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EVALUATION OF THE PHYSICAL ENVIRONMENT AND WORKING CONDITIONS IN THE ARTISANAL PRODUCTION OF TEJOCOTE JAM

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Abstract -- In scientific literature, there are few studies reporting on the side effects in terms of health, working conditions, and ergonomics in artisanal production activities. Currently, contemporary society has considered increasing the consumption of less industrialized products with minimal chemical preservatives. Thus, this research presents a descriptive, quantitative, non-experimental, and cross-sectional study on the assessment of risks in the physical environment, working conditions, and musculoskeletal disorders in five local producers engaged in the production of tejocote jams, a fruit representative of the community of Dolores Calpan, Cholula Puebla-Mexico, between October and December 2024. The NOM-011-STPS-2001 and NOM-025-STPS-2008 standards, the LEST method, and the OCRA method were used. With the exception of the instruments, the data were processed using Ergoniza® software and Ergo/IBV® ergonomic risk analysis software. The results showed noise levels of 75.45 dB and natural lighting of 773.66 lx for the physical environment. The indicators for physical workload were 2.5, mental workload 4.2, psychosocial aspects 3.2, and working time 1.0. On the other hand, the OCRA index obtained a value of 4.84. According to the LEST method, the assessment was "satisfactory"; however, the OCRA method result shows that the right hand presents a "medium unacceptable risk." These findings call for preventive actions through ongoing training plans on safe work practices. Likewise, local producers should be informed about possible health alterations due to exposure to dysergonomic conditions, and personal medical check-ups should be scheduled. Improvements in the workstation and training are proposed. Ergonomic and task redesign to reduce the impact on the health of local producers.

Keywords: Working conditions, Ergonomic injuries, Physical environment, Artisanal production.

Abstract -- In the scientific literature, studies reported on the collateral effects in terms of health, working conditions, and ergonomics in artisanal production activities are scarce. Currently, contemporary society has considered increasing the consumption of less industrialized products with a minimum of chemical preservatives. Thus, this research presents a descriptive, quantitative, non-experimental, and cross-sectional study on the evaluation of risks in the physical environment, working conditions, and musculoskeletal disorders in five local producers dedicated to the production of tejocote jams, a fruit representative of the community of Dolores Calpan, Cholula Puebla-Mexico, between the months of October and December 2024. The NOM-011-STPS-2001 Standards were used, as well as NOM-025-STPS-2008, the LEST method, and the OCRA method. With the exception of instruments, the data are processed in the Ergoniza® software and the Ergo/IBV® ergonomic risk analysis software. The results showed noise levels of 75.45 dB and natural lighting of 773.66 lx for the physical environment. The indicators of physical workload were 2.5, mental workload 4.2, psychosocial aspects 3.2, and work time 1.0. On the other hand, the OCRA index obtained a value of 4.84. According to the LEST method, there was a valuation in "satisfactory situation"; However, the result of the OCRA method shows that the right hand presents a "medium unacceptable risk". These findings invite preventive actions through continuous training plans on safe work practices; Likewise, inform local production companies about possible health alterations due to exposure to dysergonomic conditions.

and have regular medical check-ups on the personal agenda. Improvements in the workstation, ergonomic training, and redesign of tasks are proposed to reduce the impact on the health of local producers.

Key words: Working conditions, Ergonomic Damage, Physical Environment, Artisanal Production.

INTRODUCTION

Since ancient times, humanity has forged various strategies in terms of economic development in order to survive. In this regard, entrepreneurship has been an alternative for men and women to earn an income and also enjoy a sufficient quality of life [1]. Given the socioeconomic demands of modern life, entrepreneurial activity—specifically artisanal production—has undergone a significant shift, with greater emphasis on engineering and technological development in order to optimize processes and produce a variety of artisanal products on a larger scale.

In artisanal production processes, there is a need to investigate people's working conditions in order to improve efficiency, safety, and physical well-being in productive activities [2]. This suggests that the introduction of machines and devices for artisanal production can generate various risks related to workplace tasks, as well as ergonomic risks, especially in repetitive movements that affect the musculoskeletal system.

