benefits but also generates new economic opportunities for local communities, contributing to sustainable development. Workplace safety and occupational health are critical aspects of the tanning process. In Peru, Law 29783 on Occupational Health and Safety mandates the need to prevent occupational risks and protect workers from exposure to hazardous substances, such as the chromium used in tanning (Cruz & Huerta-Mercado, 2015). However, the implementation of less hazardous alternatives, such as quebracho and mimosa extracts, not only complies with existing regulations but also minimizes health risks for workers (Yuan et al., 2022).

The paiche is one of the resources fishing aquaculture with greater demand in the Amazonian markets and lately in the local, national and international market, due to the high content protein and good flavor, but, when marketing is national and international, only the meat is sold, existing a large amount of waste skin, scales, head among others, which represents (53%) being 18.9%, corresponding to the skin with scales, the same ones that are not used efficiently by the aquaculturist, since it only focuses on the sale of meat and these skins are thrown into the dumps and water sources establishing so in contamination sources environmental.

The leather industry in Peru it is in constant evolution in terms of your utilization and exploitation. Previously, they used the skins of snakes, lizards, animals, wild animals, wild, among others. In this context, the skin of the paiche plays a fundamental role, since, during the meat processing, waste to a large degree. Therefore, the objective of this research is finding a way to take advantage of the skin of the paiche, focusing in determining the parameters technological for your tanning vegetable, using quebracho and mimosa extract, in order to achieve sustainable industrial use from the environmental point of view.

For which the research was developed the following study treatments, mimosa, quebracho and combination of both, with the present research is intended give the solution to this problem of pollution and losses of this great resource and take advantage of them through his transformation in leathers exotic that can open new transformation opportunities. In the leather industry, likewise, the safety of the products was considered workers. Elaborate leather from the skin of the paiche, allowed to know the parameters technological in vegetable tanning from the reception of raw material, skin conditioning, soaking, degreasing, picking, tanning, neutralizing, dyeing, stretching, drying, sanding, greasing and finishing the which ones are acceptable? By the Technical Standards Peruvian.

Health and safety management aims to identify, evaluate and reduce health and safety risks in working conditions, related to materials, components, machinery and processes. In the operations and activities related to vegetable tanning from the receipt of raw materials, skin conditioning, soaking, degreasing, picking, tanning, neutralizing, dyeing, stretching, drying, sanding, greasing and finishing which are acceptable because they are characterized for low risks due to the minimal danger of substances and materials, which can determine minimal negative consequences for both the environment and occupational health and safety (Mazzi, 2023).

## 2. Methodology

This study proposes a systemic approach for identifying critical safety and security barriers for major accident scenarios in the chemical process industries (Yuan, 2022). Estimating and evaluating the inherent safety of processes pose a significant challenge in the field of inherent safety. Indicators are commonly employed tools to address this challenge. However, one of the weaknesses of risk-based indicators is their assumption of equal weight and importance for all indicators, despite the fact that the impact of each indicator may vary (Mohammadi, 2024). The best practice of chemical management is crucial to prevent or minimize the risk of chemical exposure to people and the environment either caused by safety or security issues (Fouzi, 2024).

### Security and health occupational

They have established standards to ensure the safety and health of employees. The Health and Safety Law in the Work is one of the norm further important. Law 29783 on Safety and Health on the Job was enacted in August 2011. The legislation national establishes a series of requirements to promote a risk prevention culture labor. All companies that operate in Peru must comply with this normative obligation (Cruz & Huerta-Mercado, 2015).

### Research design

The research was based on an experimental design, since the exposure to the experimental variables was controlled when assigning the subject to different groups. This was done in order to observe and measure responses or behaviors. In its experiment, they were carried out evaluations physical, mechanical and chemical to determine the concentration and combination optimal of the quebracho and mimosa extracts.

## Assessment parametric for the analysis

### Equations

According to (Gutiérrez & De la Vara, 2008), it indicates that the model mathematical used in the ANOVA is based on the decomposition of the total variability of the data in two components; the variability between groups and variability within the groups, before it, this investigation meets the conditions to use this model mathematician, rating 5 treatments in study with three repetitions at each one of them.

