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PORTRAYING FOOTWEAR CUSTOMER ENTER -STORE BEHAVIOR IN CHINA: BASED ON COMPUTER VISION TECHNOLOGY

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PORTRAYING FOOTWEAR CUSTOMER ENTER -STORE BEHAVIOR IN CHINA: BASED ON COMPUTER VISION TECHNOLOGY

ABSTRACT. Existing studies on customer behavior lack quantitative and high efficiency study, their technologies rely heavily on hardware. Therefore, the information of consumers in offline stores was insufficient, which made enterprises unable to accurately track consumers. However, computer vision (CV) is an expert in identifying and tracking people's behavior, and its function is suitable for investigating enter-store customer behavior. Therefore, the aim of our study was to develop an offline consumer behavior portraying system based on CV. Then we used this system to investigate enter-store consumption behavior. We selected 71 shoe stores in China, then installed the system in store for a three-month data collection, and evaluated the impact of customer's age, gender, enter time, and region factors on enter-store behavior in China. Through our system, we successfully study ways to improve the purchase conversion rate of enter-store consumers, which could guide enterprises to adjust better marketing and operation strategies.

KEY WORDS: customer behavior, computer vision, off-line retailing, enter-store data collection

CARACTERIZAREA COMPORTAMENTULUI CLIENTULUI LA INTRAREA ÎN MAGAZINELE DE ÎNCĂLȚĂMINTE DIN CHINA: PE BAZA TEHNOLOGIEI VIZIUNII COMPUTERIZATE

REZUMAT. Cercetările existente privind comportamentul clienților nu prezintă un studiu cantitativ și de înaltă eficiență, tehnologiile utilizate se bazează foarte mult pe hardware. Prin urmare, informațiile privind consumatorii care achiziționează din magazinele fizice sunt insuficiente, ceea ce face ca întreprinderile să nu poată urmări cu precizie consumatorii. Cu toate acestea, viziunea computerizată (CV) este o tehnologie expertă în identificarea și urmărirea comportamentului oamenilor, iar funcția sa este adecvată pentru investigarea comportamentului clienților din magazin. Prin urmare, scopul studiului nostru a fost dezvoltarea unui sistem offline de caracterizare a comportamentului consumatorului pe baza CV. Apoi am folosit acest sistem pentru a investiga comportamentul consumatorului în magazin. Am selectat 71 de magazine de încălțăminte în China, apoi am instalat sistemul în magazin pentru o colectare de date de trei luni și am evaluat impactul factorilor precum vârsta, sexul, timpul de intrare și regiunea asupra comportamentului clienților la intrarea în magazinele din China. Cu ajutorul sistemului nostru, am studiat cu succes modalitățile de îmbunătățire a ratei de conversie în cazul consumatorilor din magazin, care ar putea servi ca ghid pentru întreprinderile care vor să-și îmbunătățească strategiile de marketing și de operare.

CUVINTE CHEIE: comportamentul clientului, viziune computerizată, comerț cu amănuntul offline, colectarea datelor la intrarea în magazin

LA CARACTÉRISATION DU COMPORTEMENT DU CLIENT LORS DE L'ENTRÉE DES MAGASINS DE CHAUSSURES EN CHINE : BASÉ SUR LA TECHNOLOGIE DE VISION PAR ORDINATEUR

RÉSUMÉ. Les recherches existantes sur le comportement des clients ne présentent pas d'étude quantitative et très efficace, les technologies utilisées sont largement basées sur le matériel informatique. Par conséquent, les informations sur les consommateurs qui achètent dans des magasins physiques sont insuffisantes, ce qui empêche les entreprises de suivre avec précision les consommateurs. Cependant, la vision par ordinateur (CV) est une technologie experte dans l'identification et le suivi du comportement des personnes, et sa fonction est adaptée pour enquêter sur le comportement des clients dans le magasin. Par conséquent, le but de notre étude était de développer un système hors ligne pour représenter le comportement des consommateurs basé sur le CV. Ensuite, on a utilisé ce système pour enquêter sur le comportement des consommateurs dans le magasin. On a sélectionné 71 magasins de chaussures en Chine, puis on a installé le système dans le magasin pour une collecte de données de trois mois et on a évalué l'impact de facteurs tels que l'âge, le sexe, l'heure d'entrée et la région sur le comportement des clients lors de l'entrée dans les magasins en Chine. Avec l'aide de notre système, nous avons étudié avec succès des moyens d'améliorer le taux de conversion des consommateurs en magasin, ce qui pourrait servir de guide aux entreprises qui souhaitent améliorer leurs stratégies de marketing et d'exploitation.

MOTS CLÉS : comportement du client, vision par ordinateur, vente hors ligne, collecte de données à l'entrée du magasin

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INTRODUCTION

Enter-store consumers' consuming behaviors referred to a series of complex psychological characteristics and behavior rules generated by the enter-store customers [1]. The diverse consumer psychology of customers would affect their consumption decision. Jackson *et al*. [2] proposed that the psychology of consumers of different genders and age groups led to certain differences in their attitudes towards shopping. Kahler *et al*. [3] reported that the values and other psychological variables of people in different regions would lead to regional psychological and behavioral differences in customer behaviors. Then, consumers' in-store activities would also affect consumption decisions. If consumers were actively processing information to trigger new demands, so many unplanned purchase decisions would be occurred in the store [4]. Pantanoa *et al*. [5] also noted that after increasing product contact, leisurely consumers would browse a wide range of the store, which led to more purchase. Moreover, understanding offline customer's behavior is important to retailing store which provided services to enter-store people [6]. Therefore, enter-store customer behavior studies is becoming critical.

Commonly, most consumer studies were taken by questionnaire surveys, which were not objective and the sample size was limited. Thang *et al*. [7] carried out a study on the influence of in-store factors on consumer behaviors and distributed 370 questionnaires with the invalid rate of 21.6 percent. Besides, Bucko *et al*. [8] used number 1-5 to describe the consumers' willingness to purchase product from the online store to obtain the factors of affecting consumer behavior, only 232 people collected. What is more, there were series of other tracking consumers methods such as infrared, RFID, and video technology [9–11], but these methods highly depended on high cost hardware.

At present, the commercial technology used to study customer behavior in offline stores is mainly focused on the people counting. There are two main techniques for people counting: infrared technology and video flow counting. Infrared technology has high dependence on equipment. Jie *et al*. [9] invented an infrared photoelectric counting device with a high cost and low software resolution. Yang *et al*. [12] designed a better accuracy infrared counting device, but the installation process of the equipment was cumbersome. Meanwhile, the video flow technology also can count the number of people. Haritaoglu *et al*. [13] proposed a real-time camera recognition system to capture, track, and identify people walking. Masoud *et al*. [14] studied a fixed single-camera to identify pedestrians and achieved reliable counting by suspending it from the ceiling, which was based on a rectangular model of human motion analysis. However, most surveillance devices in life were only used for security [15].

Thereby, the infrared technology highly dependents on hardware and costs, while the video technology has a low application potential in the retail industry. In the previous study, the factors that affect enter-store consumer's behavior were lack of quantitative research and the results were also subjective and vogue, which also leads to customer's purchase conversions remains a great challenge [16, 17].

To further effective study offline customer behavior, we found that the computer vision (CV) was suitable to identify and track people in the store [18, 19]. However, the application of CV on the retailing stores was rarely reported. Due to lots of large shopping malls and brands were eager to adopt a technical solution to detect these three aspects automatically: customer counting, customer's attribute recognition, behavior understanding [5, 10]. We briefly introduced the realization methods of the three functions of CV.

1. Customers counting. The video stream counting was by tracking the images of the moving human body in the video sequence [13], which was one of the applications of computer vision. The counting steps of the video stream [20] were video capturing, video editing, mobile personnel monitoring, mobile personnel tracking, and people number calculation [21]. At the same time, this function has been widely used in daily life, such as real-time passenger flow calculation [22] of subway, bus and so on.

2. Identify people's attributes. As one of the typical applications of computer vision, facial recognition technology can not only count people but also recognize their attributes. The main process of it [23] were facial detection (feature point location), facial tracking, facial recognition

(gender and age recognition), Besides, Generosis *et al*. [16]proposed an emotion tracking system combined with facial recognition to detect customers' gender, age, and other information. The identified information belonged to the attribute information of consumers, which can help the store to know more accurately about their own consumers.

3. Description of human characteristics. The analysis, understanding, and description of customer behavior in changing environment were popular in the field of CV study. For example, Mckenna *et al*. [24] investigated a CV system that could track multiple people in a relatively unrestricted environment. Li Liyuan *et al*. [25] proposed a CV system successfully tracked about 90% of objects in a multi-person environment in a specific area. Besides, a real-time visual monitoring system invented by Haritaoglu *et al*. [13] could interpret the events between people and objects, by storing, exchanging or removing the objects.

In the complex and ever-changing offline buying environment, these three functions of CV technology were significantly suitable for offline research on consumer behavior.

Therefore, the aim of this study was to establish a consumer behavior portraying system based on CV. Then this system was used to conduct the enter-store customer behavior investigation. If we understand the preferences and rules of offline customers, companies can segment customers more accurately and update their marketing strategy timely in China.

METHODS

In this study, we cooperated with Red Dragonfly, a well-known footwear brand in China. We selected 71 from their 4,000 offline stores and proceeded to install our CV system, where eight in Central China, six in East China, forty-one in West China; and sixteen in South China. We also classified the data according to these four regions. The data collection period was from April 2017 to July 2017.

The structure of this system was shown in Figure 1. When customers entered the store, the video flow captured by cameras, was transited to the cloud server in real-time through the wired connection of the router. Then the cloud server processed the video data and stored the results in the cloud database so that we could use the algorithm integrated into cloud computing to analyze the data.

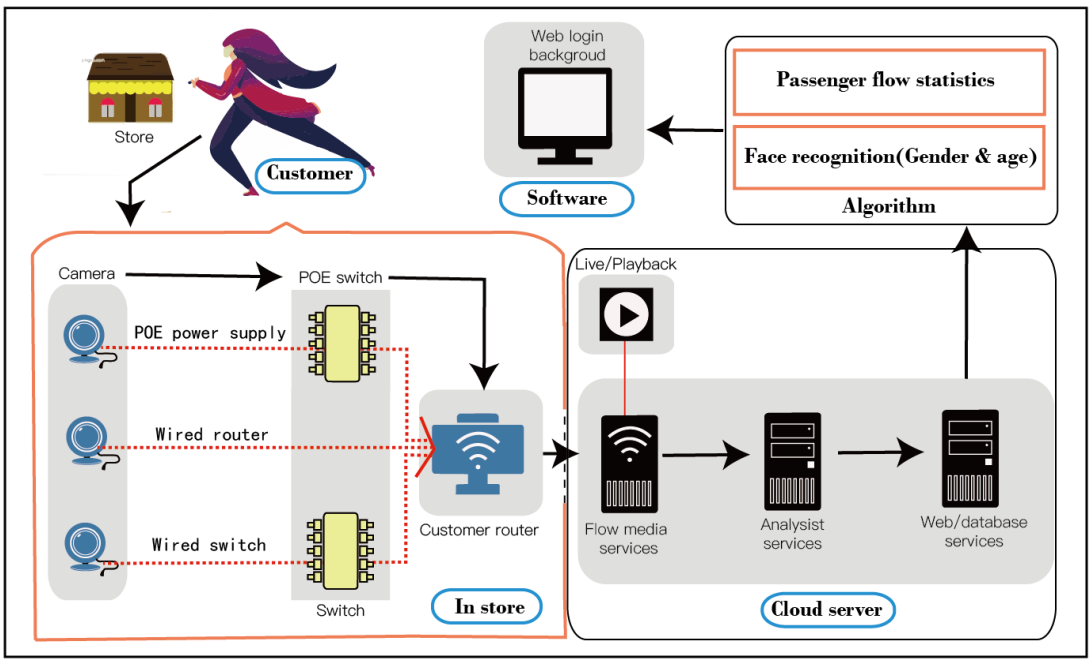

Figure 1. The detailed system operation diagram

Algorithms

The algorithms used in the data recording system in this study were provided by the Extreme Vision company, which is a professional computing vision supplier in China. The algorithm was divided into two parts: people counting; and identifying the gender and age.

Data Collection of Passenger Flow

The whole process of algorithms counting customer number was:

(1) Recognizing the moving subjects using foreground detection

The complex background is subtracted by foreground detection to simplify the image. The mixed Gaussian model in the background modeling method could smoothly simulate the probability distribution of any shape and handle the extraction of foreground under complex background;

(2) Detecting the head of the customers enter-store in the video.

A rectangle with green lines was used to identify their head, and then established a recognition frame on their head, and marked with a green line. Then the area of the entrance in-store was marked with a rectangle with blue lines, the yellow line as an analysis basic-line;

(3) Counting the valid number.

Figure 2-b shows that once the customers pass by the analysis base-line, a new valid number was recorded. Instead, Figure 2-c represents the invalid case.

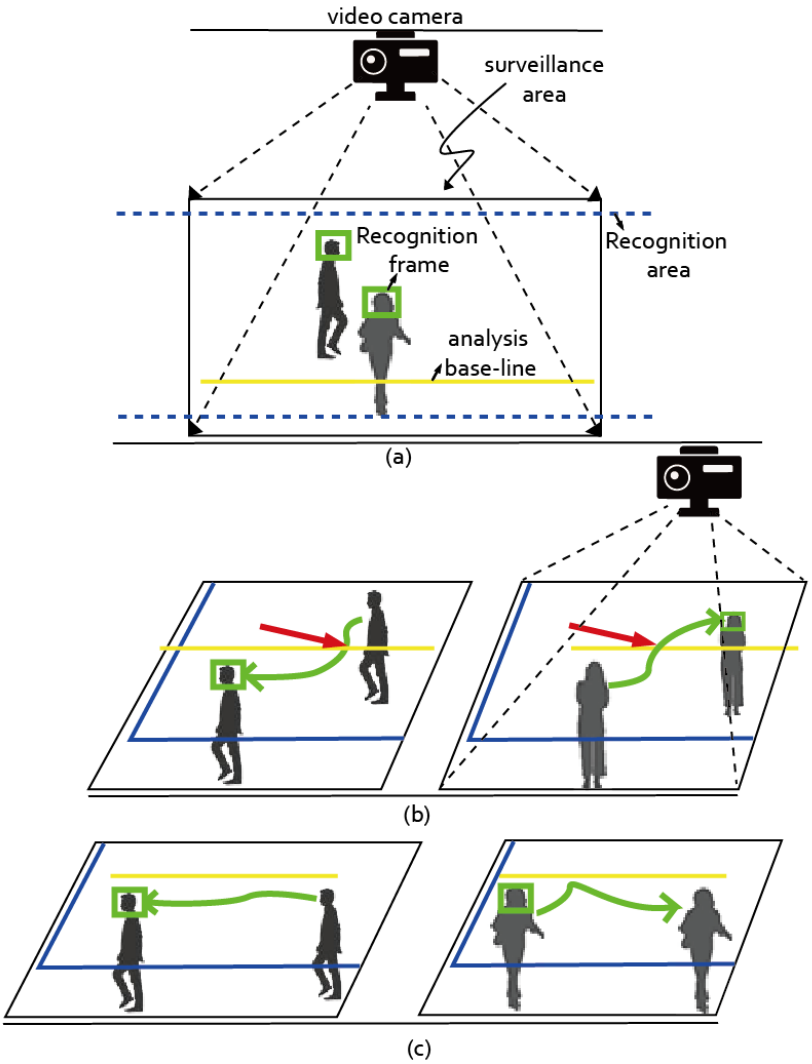

Figure 2. a) Introduction of the camera recognition; b) The entrance and exit were valid number statistics; c) Pass by and hover were not counted

Data Collection of Facial Identification

We used the face recognition algorithm to recognize the customers' gender and age. There were three steps to the face recognition process: 1. Detecting and tracking the face in each frame of video; 2. Obtaining the face movement in each frame of video, extracted the face feature points; 3. Analyzing the face feature using the face database to get the result.

(1) Gender identification

Compared to recognition based on the single gray channel information, the increased color features of the gender recognition technology used in this study improved the accuracy of gender recognition. The detailed gender determination process was:

a) Based on the multi-channel convolutional neural network technology, we obtained the RGB image of the face from the video and processed it to obtain multiple color channel information;

b) Input multiple color channel information into the convolutional neural network obtained in advance for calculation, and obtained an output result representing gender;

c) When the output result indicating gender was within the first preset range, the face gender was identified as male; when the output result indicating gender was within the second preset range, the face gender was identified as female.

(2) Age estimation

We built a face age estimation model based on multi-output convolutional neural networks to estimate customers' age. It combined ordered regression and deep learning methods to significantly improved the accuracy of age prediction performance. The specific implementation steps were:

a) Established an Asian face data set, each face image contained a real age label;

b) Established training data for binary classification, input face image sets with age tags in the Asian face data set, and generated a series of binary classification labels based on the age tags of the face images, for training data for class labels and weights;

c) Trained the deep convolutional neural network, and trained the multi-output deep convolutional neural network according to the training data, so that each output was a binary classification target of the binary classifier;

d) Input the test sample into the trained convolutional neural network, used a face image without age label in the Asian face dataset as the test sample, and input the test sample into the trained multi-output deep convolution Neural network for multi-layer convolution and pooling operations;

e) Got the age estimate of the test sample and the age of the test sample estimate. The overall steps were shown in Figure 3.

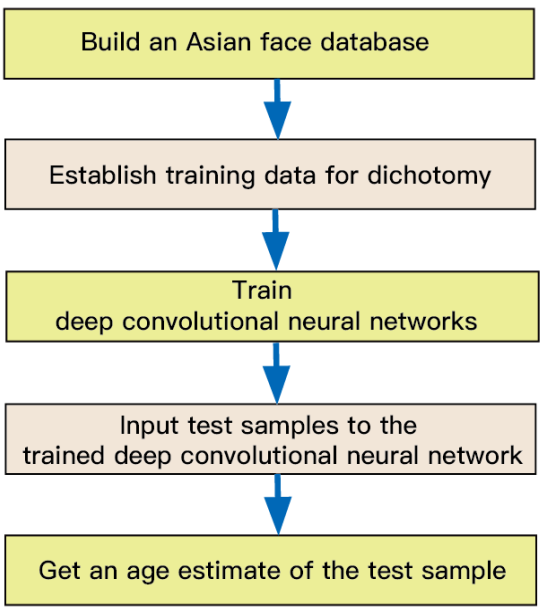

Figure 3. Flow chart of age estimation for multi-channel convolutional neural network

Data Processing and Statistical Analysis

All data normally distributed. The data collected were three types: the number of customers at different periods, the gender and age information of the consumers enter-store. The data was collected between 8:00 and 21:00 each day; the age was divided into the following five groups: under 20, 21-30, 31-40, 41-50, and over 51 years old. The descriptive analysis and One-Way ANOVA were used in this study. Since the consumer's enter-store behaviors were influenced by variables of customers' attributes, the independent variable was the number of customers, and the dependent variables were the time, age, gender, and regions. Further, this model was operated using SPSS (V24.0, IBM, USA) with a significant level of α=0.05 and a confident interval of 95%.

RESULTS

Table 1: Table of store entry in four regions

Aera		All	Central	East	South	West
Average daily number of customers of a single store		\	140	324	154	118
Sex ratio (women:men)		42:58	68:32	60:40	67:33	51:49
Age structure	Under 20	13.70%	10%	15%	12%	15%
	21-30	38.40%	36%	31%	50%	37%
	31-40	29.60%	35%	34%	24%	29%
	41-50	12.10%	14%	11%	10%	13%
	Over 51	6.20%	5%	9%	4%	6%

The cumulative monthly customer' number of all stores in this study was 321390. All subsequent results were monthly averaged for further analysis (Table 1). We conclude that the main customers of Red Dragonfly were aged 21-40. And customers in East China were the most active among the four regions.

Figure 4. Comparison of the time variation of customers' entering stores in four regions

From Figure 4, there were three peaks in the shopping time trend of all consumers, 10:00, 15:00, and 20:00. The customers aged 21-30 years old entered the store at 19:00 in East China, at 20:00 in South China, at 17:00-19:00 in Central China, at 10:00 and 15:00-16:00 in Western China. Then followed by customers ages 31-40. They preferred to visit during 17: 00-19: 00 in East and West China, while that was concentrated during 14:00-16:00 in South and West China.

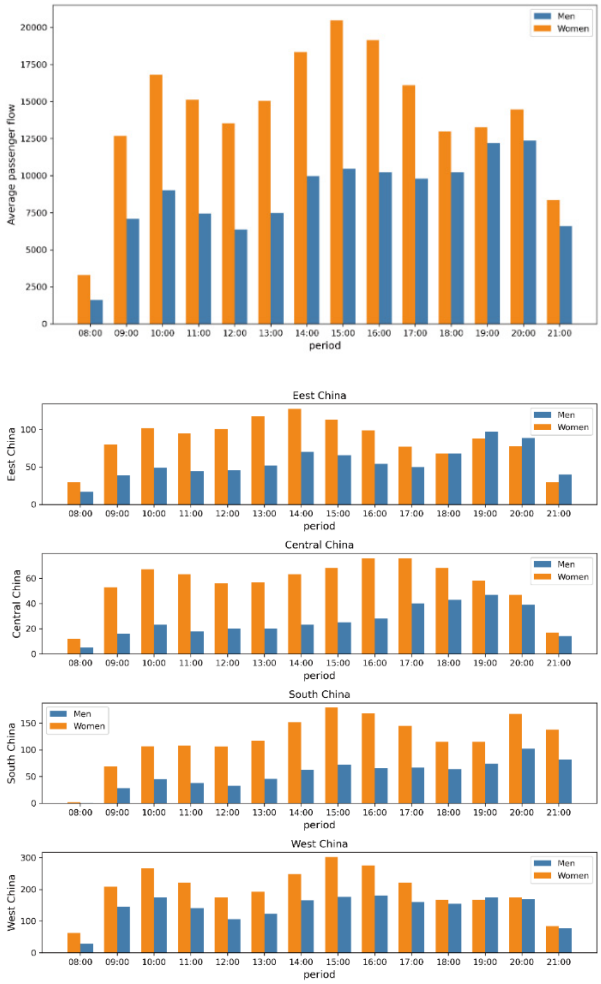

Figure 5. Results of different genders entered store at different times

From Figure 5, women except in central China more willing to shop at 16:00-17:00, they preferred shopping at 14:00-16:00 in other regions. Additionally, the number of women would increase significantly at 20:00 in South China. However, in Central China and Western China, their number would decrease from 18:00. Meanwhile, largest male customer flows were mainly concentrated in 19:00-20:00. Moreover, they were concentrated visiting at 19:00-20:00 in East and Central China, especially in East China. In general, the proportion of men and women should be more balanced.