Thus, the LEST method allows for the most objective and comprehensive assessment of working conditions possible, establishing a final diagnosis that indicates whether each of the situations considered in the workplace is satisfactory, uncomfortable, or harmful [3]. The assessment emphasizes four dimensions of study related to physical load, mental load, psychosocial aspects, and working hours.

With the aim of assessing the risks related to the tasks in the workplace, as well as ergonomic risks, five local producers from the Dolores ranch in Calpan Cholula, Puebla, Mexico, aged between 30 and 60, are relevant. For the most part, the producers' main economic activity is the manufacture of various food products, such as the preparation and packaging of jams and fruit preserves, which, in the case study of this research, will be the production of tejocote jam.

The assessment was carried out in two locations: the first was the postgraduate laboratory at the Technological Institute of Puebla, and the second was Ranchería de Dolores, Calpan, Cholula, Puebla, Mexico. In both locations, measurements of the physical environment, such as noise and lighting, were taken based on the requirements established by the Ministry of Labor and Social Welfare under Standards NOM-011-STPS-2001 [4] and NOM-025-STPS-2008 [5].

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The production of tejocote jam involves multiple tasks ranging from fruit selection, cleaning, pulp extraction, processing, and packaging. One of the key stages is pulping, which uses a machine (pulper) that was built and adapted for the exclusive use of the anthropometric measurements of the local producers under study. Thus, with the aim of assessing the risk of musculoskeletal disorders in the upper limbs—left and right hands—due to the repetitive nature of this task, the OCRA method [6] is used. The results of this study provide important information for the scientific community and the community dedicated to artisanal production in order to implement improvement actions.

DEVELOPMENT

This research is descriptive, quantitative, non-experimental, and cross-sectional [7]. It was conducted in two locations, the first in the postgraduate laboratory of the Technological Institute of Puebla-Puebla and the second in Ranchería de Dolores, Calpan Cholula Puebla-Mexico, with the aim of evaluating the factors that affect the working and ergonomic conditions of five local producers engaged in the artisanal production of Tejocote jam (Figure 1).

Figure 1. *Methodological description of the research*.

Source*: Own elaboration.*

The people evaluated used a machine built and adapted with a gender perspective (pulping machine) that requires less effort in the production of artisanal jam. The evaluation work was carried out between October and December 2024. The working day is not fixed; thus, the eight activities linked to the production process of tejocote jam carried out in the two different locations followed the same procedures from the selection of the tejocote fruit to the packaging a n d

storage of the finished product. Figure 2 shows the block diagram.

Figure 2. *Activities for the production of traditional jam.*

Source: *Own elaboration.*

The evaluation procedure is described in four stages. Stage 1 involves establishing eight activities carried out by the five local producers participating in this research (Figure 2). Based on the LEST guide, stage 2 evaluates the physical environment—noise and lighting—based on the requirements of standard NOM-011-STPS-2001 and standard NOM-025-STPS-2008, respectively. Table 1 describes the materials used.

Table 1. *Materials for the evaluation of the physical environment.*

Physical Enviro	Standard	Equipment	Study Areas
Noise†	NOM-011-STPS-2001	STEREN sound level meter HER-402	+ITP Graduate Laboratory. +Ranchería de Dolores Calpan Cholula, Puebla-Mex.
Lighting††	NOM-025-STPS-2008	Digital lux meter brand Steren model HER-410, range from 0-50,000 lux	

†The conditions for noise measurement were taken from the specifications of the standard.
††The measurement points were established based on the area index given by equation 1, contained in the standard, and based on the result of the formula, the number of points to be evaluated based on the CI table established by the standard recommends 4 measurement points per area.

Source: *Own elaboration.*

In Stage 3, measurements are taken for the dimensions of physical load, mental load, psychosocial aspects, and working time. Based on the LEST method observation guide [8], data obtained from the activities carried out by local producers in situ in the two areas are captured. The quantitative results are presented in histograms based on the report provided by the software Ergoniza® and is available at at: https://www.ergonautas.upv.es/. Table 2 describes the job evaluation supported by the LEST method of the Polytechnic University of Valencia, Spain [3].