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij} \quad (1)$$

$Y_{ij}$  : The result obtained from the group subjected to treatment " i "

$\mu$  : The general average of all the experiment data

$\tau_i$  : Effect of " i " treatment

$\varepsilon_{ij}$  : The experimental error refers to the effect random sampling in an experiment

Table 1: Treatments in study

Treatments	Quebracho ( <i>Schinopsis balansae</i> )	Mimosa ( <i>Acacia dealbata</i> )
T1	0%	20%
T2	20%	0%
T3	10%	10%
T4	5%	15%
T5	15%	5%

According to (Gutiérrez & De la Vara, 2008), the analysis of variance (ANOVA) plays a fundamental role in the data study experimentally, since it allows analyze in a way statistical differences and variability between treatments. In the ANOVA, the designation and the order of the treatments are carried out random to avoid possible biases or influences external in the results. In it study was assigned five treatments randomly, and each treatment was repeated three times.

## 3. Procedure and Results

### 3.1 Procedure

The investigation implements filleting, skin removal, conditioning and tanning process was carried out in the environments of the Innovation Center Technology and Transfer Technological Fishing Amazonian located in Pucallpa (CITE PAP). The analysis Physical mechanics were carried out in the Innovation Center Technology and Transfer Tecnológica Calzado Lima (CITE Call Lima) and the analysis chemicals were made in the Research, Development, Innovation and Transfer Directorate Technology (DIDITT), of the Ministry of Production. Figure 1 shows the flow chart tanning paiche skin.

### 3. Results

The prevention of risks labor has to be understood as an activity permanently that must be integrated into all of the company's actions and in all the levels hierarchical of it. The employer developed and executed a Health and Safety Program in the Work, according to the rules current, with the objective of incorporating the measures techniques necessary to allow check the risks in his source, evaluate the risks that cannot be avoided, reduce the risks to a minimum using work methods, processes and equipment insurance, adopt measures that prioritize protection collective before the individual, incorporate prevention and / protection measures consistent with the top principles that advise the media technicians available, provide the personal protective equipment and elements appropriate to the risk, provide the resources human, physical and economic necessary in order to ensure his appropriate compliance with the Health and Safety Program.

The results of the flexural resistance properties, it was observed that the 5 treatments were found within the parameters of the 30 thousand push-ups, described in the table 18, NTP 241(021, 022 and 023) 2022 for the manufacture of casual footwear (men's and women's).

The results average of the tear resistance tests, it is observed that the values were within the intervals established in the Peruvian technical standard NTP 241 (021, 022 and 023) 2022. These ranges are defined for the manufacture of casual footwear (men's and women's).