One-way ANOVA Results

When considering the differences of time, age, gender, regional and the number of customers separately, the time (P = 0.01 <0.05) and age (P = 0.00 <0.05) have significant influence. Further, when we considered the combination of time, age, gender, and region in pairs, there were five combinations: time and gender (P = 0.00 <0.05), time and region (P = 0.00 <0.05), time and age (P = 0.00 <0.05), gender and region (P = 0.00 <0.05), age and region (P = 0.00 <0.05). Significant impacts were found in all the five groups above. In general, under the

same time and region conditions, genders (P = 0.02 <0.05) had a significant effect on number of enter-store customers, but ages (P = 3.45> 0.05) had no significant difference in enter-store behavior.

DISCUSSION

In this study, our experience proved that CV technology was reliable, which was also confirmed by other research. Firstly, compared with other tracking technologies, the CV technology could realize real-time and efficient data collection [26]. Secondly, compared with the traditional survey, we had a larger sample base contained more than 300000 people. These cases prove that our CV technology, enriches the research methods of offline customer behavior as a technical supplement, and then it can help enterprises quickly realize the digital transformation [27].

In addition, the data results could give us a deeper understanding of regional differences in consumer behavior and heterogeneity. We were not surprised that most of the customers entering the store were female [28]. The reason for this phenomenon was related to the product and brand. Grohmann [1] proposed that the brand spokesperson had created a brand's personality, which was related to the consumer's gender role identity and emotion. Red Dragonfly's brand ambassadors have always been women, so this would lead a positive impact on women's responses. Meanwhile, the sexes had different consumption psychology and led to different products shopping attitudes [29]. Women would pay more attention to emotional and appearance needs. As well the shoes in Red Dragonfly have stronger appearance attributes and lower functionality. Fugate *et al*. [30] also proposed that women were willing to buy accessories, such as shoes, while men were preferred to buy products that match their gender, such as electronic products, etc.

Furthermore, there were obvious differences in the characteristics of consumers in each region. It indicated that the differences in living habits and regions would affect the basic consumer behavior of consumers. It also helped to verify Liu *et al*.'s view that China's consumer market was a segmented market with huge territorial and regional differences. Then among the average daily customer flow of separate stores in the four regions, East China was the most active. This may be due to the fact that Southeast China was considered to be a trend leader, an opinion leader, and a consumer pioneer in other parts of China. In contrast, consumers in central and southwestern China have lower incomes than in southeast coastal areas whose were generally satisfied with their lives and relatively conservative, not so willing to try fresh products [31]. Therefore, when new products were launched in chain retail stores, products should priority be placed in East China and South China. This could drive consumption benefits in Central China and West China.

In summary, our findings would assist the company flexibly arrange personnel for a specific period. Company should pay more attention to promoting the transaction conversion rate of the female, by increasing lively activities to attract young people enter in the evening. Our study also had shortcomings. On the one hand, the accuracy and convenience of video recognition should be improved. On the other hand, more factors affecting consumer behavior should be considered. Therefore, with the support of CV technology, the next steps are to study in-depth the detailed customers' trajectories or actions and complement the research on consumer decision-making mechanisms.

CONCLUSION

Our study aimed to develop a CV system to count and portray enter-store consumer attributes, then use this system to investigate offline customer behavior in Chinese different region. We selected 71 stores of Red Dragonfly and installed the system in them for a three-month data collection. And based on the geographical location of these stores in China, we divided them into four regions for later data analysis. Further, we evaluated the impact of customer gender, age, and time in regional stores on the number of customers. Finally, by our CV system, we found that the characteristic behaviors and influencing factors of consumer groups within four regions were indeed different.

Therefore, according to the findings of detailed customer behavior differences, enterprises can make accurate operational

decisions to increase the chance of consumers' purchasing. Meanwhile, this method can also be used as a scientific and effective standard to explore ways to improve the purchasing probability of enter-store consumers, and then it can be widely used in the offline retail industry.

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DOWN THE SEWER: HOW SEMI-INFORMAL TANNERIES MANAGEMENT POLICIES AFFECT RESIDUAL WATER DISPOSAL IN COLOMBIAN BUSINESS SCENARIOS

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DOWN THE SEWER: HOW SEMI-INFORMAL TANNERIES MANAGEMENT POLICIES AFFECT RESIDUAL WATER DISPOSAL IN COLOMBIAN BUSINESS SCENARIOS

ABSTRACT. In Colombia, the issue of waste discharges derived from the tanning process to water bodies is a scenario that has been widely documented. However, measurement exercises have failed to identify improvements in this process that integrates administrative knowledge with concepts of labor, social and environmental welfare. The present article is the culmination of research conducted within the framework of the project "Estudio comparativo de la administración y las repercusiones socio-ambientales en las empresas del sector de curtiembre. Case Bogotá (Barrio San Benito), Case Barranquilla and Case Villapinzón (Cundinamarca)" (Comparative study of the administration and the socio-environmental repercussions in tanning sector companies. Case Bogotá (Barrio San Benito), Case Barranquilla and Case Villapinzón (Cundinamarca)) concerning the administrative practices and the negative effects derived from the absence of management systems for negative externalities caused to the environment by companies in the tanning sector. The study was developed as follows: initially, a systematic documentary review of the laws, decrees and regulations that have a direct or indirect impact on the tanning sector was carried out, followed by field work using data collection instruments (questionnaires) in the San Benito neighborhood (Bogotá), in the town of Villapinzón (Cundinamarca) and in the city of Barranquilla (Atlántico), where there are formal and informal work clusters dedicated to the leather industry. The objective of this study was to identify the relationship between administrative styles and formal processes of strategic planning activities development with the adoption of dumping control systems and other aspects related to environmental management, oriented to the organizational level. Based on the above, the information was analyzed with emphasis on those companies with a common denominator in their control strategies in relation to those policies that were the result of administrative and business practices and that finally led to the desired effects in the social, environmental and economic spheres. Finally, the discussion section focuses on the recognition of these good practices and the possibility that they could be replicated by other actors on the global level.

KEY WORDS: strategic planning, regulations, socio-environmental effects

ÎN CANALIZARE: CUM AFECTEAZĂ POLITICILE SEMI-INFORMALE DE GESTIONARE A TĂBĂCĂRIILOR ELIMINAREA APEI REZIDUALE ÎN CONTEXTUL DE AFACERI DIN COLOMBIA

REZUMAT. În Columbia, eliminarea deșeurilor derivate din procesul de tăbăcire a pieilor în corpurile de apă este un scenariu documentat pe larg. Totuși, în exercițiile de măsurare nu s-a reușit identificarea unor îmbunătățiri ale acestui proces care să integreze cunoștințele administrative cu conceptele de bunăstare socială, a muncii și a mediului. Acest articol reprezintă punctul culminant al cercetărilor desfășurate în cadrul proiectului „Studiu comparativ al administrației și repercusiunilor sociale și de mediu din cadrul companiilor din sectorul tăbăcăriei. Cazurile Bogotá (Barrio San Benito), Barranquilla și Villapinzón (Cundinamarca)" care vizează practicile administrative și efectele negative derivate din absența sistemelor de gestionare a externalităților negative cauzate mediului de către tăbăcării. Studiul a fost realizat după cum urmează: inițial, un studiu documentar sistematic al legilor, decretelor și reglementărilor care au un impact direct sau indirect asupra sectorului de tăbăcărie, ulterior s-a efectuat o lucrare pe teren aplicând instrumente de colectare a datelor (chestionar) în cartierul San Benito (Bogotá), în orașul Villapinzón (Cundinamarca) și în orașul Barranquilla (Atlántico), unde se găsesc grupări formale și informale de tăbăcării. Obiectivul acestui studiu a fost identificarea relației dintre stilurile administrative și procesele formale de dezvoltare a activităților de planificare strategică cu adoptarea sistemelor de control al deversărilor și a altor aspecte legate de gestionarea mediului, orientate la nivel organizațional. Pe baza celor de mai sus, informațiile au fost analizate punând accentul pe acele companii care au ca numitor comun strategiile de control în raport cu acele politici care au fost rezultatul practicilor administrative și de afaceri și care, în final, au avut efectele dorite în domeniile social, economic și de mediu. În cele din urmă, secțiunea de discuții este centrată pe recunoașterea acestor bune practici și posibilitatea ca acestea să fie replicate de alți actori din întreaga lume.

CUVINTE CHEIE: planificare strategică, reglementări, efecte sociale și de mediu

EN BAS DE L'ÉGOUT : COMMENT LES POLITIQUES SEMI-INFORMELLES DE GESTION DES TANNERIES AFFECTENT L'ÉLIMINATION DES EAUX RÉSIDUELLES DANS LES SCÉNARIOS D'AFFAIRES COLOMBIENS

RÉSUMÉ. En Colombie, le cas du déversement de déchets dérivés du processus de tannage des peaux dans les eaux est un scénario largement documenté. Cependant, l'exercice de mesure n'a pas permis d'identifier des améliorations qui intégreraient les connaissances administratives aux concepts de protection sociale, de travail et d'environnement. Cet article est le fruit d'une enquête menée dans le cadre du projet « Etude comparative de l'administration et des répercussions socio-environnementales sur les entreprises du secteur du cuir. Les cas de Bogotá (Barrio San Benito), Barranquilla et Villapinzón (Cundinamarca) » sur les pratiques administratives et les effets négatifs découlant de l'absence de systèmes de gestion des externalités négatives causées à l'environnement par les entreprises du secteur du cuir. L'étude a été réalisée comme suit : dans un premier temps, une revue documentaire systématique des lois, décrets et réglementations ayant un impact direct ou indirect sur le secteur du cuir, puis un travail de terrain a été effectué en utilisant des instruments de collecte de données (questionnaire) dans le quartier de San Benito (Bogotá), dans la ville de Villapinzón (Cundinamarca) et dans la ville de Barranquilla (Atlántico), où se trouvent des groupes de travail formels et informels dédiés au travail du cuir. L'objectif de cet exercice d'enquête était d'identifier la relation entre les styles administratifs et les processus formels de développement des activités de planification stratégique avec l'adoption de systèmes de contrôle des déversements et d'autres aspects liés à la gestion de l'environnement, orientés au niveau organisationnel. Sur la base de ce qui précède,

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les informations ont été analysées en mettant l'accent sur les entreprises ayant un dénominateur commun dans leurs stratégies de contrôle par rapport aux politiques qui résultaient de pratiques administratives et commerciales et qui ont finalement abouti aux effets souhaités dans les domaines sociaux, environnemental et économique. Enfin, la section discussion se concentre sur la reconnaissance de ces bonnes pratiques et la possibilité pour elles d'être reproduites par d'autres acteurs à travers le monde.
MOTS CLÉS : planification stratégique, réglementation, effets socio-environnementaux

INTRODUCTION

As mentioned by Martínez & Romero [1], the inception of the leather industry coincided with the birth of the first civilizations, and already in pre-Hispanic American cultures animal skins were used as a means of protection. Over the years, hides continued to be used and in the case of Colombia, the first developments in this industry occurred with the colonization of Antioquia[i]. In the 1920's, this change occurred due to the increase in demand for tanned bovine hides. It was not until the 1950's that the first industries were installed in the municipality of Villapinzón (province of Almeidas, northeast of Cundinamarca)[ii], and in the 1970's some of these producers moved to the south of Bogotá (Barrio San Benito, Municipality of Tunjuelito) to meet the demand for this raw material for the footwear and other leather goods in the capital city and because of the outbreaks of violence that afflicted the regions of Colombia due to internal conflict.

When the first fur producers who developed their activity in a semi-artisanal way began associating with academic and university institutions in Bogotá that had an academic line of business administration, what they found, as mentioned by Malaver [2], were professorships held by teachers qualified in different disciplines, such as lawyers and/or economists, who taught mostly theoretical approaches to the recently postulated administrative theories of authors like Taylor and Fayol. This situation contrasted with the family-based origin and conformation of the industries created in the sector. Moreover, the management styles of these industries, in their beginnings, were established and organized in an empirical way. Omaña & Briceño [3] list a series of common characteristics of these companies, among which the following stand out: the Family has total power over the property and exercises control over it; the Upper Management in the organization is given by a cession of power from the family to a member; and the primordial tradition consists of inheriting this control and power to the coming family generations.

The management styles of these industries have proven to have effects on society and the environment, which is why the development of this article describes those externalities that can be associated with negative effects, specifically with the disposal of process waste that directly affects the water resource; even more so in a city like Bogotá, since in proportion to the number of inhabitants it is the one that most requires the availability of drinking water in the country and which consequently requires the rationalization of its use.

The above situation is aggravated for the neighboring communities, if one takes into consideration statistics corresponding to uncontrolled water consumption in illegal neighborhoods in the study areas, where the phenomenon of extreme poverty occurs. Strata 2 and 3, which in Colombia are associated with social classes with low to moderate incomes, consume 50% of the water available for the city of Bogotá, and on the other hand there is the industrial sector, which consumes 5.8% of total consumption for estimates for the year 2014, showing a downward trend. This percentage represents 58 million cubic meters of water per day [4], which is enough to supply the Guajira department (one of Colombia's northern regions) for an entire year; the figures were calculated by the author based on studies by DANE & Solano [5, 6].

There are several initiatives in Colombia to rationalize the use of water in Bogotá, taking into account not only its location and consumption quota but also that it is upstream in the water cycle of the country's main river artery - the Magdalena River. More than 30% of the total population of the country depends on the Magdalena and its middle and lower tributaries, before it finally empties into the Caribbean Sea. An important initiative in this sense refers to the fact that the industrial sectors reuse their wastewater by means of physical, chemical and biological processes to obtain almost drinkable water, as mentioned by Peña-Guzmán, Melgarejo, & Prats: "Discharge zero industrial sector" [4, p. 67].

The above-mentioned authors consider that for these solutions to be effective, the organizational styles, the company policies and the productive processes must be considered in concert with the organizational styles of the companies, so that they are not felt to burdensome or too expensive, but rather as a strategic opportunity for the company, which in the Colombian case, corresponds, as already mentioned, to family structures shaped in an empirical way and with administrative practices centered in reactive models and little commitment to environmental safety.

Background

The development of an environmental management model for the processes and products of the tanning sector, implies the knowledge of the technical, operational, commercial, legal and financial aspects of the activity, and fundamentally, of the impact that the tanning industry generates on the environment. Animal skins have been linked to the daily life of human beings since prehistoric times; they have constituted a fundamental element, with various uses in the home and in industry, continuing to be in force at the same time as the enormous advances in technological processes that determine innovations in manufacturing and in the characteristics of products, including those of mass consumption such as footwear and more recently with respect to the high environmental impact produced by traditional leather tanning practices. A case to be taken into account in this respect is identified in the document carried out by Cruz, Obregón and Puello-Socarrás [7], in which the Becattinian model is identified as an important experience of cluster work in the industrial districts of Baretta and San Mauro (Italy) where "(...) the specialization and cooperativism of a group of companies around a trade such as the manufacture of leather, footwear and leather goods led to the rise of this industry" and that was based on the productive transformation of family units, where one of its components was the organizational styles of these small productive units.

Globally, the tanning industry is on par with the worst polluters, and every year significant financial resources are spent in an attempt to repair the negative effects of its activities, and to a lesser extent in the prevention of these negative externalities. The funds allocated for this purpose are intended to comply with environmental parameters (such as what is strictly necessary at the administrative level to obtain environmental licenses) and to avoid penalties involving economic payment [8]. The Corredor study makes important reference to the treatment of liquid waste generated by tanneries that pollute the upper basin of the Bogotá River coming from the municipality of Villapinzón, Cundinamarca (where an important cluster associated with fur work is located), to the San Benito neighborhood in the city of Bogotá, where the waste from their activities is carried by the Tunjuelito River to the Bogotá River. In Figures 1 and 2, maps with the location of these tanneries around these tributaries are presented:

Figure 1. Location of Villapinzon Tanneries [9]

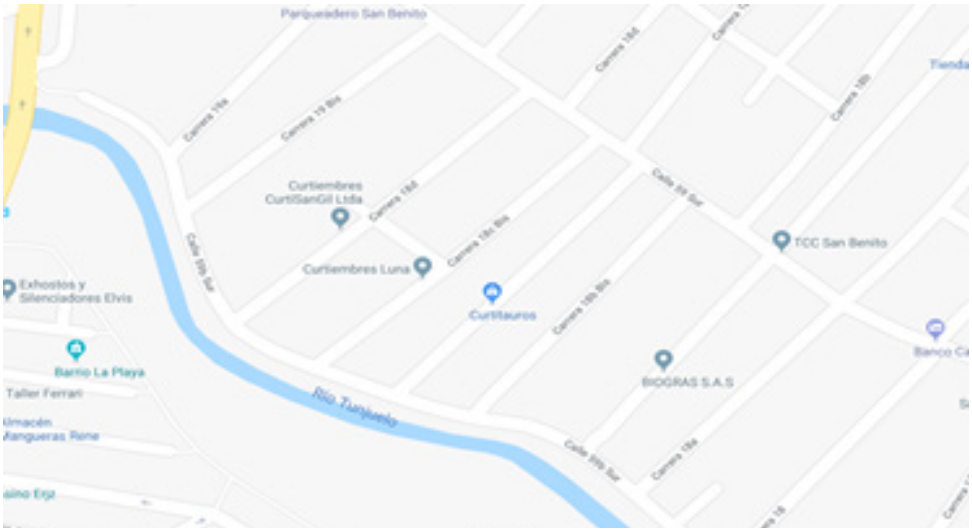

Figure 2. Location of San Benito Tanneries [9

Similar studies that tangentially tackle the administrative styles associated with these family productive units include Cruz, Obregón and Puello-Socarrás [7], as well as in the work of Martínez and Romero [10], although in this last case the problem of tanneries is studied from the point of view of the relation of different aspects of the competitive environment, beyond the relation between administrative styles and their repercussion in the dumping management policies at the business level.

One element to take into account is the geographical location of the study area, since the city of Bogotá is politically and administratively divided into localities. The San Benito tanneries are located in locality 6 of Tunjuelito, bordering on locality 19 of Ciudad Bolivar to the south, Both locations are known for their high poverty rates and environmentally hazardous conditions, mostly due to administrative styles similar to those found in the case studied in the project, as well as similar problems in the development of their environmental policies and discharges and emissions management. Moreover, it is necessary to emphasize that this locality has very little vegetal area and small water discharges (as identified in Figure 3), which constitute water bodies that receive a high pollutant load due to the intervention and industrial activities described above, as it is in these water bodies where all types of solid waste are dumped. “Limas Creek, which spans 10.5 kilometers in length, runs through a large part of the town of Ciudad Bolivar and flows into the left side of the Tunjuelo River. Since 1994, pollution has been reported in the middle and lower parts of the ravine.” [11, p. 98].

Current Status

It is essential to take into consideration the administrative and productive practices that have been implemented in the tanning sector in developed countries. Martinez [1] mentions Italy as the country with the highest production of hides and skins, corresponding to 60% of all European demand, and has very clear business policies regarding the development of “the highest quality standards in pollution prevention; it carries out good practices such as: substitution of polluting substances, integration of processes, management and treatment of waste water and final disposal of sludge.” [1, p. 115].

The business practices of companies in the tanning sector in Colombia are affected by the semi-artisanal characteristics of national production and the geographic distribution of these tanneries. Some of them are distributed in a cluster scheme, between Cundinamarca and Bogotá, which concentrate 80% of Colombian industries [1], and Barranquilla (northern Colombia), which contributes 0.30% of the national total. National production of hides and skins in 2010 amounted to 9,487 tons, which represents only 0.66% of Latin American production and 0.15% of global production. The first two baseline scenarios (Cundinamarca and Bogotá) contribute 36% and the third baseline scenario (Barranquilla) participates with 7% [13].