Table 2. *Materials for LEST assessment.*

Score	Assessment
0-1-2	Satisfactory situation
3-4-5	Minor discomfort. Some improvements could make the worker more comfortable.
6-7	Moderate discomfort. There is a risk of fatigue.
8-9	Severe discomfort. Fatigue
10	Harmful situation

Source: *Diego-Mas (2015).*

In stage 4, supported by the OCRA method, the risk of musculoskeletal disorders in the upper limbs due to repetitive tasks performed by local producers is assessed, with special emphasis on obtaining the pulp from the tejocote fruit with the aid of a pulping machine. From the measurements obtained, the OCRA index is calculated using the following formula:

$$IndiceOCRA = [OCRAmax + INC] \quad \text{Eq. (1)}$$

Where OCRAmax is the maximum OCRA index of subareas and INC is the increase associated with the rest of the subareas. The quantitative results are presented in a table of results provided by the Ergo/IBV® ergonomic risk analysis software and is available atthe following page: https://www.ergoibv.com/es/evaluacionesergonomicas/metodo-ocra-index/. Table 3 describes the risk assessment using the OCRA index developed by the Polytechnic University of Valencia, Spain [9].

Table 3. *Materials for OCRA*

OCRA Index	Assessment
>9.1	Unacceptable risk HIGH
4.6 — 9	Unacceptable risk MEDIUM
3.6 — 4.5	Unacceptable risk LOW
2.3 — 3.5	UNCERTAIN risk
≤ 2.2	ACCEPTABLE risk

Source: *Occhipinti, E. (2001).*

Finally, the results are presented descriptively through an approximation of physical damage, working conditions, and ergonomic risks in the production of traditional tejocote jam.

DISCUSSION AND ANALYSIS OF RESULTS

Evaluation of the physical environment of noise using Mexican standards

Table 4 shows the measurements taken in the ITP Postgraduate Laboratory and at Ranchería de Dolores Calpan, Cholula Puebla, Mexico. The values recorded range from 72.6 dB to 78.3 dB. These

measurements correspond to a SEVERE level of hearing damage, so they do not represent a hearing risk for local producers in the performance of the activities assigned for the production of artisanal tejocote jam.

Table 4. *Noise measurement results†*

Areas of Study	Measurement*	Requirement**	Risk Risk
+Graduate Laboratory ITP.	72.6dB	85dB	**Severe**
+Ranchería de Dolores Calpan Cholula, Puebla-Mex.	78.3dB	85dB	**Severe**
*Measurement = Average NER (dBA) per Work Area **Requirement = Permissible dBA according to Standard NOM-011-STPS-2001			
†Based on standard NOM-011-STPS-2001 [4], 20 measurements are taken in the aforementioned study areas			

Source*: Own elaboration.*

Evaluation of the lighting environment using Mexican Standards

Table 5 describes the average lighting values for the two areas under study. The measurements were taken at three different times on the same day and during the process of making tejocote jam.

Table 5. *Lighting measurement results†*

Study Areas	††TTM (24:00 hrs)	†††LFI (luxes)	Q1*	Q2**
+ITP Graduate Laboratory.	09:00	578	Yes	No
	11:00	639	Yes	No
	2:00 p.m.	892	Yes	No
+Ranchería de Dolores Calpan Cholula, Puebla-Mex.	09:00	715	Yes	No
	11:00	891	Yes	No
	2:00	927	Yes	No
††TTM (Time of measurement) | †††LFI (Illuminance level) Q1*= Does it comply with NOM-025-STPS-2008? [5] Q2**= Is there a risk of reflection in the area? [5]				
† Based on NOM-025-STPS-2008 [5], illumination levels were evaluated in the work areas of: ITP Graduate Laboratory and Ranchería de Dolores, Calpan Cholula Puebla-Mexico.				