**Flowchart - Paiche skin tanning**

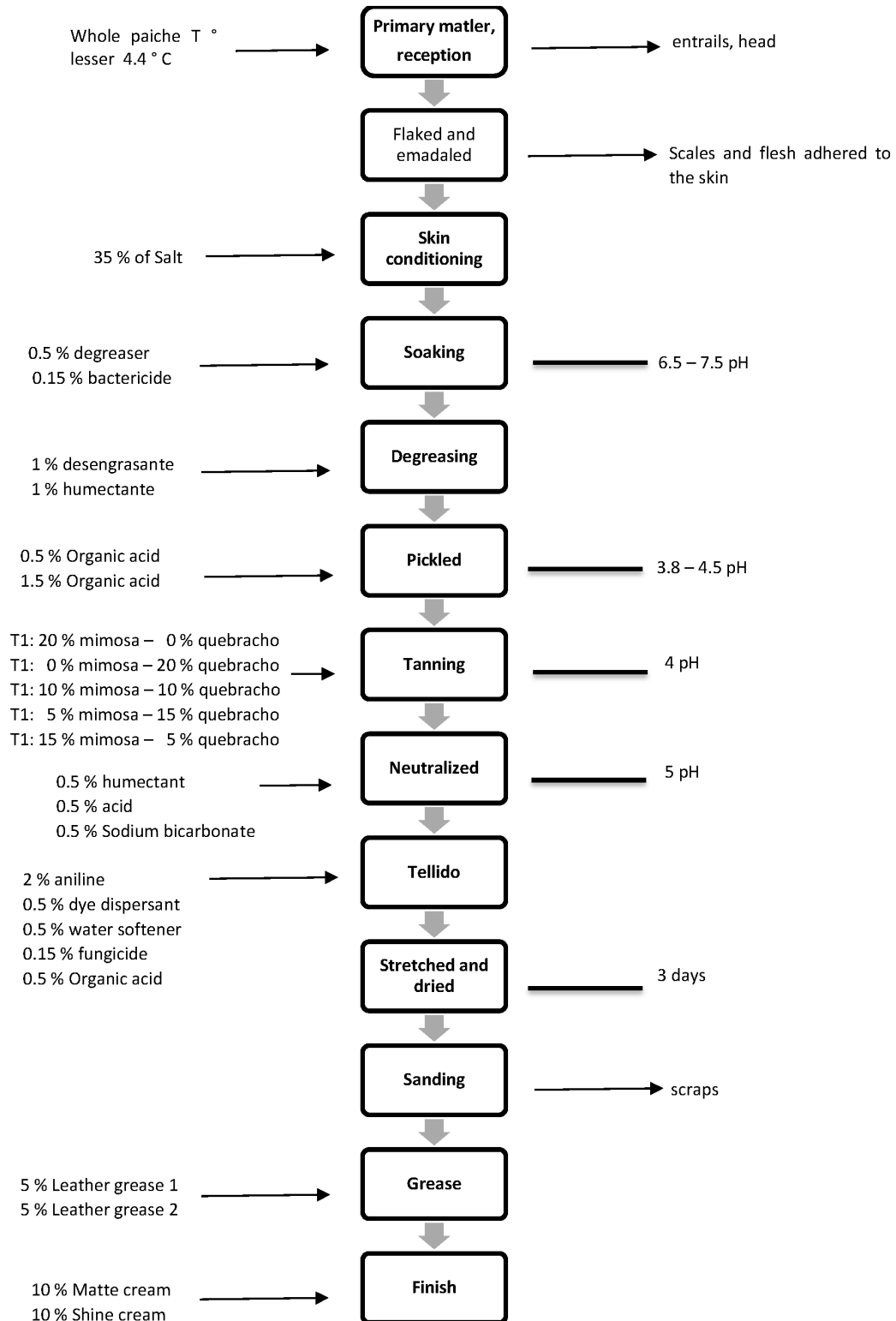


Figure 1: Flow Chart – tanning paiche skin

It is observed that the tensile strength characteristics of the 5 treatments analyzed it will be found within the ranges established for leather according to the table 24, NTP 241(021, 022 and 023) 2022, the which ones are applicable in the manufacture of casual footwear. The results of the ash content, it was observed that all the data from the 5 treatments will be located within the boundaries established for leather, such as indicated in the table 28 of the NTP 241 (021, 022 and 023) 2022 standard for the manufacture of casual footwear. The chromium oxide content values are observed to be all the data from the 5 treatments were within the boundaries established for leather, as indicated in the table 34 of the NTP 241 (021, 022 and 023) 2022 standard for the manufacture of casual footwear, footwear.

The results of the analysis of variance carried out to evaluate he chromium oxide content, it was noted that it was not present differences significantly among treatments in terms of chromium oxide content. As the chromium oxide content was At least, he didn't show up dangerous situations and risks in health and safety, occupational. According to as a result, we have a p value of 0.740. Since alpha (0.05) is less than the value p (0.740), the H0 is not rejected, that is, the type of treatment employee does not influence in the chromium oxide content results.