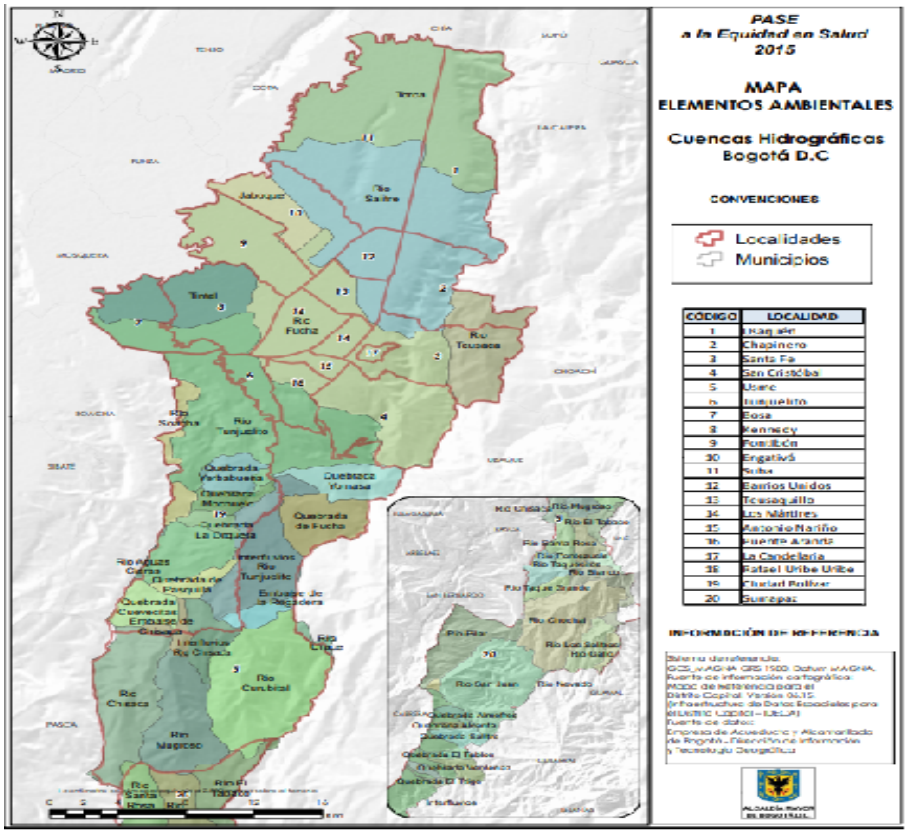

Figure 3. Water basins of Bogotá [12]

Theoretical Reference

Various environmental studies talk about the contamination of the Bogotá river and as one of its main causes the dumping of waste (solid and liquid) to river tributaries in the companies that are dedicated to the tanning process from Villapinzón-Cundinamarca, to the San Benito-Tunjuelito-Bogotá neighborhood. Artuz, Martinez, & Morales [14] mention that it is necessary to create environmental preservation guidelines for the sector's industries and also to emphasize the direct relationship between productivity and the state of river pollution. On the other hand, they make reference to externalities between companies, and the type of job training these industries can implement for pollution prevention. In that sense, the main issue at the core of this study is the relation between administrative styles and organizational policies of management that impact the environment as a by-product of trying to remain competitive in the industry. Other important elements to be taken into account in these relationships are organizational culture and communication, as well as personnel administration and the creation and maintenance of human capital, which are part of the administrative styles that predominate in the sector.

It is from these experiences that it is possible to suggest that the way in which management styles are applied and developed has positive effects on the company's environmental management and financial performance. Martinez [1] also mentions that of the productive costs in Italian tanneries, 30% are used in chemical products, energy and waste treatment, clarifying that there are also financial commitments assumed by the companies as a way to achieve a productive transformation committed to the environment where they operate. This raises the promise of value and its possibility to add and capture value for the product they market.

As mentioned above, the administrative theories found in the universities were those of Taylor and Fayol, who in their treatises on "Principles of Scientific Management & Industrial and General Management" respectively mentioned different aspects such as scientific studies to jobs, specialization of functions, the need for permanent supervision, unity of command, remuneration, hierarchy

and components of the administrative cycle: Forecasting, Organization, Execution, coordination and Control. In addition, they also mentioned the psychology of the worker and it is in this field where the article intends to shed other theoretical light on the research [15].

Additionally, it is necessary to identify some theoretical guidelines that are relevant to this study and which provide important elements in exploration, including: externalities between companies, labor learning and personnel management, organizational culture and organizational communication, as can be seen below:

Externalities between Companies

Olivera & Fernandes [16] mention that these externalities can be negative because no one is responsible for the costs involved, but the good intentions of management are to promote positive externalities and that increasing the productivity of a company is the engine for the benefit of another organization that is included in the process.

Workplace Learning (WL)

WL is essentially a process that implemented inside the organizations, with the intention of training the employees in the specific tasks of the organization, methods and methodology. The same work in two companies can have very different procedures. But for Cano, Chamizo, & Martín [17], WL is characterized by two aspects: informal learning, which is carried out in the organization in an empirical way, by imitation, and by trial and error; and organizational training processes of a structured nature, with objectives, goals and evaluations, where once employees pass these stages they are qualified to perform these tasks, as well as future reconditioning or retraining processes.

Personnel Management

Another element mentioned above as a component of the type of management of companies is that which refers to personnel management. In the tanning sector industries, this is handled without stopping to review the current situation mentioned by Morales & Salvador [18], where they comment that companies must be prepared to face the information age and be able to see that employee management is the dynamic that involves companies in the vanguard, facilitating their continual transformation on par with the accelerated development of current technology.

The organizational culture-OC

The OC is, in essence, all the elements of a system, composed of organs and links. If culture alone is everything that has records, history, and folklore among others, the OC reviews these elements within a company, Alvarado & Monroy [19] states that the collective behaviors of any organization can be of a formal nature, expressed in a strategic plan, where the records and history are in mission, vision, goals, objectives and policies; in some organizations there are even hymns and other cultural expressions as well as other behaviors of an informal nature, such as the customs that have been nested in the companies and are part of the budgets and other administrative processes.

Organizational Communication

An integrated element within the organizational culture is organizational communication. As mentioned by Medina [20], communication as a business discipline is based on three components: orality, persuasion and discourse. Orality is the day-to-day life of an organization, as a social entity, as a group of people; this orality is transformed into writing as memos and circulars as a formality of communication. The second component is the communication between the company and its customers, all the elements of marketing and advertising to promote purchase persuasion. The speech component speaks of oratory – essentially, the power of love that the company has over its employees.

In conclusion and apart from the previous elements central to the analysis, Cruz, Obregón and Puello-Socarrás [7] carried out an analysis of the administrative theories applied to the administrative styles of the leather sector that is congruent with the results of the study in the tannery sector:

Table 1: Administrative theories applied to the administrative styles of companies in the footwear and leather goods sector in Colombia [7]

Year of development	Administrative theory	Characteristics associated with the MSMEs of the cluster studied
1911	Scientific Theory (Taylor)	Division of labor between managers and workers, when circumstances allowed. The other elements (replacement of informal methods of work, selection and training, preparation of machines and arrangement of machines and materials, control and planning were not adequately achieved, so the work was carried out in a semi-formal way)
1916	Classical Theory (Fayol)	Of the 14 principles proposed by Fayol, only a few were applied in a reactive manner to what was established in the large companies that were related to the cluster in Colombia: **Division of labor, in an** incomplete manner, **Authority** derived from **units of command** (bosses - owners) but without responsibilities towards collaborators, **hierarchization** with a notable development of the vertical hierarchy, characterized by a hypercentralization of decisions and command processes. The other elements (**discipline**, **unity of direction**, **subordination of individual interest to the general**, **remuneration**, **order, equity**, **stability, initiative**, esprit de **corps**) are still not adequately complied with, which keeps companies in a state of labor semi-formality vis-à-vis their employees or collaborators.
1930s	Human Relations Theory (Mayo)	The companies are characterized by being constituted as family productive units, the hierarchies and relations are given by the family structure and influenced by these relations and family dynamics. Of the main elements (authority, communication, behavioral structure, formalization structure) only the first one was deeply developed; the others were not adequately developed. There was no reduction in labor, as this sector is labor intensive and has no automation of processes.
1940s	Structuralist theory (Dahrendorff, Mayntz, Selznick, Barnard, Etzioni and ECLAC)	
1950s	Neo-classical theory (O'Donell, Dale Koontz, Drucker)	
1960s	Behavior theory (Simon, Barnard, Likertt, Argyris)	There is no approach that integrates the behavior of individuals from incentives and motivation. Administrative theories from this point on are not applicable to the productive units studied, assuming a stagnation in administrative styles with some incomplete developments of classical administrative theories.
1970s	Total Quality and Z-Theory (McGregor, Blake) Contingency - Environmental Impact (Woodward, Lawrence, Lorsh)	There is no application of these theories in the administrative styles of the productive units studied. Neither total quality nor environmental impact management are taken into account.

METHODOLOGY

The research conducted will be a mixed case study and analysis with all the seriousness of a scientific investigation as argued by Coria, Roman, & Torres [21]. It should be characterized taking into account many different aspects and perspectives, some of those classified in the works of Sierra [22], and developed through a transversal research method, allowing the discussion to become a descriptive one. Mainly focused upon qualitative primary sources the authors consider and analyze the results from the baseline scenario as a whole, as does Sandin [23], also relying on secondary sources in a quantitative manner. Bottomline, this was a pre-experimental study, designed to understand the situation prior to intervene with some good practices and strategies in the field to solve some managerial issues that affect residual water discharges from these tanneries.

After defining exactly which entities will be the subject of this study, the writing of the case helps to consolidate the good practices and improvement options in the management - environment relationship of the tanning sector.

The techniques used will be: structured observation, interviews, surveys (questionnaires), and printed information in articles. The references of the topics that apply to management can be the study of the business innovation of several companies, while combining the management style of the same companies – which, in essence, is the objective of this article.

Research Variables

Demographic: know the size of the tanneries.

Social factors: number of employees, type of company, seniority.

Environmental factors: dumping management, solid waste controls, handling of hazardous materials, management system and safety at work.

Economic factors: current and past financial situation, as well as portfolio collection and cancellation of obligations with third parties and net sales.

Operational and organizational factors: types of employee responsibilities (managerial and operational), type of organizational structure (roles and hierarchies).

Administrative factors: strategic plan, policies, incentives, motivation, organizational school.

The subject population of the study are the companies dedicated to the tanning of skins, in Villapinzón Cundinamarca, San Benito Bogotá and Barranquilla, with the method of probabilistic sampling, of a universe of 483 industries (active and in suspension), the population of which includes 336 operating industries. This study narrowed the sample to 34 companies, with a margin of error of 5% and a level of confidence of 95%.

RESULTS AND DISCUSSIONS

Time Line

The documentary review, including the Ministry of the Environment of the Republic of Colombia, the Secretary of Health of Bogotá, the Congress of the Republic of Colombia and regional entities such as the Regional Autonomous Corporation (CAR), yielded the following results regarding the review of regulations related to the obligations of companies in their environmental administration and management:

Decree 2811 of 1974: The preservation of renewable natural resources is of public utility and social interest and is provided for in the National Code of Renewable Natural Resources and Environmental Protection.

Law 99 of 1993: Creation of the Ministry of the Environment, which reorganizes the public sector in charge of the environment and its conservation.

Decree 1401 of 1997: Assigned to the Ministry of the Environment, as the Administrative Authority of Colombia that initially establishes the issuance of permits and certificates of CITES (Convention on International Trade in Wild Fauna and Flora Endangered Species), it establishes measures related to the management of tanneries and wildlife traders.

Decree 3100 of 2003: Regulates the retributive rates for the direct use of water as a receiver of the punctual discharges.

Decree 190 of the year 2004: By means of which the dispositions contained in the district decrees 619 of the year 2000 are compiled, (Environmental aspects, hydric resource and soil).

Decree 3440 of 2004: Modifies decree 3440 of 2003 and establishes new fees for direct water use.

Resolution 1433 of 2004: Determines Discharge Management and Sanitation Plans, (PSMV), necessary investments to advance in the sanitation and treatment of discharges, including the collection, transportation, treatment and final disposal of wastewater discharged into the public sewage system.

Agreement 043 of 2006: Establishes water quality objectives for the Bogotá River Basin.

Decree 3930 of the year 2010: By which title I of law 9a of 1979 is partially regulated, regarding the use of water and liquid waste and other provisions that are issued.

Legal Concept No 199 of November 16, 2011: The District Secretary of Environment as an environmental authority within the Capital District has the competence to require the respective discharge permit to those who generate discharges of sanitary interest.

Resolution 631 2015, Ministry of the

Environment and Sustainable Development: Establishes the parameters and maximum permissible limits to be met by those who perform specific discharges into surface water bodies and public sewerage systems. It also establishes the parameters that are subject to analysis and reporting by industrial, commercial, or service activities.

Decree 050 of 2018: Partially modifies Decree 1076 of 2015, the Sole Regulatory Decree for the Environment and Sustainable Development Sector, regarding the permit, requirements and study of the discharge application, as well as its environmental evaluation. It also establishes that no dumping will be allowed [24].

Taking into account the above, the previous legislative analysis revolves around sentence 479 of 2014 of the Council of State, the main legal guideline, which has made it possible to adopt a series of measures that seek to protect the Bogotá river basin. Known as the "Ruling of the Bogotá River", this ruling contains the design and implementation of measures to decontaminate the river and prevent future contamination. The decision was made in the face of the environmental, ecological and economic-social catastrophe of the Bogotá river basin, caused by the high degree of contamination due to domestic and industrial wastewater discharges, bad agricultural practices and inadequate waste management by the inhabitants and neighboring industries, as well as the omission of the authorities from these situations for more than thirty years [25].

The judgment adopted a series of orders of a national, regional and local nature, involving different authorities. Some orders are of an immediate nature and others extend for a maximum of 3 years. The sentence declares the inhabitants and industries of the basin responsible for the pollution of the river and its tributaries. The authorities that have not taken measures for decontamination and pollution prevention are also declared responsible.

The judicial decision of the Council of State seeks to protect, among others, the following rights [26]:

- Rights related to water and the enjoyment of a healthy environment.
- The existence of an ecological balance and the management and rational use of natural resources to guarantee their sustainable development, conservation, restoration or replacement.
- The conservation of animal and plant species.
- Protection of areas of special ecological importance and of ecosystems located in border areas
- Other interests of the community related to the preservation and restoration of the environment
- The enjoyment of public space and the use and defense of public goods.
- Defending the public heritage.
- Defending the cultural heritage of the Nation.
- Public safety and health.
- Access to a service infrastructure that guarantees public health
- Access to public services and their efficient and timely delivery.
- The right to security and prevention of technically foreseeable disasters.
- Access to public services and their efficient and timely delivery.
- Consumer and user rights.

In this sense, companies are not only obliged by morality to maintain healthy conditions in the ecological environments where they develop, but there are also legal norms that oblige them to control these negative externalities with the threat of sanctions and economic effects of their activities in case of non-compliance.

Business Census

In an interview with Vladimir Fernandez (Plant Manager, Industria de Curtidos la Sabana Ltda.), an initial proposal within the improvement plan would be to raise awareness in the production units in order to propose plans within the tanning companies that would also document all of their activities (financial and administrative) [27].

Another interview was conducted with Dr. Gloria Silva, (Manager, Cooperativa Integral de Curtidores), since 25 years ago the rules protecting the environment issue came out and the companies took other ways, some very few

took the necessary precautions and were making the required adjustments and investments. The role of the cooperative in the early days was to act as an intermediary between suppliers and companies, and today it helps with the entire commercial chain and permanent training processes [28].

In the interviews and visits, the following was found:

San Benito Neighborhood Census - Bogotá

- Initial census of companies in the sector: 325
- Census of operating companies (formal and informal): 216
- Companies with certification of treatment of waste and water disposal sites: 62
- Companies affiliated to the cooperative: 24

Census of the sector - Barranquilla

- Initial census of companies in the sector: 25
- Census of operating companies (formal and informal): 10
- Companies with certification of treatment of waste and water disposal sites: 4

Census of the sector - Villapinzon

During our field work, 133 tanneries were located, 23 of which were found to have no production infrastructure whatsoever and 110 were found to have open production infrastructure (74 in Villapinzón and 36 in Chocontá).

There are three associations ACURTIR, ASECHI and ICOLPIELES. Approximately half of the tanners are affiliated to some tannery associations and 75% have been affiliated at some time; 61% show an interest in joining to share processes, machinery or to obtain favorable prices in the purchase of raw materials.

It is recorded that tanners wish to join these associations in order to seek shared benefits and improve their processes and ways of operation.

Environmental Cost

Attributing economic value to the environment is a complex task, but if the effects of the damage to the environment can be measured and quantified, the decontamination of the Bogotá River is a priority for government agencies. The Mayor's Office of Bogotá has put into operation a water treatment plant called El Salitre for two billion pesos ($USD 572 million), and a second plant called Canoas is in the process of being awarded 430 million USD), which only guarantees 60% of the river's decontamination.

Figure 4. El Salitre treatment plant [29]

Measuring the health effects of a contaminated environment is also a complex investigation. Effects on the respiratory tract are identified in the community due to the odors generated by the chemical reactions of the raw materials used, and it is a task for the health secretary who is more concerned about the costs of treating the diseases than the costs of preventing them.

The truth is that the judiciary takes measures for which the government did not train or finance. Colombia is obliged to comply with the Sustainable Development Goals (SDG), namely of the SDG 12 on responsible and sustainable production and consumption, which must be linked with the SDG 11 on Sustainable Cities and Communities, and finally with SDG 3 on Health and Welfare [30].

Fresh water is an abundant natural resource in Colombia, which ranks 6th in the world in most absolute water reserves, only surpassed by Brazil, Russia, the United States, Canada and China. The relative reserves by number of inhabitants are an unknown figure.

The 58 million cubic meters of water (from the industrial sector) amount to $240 billion pesos (67 million USD), according to the tariffs of the Bogotá water company [31].

The situation in Latin America is not very different. Operational costs are consumed in fines, recovery and repair work. However, the situation does not improve when the global participation in the sector is reviewed, which for 2010 in the case of bovine leather in relation to the effective world production forecast was 6,214 thousand tons, in which Latin America participated with 1,439 thousand tons, representing 23.15%, where the majority participation of this value is contributed by Argentina [32].

The business practices of companies in the sector in Colombia are affected by national production and the geographic distribution of these tanneries. Between Cundinamarca and Bogotá, 80% of the industries are concentrated [1], and Barranquilla contributes 0.30%. National leather production in 2010 was 9,487 tons, which is only 0.66% of Latin American production and 0.15% of world production. The first two countries account for 36% and the third participates with 7% [13].

Administrative Characteristics of Tanneries

The administrative characteristics of organizations are the response to policies adapted and implemented from administrative theories, which can be of many tendencies: the bureaucratic type, personnel welfare, total quality, scientific administration or the administrative cycle. In Colombia, the strategic planning scheme has become a tool for administrative control.

Strategic planning in an organization is composed of three levels based on time horizon and scope.

Table 2: Planning levels [33]

Planning	Time horizon	Scope	Content
Strategic	Long Term	Macro-oriented, ontological organization	Generic
Tactics	Medium Term	For each area of the organization	Detailed
Operation	Short Term	Exclusive by task	Specific

Tanneries apply classical management theories in terms of the following:

- Specialization of the worker's functions, although there are employees with 'super-numerary' level characteristics, who are trained to perform functions in different areas.
- Training strictly of a practical level, there are no formal training processes. In Colombia there are no technical studies or higher studies of the tanning profession. The processes have some main operators and some auxiliary operators, the latter through observation and assistance of the former, are 'learning' the work.
- The need for a supervisor is evident, which would entail reviewing processes, results, work safety, scheduling preventive maintenance, supplying inputs (chemical formulas for tanning).
- The control of times and movements is fundamental because 90% of the payroll is piecework; it is the employees themselves who determine its value.
- In the sector it is clear that in the absence of strategic plans and partnership, the work becomes a daily solution to problems, and there is no planning or future budgets, production costs are completely variable upwards.

CONCLUSIONS AND DISCUSSIONS

The leather industry has occupied a prominent place in the Colombian national economy. The treatment of skins and, in general, all its process is one of the trades of greater rooting and tradition in Colombia. The structure and generalities of the productive chain of the leather are composed of five processes that even when they are not always in the hands of the same productive unit, however, they should be articulated closely to achieve a final result of satisfactory quality: 1) breeding of the cattle,

2) slaughter of the animal, 3) tanning process, 4) manufacture of the footwear, and the 5) manufacture of other leather products. In this way, the industrial process of the chain evolves with the tanning of leather, shoe making, leather goods and saddlery.

In economic terms, the tanneries are micro enterprises, both in terms of employment and sales and assets: 70% of the tanneries are micro enterprises, 27% are small enterprises, and only 1.8% are classified as medium enterprises; 79% of the tanneries stated to establish a verbal contract, and only 21% a formal contract; 57% are temporary or piece-rate, and only 43% are permanent. The employment is low skilled and dedicated to the operation, men are the most hired (87%); 89% of the tanneries in the sector are family owned.

As for their technological level, the tanneries in the sector have a low technology penetration. Nearly 80% of the tanneries do not have standardized or automated processes, despite the fact that they process hides with traditional equipment (buffers and downgraders).

A majority of 80% of the tanneries are run by people of mature age and with a maximum level of education of full secondary school, and their employees have a similar level of education. 67% of the tanneries report selling less than $25,000,000 per month (7.000 USD); 29% report monthly sales between $25,000,000 and $250,000,000 (7.000 - 70.0000 USD); 80% of the sales are destined to Bogota and 15% to the rest of the country. It is worth noting that 96% of the tanners expressed interest in learning to export.

The management and technological capabilities of the tanneries' human resources are also deficient. The characterization reflected that the level of managerial training is low. The educational and technical background of the decision makers is very low, with only 8% having attended college and the predominant 89% having passed only basic and secondary education. To this must be added the advanced age of the managers. More than half of the tanners are over 45 years old. In addition to the management training level, there is a low level of technical training at the operational level (89% have a high school diploma and 2% have a technology-related or other professional degree). All this is configured as a structural barrier to change in the management style.

In the tanning sector, companies should not only think about their economic sustainability, but also comply with environmental and ecological regulations, taking their socio-economic impact on the community where they are located. As Duque says [34], the business competitiveness of the leather processing industries has an additional challenge to keep up in the sector, and that is to adopt productive measures that use the latest technologies in the ecological evolution of the processes. This subsequently increases their operating costs, posing a clear obstacle to sustainability.