Source*: Own elaboration.*

The areas evaluated are semi-open, which allows for the use of natural light. Thus, the average natural lighting measurements corresponded to
773.66 lumens, which is considered acceptable under NOM-025-STPS-2008.

Evaluation of working conditions using the L.E.S.T. method.

During the development of activities for the production of tejocote jam, information was captured in the Ergoniza® software, an online tool that presents the assessment scale based on the score [3] (Table 5).

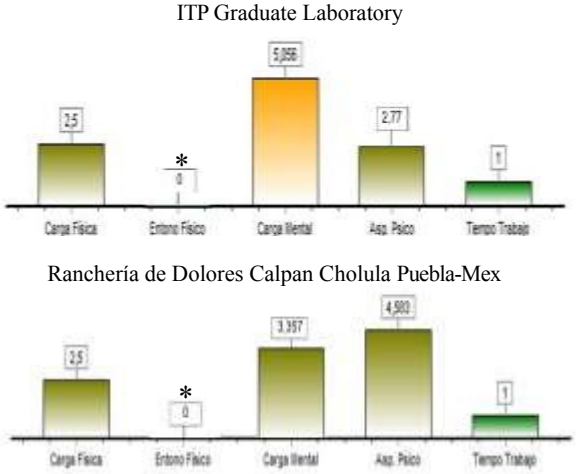
Table 6. *Areas evaluated and results obtained from the LEST dimensions.*

Areas of Study	Observable Position	Result (Average Value)
+ITP Graduate Laboratory.	Local production company	2.85
+Ranchería de Dolores Calpan Cholula, Puebla-Mexico	Local producer	2.83

Source*: Own elaboration.*

The results for the dimensions of physical environment, physical load, mental load, psychosocial aspects, and working hours are presented in Figure 3. In accordance with the activities established in the block diagram (Figure 2), information was collected on the scores obtained in the two areas of study. In particular, the average value shows slight discomfort, and some improvements are suggested that could make the local production company more comfortable.

Figure 3. *Results obtained in LEST.*



**These assessments were carried out in accordance with NOM-025-STPS-2008 and NOM-011-STPS-2001.*

Source*: Own work.*

Ergonomic Risk Assessment using the OCRA method

At this stage, measurements were taken with particular interest in the repetitive movements of the left and right hands. This activity, related to obtaining the pulp from the tejocote fruit, uses a pulping machine built and adapted with a gender perspective for local women producers in Ranchería de Dolores, Calpan Cholula, Puebla, Mexico. The information was captured in the Ergo/IBV® ergonomic risk analysis software, an online tool that presents the calculations of the variables and their assessment based on the score obtained from the repetitive movements [9] (Table 7).

Ergo/IBV® risk analysis software, an online tool that presents the calculations of the variables and their assessment based on the score obtained from the repetitive movements [9] (Table 7).

Table 7. *Results of the measurement of repetitive movements of both hands.*

Variables and Calculations	Right Hand Right		Hand Left	
Subtask	**A**	**B**	**A**	**B**
D-Duration (min)	200	260	200	260
Cycle time (sec)	30.0	60.0	30.0	60.0
Number of technical actions in one cycle	21.00	32.0	8.0	16.0
F-Frequency (actions techniques/min)	42.00	32.0	16.0	16.00
ATA-No. Current technical options current, sub-area	8,400	8.32	3,200	4,160
ATA-No. Current technical options current, total	**16,720**		**7,360**	
CF- Frequency constant	30	30	30	30
FoM- Force multiplier force	1.0	1.0	1.00	1.0
PoM- Posture Multiplier Posture	0..60	1.0	0.7	1.0
ReM- Repetition Multiplier Repeatability	0.70	1.0	1.0	1.0
AdM- Additional multiplier additional	1.00	1.0	1.0	1.0
DuM- Duration multiplier Duration	1.5	1.0	1.5	1.0
RcM- Recovery multiplier recovery	0.60	0.60	0.60	0.60
RtA- No. of technical actions reference, subtask	2,268	4.68	3,780	4,680
OCRA- OCRA Index Subtask (ATA/RTA)	3.70	1.78	0.85	0.89
INC- Increase associated with remaining subtasks	**1.14**		**0**	

Source: *Own elaboration.*

As shown in Table 7, the values in column A for both hands represent the standard/expected conditions in the task evaluated. However, the values in column B for both hands are those obtained in the evaluation of the tasks. Based on these results in the same software, the risk index is obtained from equation Ec. (1) and is shown in Table 8.