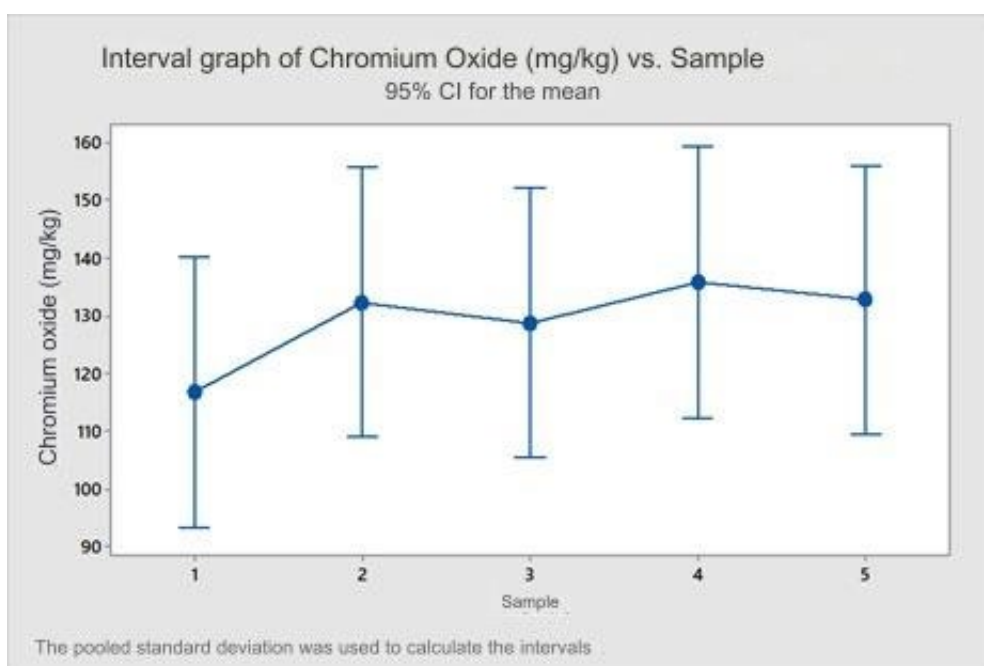


Figure 2: Chromium oxide content

The results of the analysis of variance carried out to evaluate he chromium oxide content in relationship to each treatment are shown in Figure 2. In the graphic, you can appreciate that they are not observed differences significantly among treatments in terms of chromium oxide content.

#### 4. Conclusions

The process technology applied in the vegetable tanning of paiche skin, using quebracho and mimosa extracts, includes a sequence of stages that cover from the receipt of the raw material, the skin conditioning, soaking, degreasing, pickling, tanning, neutralizing, dyeing, stretching, drying, sanding, oiling and finishing. Furthermore, the relevance of water treatment is highlighted residual produced during the tanning process.

When evaluating the properties physical-mechanical characteristics of paiche skin leather, are evident differences significant in the different treatments in terms of flexural strength. Furthermore, it is observed differences significant in tear resistance between treatments T1 (mimosa 20% and quebracho 0%) and T5 (mimosa 15% and quebracho 5%). Likewise, it was observed a disparity significant in tensile strength, obtaining results superiors in the T4 treatment (mimosa 5% and quebracho 15) in comparison with the treatments they used mimosa and quebracho extracts.

When evaluating the properties chemicals, not observed differences significant in the ash, moisture and chromium oxide content levels when using different concentrations and/or combinations of quebracho and mimosa.

As the chromium oxide content was At least, he didn't show up dangerous situations and risks in health and safety, occupational, therefore Processes that use quebracho and mimosa are safe for health occupational workers. All the results obtained from the 5 treatments in the study in the pH and demand analysis, oxygen chemistry (COD) of effluent treated after the tanning process complies with the boundaries established by the Supreme Decree No. 071-2022-MINAM for the water treatment residual generated during the tanning process.

## References

- Cruz, I., & Huerta-Mercado, R. (2015). Occupational Safety and Health in Peru. *Annals of Global Health* , 81 (4), 568–575. <https://doi.org/10.1016/j.aogh.2015.08.027>
- Gutierrez, H., & De la Vara, R. (2008). Analysis and design of experiments (second edition). McGRAW-HILL /INTERAMERICANA EDITORES, SA de CV, Mexico. Retrieved from [https://gc.scalahed.com/recursos/files/r161r/w19537w/analisis\\_y\\_diseno\\_experimentos.pdf](https://gc.scalahed.com/recursos/files/r161r/w19537w/analisis_y_diseno_experimentos.pdf)
- Fouzi, N. F. R., Aziz, H. A., & Yaakub, N. (2024, March 1). Systematic review of chemical safety and chemical security risk management approach. *Process Safety and Environmental Protection*. Institution of Chemical Engineers. <https://doi.org/10.1016/j.psep.2024.01.035>
- Mazzi, A. (2023). Environmental and safety risk assessment for sustainable circular production: Case study in plastic processing for fashion products. *Heliyon* , 9 (11), e21352. <https://doi.org/10.1016/j.heliyon.2023.e21352>
- Mohammadi, H., Jafari, M. J., Pouyakian, M., Keighobadi, E., & Moradi Hanifi, S. (2024). Development of a new index for assessing the inherent safety level of chemical processes using a multi-criteria fuzzy decision-making approach. *Journal of Loss Prevention in the Process Industries*, 87. <https://doi.org/10.1016/j.jlp.2023.105238>
- NTP 241.021:2022 FOOTWEAR. Men's footwear. Requirements and test methods. 5th Edition. Peruvian Technical Standards
- NTP 241.022:2022 FOOTWEAR. Ladies footwear. Requirements and test methods. 5th Edition. Peruvian Technical Standards
- NTP 241.023:2022 FOOTWEAR. Casual footwear. Requirements and test methods. 5th Edition. Peruvian Technical Standards
- Yuan, S., Reniers, G., & Yang, M. (2022). The Necessity of Integrating Safety and Security Barriers in the Chemical Process Industries and its Potential Framework. *Chemical Engineering Transactions*, 91, 13–18. <https://doi.org/10.3303/CET2291003>