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[i] The colonization of Antioquia took place in part of the central mountains of Colombia since the late nineteenth century and until the early twentieth century, is so named because the colonists came from the region of Colombia called Antioquia, which is located in the west of the country.

[ii] Cundinamarca is one of the departments in central Colombia and is the region around the capital, Bogotá.

ASSESSMENT OF THE INFLUENCE OF GLOVE AND HABERDASHERY SKIN PRODUCTION TECHNOLOGY ON THE ENVIRONMENT

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ASSESSMENT OF THE INFLUENCE OF GLOVE AND HABERDASHERY SKIN PRODUCTION TECHNOLOGY ON THE ENVIRONMENT

ABSTRACT. Results of calculation of ecological optimality for application technologies of using chrome-aluminium, chrome-titanium, chrome-aluminium-titanium of complex compounds for production of glove and haberdashery leather are given in the article. In semi-working conditions tanning processes of glove and haberdashery leather by ecologically harmless tanner were carried out at the corresponding parameters and expenses of chemical materials. The received integrated coefficients of waste lessen of production of glove and haberdashery leather showed that offered technologies are "conventionally waste-free".

KEY WORDS: glove and haberdashery leather, ways of tanning, ecologically safe tanner, waste-free technologies

EVALUAREA INFLUENȚEI ASUPRA MEDIULUI A TEHNOLOGIEI DE PRODUCȚIE A MĂNUȘILOR ȘI ALTOR OBIECTE DE GALANTERIE DIN PIELE

REZUMAT. Articolul prezintă rezultatele calculului nivelului optim din punct de vedere ecologic pentru aplicarea tehnologiilor de utilizare a compușilor complecși de crom-aluminiu, crom-titan, crom-aluminiu-titan la obținerea pieilor pentru mănuși și alte obiecte de galanterie. În condiții de semi-operabilitate, s-au realizat procese de tăbăcire ecologică a pieilor pentru mănuși și alte obiecte de galanterie, la parametri corespunzători și cu cheltuielile aferente materialelor chimice. Coeficienții integrați ai producției de piele pentru mănuși și alte obiecte de galanterie cu nivel redus de deșeuri au arătat că tehnologiile prezentate sunt „fără deșeuri generate în mod convențional".

CUVINTE CHEIE: piele pentru mănuși și obiecte de galanterie, metode de tăbăcire, tăbăcărie ecologică, tehnologii fără deșeuri

ÉVALUATION DE L'INFLUENCE ENVIRONNEMENTALE DES TECHNOLOGIES DE PRODUCTION DES GANTS ET AUTRES ARTICLES EN CUIR

RÉSUMÉ. L'article présente les résultats du calcul du niveau optimal d'un point de vue écologique pour l'application de technologies pour l'utilisation de composés complexes de chrome-aluminium, chrome-titane, chrome-aluminium-titane dans l'obtention de cuir pour les gants et autres articles de mercerie. Dans des conditions semi-professionnelles, des processus de tannage écologique du cuir pour les gants et autres articles de mercerie ont été effectués, à des paramètres appropriés et aux dépenses liées aux matières chimiques. Les coefficients intégrés de production de cuir pour les gants et autres articles de mercerie à faible gaspillage ont montré que les technologies présentées sont « conventionnellement sans déchets ».

MOTS CLÉS : cuir pour gants et mercerie, méthodes de tannage, tannage écologique, technologies sans déchets

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INTRODUCTION

For practical realization of main principles of ecological safety, numerical estimation of the influence of proposed technologies upon the environment should be carried out.

The solution of this problem can be obtained through technical-ecological and ecological-economical estimation of technologies [1, 2]. Material balance of glove-haberdashery leather production, represented on Figure 1, is used for calculation of technical-ecological and ecological-economical indices of technological cycle [3-5].

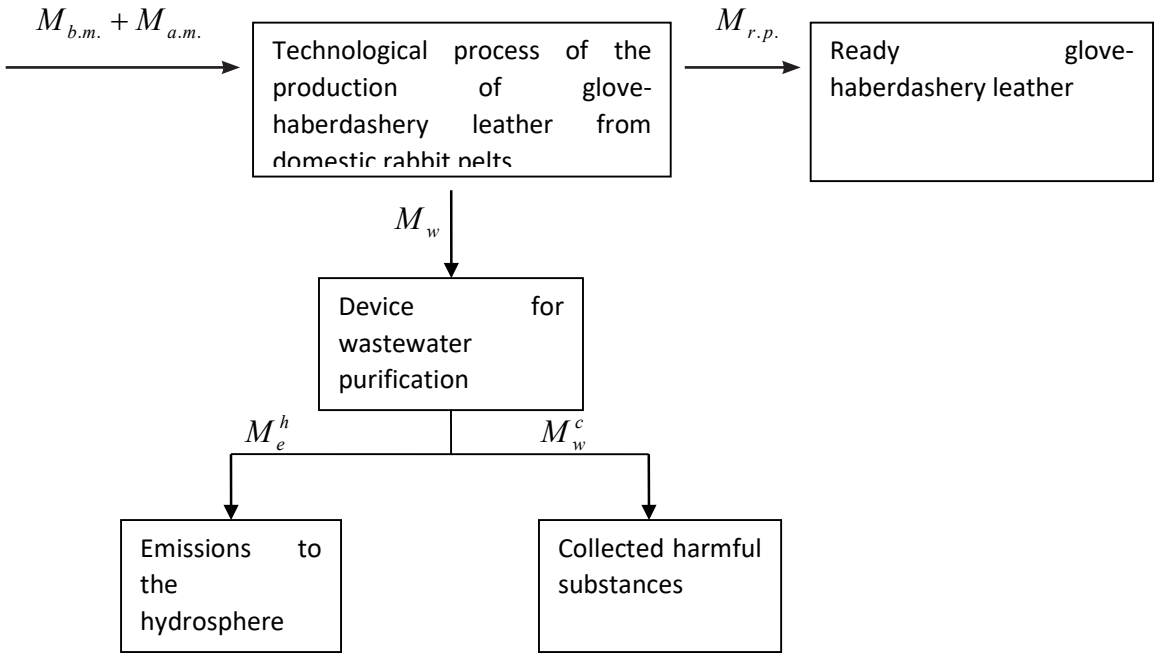

Figure 1. The scheme of the technological process of glove-haberdashery leather production

In terms of environmental defense technology, material balance of the production of glove- haberdashery leather has the following form:

$$M_{b.m.} + M_{a.m.} = M_{r.p.} + M_w \quad (1)$$

$$M_w = M_w^c + M_e^h, \quad (2)$$

where $M_{b.m.}$ and $M_{a.m.}$ are masses of basic raw material and auxiliary materials;

$M_{r.p.}$ – mass of ready product;

M_w – total mass of wastes;

M_w^c – mass of collected wastes;

M_e^h – mass of wastes, discharged into hydrosphere.

Equation (1) takes into account capture coefficient of device for wastewater purification:

$$M_{b.m.} + M_{a.m.} = M_{r.p.} + M_e^h(1-\zeta_r) + \zeta_r M_e^h \quad (3)$$

K_{ϕ} is introduced for evaluation of the influence of glove-haberdashery leather production technology upon the environment.

For quantitative evaluation of the treatment facilities of waste processing technology of glove- haberdashery leather production, the following coefficients are introduced: $K_{\text{пр}}$ – is the coefficient of exploitation of productive capacity; $K_{\text{пм}}$ – is the coefficient of complete use of raw materials; G_f, G_p – are actual and design capacity of the production cycle, consequently.

Technical-ecological coefficient, characterizing the level of rational functioning of technological process, is the following:

$$K = K_{pc} * K_m * K_{ef} \quad (4)$$

For glove-haberdashery leather production process the coefficient of exploitation of productive capacity is $K_{pc} \to 1$, the coefficient of complete use of raw materials, characterizing technological output of leather $K_m \langle 1$. The coefficient, characterizing the level of the influence of technological process upon environment, is $K_{ef} \to 1$. So, technical-ecological coefficient, characterizing the level of rational functioning of glove-haberdashery leather production technology, is less than 1. Physical meaning of K points out the level of rational exploitation of natural resources [6].

In order to evaluate ecological-economical level of glove-haberdashery leather production the following coefficient is introduced:

$$R = K * E_n, \quad (5)$$

where E_n – is nature protection expenditures (tg) per one unit of product.

EXPERIMENTAL

Materials and Methods

Environmental and economic sense of R is to express the specific proportion of all rational costs for production of one unit of glove-haberdashery leather. This method of calculation puts on equal economic status realization of nature protection measures and technological engineering works as well. The increase of nature protection measures expense should be limited by economic conditions and directly related to the minimal level of profitability of technological process (optimal expense), because its deviation entails changes in technological process. Initial data for calculation of K and R coefficients are represented in Table 1.

Table 1: Data for calculation of technical-economic and ecological-economic indices of functioning of technological process

Index	Unit of measurement	Value
Production volume:		
• Projected, G_p	dm^2	20.0
• Actual, G_f		19.3
Nature protection expenditures per one unit of product, En	tg/unit of product	0.23
Consumptions:		
• of basic raw material, $M_{b.m.}$	kg	
• of auxiliary materials, $M_{a.m}$	(unit)	1.5
Mass of ready product, $M_{r.p.}$	kg (unit)	1.2
Total mass of wastes:		
• mass of collected wastes, M^c_w	kg	0.21
• mass of wastes, discharged into hydrosphere, M^h_e	kg	0.09

The results of calculation of technical-economic and ecological-economic indices of functioning of technological process are presented in Table 2.

Table 2: Results of calculation of K and R coefficients

Coefficient	Value
Coefficient of exploitation of productive capacity, K_{pc}	0.965
Coefficient of complete use of raw materials, K_{rm}	0.8
Coefficient of the influence of technological process upon the environment, K_{ef}	0.9
Coefficient of collection of harmful substances: in water, ζ_g	0.7
Coefficient, characterizing technical-ecological level of functioning of technological process, K	0.695
Coefficient, characterizing ecological-economic level of functioning of technological process, R	0.160

Human industrial activity results in negative influence upon the environment, which consists in certain qualitative and quantitative anthropogenic changes. One of the main sources providing a large negative effect on hydrosphere is wastewater of leather industry. Large-scale industrial water consumption makes the problems of protection of water quality in natural pools and rational exploitation of water resources to be the most actual national economic problem. In order to prevent further environmental degradation, it is necessary to provide measures for protection and science-based rational exploitation of natural resources. These problems have been reflected in public policy, incorporated in the environmental code of the republic of Kazakhstan and in the law "About environmental protection", in the Concept of ecological safety, supported by a system of laws and normative-technical documents [7, 8].

Characteristic feature of leather enterprises is great consumption of water and therefore large volume of wastewater. Wastewater of leather industry belongs to the group of particularly ecologically hazardous wastes because of the presence of various toxic chemical substances in high concentrations [9].

Reduction of environmental loading of nature (namely, natural waters) is possible by improving the existing system of quality criteria of environment. When assessing the impact of the technology on the environment, ecosystem response to the proposed technological solutions should be taken into account. Environmental response on the technogenic emissions can be demonstrated by integral evaluation.

In glove-haberdashery leather production tanning is regarded the most ecologically dangerous process because of the use of chemical substances. Therefore, ecological safety of technological process is evaluated by the index of ecological safety of tanning method:

$$K_{ies} = \frac{\varphi^a}{m}, \qquad (6)$$

where φ^a – is the background, or a threshold response;

m – the change of environmental state.

RESULTS AND DISCUSSIONS

Based on this method of calculation of pollution influence upon hydrosphere, taking into account the maximal allowable concentrations and integral criteria of ecological safety, the mechanism of environmental response on technogenic emissions is discussed on the example of the tannery «TarazKozhObuv».

Using characteristics of wastewater of an enterprise, reduced concentration of harmful substances, discharged by the tannery into a common sewer system, is estimated.

In this case the calculation is carried out with respect to the concentration of suspended solids, formed in the chromium and combined tanning processes, according to the formula:

$$C_p^f = C_1^f + C_2^f \frac{MPC_1}{MPC_2} + C_3^f \frac{MPC_1}{MPC_3} + \ldots + C_n^f \frac{MPC_1}{MPC_n}, \qquad (7)$$

where MPC is maximal permissible concentration.

According to the data obtained from «TarazKozhObuv», actual reduced concentration of harmful substances, discharged by the tannery into a common sewer system, has been determined.

Formula (7) allows calculating ecological safety coefficient for chromium tanning technology, $K_{ies} = 0.9$ and for complex mineral tanner, $K_{ies} = 0.8$

According to Figure 2, demonstrating the dependence of coefficient of ecological safety index on

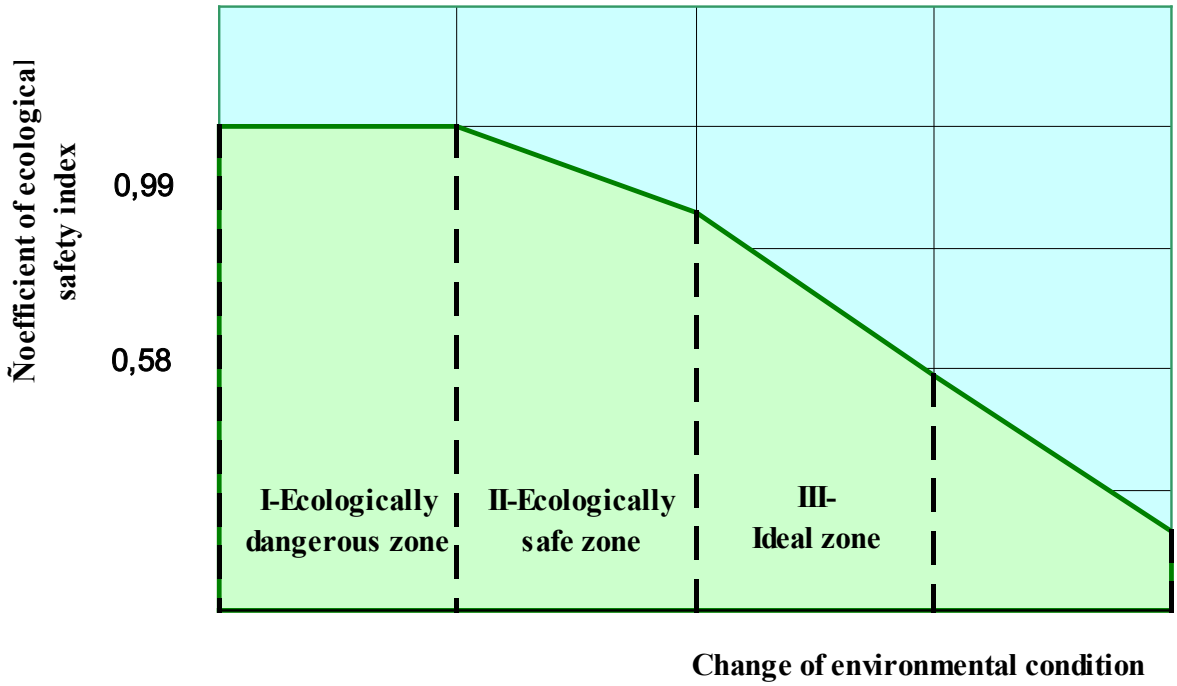

Figure 2. Dependence of K_{ies} on the value of change of environmental condition (m)

the value of change of environmental condition, we can conclude that water bodies receiving wastewater are environmentally friendly for the reduced value of the concentration of harmful substances for combined tanning.

Waste liquids after tanning are locally purified in contact reservoirs at chromium sedimentation station, discharged into the waste storage and then bypassed into the secondary ponds (filtration fields).

Based on the characteristics of tannery wastes the pollution level, excess of the level of contamination and the value of decreasing coefficient for ground water are estimated.

The level of environmental contamination (namely, ground water) by harmful substances in the concentrations, exceeding maximal permissible concentration, is calculated by formula:

$$d_i = \frac{C_i}{MPC_i}\ , \qquad (8)$$

where d_i – the level of pollution by i-substance

MPC_i - maximal permissible concentration

of i - substance, mg/l.

To determine the level of contamination, exceeding maximal permissible concentration, the following formula is used:

$$\Delta d_i = d_i - 1\ , \qquad (9)$$

where Δd_i – is exceeding of pollution level by

i-polluting substance over maximal permissible concentration

The final stage is calculation by the following formula the total level of contamination of ground waters, taking into account coefficients of equal efficiency:

$$d_w = 1 + \sum_{i=1}^{n} \alpha_i * \Delta d_i\ , \qquad (10)$$

where α_i – is the coefficient of equal efficiency for i-contaminant

n – is the number of contaminants.

The results of contamination level, exceeding of pollution level and values of decreasing coefficients for ground waters, are presented in Table 3.

Table 3: Calculation results of water contamination level, exceeding maximal permissible concentration, and values of decreasing coefficients for ground waters

Method of tanning	Parameter		
	The contamination level of ground waters	Exceeding of pollution level of maximal permissible concentration	Decreasing coefficient
chromium tanning	dCr=2.74	ΔdCr=1.74	K_w=0.7
combined tanning	dCr=1.2 dTi=1.2 dAl=1.25	ΔdCr=0.28 ΔdTi=0.2 ΔdAl=0.25	K_w=0.9

The results obtained show that ground waters are susceptible to contamination by chromium tanning of glove-haberdashery leather (K_w=0.7) to a greater extent than by combined (chromium-aluminum) tanning (K_w=0.9).

Change of chromium content in waste solutions, when using complex chromium-titanium, chromium-aluminum and chromium-aluminum-titanium tanners are discussed on the basis of material balance of tanning process.

Application of complex mineral compounds for tanning will reduce chromium content in waste solution due to partial replacement by ecologically harmless tanning metals and due to greater absorption of complexes by dermis collagen as well, so chromium oxide content in the solution will reduce: in chromium-titanium – for 10.9 times; chromium-aluminum – for 10.1 times; chromium-aluminum-titanium – for 21.2 times.

In present technology in order to settle chromium compounds, waste solutions after tanning are mixed with the general flow of industrial waters in the ratio 1:15-20. For example, in «TarazKozhObuv» over 8000 m³ of wastes instead of 400 m³ are treated every day. Base cost of wastewater treatment to existing technology is 1.26 tg/m³, and to propose technology base cost of purification from chromium compounds will be 0.252-0.126 tg/m³ due to the decrease of wastewater volume in 5-10 times.

Calculation and comparison of expenses for waste disposal for existing and proposed technologies are carried out in the following order:

1. For existing technology total quantity of chromium compounds (in terms of Cr_2O_3) in wastewater of «TarazKozhObuv» is as follows $m_{Cr_2O_3} = 4{,}01\ tones$;

2. Parameter of relative aggressiveness ($A_{Cr_2O_3}$) of Cr_2O_3 is defined on the base of maximal permissible concentration – 0,5 vg/l, $A_{Cr_2O_3} = 2$;

3. Reduced mass of chromium oxide, polluting environment, $M_{Cr_2O3} = 8{,}02$ (conventional tones);

4. The value of pollution damage ($D_{Cr_2O_3}$) of environment by chromium compounds, $D_{Cr_2O_3} = 100891{,}6$ (tenge);

5. Standard payment for storage (S) of wastes, for which processing technologies are available, but there is no production capacity, $S_{Cr_2O_3} = 2190955$ (tenge per tonne);

The rate of payment for the storage of waste, for the processing of which there are technologies, but necessary production capacities are not available, $S_{Cr_2O_3} = 2190955$ (tenge / t);

6. Value of payments (P) for accommodation (storage, disposal) of wastes $M^n_{Cr_2O_3} = 3{,}6892$, $P_{Cr_2O_3} = 8082871$.

CONCLUSIONS

Expected savings for the proposed technology of accommodation (storage, disposal) of wastes are: for chromium-titanium (concentration of chromium compounds 47.2%) – 4267.8 thousand tenge; chromium-aluminum (concentration of chromium compounds 56.8%) – 3491.8 thousand tenge and chromium-aluminum-titanium (concentration of chromium compounds 33.4%) – 5383.2 thousand tenge.

Tannery is one of the main polluters because of the use of chromium compounds, thereby, ecological problem should be solved by the development of environmentally friendly leather technology by introducing chromium saving technology, based on the use of ecologically harmless complex mineral tanners, providing conformity of chromium content with its maximal permissible concentration in wastewater, and through the elaboration of ecologically harmless, resource saving "conventionally waste-free" technologies of rational and complex utilization of natural resources, providing completeness of their processing and diminishing of wastes, followed by the discharge of harmful substances in the environment.

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INTERACTION BETWEEN GELATIN AND NANO-SILVER PARTICLE: FOUNDATION FOR NANO-SILVER IN ANTIBACTERIAL LEATHER

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INTERACTION BETWEEN GELATIN AND NANO-SILVER PARTICLE: FOUNDATION FOR NANO-SILVER IN ANTIBACTERIAL LEATHER

ABSTRACT. In order to explain the interaction between collagen and nano-silver, gelatin solution was blended with nano-silver particles (AgNPs) with particle size 26 mm, and then the mixture was interacted under different time, pH and temperature. The changes in the process were measured by UV-Vis, fluorescence spectroscopy, dynamic light scattering and FT-IR. The results showed that the main type of reaction between gelatin and AgNPs was electrostatic interaction and the interaction was diffusive encounters. The particle size and distribution of nano-silver would not be affected by gelatin, however, there was dynamic fluorescence quenching of gelatin after nano-silver particle induced. The longer time and lower pH were beneficial for the interaction process while the interaction balanced after 60 min and pH 3.0 resulted in the most drastic interaction. Moreover, nano-silver would not impair gelatin structure during the interaction process. In short, the results in this work might be a foundation and reference for applying nano-silver in antibacterial leather producing.