Table 8. *OCRA index result.*

Task Risk	Right Hand		Left Hand	
Subtask	**Value Obtained**		**Value Obtained**	
OCRA Index (OCRA max+ INC)	4.84	Unacceptable Average	0.89	Acceptable

Source: *Own elaboration.*

According to the results in Table 8, the resulting OCRA index allows us to identify that the risk of musculoskeletal damage in both hands of local producers shows that the right hand obtained an unacceptable average index compared to the left hand; that is, the right hand performs more repetitions, which is evident that in the medium and long term can result in mild and temporary discomfort to irreversible and disabling injuries [10]. In addition, repetitive movements increase physical fatigue, leading to low performance and affecting product quality [11].

Approximation of physical damage, working conditions, and ergonomic risks in the production of traditional tejocote jam

In order to assess the collateral effects in terms of health, working conditions, and ergonomics present in artisanal production activities such as jam making, it is emphasized that contemporary society has placed significant importance on the consumption of less industrialized products with minimal added chemical preservatives [12]. This reality has led to a significant shift, with engineering and technological development becoming more prominent in order to optimize various production processes and meet the demand for artisanal products.

Based on the above, producers, and specifically women, are exposed to various risks related to their workplace tasks, such as physical and ergonomic risks, especially repetitive movements that affect the musculoskeletal systems [6, 13]. In this regard, it has been reported that repetition and force in the hands and wrists in the medium term can lead to musculoskeletal problems [14]. However, it has been reported that strenuous work, uncomfortable spaces in terms of noise and lighting, as well as prolonged postures, lifting and handling of loads, and repetitive movements generate MSDs (musculoskeletal disorders) [15].

In order to evaluate the factors that affect the working and ergonomic conditions of five local production companies, it was found that in the occupational risk assessment using the LEST method, the dimensions evaluated in the two study sites suggest a satisfactory score, except for the mental load dimension, where the result shows slight discomfort in the ITP Postgraduate Laboratory area. Thus, a harmful mental load affects interpersonal relationships, work performance, and work quality [16].

The results obtained from the LEST method show that the physical load dimension obtained an average score of 2.5, which, according to the established assessment, corresponds to a "Satisfactory Situation." For the physical environment, the noise measurement based on the official Mexican standard NOM-011-STPS-2001 shows that the two areas evaluated have levels considered severe, with an average of 75.45 dB. However, the evaluation of lighting in the same areas shows that it complies with

the official Mexican standard NOM-025-STPS-2008 because natural lighting was used, obtaining an average value of 773.66 lumens.

With regard to mental load, the average score for the two areas was 4.20, representing a rating of "Mild Discomfort." In this regard, it is concluded that it is important to develop and implement strategies to prevent mental load from increasing. On the other hand, in psychosocial aspects, the average rating obtained was 3.27, which refers to "Mild Discomfort." Thus, the local producers evaluated value and are aware of the importance of producing tejocote jam under the necessary conditions for consumption.

Last but not least, in terms of working time, an average score of 1.0 was obtained, indicating a "Satisfactory Situation" rating. This result indicates that local producers stated that the amount and organization of time for the production of artisanal tejocote jam does not represent—for them—a form of pressure to fulfill an order, since they establish an organized time frame according to consumer demand.

Regarding the application of the OCRA method, it was observed that, in the tasks corresponding to obtaining the tejocote pulp, local producers performed repetitive movements with both hands. According to the index obtained with a value of 4.84, it was found that the right hand presents a "medium unacceptable risk."

Based on these results, it is extremely important to identify ergonomic risks, including the analysis of the machinery, equipment, and tools used, as well as to develop training actions in order to reorient current methods [17]. Thus, this research contributes by providing the value of lighting, noise, working conditions, and ergonomic risk assessment factors in the production of artisanal products such as tejocote jam. Generating and implementing actions to reduce musculoskeletal risks and diseases is a task that remains to be done.

CONCLUSIONS

The findings of this research revealed the physical environment factors, working conditions, and ergonomic risks to which five local producers engaged in the production of traditional tejocote jam are exposed. The evaluation was carried out in two locations: the first was the postgraduate laboratory of the Technological Institute of Puebla, and the second was the Dolores Calpan ranch in Cholula, Puebla, Mexico. In both locations, physical conditions such as noise and lighting were acceptable according to the parameters established by the Ministry of Labor a n d Social Welfare under Standards NOM-011-STPS-2001 and NOM-025-STPS-2008 in particular.

Several previous studies have been conducted in relation to these assessments. For example, in Colombia, an assessment of the occupational and environmental impacts associated with artisanal panela production was reported. Using the Leopold matrix, a numerical value was assigned to the work activities performed by individuals, as well as the physical conditions of the facilities. This assessment made it possible to identify and characterize significant impacts on the health of individuals who perform activities related to artisanal panela production on a daily basis.

Another more recent example is a study on occupational health in the marble industry in Mexico published in 2024: The case of Tepexi de Rodríguez-Puebla, which showed that the use of the LEST method, as well as noise and lighting measurements under official Mexican standards, can warn of physical, environmental, and psychosocial risks present in the local marble industry.

It should be noted that, given the trend toward consumption of artisanal products, there is a need to develop strategies to enhance artisanal production processes. Therefore, in addition to meeting demand with optimal quality, the collateral risks in terms of ergonomics and the physical and mental health of local producers must be considered.

The evaluation of working conditions is of particular interest given that, in the traditional tejocote jam production process, local producers used a machine built with a gender perspective (a pulping machine) in order to minimize the physical and mental strain on them. Thus, the LEST method was the starting point for assessing working conditions in four dimensions of study.

The well-structured methodological development in this research made it possible to evaluate the working conditions observed by five local producers from two different perspectives in order to objectively compare the effects of tejocote jam production on personal health and physical conditions in the environment.

In accordance with the activities established in the tejocote jam production process, each stage was characterized and standardized operating rules were established, which were applied equally at both locations mentioned in the research.

Thus, the LEST method has the characteristic of evaluating working conditions in the most objective manner and establishes a diagnosis that indicates whether each evaluation situation is satisfactory, uncomfortable, or harmful. Therefore, for the purposes of this research, special importance was given to the evaluation of working conditions based on physical load, physical environment, mental load, psychological aspects, and working time.

According to the results obtained, the physical load was found to be acceptable, and the mental load was also satisfactory. Within these results, the workers stated that they do not feel any pressure with regard to the organization and working hours, given that they work according to their conditions and production times in traditional jam making. In relation to this part, the evaluation—through the LEST method applied to local producers—made it possible to evaluate working conditions within an observation framework, taking into account the producers' opinions regarding their feelings.

On another note, the recurring tasks involved in cleaning and pulping tejocote fruit affect the health of local producers in the community of Dolores Calpan, Cholula Puebla, Mexico, who report pain in their backs, shoulders, and hands, with the latter being of particular interest when assessing ergonomic risk using the OCRA method.

The application of this method in local production facilities revealed that the tasks involved in obtaining tejocote pulp require local producers to perform repetitive movements and that, according to the index obtained for exposure to repetitive movements of the upper limbs, there is a medium unacceptable risk for the right hand.

In conclusion, the results obtained are the starting point for generating strategies that ensure an adequate balance of movements between both hands; that is, that local producers can carry out the activities inherent in the artisanal production of tejocote jam without repeatedly using their right hand. Achieving this involves constructing operational process diagrams that balance the movements of both hands.

Future work on this research would be to propose and implement actions through ongoing training plans on safe work practices. Likewise, local producers should be informed about the possible health risks of exposure to non-ergonomic conditions and should schedule regular medical check-ups.

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