KEY WORDS: gelatin, nano-silver, interaction process

INTERACȚIUNEA DINTRE GELATINĂ ȘI NANOPARTICULE DE ARGINT: FUNDAMENTUL UTILIZĂRII NANOPARTICULELOR DE ARGINT PENTRU A OBȚINE PIELE CU PROPRIETĂȚI ANTIBACTERIENE

REZUMAT. Pentru a explica interacțiunea dintre colagen și nanoparticule de argint, soluția de gelatină a fost amestecată cu nanoparticule de argint (AgNP) cu dimensiunea particulelor de 26 mm, iar apoi amestecul a fost supus unor interacțiuni în condiții diferite de timp, pH și temperatură. Modificările procesului au fost măsurate prin UV-Vis, spectroscopie de fluorescență, împrăștiere dinamică a luminii și FT-IR. Rezultatele au arătat că principalul tip de reacție dintre gelatină și AgNP a fost interacțiunea electrostatică prin difuzie. Dimensiunea particulei și distribuția nanoparticulele de argint nu au fost afectate de gelatină, cu toate acestea, a existat stingerea dinamică a fluorescenței gelatinei după inducerea nanoparticulelor de argint. Timpul mai lung și pH-ul mai scăzut au fost benefice pentru procesul de interacțiune, în timp ce interacțiunea s-a echilibrat după 60 de minute, iar pH-ul de 3.0 a dus la cea mai drastică interacțiune. Mai mult, nanoparticulele de argint nu afectează structura gelatinei în timpul procesului de interacțiune. Pe scurt, rezultatele acestei lucrări ar putea constitui un fundament și o referință pentru aplicarea nanoparticulelor de argint în obținerea pielii cu proprietăți antibacteriene.

CUVINTE CHEIE: gelatină, nanoparticule de argint, proces de interacțiune

L'INTERACTION ENTRE LA GÉLATINE ET LES NANOPARTICULES D'ARGENT : LES FONDAMENTAUX DE L'UTILISATION DE NANOPARTICULES D'ARGENT POUR OBTENIR UNE PEAU AUX PROPRIÉTÉS ANTIBACTÉRIENNES

RÉSUMÉ. Pour expliquer l'interaction entre le collagène et les nanoparticules d'argent, la solution de gélatine a été mélangée avec des nanoparticules d'argent (AgNP) d'une taille de particule de 26 mm, puis le mélange a été soumis à des interactions dans différentes conditions de temps, de pH et de température. Les changements de processus ont été mesurés par UV-Vis, spectroscopie de fluorescence, diffusion dynamique de la lumière et FT-IR. Les résultats ont montré que le principal type de réaction entre la gélatine et les AgNP a été l'interaction électrostatique par diffusion. La taille des particules et la distribution des nanoparticules d'argent n'ont pas été affectées par la gélatine, cependant, il y avait une extinction dynamique de la fluorescence de la gélatine après l'induction de nanoparticules d'argent. Un temps plus long et un pH plus bas ont été bénéfiques pour le processus d'interaction, tandis que l'interaction a été équilibrée après 60 minutes, et un pH de 3,0 a conduit à l'interaction la plus drastique. De plus, les nanoparticules d'argent n'affectent pas la structure de la gélatine pendant le processus d'interaction. En bref, les résultats de ce travail pourraient être une base et une référence pour l'application de nanoparticules d'argent envers d'obtenir une peau aux propriétés antibactériennes.

MOTS CLÉS : gélatine, nanoparticules d'argent, processus d'interaction

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INTRODUCTION

Leather is a useful intermediate product with various applications in downstream industries like furniture, garment and footwear [1]. Footwear made from leather feels comfortable owing to its collagen interwoven structure and characters of breathability and softness [2]. However, leather is known to harbor bacterial growth due to its large surface area and richness in protein (collagen) that enhance bacterial reproduction by providing space and nutrients [3]. Especially, ideal moisture and temperature for bacterial reproduction will be emerged in shoes under the circumstance that sweat from foot skin is absorbed by leather [4]. The large scale of microbial reproduction on leather will not only cause unpleasant odor but also may bring numerous infectious diseases [5-7]. Therefore, antibacterial leather is urgent and necessary for upgrading leather goods quality and generating better experience for customer. Antibiotics can be used to inhibit bacterial growth on leather, but drug-resistant bacteria and compatibility may become a big challenge and obstacle [8, 9].

Silver nanoparticles (AgNPs) are an excellent antibacterial agent with broad-spectrum antimicrobial property and low toxicity [10, 11]. AgNPs have been widely investigated and applied to improve antimicrobial activity of leather by coating or soaking [12, 13]. The AgNPs with particle size of 26 nm was prepared by using sodium borohydride as reductant and benzalkonium bromide as protective agent [14], and this kind of AgNPs was used for producing antibacterial sheepskin [15] and antibacterial leathers [16, 17]. In order to realize the process of making antibacterial fur with AgNPs and help optimize technology parameters, the theoretical research on interaction between keratin and AgNPs was carried out [18]. No matter what kinds of procedures are used to apply nano-silver in antibacterial leather making, the interaction between collagen and AgNPs is essential. Nevertheless, there are few studies on interaction between collagen and AgNPs [19], consequently, antibacterial leather producing with AgNPs was still based on empirical rule rather than scientific foundation.

Collagen could be used for studying the influence of AgNPs on leather structure [20]. However, collagen is thermal sensitive, thus the temperature in the study would be too narrow in order to avoid collagen denaturing [21]. Gelatin is a collagen hydrolysate with almost the same component and structure excluding triple helix structure [22]. Therefore, gelatin could mimic collagen for carrying out reactions under wide temperature and other extreme conditions. Hitherto, the studies on interaction between collagen or gelatin and nano-silver focused on using protein in AgNPs synthesis [23, 24]. Some researchers also paid attention to applying AgNPs for preparing gelatin based antibacterial hydrogel [25, 26]. But the interaction between prepared AgNPs and gelatin in solution to clarify the regulation of the process had not been studied yet. In this work, the gelatin as mimics of collagen was interacted with AgNPs under different time, pH and temperature. The changes in the process were measured by UV-Vis, fluorescence spectroscopy, dynamic light scattering and FT-IR. The results could provide foundation and reference for antibacterial leather with nano-silver.

EXPERIMENTAL

Materials

Silver nitrate, sodium borohydride, hydrochloric acid and sodium hydroxide were research grade chemicals from Chengdu Kelong Chemical Ltd. Benzalkonium bromide solution (5% w/w) was bought from Nanchang Baiyun Pharmaceutical Co., Ltd. Type B gelatin with molecular weight about 100 kDa was purchased from Sigma-Aldrich. Other reagents in the research were research grade.

Sample Preparations

Nano-silver Particle (AgNPs) Preparation

0.015 g silver nitrate was dissolved in 100 mL distilled water and warmed by DF-101S water bath heater (Wuhan Ke'er instrument Company) at 30°C for 15min. 0.4 g benzalkonium bromide solution was blended with 100 mL distilled water and then added into silver nitrate solution with intense stirring for 30min to form mixed

solution. Subsequently, 200 mL solution containing 0.0074 sodium borohydride and 0.8 g benzalkonium bromide solution was dropped into the mixed solution with intense stirring for 1.5 h to obtain silver nano-silver particle (AgNPs). Particle size of the AgNPs was 26 mm and silver concentration was 0.024 g/L or 8.25×10^{-11} mol/L.[14]

Interaction between Gelatin and Nano-silver Particles under Different pH

20 mL gelatin solution with concentration 1 g/L was mixed with 20 mL AgNPs solution with particle size of 26 nm; then 0.01 mol/L hydrochloric acid or 0.01 mol/L sodium hydroxide was used to adjust the pH of each mixed solution to 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0 and 10.0; finally, the solutions were stirred at 30°C for 120 min.

Interaction between Gelatin and Nano-silver Particles under Different Time

20 mL gelatin solution with concentration 1 g/L was mixed with 20 mL AgNPs solution with particle size of 26 nm; then the solutions were stirred at 30°C for 0.5, 6, 15, 30, 60 and 120 min.

Interaction between Gelatin and Nano-silver Particles under Different Temperature

Gelatin solution was blended with different AgNPs and the gelatin-AgNPs solutions with silver concentration 0, 8×10^{-12}, 1.6×10^{-11}, 2.4×10^{-11}, 3.2×10^{-11} and 4×10^{-11} mol/L were prepared. The gelatin-AgNPs solutions were stirred at 20, 30 and 40°C for 60 min.

Testing Methods

UV-Vis Measurement

Lambda 25 UV-Vis spectrometer (Perkin Elmer, America) was used to measure gelatin-AgNPs solution at 25°C with wavelength from 200 to 800 nm and scanning rate 240 nm/min.

Fluorescence Determination

The fluorescence emission spectra of gelatin-AgNPs solution were tested at 25°C or 20, 30 and 40°C corresponding to the interactive temperature by using F-4010 fluorescence spectrometer (Hitachi, Japan). The excitation and emission wavelengths were 278 nm and 307 nm; wavelength range was from 285 to 400 nm; scan rate was 60 nm/min; excitation and emission slit widths was 5.0 nm.

Zeta Potential Test

Zeta potential of gelatin-AgNPs solution was tested by Nano-ZS laser particle size analyzer (Malvern, UK). The solution was firstly filtered through 0.45 µm microporous membrane and then transferred to a polystyrene cube for the measurement. All measurements were performed in triplicate and the solution was equilibrated for 5 min before the measurement at 25°C.

FT-IR Measurement

The gelatin-AgNPs solution stirred at 30°C for 120 min was lyophilized, and the dried sample was ground with potassium bromide and made into thin sheets. Nicolet 10 FT-IR (Thermo Scientific Corporation, America) was used to scan in wavenumber range from 500 to 4000 cm^{-1} for 32 times, and the data was recorded.

RESULTS AND DISCUSSION

Influence of Time on the Interaction between Gelatin and AgNPs

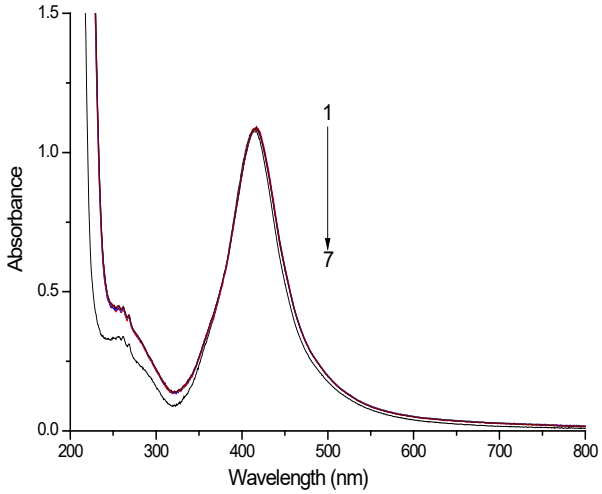

Figure 1. UV-vis spectra of gelatin-AgNPs solution interacted for different time (2 to 7 representing 0.5, 6, 15, 30, 60 and 120 min interaction time respectively and 1 representing AgNPs)

The absorption peak of AgNPs usually locates at about 420 nm in UV-Vis spectrum and there is no peak of gelatin in the same place. Since AgNPs is a metastable system, it will be affected by environmental factor and result in UV-vis spectrum change. The peak intensity trends to weak and the peak width becomes wider when the stability of AgNPs is damaged [27]. As shown in Figure 1, the peak intensity and width of gelatin-AgNPs solutions were almost the same as solo AgNPs with interaction time increasing, indicating AgNPs particle size and distribution were not impacted by gelatin [28].

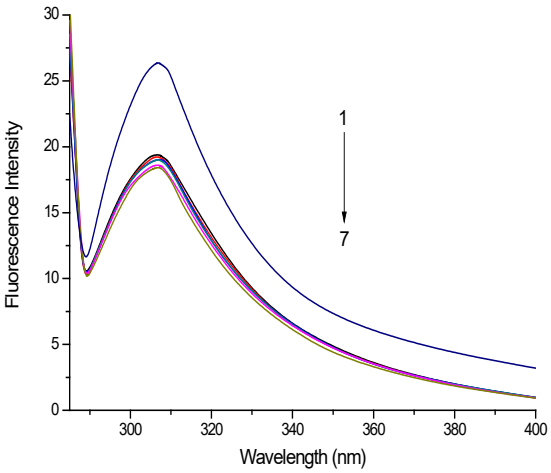

Figure 2. Fluorescence spectra of gelatin-AgNPs solution interacted for different time (2 to 7 representing 0.5, 6, 15, 30, 60 and 120 min interaction time respectively and 1 representing gelatin)

Gelatin contains tyrosine and phenylalanine but tyrosine content is more than 10 times than phenylalanine, consequently, the intrinsic fluorescence of gelatin mainly comes from tyrosine. Protein structure transforming will change gelatin fluorescence intensity [29]. The fluorescence intensity of gelatin interacted with AgNPs for different times was shown in Figure 2. It was clear that AgNPs inducing caused obvious fluorescence quenching and fluorescence intensity of gelatin decreased with interaction time prolonging but nearly balanced after 60 min.

As there was no change in UV-Vis spectra but fluorescence intensity decreasing, in other words, structure of AgNPs remained but gelatin conformation was affected. It could infer that the interaction was that AgNPs was adsorbed on gelatin surface. This adsorption might alter spatial structure of gelation and led to fluorescence quenching. However, the adsorption interaction was too weak to impact AgNPs particle size and distribution.

Influence of pH on the Interaction between Gelatin and AgNPs

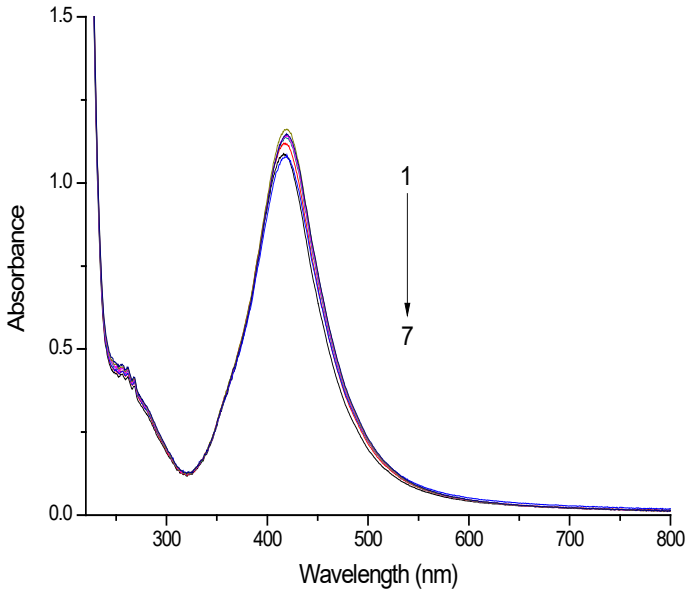

Figure 3. UV-vis spectra of gelatin-AgNPs solution interacted under different pH (1 to 7 representing pH values 9.0, 8.0, 7.0, 6.0, 5.0, 4.0, 3.0)

UV-vis spectra of gelatin-AgNPs solution interacted under different pH (Figure 3) showed lower pH benefited for the interaction between gelatin and AgNPs because smaller absorbance and violet shift was observed during interaction with pH reducing.

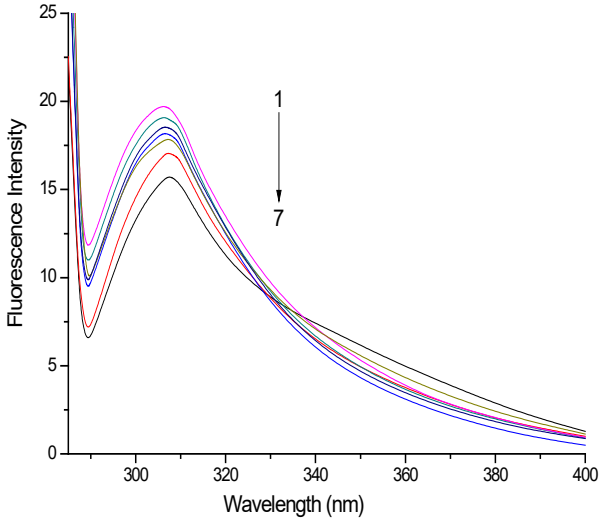

Figure 4. Fluorescence spectra of gelatin-AgNPs solution interacted under different pH (1 to 7 representing pH values 9.0, 8.0, 7.0, 6.0, 5.0, 4.0, 3.0)

Fluorescence intensity of gelatin interacted with AgNPs under different pH was shown in Figure 4, and the results illustrated higher fluorescence intensity of gelatin was obtained under higher interaction pH. The isoelectric point of gelatin used in the study was 9.6 based on experimental measurement, thus protein chain trended to unfolding under high pH. Consequently, more tyrosine residues were exposed to generate more intense fluorescence. Gelatin chains became folding with pH reducing and resulted in fluorescence intensity decreasing on one hand. On the other hand, gelatin folding with pH reducing might promote the absorption interaction and resulted in more tyrosine residues being hidden.

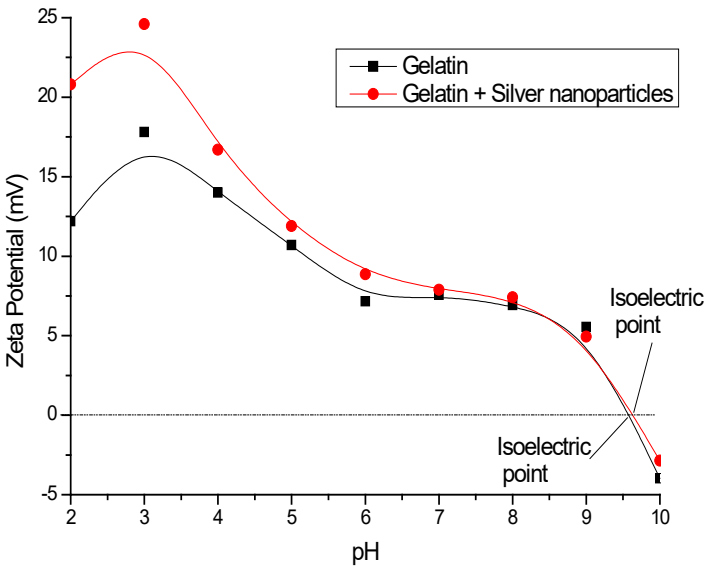

Figure 5. Zeta potential of gelatin-AgNPs solution interacted under different pH

Figure 5 showed Zeta potential of gelatin-AgNPs solution interacted under different pH. In Figure 5, there were two stages, the first one illustrated Zeta potential enlarged from pH range 2 to 3, the second one demonstrated Zeta potential diminished with pH ascending from pH range 3 to 10. Since Zeta potential of AgNPs was positive as cationic surfactant benzalkonium bromide was applied in the preparation procedure, the Zeta potential gelatin-AgNPs was larger than pure gelatin below isoelectric point as AgNPs was absorbed by gelatin. In addition, the differences of Zeta potential between gelatin-AgNPs solution and pure gelatin narrowed down with pH increasing, indicating lower pH facilitating the interaction process. However, much lower pH representing too hydrogen ion would impair colloidal electrical double layers and might have negative effect on system stability, thus the Zeta potential was maximum under pH 3.0.

Furthermore, the Zeta potential of pure gelatin was 0 when pH was 9.6 but it was 9.7 for gelatin-AgNPs solution. That was to say, isoelectric point of gelatin was 9.6 and isoelectric point of gelatin-AgNPs was 9.7. The increasing of protein isoelectric point indicated more basic amino acids remaining in gelatin-AgNPs. It was evidence that AgNPs were mainly absorbed by gelatin acid amino acids.

Influence of Temperature on the Interaction between Gelatin and AgNPs

Fluorescence Quenching Type Classification

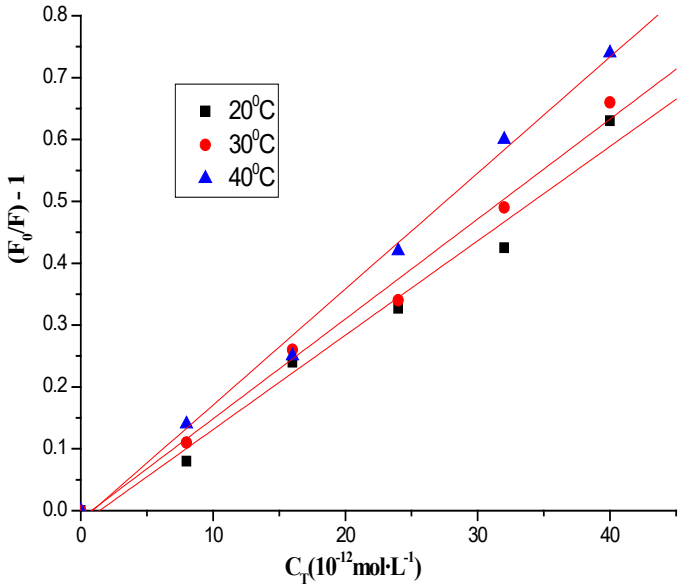

Figure 6. Stern-Volmer relationship between the concentration of AgNPs and fluorescence intensity of gelatin at different temperature

Stern-Volmer relationship between the concentration of AgNPs and fluorescence intensity of gelatin at different temperature was shown in Figure 6, where F_0 and F were the fluorescence intensities of gelatin in absence and presence of AgNPs separately, and C_t was the concentration of the AgNPs in the mixed solution. As shown in Figure 6, more significant fluorescence quenching generated under higher temperature and the slope of each line increased with temperature ascending.

Fluorescence quenching could be divided in to dynamic quenching and static quenching. For both quenching processes, the fluorescence intensity is proportional to the fluorescence quencher concentration. The linear Stern-Volmer equation was [30]:

$$F_0/F = 1 + K_q \tau_0 C_t = 1 + K_{sv} C_t \quad (1)$$

where K_{sv} was the quenching constant and equaled to $K_q \tau_0$, in which K_q was the biomolecular quenching rate constant and τ_0 was the average lifetime of the fluorescent molecules without addition of a quencher. Since dynamic fluorescence depended on diffusion rate, and diffusion rate increased with temperature rising, meaning constant of dynamic quenching (K_{sv}) enlarging with temperature increasing. Therefore, it could conclude the fluorescence quenching of gelatin interacted with AgNPs was dynamic quenching.

Binding Constant and Number of Binding Sites Analysis

The binding constant and the number of binding sites between gelatin and AgNPs could be calculated based on fluorescence intensity changing under different temperature. If there were equal and independent binding sites (n) between gelatin (G) and the fluorescence quenchers AgNPs (S), the quenching reaction between gelatin and AgNPs was as follows:

$$nG + S = G_nS \quad (2)$$

The binding constant K_A was:

$$K_A = C_{GnS} / C_S^n \cdot C_G \quad (3)$$

where C_S= concentration of fluorescence quencher (AgNPs);

C_G= concentration of gelatin;

C_{GnS}= concentration of G_nS.

The fluorescent substance concentration (C_{G0}) was:

$$C_{G0} = C_{SnG} + C_G$$

Then,

$$K_A = C_{G0} - C_G / C_S^n \cdot C_G \quad (4)$$

During the static fluorescence quenching process, the fluorescence intensity is proportional to the concentration of the free fluorescent substance, and the equation is as follows:

$$C_G / C_{G0} = F/F_0 \quad (5)$$

According to (4) and (5),

$$\lg (F0-F)/F = \lg K_A + n \lg C_S \quad (6)$$

The binding constant (K_A) and the number of reaction sites (n) in equation (6) could be calculated from the intercept ($\lg K_A$) and the slope in Figure 7, and the results were shown in Table 1.

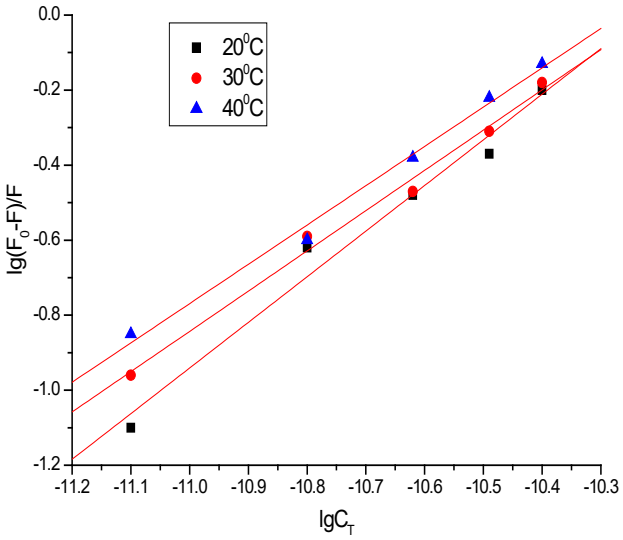

Figure 7. Relationship between the fluorescence intensity of gelatin and the different concentration of AgNPs

Table 1: Number of interaction sites (n) and interaction constants (K_A) at different temperatures

T (°C)	K_A	n
20	2.75×10^{11}	1.22
30	9.15×10^{10}	1.07
40	5.7×10^{10}	1.05

In Table 1, binding ratio of gelatin and AgNPs at different temperatures was about 1:1 and decreased with temperature. The relationship between reaction constant and temperature was negative. K_A decreased from 2.75×10^{11} at 20°C to 5.7×10^{10} at 40°C, indicating the interaction between gelatin and AgNPs was diffusive encounters.

Thermodynamic Functions Calculation

The $\Delta H_m^\ominus$, $\Delta G_m^\ominus$ and $\Delta S_m^\ominus$ could demonstrate the main type of the reaction between gelatin and AgNPs based on Van't Hoff equations.

$$\Delta G_m^\ominus = \Delta H_m^\ominus - T\Delta S_m^\ominus \quad (7)$$

$$\Delta G_m^\ominus = -RT\ln K \quad (8)$$

$$\ln[K_{T2}/K_{T1}] = \Delta H_m^\ominus (T_2-T_1)/RT_1T_2 \quad (9)$$

where T_1, T_2 and T were the temperatures of the reaction, $\Delta H_m^\ominus$ was considered as a constant when the temperature slightly changes. Combining the reaction constants (K_A) from Table 1, $\Delta H_m^\ominus$, $\Delta G_m^\ominus$ and $\Delta S_m^\ominus$ can be calculated by equations (7), (8) and (9), separately. The results were shown in Table 2.

Table 2: Thermodynamic functions of gelatin with AgNPs at different temperatures

T (K)	$\Delta H_m^\ominus$ (kJ/mol)	$\Delta G_m^\ominus$ (kJ/mol)	$\Delta S_m^\ominus$ (J/mol·K)
293	-37.3	-69.7	100.6
303	-37.3	-63.5	86.5
313	-37.3	-64.4	86.6

In Table 2, ΔG_m^{Θ} at each temperature was below zero, showing that the reaction between gelatin and AgNPs was spontaneous. According to the thermodynamic regulation of reaction types [31], the main type of reaction between gelatin and AgNPs was electrostatic interaction.

Influence of AgNPs on Gelatin Structure

FT-IR Results

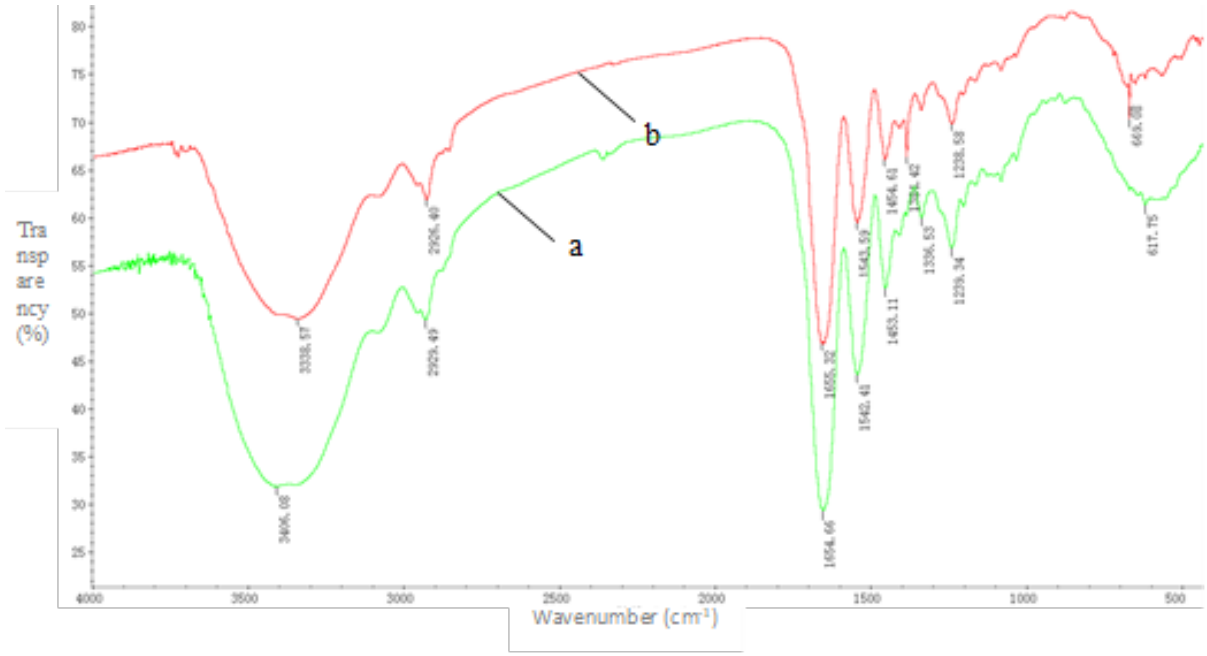

Figure 8. FT-IR image of gelatin interacted with AgNPs (a: pure gelatin, b: after)

The FT-IR image of gelatin interacted with AgNPs was shown in Figure 8. The wavenumber of gelatin-AgNPs at around 1650 cm^{-1} was almost the same as pure gelatin, indicating AgNPs did not impact protein structure during interaction, and the conformation of gelatin was still α helix. However, new peaks emerged at wavenumber at around 1380 cm^{-1} and 669 cm^{-1} after gelatin interacted with AgNPs might be the results that AgNPs reacted with oxygen atom in gelatin through electrostatic interaction.

CONCLUSIONS

When gelatin was blended with nano-silver particle, an interaction was generated but the interaction was weak and no chemical bond was formed. The main type of reaction between gelatin and AgNPs was mainly electrostatic interaction and mainly generated by gelatin acid amino acid. Gelatin could not affect the particle size and distribution of nano-silver, however there was dynamic fluorescence quenching of gelatin under nano-silver particle induced. The longer time and lower pH were beneficial for the interaction between gelatin and nano-silver particle while the interaction balanced after 60 min and pH 3.0 resulted in the most drastic interaction. Moreover, nano-silver would not impair gelatin structure during the interaction process. The results in this work might be a foundation and reference for applying nano-silver in antibacterial leather producing.

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PRODUCTION PLANNING THROUGH LEAN MANUFACTURING AND MIXED INTEGER LINEAR PROGRAMMING

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PRODUCTION PLANNING THROUGH LEAN MANUFACTURING AND MIXED INTEGER LINEAR PROGRAMMING

ABSTRACT. Production planning is one of the most important administrative decisions a company can make, as it involves achieving the lead times set by the customers while taking advantage of the resources the organization has. Over time, different strategies using mathematical models have been implemented in production planning, aimed at finding the best solution for optimizing the available resources. In recent years companies throughout the world have successfullly implemented Lean Manufacturing, aimed at improving their production processes and eliminating everything that does not add value to the product. This article exemplifies a new strategy for production planning, using basic concepts from Lean Manufacturing and mixed integer linear programming models by stages. We took a women's footwear factory in the city of León, Guanajuato, México, as a case study. The results show that it is possible to get planning that optimizes the organization's resources and shortens the products' lead times by shrinking inventories, from a Lean Manufacturing perspective.

KEY WORDS: production planning, lean manufacturing, mixed integer linear programming, footwear factory

PLANIFICAREA PRODUCȚIEI PRIN ADOPTAREA PRODUCȚIEI DE TIP LEAN ȘI A PROGRAMĂRII LINIARE MIXTE ÎN NUMERE ÎNTREGI

REZUMAT. Planificarea producției este una dintre cele mai importante decizii administrative pe care o poate lua o companie, deoarece implică atingerea timpilor de livrare stabiliți de clienți, profitând în același timp de resursele pe care le are organizația. De-a lungul timpului, diferite strategii care utilizează modele matematice au fost implementate în planificarea producției, având ca scop găsirea celei mai bune soluții pentru optimizarea resurselor disponibile. În ultimii ani, companiile din întreaga lume au implementat cu succes producția de tip lean, având ca scop îmbunătățirea proceselor de producție și eliminarea a tot ceea ce nu adaugă valoare produsului. Acest articol exemplifică o nouă strategie pentru planificarea producției, utilizând concepte de bază din producția de tip lean și modele de programare liniară mixtă în numere întregi pe etape. S-a efectuat un studiu de caz implicând o fabrică de încălțăminte pentru femei din orașul León, Guanajuato, México. Rezultatele arată că se poate face o planificare care să optimizeze resursele organizației și să reducă termenele de livrare ale produselor prin reducerea stocurilor, din perspectiva producției de tip lean.

CUVINTE CHEIE: planificarea producției, producție de tip lean, programare liniară mixtă în numere întregi, fabrică de încălțăminte

PLANIFICATION DE LA PRODUCTION EN ADOPTANT LA PRODUCTION AU PLUS JUSTE ET LA PROGRAMMATION LINÉAIRE MIXTE EN NOMBRES ENTIERS

RÉSUMÉ. La planification de la production est l'une des décisions administratives les plus importantes qu'une entreprise puisse prendre car elle implique de respecter les délais de livraison fixés par les clients, tout en tirant parti des ressources dont dispose l'organisation. Au fil du temps, diverses stratégies utilisant des modèles mathématiques ont été mises en œuvre dans la planification de la production, dans le but de trouver la meilleure solution pour optimiser les ressources disponibles. Ces dernières années, des entreprises du monde entier ont mis en œuvre avec succès une production au plus juste, visant à améliorer les processus de production et à éliminer tout ce qui n'ajoute pas de valeur au produit. Cet article illustre une nouvelle stratégie de planification de la production, utilisant des concepts de production au plus juste et des modèles de programmation linéaire mixte en nombres entiers par étapes. Une étude de cas a été menée sur une fabrique de chaussures pour femmes à León, Guanajuato, Mexique. Les résultats montrent que la planification peut être effectuée pour optimiser les ressources de l'organisation et réduire les délais de livraison des produits en réduisant les stocks, du point de vue de la production au plus juste.

MOTS CLÉS : planification de la production, production au plus juste, programmation linéaire mixte en nombres entiers, fabrique de chaussures

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INTRODUCTION

Production planning is a problem that manufacturing companies worldwide have. Its purpose is to choose the best alternative for attending to customers' orders, while considering the resources available within the organization.

Over time, different strategies using mathematical models have been implemented in production planning, aimed at finding the best solution for optimizing the available resources. These types of problems are classified as NP-Hard [1] because of their computational complexity.

The first studies used deterministic linear programming models [2-7]. However recent authors have developed mixed integer linear programming models for solve this problem [8-11].

In another vein, some authors have opted for hybrid algorithms, that combine linear programming and simulation models in the search for the best solution [12-22].

Another approach is the use of stochastic models that consider event probabilities in planning [23-29].

Robust optimization models have also been developed that consider uncertain parameters for the problem [30-36].

Over the last few years, a significant number of companies have opted for the implementation of the Lean Manufacturing approach, to improve their production processes and generate higher profits, by eliminating or reducing everything that, without adding any value to the products, adds cost and work [37]. This has made it necessary to consider planning with a different approach, such as product families in work cells or production lines, creating flexible processes with continuous operations.

The main contribution of this study is a new strategy that permits production to be planned over three stages, with it distinguishing itself from the aforementioned papers by the combination of mixed integer linear programming models with the basic concepts of Lean Manufacturing. We considered a women's footwear factory for a case study. The document is limited to the analysis of the problems faced by footwear companies in the city of León Guanajuato, Mexico. The analysis consider restrictions on demand, time, budget, machinery, personnel and available space for inventory.

The implementation of Lean Manufacturing in footwear manufacturing companies has been documented in different studies reported in the literature [38-43]. However unlike these, in this article we detail the production planning.

The rest of this document is organized as follows: First we describe the case study. Then we give a step-by-step breakdown of the proposed strategy in the search for a solution and the mathematical models developed in each stage appear. Next we show the experimentation as well as the results achieved in the fulfillment of objectives. Lastly, we give the conclusions of our research.

CASE STUDY

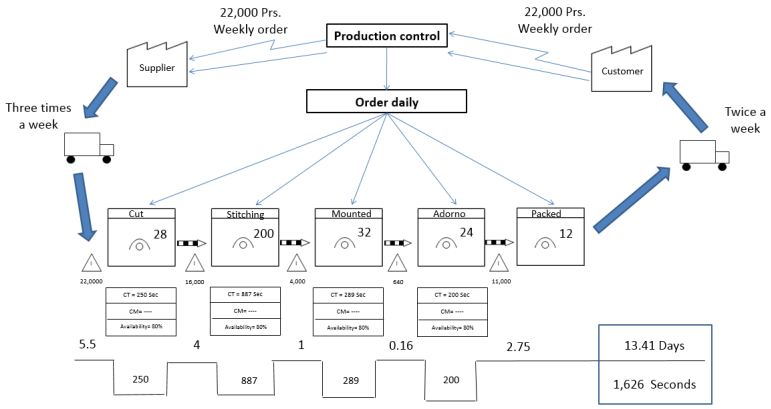
The leather Industry is the main economic motor of the city of León, Guanajuato, México. The quality of the products largely depends on the qualified personnel that organizations have in the production area. The constant changes of product with each new season (Spring-Summer and Fall-Winter) together with customer demand require frequent adjustments to the operations personnel, which in turn makes it hard to plan production in these companies.

The most complex process in footwear manufacturing is in the stitching (or seam) department because of the variation to be found in the assembly of the products and the different jobs involved. This department is considered to be the bottleneck of the manufacturing process. Large batches are commonly handled and the operations of the different work stations are isolated, without following a continuous flow. A lot of the companies use outside manufacturers, known as maquiladoras, in order to be able to produce the customers' orders on time.

We took as a case study a women's footwear factory that is just starting to implement Lean Manufacturing concepts. It normally works an eight-hour day from Monday to Friday with half-days on Saturday, producing an average of 22,000 pairs of shoes a week for customers in México and abroad.

Figure 1 details the initial value stream mapping drawn up before starting the planning strategy. As can be observed the stitching department in production has the biggest inventory, increasing the lead time of the products.

Production planning in this company, as in the majority of the footwear factories in the region, focuses on what the stitching department can do. A large part of the inventory generated therein corresponds to the poor planning of workloads on the part of the management, who do the planning empirically from week-to-week, investing a lot of time and effort without getting any efficient results.



Weekly demand	22,000
Working days	5.5
Daily demand	4,000
Working hours	8
Tack time (seconds)	7.2

Time adding value in seconds	1,626
Time adding value in days	0.056458
Time that doesn't add value in days	13.410
Lead Time in days	**13.466**
% Time adding value	**0.419%**
% Time that doesn't add value	**99.581%**

Figure 1. Value stream mapping of the company

STAGED STRATEGY FOR PRODUCTION PLANNING

The production planning proposed in this study is done in stages. It starts by defining the workers that need to be hired every month to meet the customers' demand, considering the company's resources. Then we proceed to assign the products to be manufactured on the production lines, taking into account their export quality and construction family. Lastly, the day and quantity in which each of them will be manufactured is established in accordance with the personnel's historical performance in the company (see Figure 2).

Mixed integer linear programming mathematical models are established in every stage and solved sequentially. The described strategy was applied to the stitching department of the case study.

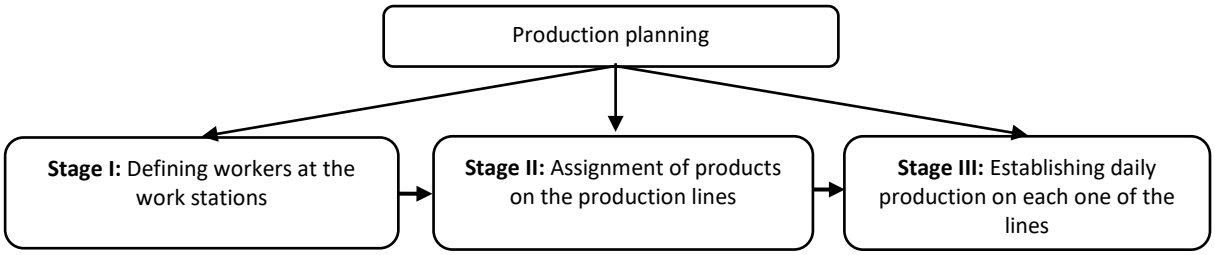


Figure 2. Three-stage production planning

Notation Employed in the Development of the Mathematical Models

Sets

I Work stations I={work station$_1$, work station$_2$,..., work station$_{|I|}$} .

J Products j={Product$_1$, Product$_2$,..., Product$_{|J|}$}.

K Production lines k={ Line$_1$, Line$_2$,..., Line$_{|k|}$} .

D Days D={Monday, Tuesday, Wednesday, Thursday, Friday, Saturday}.

Indexes

i Work station i ϵ I.

j Product j ϵ J.

k Production line k ϵ K.

d Day d ϵ D.

Subsets

$I_1 \subset I$ Work stations with sewing machines

I_1={work station1, work station$_2$,..., work station$_{|c|}$}.

$I_2 \subset I$ Work stations without sewing machines

I_2={work station$_{c+1}$,..., work station$_{|I|}$}.

$I = I_1 \cup I_2$

Integer variables

x_i = Number of workers to hire per work station i.

y_{jk}= Number of pairs of product j to be manufactured on the production line k.

z_{jd}= Number of pairs of product j to be manufactured on day d.

Binary variables

W_{jk}= Auxiliary binary variable to establish product j to be manufactured on production line *k*.

W_{jd}= Auxiliary binary variable to establish product j to be manufactured on day d.

Coefficients of the objective function

α_i = Rating work station i.

β_{jk}= Compatibility of product j with the production line k.

δ_j= Product quality j.

λ_d= Performance rating for the workers on each day d of the week.

Parameters

Available machinery$_i$ = Machinery available for each work station *i*.

a_i= Weekly base salary at each work station i.

Workers required by work station$_i$= Workers needed in each work station *i* to manufacture the products demanded by customers.

Minimum of Workers per work station$_i$= Minimum number of workers to be hired at each work station *i*.

Budget = Economic resource available for the payment of weekly wages.

Demand$_j$= Number of pairs to produce of product j required by customers.

Manufacturing time$_{ij}$= Standard operating times of work station i by product *j*.

Weekly minutes of the work *station$_i$*= Minutes available to manufacture products per work station *i* in the company weekly.

$$Weekly\ minutes\ of\ the\ work\ station_i = Number\ of\ workers_i * Working\ day\ minutes * Manufacturing\ days * OEE \quad (1)$$

Daily minutes of the work station$_i$ = Minutes available to manufacture products per work station *i* in the company daily.

$$Daily\ minutes\ of\ the\ work\ station_i = Number\ of\ workers_i * Working\ day\ minutes * OEE \quad (2)$$

Space sewing machines$_{ik}$= Space available for the installation of sewing machines per work station *i* in each production line *k*.

Space machines$_{ik}$= Space available for the installation of machinery or equipment per work station *i* in each production line *k*.

Weekly schedule$_j$ = Weekly programming of products to be manufactured *j*.

STAGE I: DEFINING WORKERS AT THE WORK STATIONS

In this first stage we define the workers that need to be hired every month (or four weeks) to meet customer demand.

The process starts by estimating the workers needed at each work station every week. For this we use equation (3), that considers the total minutes needed for the manufacture of the different products, as well as the OEE (Overall Equipment Effectiveness) indicator for the total effectiveness of the equipment, used in Lean Manufacturing [37].

$$\forall\, i \in I \quad Estimated\ workers\ per\ week\ at\ each\ work\ station_i = \frac{\sum_{j=1}^{J} Demand_j * Manufacturing\ time_{ij}}{Manufacturing\ days * Working\ day\ minutes\ * OEE} \tag{3}$$

Each week, every station has different personnel requirements, so we propose to find the weighted average of these results through equation (4), seeking a balance during the month. The biggest values shall have the highest weighting.

$$\forall\, i \in I\ \ Weighted\ average_i = (workers\ 1 * 0.4) + (workers\ 2 * 0.4) + (workers\ \ 3 * 0.1) + (workers\ \ 4 * 0.1) \tag{4}$$

The decision-maker determines the number workers required by each work station by rounding up or down the value obtained in equation (4). The decision-maker is also responsible for rating work stations α_i in the order of their importance in the manufacture of the products using a range of values going from five as the most important to three as the least critical for the process. Once defined, they are substituted in the mathematical model of the first stage. Said model prioritizes hiring workers for work stations that are critical for the manufacture of the products.

Mathematical Model 1- Production Workers

$$Maximize\ \ F = \sum_{i=1}^{I} \alpha_i\, x_i \tag{5}$$

Subject to: (6)

$$x_i \leq Available\ machinery_i \quad \forall\, i \in I \tag{7}$$

$$x_i \leq Workers\ required\ by\ work\ station_i \quad \forall\, i \in I$$

$$x_i \geq Minimum\ of\ workers\ per\ work\ station_i \quad \forall\, i \in I \tag{8}$$

$$\sum_{i=1}^{I} a_i\, x_i \leq Budget \tag{9}$$

$$x_i \in \mathbb{R}^+ \tag{10}$$

Objective function (5) seeks to maximize the hiring of personnel at work stations that are critical for the manufacture of the products.

The constraints, for their part, are:

(6) The personnel hired should not exceed the available machinery.

(7) No more personnel should be hired than are required to meet customer demand.

(8) The minimum number of personnel per work station, as established by the decision-maker, should be hired.

(9) The weekly wages budget should not be exceeded.

STAGE II: ASSIGNMENT OF PRODUCTS ON THE PRODUCTION LINES

Before starting this stage, the production lines that will work in a continuous flow per product family will have to have been designed, in accordance with the operations and work stations involved.

This stage is divided into two parts. First the products to be manufactured every week on each production line are established, considering their export quality and construction family with the use of a mathematical model. Then the operations personnel are distributed on each line.

The aim of the mathematical model is to assign the products that are more compatible with the production line according to their construction family (see Figure 3), with the aim of reducing the variability of the process (Mura), considered to be one of the limitations of Lean Manufacturing production [37]. This also prioritizes the manufacture of export quality products in the company and considers the maquila of products for domestic consumption when so required.

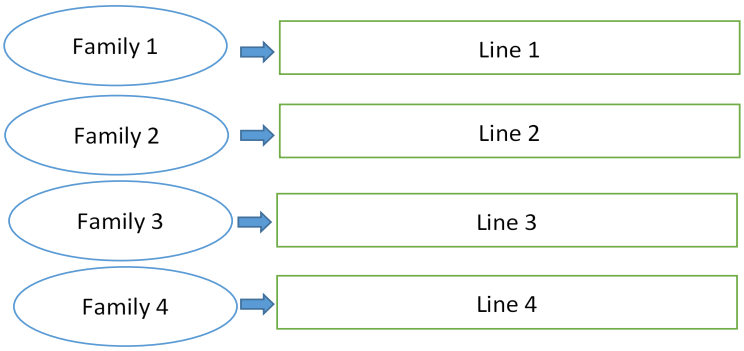


Figure 3. Construction family-production line

Coefficients β_{jk} weight the degree of compatibility of each product *j* with production line *k*, in accordance with their construction family, considering the value of five as high, the value of four as medium, the value of three as low and minus one for when it is not compatible. Values δ_j define the quality of the product, considering the value of two for export and one for national customers. Coefficients β_{jk} and the values of δ_j are established by the decision-maker. The mathematical model used in this stage is detailed below:

Mathematical Model 2- Product - Production Line

$$Maximize\ F = \sum_{j=1}^{J}\sum_{k=1}^{K} \beta_{jk}\ y_{jk}\ w_{jk} + \sum_{j=1}^{J}\sum_{k=1}^{K} \delta_j\ y_{jk}\ w_{jk} - \sum_{j=1}^{J}\sum_{k=1}^{K} 3\ w_{jk} \quad (11)$$

Subject to:

$$\sum_{k=1}^{K} y_{jk} \leq Demand_j \quad \forall\, j \in J \quad (12)$$

$$\sum_{j=1}^{J}\sum_{K=1}^{K} Manufacturing\ time_{ij}\ y_{jk} \leq Weekly\ minutes\ of\ the\ work\ station_i \quad \forall\, i \in I \quad (13)$$

$$\frac{\sum_{j=1}^{J} Manufacturing\ time_{ij} * y_{jk}}{Manufacturing\ days * Working\ day\ minutes\ * OEE} \leq Space\ sewing\ machines_{ik} \quad \forall\, i \in I_1, \forall\, k \in K \quad (14)$$

$$\frac{\sum_{j=1}^{J} Manufacturing\ time_{ij} * y_{jk}}{Manufacturing\ days * Working\ day\ minutes\ * OEE} \leq Space\ machines_{ik} \quad \forall\, i \in I_2, \forall\, k \in K \quad (15)$$

$$y_{jk} \in \mathbb{R}^{+} \quad (16)$$

$$w_{jk} \in \{0,1\} \quad (17)$$

Objective function (11) seeks to maximize the compatibility of each product with the production line as well as prioritizing the manufacture of export quality products within the company. It also penalizes the scheduling of different products on each line.

The constraints, for their part, are:

- (12) No more products should be produced than those needed to meet customer demand.
- (13) No more products are scheduled than the company can produce with the personnel hired in the jobs (defined in stage I).
- (14) Avoid scheduling more products per line than the space available for sewing machines required at the work stations.
- (15) Avoid scheduling more products per line than the space available for other equipment or machines required at the work stations.

Distribution of the Workers on Each Line

Once it has been established which products are to be manufactured every week, the number of workers to work on each one of the lines is determined with the help of equation (18):

$$\forall\, i \in I\,, \forall\, k \in K \quad Workers_{ik} = \frac{\sum_{j=1}^{J} Manufacturing\ time_{ij} * y_{jk}}{Manufacturing\ days * Working\ day\ minutes * OEE} \tag{18}$$

Lastly, the decision-maker makes adjustment to the personnel according to their criterion and experience.

STAGE III: ESTABLISHING DAILY PRODUCTION ON EACH ONE OF THE LINES

During this last stage, we establish the order and quantity of products to be manufactured on each day of the week, per production line.

The aim of the mathematical model is to distribute workloads to days of the week, in accordance with the historical performance of the workers in the company. This avoids the existence of an overburden of work (*Muri*) at each work station that, in Lean Manufacturing, is considered to be another one of the limitations on productivity [37]. It also seeks to lower the number of different products to be manufactured per day, simplifying variability (*Mura*) in the process.

Coefficients λ_d of the model establish a performance rating for the workers on each day of the week. For the case study, the value of six is assigned to Tuesdays and Wednesdays as the most productive days, five to Mondays and Thursdays, four to Fridays and three to Saturdays as the least productive. Coefficients λ_d, help to assign the heaviest workloads to the most productive days of the week, leaving the remaining days for closing the production schedule. The mathematical model employed in this stage is given below:

Mathematical Model 3- Daily Production on the Line

$$Maximize\ F = \sum_{j=1}^{J}\sum_{d=1}^{D} \lambda_d\ z_{jd}\ w_{jd} - \sum_{j=1}^{J}\sum_{d=1}^{D} 3\ w_{jd} \tag{19}$$

Subject to:

$$\sum_{d=1}^{D} z_{jd} \leq Weekly\ schedule_j \quad \forall\, j \in J \tag{20}$$

$$\sum_{j=1}^{J} Manufacturing\ time_{ij}\ z_{jd} \leq Daily\ minutes\ of\ the\ work\ station_i \quad \forall\, i \in I,\ \forall\, d \in D \tag{21}$$

$$z_{jd} \in \mathbb{R}^{+} \tag{22}$$

$$w_{jd} \in \{0,1\} \tag{23}$$

The objective function (19) seeks to maximizes the workload on the production line on each day of the week as per the historical performance, while also penalizing the scheduling of different products per day.

The constraints, for their part, are:

- (20) The weekly schedule on the production line, generated in stage II, should not be exceeded.
- (21) No more products should be scheduled then the production line can produce with the workers available at the work stations.

EXPERIMENTATION

For the experiment, we considered for the case study the planning for four weeks of the spring-summer season, which is characterized by the production of two types of footwear; flats and sandals. The factory has planned to produce 42 different products during this season.

Four production lines were created in the stitching department. Each one of these was designed based on a construction family for the

different products to be manufactured in the season. Table 1 shows the lines and construction families, as well as the products according to each family.

Table 1: Product families by production line

Line-Family	Line 1 Flats	Line 2 Sandal 1	Line 3 Sandal 2	Line 4 Sandal 3
Products	P-01	S1-01	S2-01	S3-01
	P-02	S1-02	S2-02	S3-02
	V-01	S1-03	S2-03	S3-03
	V-02	S1-04	S2-04	S3-04
	V-03	S1-05	S2-05	S3-05
	V-04	S1-06	S2-06	S3-06
	V-05	S1-07	S2-07	S3-07
	V-06	S1-08	S2-08	S3-08
	V-07	S1-09	S2-09	
	V-08	S1-10	S2-10	
		S1-11	S2-11	
		S1-12		
		S1-13		

Customer demand (in pairs of shoes) is broken down in Table 2, where the level of quality required in the products can be appreciated; the value of two for export and one for the domestic market. 21 Different products are demanded during this month.

Table 2: Demand of the month

Nº	Product	Quality	Week 1	Quality	Week 2	Quality	Week 3	Quality	Week 4
1	P-01	1	1,500	2	2,500	1	1,250	1	3,200
2	P-02	1	500					1	1,000
3	S1-01	1	1,500	1	1,000			1	1,200
4	S1-02	2	3,000			1	1,500	1	3,000
5	S1-03	1	2,000	1	3,600				
6	S1-08	1	1,000			1	2,500		
7	S2-01	2	2,000	1	1,000			1	1,000
8	S2-04	1	1,200	1	1,000	1	2,800	2	1,200
9	S2-05	2	1,000	1	1,500	1	3,000	1	1,200
10	S2-06							1	4,000
11	S2-07	1	1,800	1	1,100	2	1,600		
12	S3-01	1	2,000	1	1,200	1	1,000	2	1,000
13	S3-02	1	550			1	2,500	1	800
14	S3-03			2	1,000	1	2,500	1	1,800
15	S3-04	1	1,000	1	2,000	1	1,280	1	250
16	S3-07			1	1,000				
17	S3-08							1	1,000
18	V-01	1	2,000	1	2,000	2	1,000	2	1,000
19	V-05			2	500	1	500		
20	V-06					1	500	1	1,000
21	V-08			1	1,650	2	1,500		
Total pairs			21,050		21,050		23,430		22,650

The company has a weekly payroll of $350,000 pesos. Salaries and the machinery or equipment limitations are given in Table 3. A total effectiveness of the equipment or OEE of 60% for production planning was also considered.

The standard operating times in minutes per pair for each work station in the manufacture of the different products are given in Table 4.

Table 3: Weekly salaries and machinery available per workstation

Work station	Weekly salary per worker	Machinery or equipment available
1	$2,200	74
2	$2,200	6
3	$1,400	90
4	$1,500	2
5	$1,400	16
6	$1,700	16
7	$1,500	6
8	$1,400	2
9	$1,700	3

Table 4: Standard operating times in minutes per pair of products

Nº	Product	Work station								
		1	2	3	4	5	6	7	8	9
1	P-01	1.80		3.15	0.43	0.42	0.50			
2	P-02	4.27	1.71	5.04	0.90	1.54			0.23	1.49
3	S1-01	5.07		7.42		1.33	1.00	0.52		
4	S1-02	4.58		3.73		1.75	1.38	0.25		
5	S1-03	6.33		8.73		2.00	1.42	1.60		
6	S1-08	3.83		1.88		1.07	1.00			
7	S2-01	4.08		4.73		0.67	0.67	0.27		
8	S2-04	4.25		4.53		0.92	1.08	0.25		
9	S2-05	3.30		4.35		0.42	0.92	0.25		
10	S2-06	3.38		2.90		0.42	0.92	0.25		
11	S2-07	4.33		3.83		0.83	0.75	0.25		
12	S3-01	8.62		23.05		4.63	0.97		0.23	
13	S3-02	4.62		4.77		0.67	1.52	0.33		
14	S3-03	9.28		11.48		1.92	2.17	1.40		
15	S3-04	13.43		8.38		1.50	4.08	1.58	0.23	
16	S3-07	7.63		9.22		2.58	2.33	1.75		
17	S3-08	3.85		3.95		1.47	1.55	0.27		
18	V-01	2.88		2.11					0.26	0.63
19	V-05	5.18	1.03	3.63		0.70	0.73	0.28	0.23	
20	V-06	6.15	2.82	3.33		0.75	0.93	0.28	0.23	
21	V-08	6.27	2.17	3.38		0.75	1.02	0.28	0.23	

We used a computer with an Intel Celeron processor of 2.16-GHz N2840 CPU and 4 GB of RAM, together with the Windows 10 Home operating system for the generation going to the solutions in each stage. The data matrices were programmed in Excel, which was linked to LINGO 17 software where we captured the mathematical models and solved them using the exact branch and bound technique. The runtime is reasonable and was not a variable to be considered in our case.

RESULTS AND DISCUSSIONS

Table 5 shows the estimated workers per work station required to satisfy the weekly demand, as well as the result obtained in stage I. It must be pointed out that personnel requirements often change, with it being unsuitable for the

company to be constantly hiring and firing workers. The strategy being proposed in this study tries to generate a balanced solution for the operations personnel to be employed each month, considering the company's limitations. With the solution we obtained, we get a weekly payroll worth $349,500 pesos, within the budget limit.

Table 5: Estimated operators vs Workers to hire (Stage I)

Work station	Estimated workers per week				Stage I workers to hire
	1	2	3	4	
1	66.93	77.80	79.52	64.27	71
2	0.54	2.58	3.27	2.86	3
3	86.11	90.59	82.83	76.54	87
4	0.69	0.68	0.34	1.44	1
5	18.43	17.26	16.30	15.70	16
6	13.88	17.15	18.90	14.69	16
7	5.07	9.07	5.87	4.40	6
8	0.85	1.12	0.87	0.64	1
9	1.26	0.79	0.39	1.34	2
Total	193.76	217.05	208.29	181.87	203

The results of stage II are given in Table 6 and Figure 4.

Table 6 illustrates the assignment of products to be manufactured on each production line. Because of the conditions of the problem, it is impossible to plan the manufacture of all the products of the stitching department within the company, so some of them are outsourced to maquiladoras.

Most of the products to be manufactured were highly compatible with the production line, as per their construction family (see Figure 4), thus fulfilling one of the most important objectives of stage II.

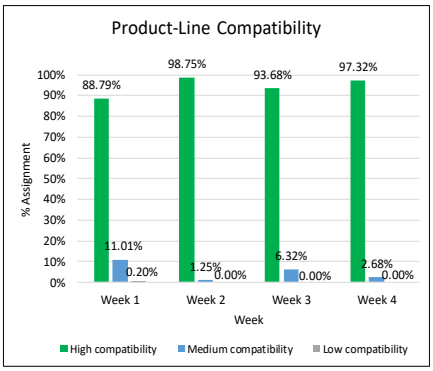


Figure 4. Product-Line Compatibility

The results of stage III in the daily production planning on each line are summarized in the graphs of Figure 5-9.

More pairs were scheduled for the most productive days (Mondays to Thursdays) of each week, as can be appreciated in the graphs of Figure 5-8, leaving Fridays and Saturdays for closing the production schedules.

The average number of different products to be produced on each line every day during the month is given in Figure 9. With the strategy implemented, there are few product changes and small production batches of 12 pairs were handled.

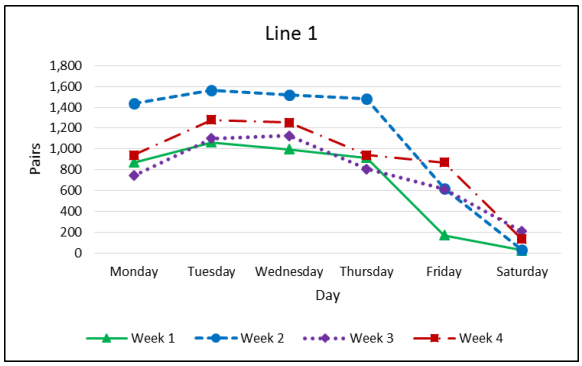


Figure 5. Pairs - Day line 1

Table 6: Stage II Results: Product-Production Line

Nº	Product	Week 1				Week 2				Week 3				Week 4			
		Line 1	Line 2	Line 3	Line 4	Line 1	Line 2	Line 3	Line 4	Line 1	Line 2	Line 3	Line 4	Line 1	Line 2	Line 3	Line 4
1	P-01	1,500				2,500				1,250				3,200			
2	P-02	500												219			
3	S1-01		1,500				1,000								1,200		
4	S1-02		2,773	227							1,500				3,000		
5	S1-03			1,586	413		2,646										
6	S1-08		1,000								2,500						
7	S2-01			2,000				1,000								1,000	
8	S2-04			1,200				1,000				2,800				1,200	
9	S2-05			1,000				1,500				3,000				1,200	
10	S2-06															4,000	
11	S2-07			1,800				1,100				1,600					
12	S3-01	41			1,128			227	973		138	174	688		220	311	469
13	S3-02				550								2,500				800
14	S3-03								1,000		902		1,598				1,800
15	S3-04				1,000				996			188			33	21	196
16	S3-07																
17	S3-08																1,000
18	V-01	2,000				2,000				1,000				1,000			
19	V-05					500				500							
20	V-06									349				1,000			
21	V-08					1,650				1,500							
	Total pairs per line	4,041	5,273	7,813	3,091	6,650	3,646	4,827	2,969	4,599	5,040	7,762	4,786	5,419	4,453	7,732	4,265
	Total pairs per week		20,218				18,092				22,187				21,869		
	Unscheduled pairs (destined for maquila)		832				2,958				1,243				781		

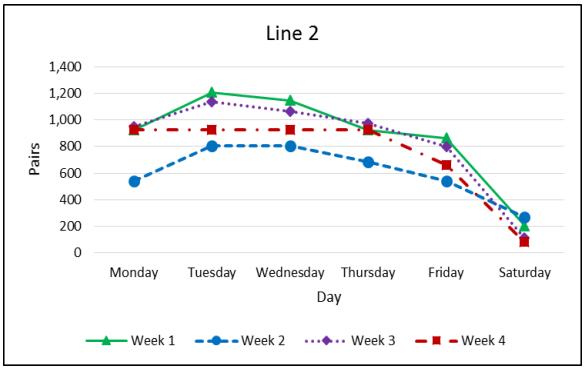


Figure 6. Pairs - Day line 2

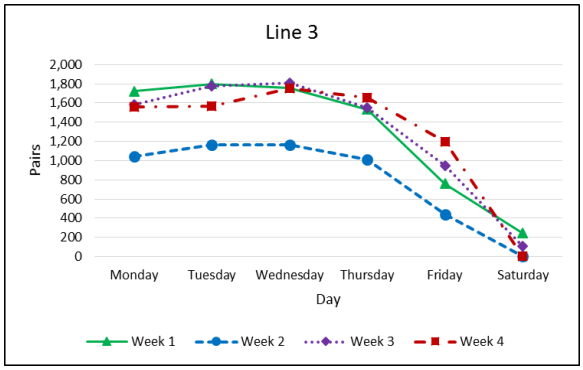


Figure 7. Pairs - Day line 3

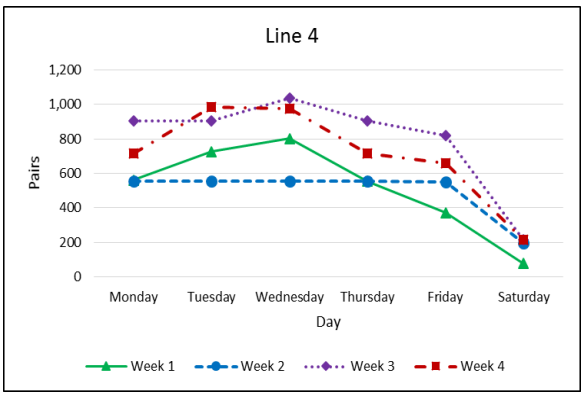


Figure 8. Pairs - Day line 4

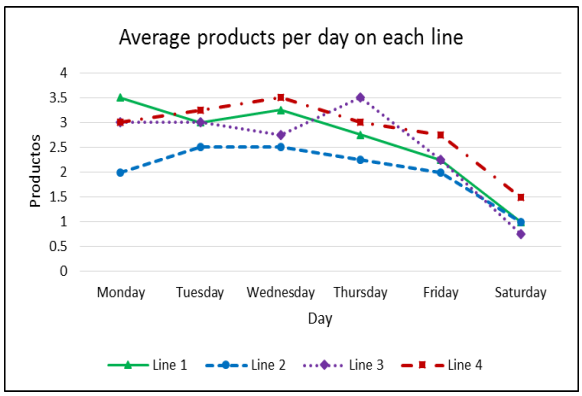
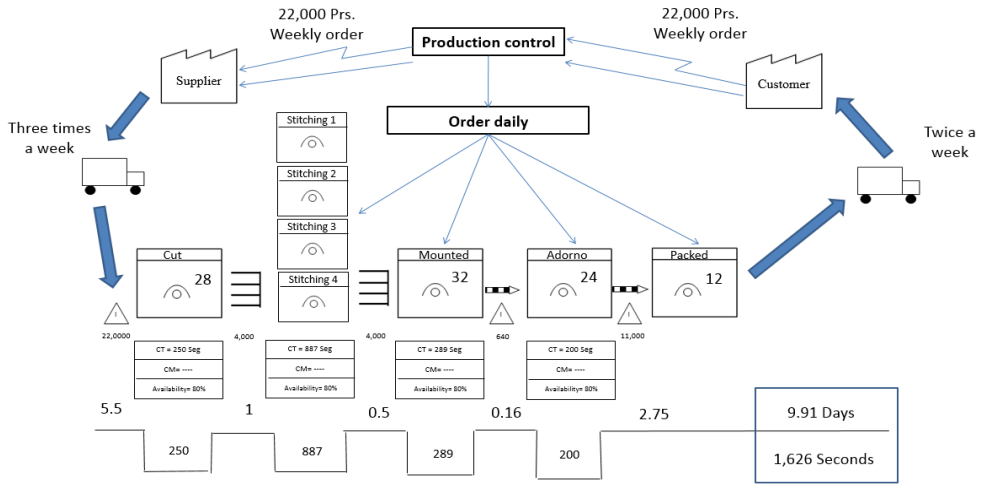


Figure 9. Average products per day on each line

Figure 10 shows the value map generated when the strategy described in this study is applied, considering four production lines in the stitching department.

The most important results include reductions in: 1) the size of the batch in production, 2) the number of defective pairs, 3) inventory in the stitching department, 4) the lead time and 5) the time that does not add value to the products (see Table 7), thus fighting waste (*Muda*), which is the last limitation on productivity considered in Lean Manufacturing [37].



Weekly demand	22,000
Working days	5.5
Daily demand	4,000
Working hours	8
Tack time (seconds)	7.2

Time adding value in seconds	1,626
Time adding value in days	0.056458
Time that doesn't add value in days	9.910
Lead Time in days	**9.966**
% Time adding value	**0.566%**
% Time that doesn't add value	**99.434%**

Figure 10. Value stream mapping of the company after the staged strategy

Table 7: Benefits generated by the staged strategy in production planning

Concept	Before the staged strategy	After the staged strategy	% Reduction
Size of the batch (Pairs)	60	12	80%
Number of defective pairs in the stitching daily	300	150	50%
inventory in the stitching department (days)	4	1	75.00%
Lead time (days)	13.466	9.966	25.99%
Time that does not add value (days)	13.41	9.91	26.10%

CONCLUSIONS

The fundamental contribution of this study is a new strategy for production planning, using basic concepts of Lean Manufacturing and mixed integer linear programming by stages.

This strategy primarily considered the definition of the workers per work station, followed by the assignment of products on production lines and lastly, the establishment of the daily workloads on each line.

We used a footwear factory in the city of León Guanajuato, México as a case of application to exemplify the process involved with the analysis, mathematical modeling and solution. This administrative problem is normally solved by trial and error, which takes up a great deal of the administrative personnel's time. However, the proposal developed in this study now makes it possible to standardize this process and facilitate the work involved in planning.

This study deals with a problem faced by most of the region's footwear companies. This demonstrated that it is possible to generate solutions where the company's resources are optimized, by decreasing the work-in-process inventory, defective products, the time that does not add value and, mainly, the lead time required to deliver the products to the customer by up to 25.99%, by dealing with the limitations on productivity (*Muri, Mura and Muda*) considered in Lean Manufacturing.

The proposal described in this article can be adopted by other companies that are starting to apply Lean Manufacturing, particularly if they form part of the footwear manufacturing industry. For future research it would by interesting to study the impact of this strategy on the analysis of other manufacturing industries. Stochastic programming or fuzzy programming could also be used with uncertain parameters of the problem.

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We would like to thank the Consejo Nacional de Ciencia y Tecnología (Mexican Council of Science and Technology - CONACYT) for financing this research, under the Unique Resumé registration number: 375569 and the Tecnológico Nacional de México/ IT de Celaya, for the support it has provided.

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EUROPEAN RESEARCH AREA

COTANCE NEWSLETTERS

Starting with January 2019, the COTANCE Council will issue a monthly ***COTANCE Newsletter*** with the purpose of **promoting an improved image of leather** to relevant decision makers and domestic stakeholders including Members of the European and National Parliament, Governmental authorities, Ministerial officers, Customers of the leather industry, Brands, Retail chains, Relevant NGOs, Designers, etc. The monthly newsletters present topics that tell the truth about a controversial aspect or a fact that is not well known by the general public to bring about a better understanding of leather and the European leather industry, as well as a positive predisposition to legislate in favor of the leather industry. The newsletters are available in seven languages at https://www.euroleather.com/index.php/newsletter, and were also published in the 2019 and 2020 issues of *Leather and Footwear Journal*. Newsletters 1-3 of 2021 are given below.

NEWS 1/2021

Vintage is cool!

When you think about leather, long lasting items that go from one generation to the next come to mind. One day you go up to the attic in your grandfather's house and you find a leather briefcase. Once cleaned and restored, it looks as good as new!

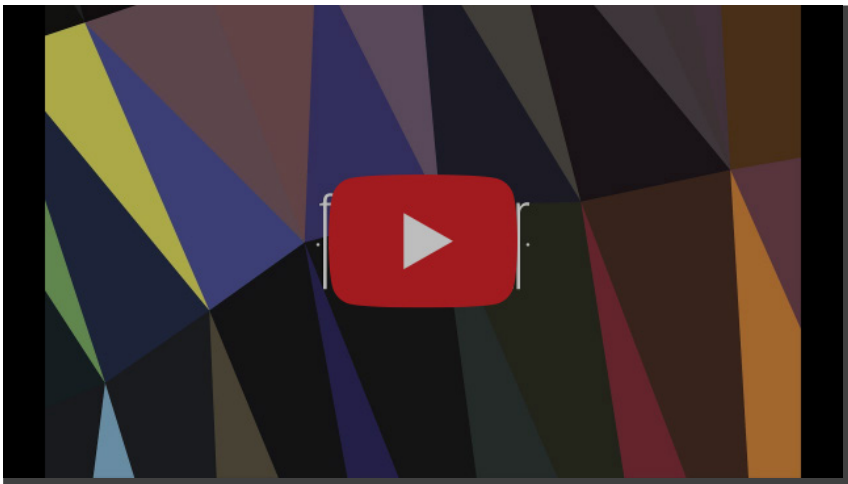
This highlights one essential quality of leather: it ages well.

However, while the vintage leather briefcase looks great, it has no place to store your smartphone nor zippers, and you don't know if you want to use it without those modern additions. Well, that's when design comes along!

Leather is the perfect material for slow fashion and today we produce the articles that will become “vintage” in future generations.

Designers and stylists love leather and they constantly reinvent it. They have learnt how to take advantage of the wonderful properties of leather, and in particular of the ‘aura of eternity’ that will make it vintage with time. Leather creations combine the most modern design trends with the perpetuity of leather.

Leading leather industry organisations in Europe support designers and stylists with trend selections. In a constructive dialogue between stylists and tanners major trends are identified ahead of time to help designers and manufacturers in the production of articles that will fit well with the Zeitgeist.



Take a look at the presentation of the Trend Book and Collection Fall - Winter 2021–2022.

Following similar initiatives in Italy, France, Spain and other countries, the PT Leather InDesign in Portugal has been promoting leather as a material for designers for the last 4 years with very interesting results.

Are you active in fashion, design and style? Why don’t you have a look at this 10’ video where internationally renowned stylist Joao Carvalho presents the Trend Book and Collection Fall - Winter 2021 – 2022.

The above Trendbook is also available online for designers to use as an inspiration and a tool for their product creations.

Yes… leather is a cool and modern material that one day future generations will discover as vintage!

edited by

COTANCE

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APIC

NEWS 2/2021

Leather is not boring!

Uninformed consumers seeking new, trendy products are quick to confine leather to its most traditional applications: footwear, clothing, accessories. They tend to take a **reductive view** limited to its best-known qualities - finesse, durability, and patina – in their haste to embrace new “alternative” materials lauded in the Media as “green”.

While there is no disputing the **unmistakable qualitative advantages that make leather a classic choice** for these traditional uses, its applications are constantly evolving and surprising. Ever more **efficient and astonishing innovations** mean leather can be used in almost all areas of everyday/modern life. No other traditional material has lent itself to such extensive renewal, integrating technology into the heart of production.

Thanks to R&D, today's leather can be conductive, tactile, washable, stretchy, flame-retardant, water-repellent, anti-UV or reflective, meeting most of the needs of modern life. The tanning industry is constantly working on new technological developments.

These innovations have introduced **new possibilities**, particularly when it comes to using this material **for interior decoration and furnishings**. It is now possible to produce leathers that can endure almost any environment thanks to specific treatments that make them suitable for use in most areas of the home: as a floor or wall covering, in furniture and for decorative objects. We can even opt for **weather-resistant garden furniture** made from leather.

For clothing, leather can now be **machine washed**, and be made as soft and comfortable as cotton through **stretch technology**. It can also be worn in summer thanks to **anti-UV treatment**. Gloves can now be made from **tactile leather** for easy smartphone and tablet use without needing to take them off!

There have also been some remarkable innovations in footwear. Leather can be water-repellent, and waterproof, but also breathable, sweat-resistant, and hypoallergenic.

No, leather is not boring! Leather is the target of constant innovation, with many more surprises in store...

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Fédération Française
Tannerie Mégisserie

NEWS 3/2021

Leather often copied – never equalled!

In recent years, leather alternatives have gained traction in the media with unsubstantiated claims of being: “better” than leather; better for the planet and better for the consumer.

On first inspection, some of these substitutes hardly differ from a leather product.

The Research Institute for Leather and Synthetic Materials (FILK) in Freiberg examined the material properties of ten of the most frequently referenced alternatives to leather (DESSERTO, PINATEX, APPLESKIN, MUSKIN, SNAP PAP, KOMBUCHA, NOANI, TEAK LEAF, VEGEA as well as PVC/PUR) against material performance characteristics such as crack resistance, tear resistance, water vapour permeability and water vapour absorption and compared the results to those of leather.

Figure 3. Surfaces of the investigated materials: Naturally grown material (Leather (**A**), Muskin® (**B**), Kombucha (**C**), Teak Leaf® (**D**)); embossed surfaces of coated textiles (PUR-coated textile (**E**), Desserto® (**F**), Appleskin® (**G**), Vegea® (**H**)); fiber structures of non-woven natural fibers (Pinatex® (**I**), SnapPap® (**K**)), and micro-fiber material (Noani® (**L**), embossed).

The conclusion was that none of the tested materials could really be called an “alternative” to leather. None of them had all the performance characteristics of leather and FILK found even chemicals of concern or leather fibres in a material claiming to be vegan.

Typically, their product descriptions to the consumers often use and abuse the term “leather”, in an attempt to associate themselves with the positive quality characteristics of leather, while in reality they fall into three categories: materials of natural origin (such as MuSkin, Kombucha, SnapPap), those materials, predominantly plastic, but with proportions of natural materials (Apple leather, Desserto, Pinatex, Vegea, Teak-Leaf), and products made exclusively from plastic, such as conventional PVC or polyurethane (PUR).

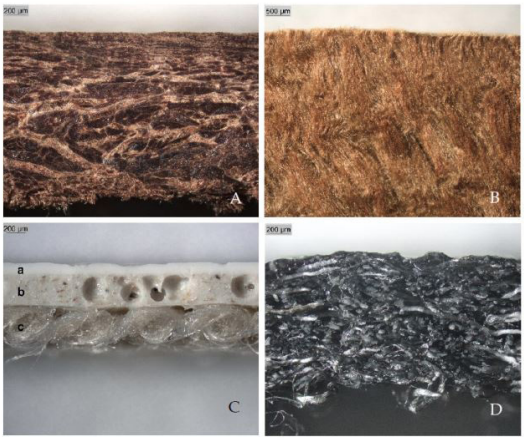


Figure 2. Leather (**A**) and a material with a naturally grown fiber structure (Muskin®) (**B**); structure of a typical coated textile (example Desserto® (**C**); (**a**) topcoat; (**b**) foamed middle layer; (**c**) textile support); non-woven made of natural fibers (example Pinatex®) (**D**). The scales between Muskin® and the other samples differ by 2.5 times.

Better than Leather? Clearly not! Especially in terms of durability, which has obvious implications in environmental sustainability.

They are different and perform differently. It is an unfair commercial practice to confuse customers and consumers by naming them X-leather or employ defamatory comparative assertions with regard to leather in their marketing.

But above all, it is important that customers and consumers understand the performance deficit of such alternative materials and give this proper consideration to ensure that the products they buy will perform as they expect them to.

Read more and access the full report.

edited by COTANCE

in collaboration with leather UK

News Release from the IULTCS

21 February 2021

IULTCS Announces Two New Testing Commission Convenors

At the recent virtual meeting of the IULTCS leather test method commissions two of the three Convenors were replaced -The IUP (Physical) and IUF (Fastness) Commissions have new Convenors:

Jacqueline Glasspool was appointed as the new Convenor of the IUP Commission (and also of the Working Group 2 (WG2) of the European Committee for Standardisation CEN/TC 289 - Leather). Jackie is the group quality manager at SATRA Technology Centre Ltd in the United Kingdom. She replaces Mike Wilson who has recently retired.

Gustavo Defeo was appointed as the new Convenor of the IUF Commission (and also of the Working Group 3 (WG3) of the European Committee for Standardisation CEN/TC 289 - Leather). Gustavo is founder and director of Ars Tinctoria srl in Italy. He replaces Campbell Page who has been the IUF Convenor since 1994.

The Convenors of the IU Commissions are automatically also members of the IULTCS Executive Committee, so the IULTCS EC welcomes these new members and also give their thanks and gratitude for the many years of professionalism and dedicated service given by Mike Wilson and Campbell Page.

Jacqueline Glasspool

Gustavo Defeo

News Release from the IULTCS

22 February 2021

Winners of Two 2021 IUR Research Grants Announced

The Executive Committee of the IULTCS is pleased to announce the winners of the 2021 IUR research grants to be awarded to two young scientists, under the age of 35. The monetary awards help support the work of young talent in the leather sector.

This is the seventh year of the grants which have been generously supported by industry and IULTCS alike. The Selection Committee of the IULTCS Research Commission (IUR), chaired by Dr Michael Meyer, is pleased to announce the following recipients:

Young Leather Scientist Grant 2021 Basic Research

Hon Wei Ng, Research Assistant from New Zealand Leather and Shoe Research Association (LASRA), Palmerston North, New Zealand. IULTCS has provided the monetary sponsorship for a single sum of €1,500 grant to Basic Research. The title of his project is **"Study on Molecular Level Collagen Structure Changes of Enzymatic Depilation Using X-Ray Scattering"**.

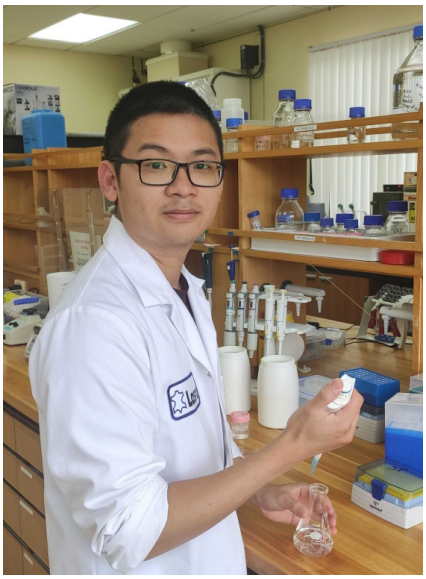
Hon Wei Ng's project's main objective is to evaluate the performance of a novel environmental isolate for enzymatic depilation of skin/hide for leather manufacturing. The study also aims to use small-angle X-ray scattering to elucidate molecular level structural features changes of collagen caused enzymatic depilation compared to a conventional unhairing process.

Professor Mike Redwood Young Leather Scientist Grant 2021 Sustainability / Environmental Award

Caroline Borges Agustini from the Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, Brazil, will be the beneficiary of the generosity of Leather Naturally who have sponsored the €1,000 grant for the project entitled **"Hydrocarbon Release During the Biodegradation of Solid Waste from Tanneries for BIOGAS Production"**.

The objective of this project is to investigate the evolution of the hydrocarbon release, the energy efficiency and the efficiency of the treatment of the waste of the anaerobic digestion of the solid waste of tanneries. The originality of this study is gaining the innovation of how chemical, physical and environmental parameters work is an important step in improving the efficiency and process stability of anaerobic digesters to be able to adjust in which step of the batch process the continuous process must be designed and which pre-treatments are most suitable to increase the carbon depletion of the waste.

Dr Michael Meyer, the IUR Chair of the Selection Committee, stated "Both project proposals show technological knowledge at a very high level and demonstrate the competitiveness of research activities in the leather industry is comparable with other industries worldwide." The IULTCS looks forward to seeing the outcomes of the projects and wishes all the Award recipients every success as they contribute to expanding our industry knowledge.



Hon Wei Ng

Caroline Borges Agustini

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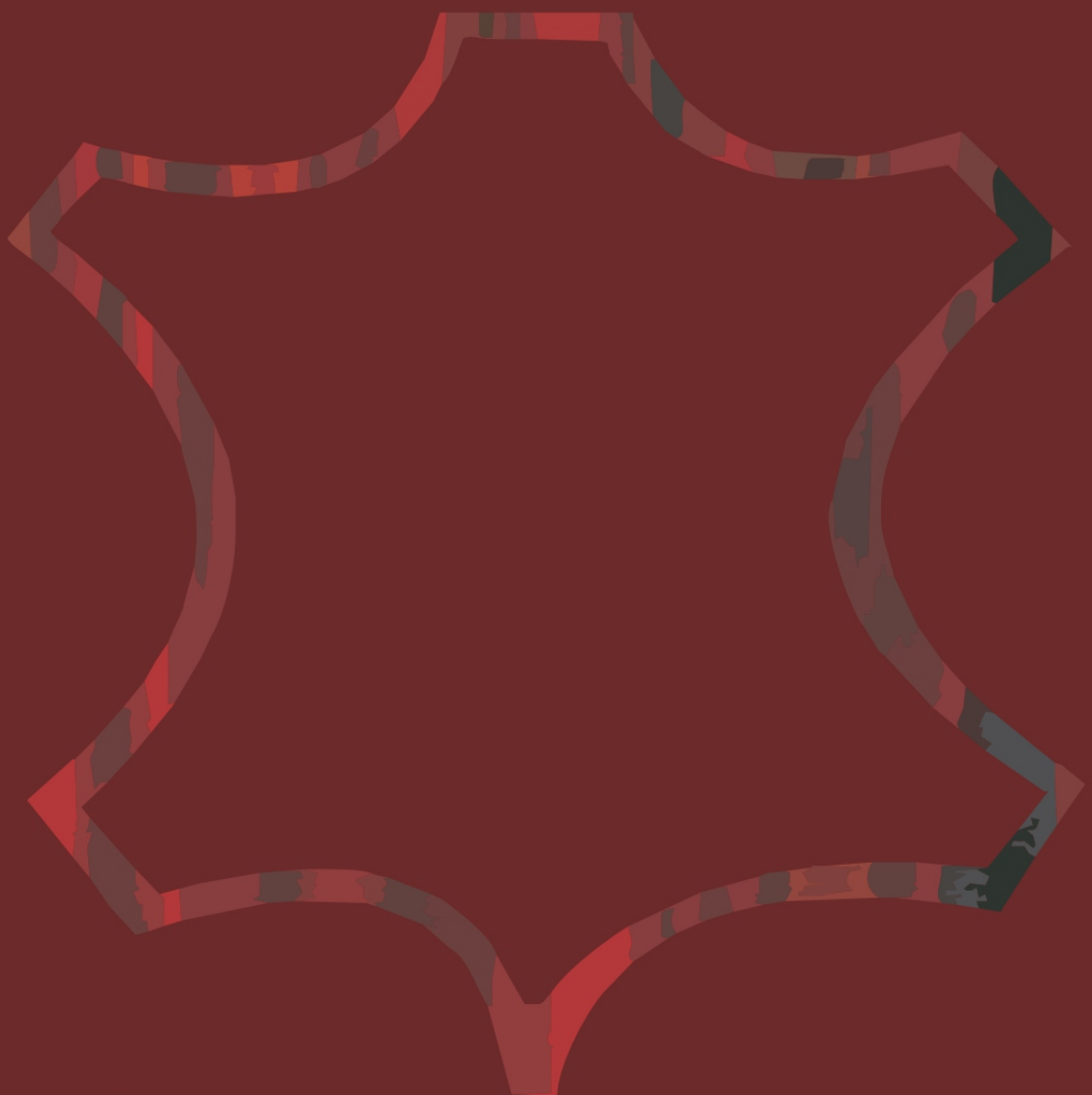

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