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Local Knowledge of Wool Dyeing in a Mazahua Community in the State of Mexico

Ir a la versión en español

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ABSTRACT

The dyeing of wool is part of the cultural heritage of the Mazahua people. In the community of Santa Rosa de Lima, local knowledge of their techniques has been lost due to various social and economic factors. An ethnographic survey was conducted to make a comparative analysis of the dyeing processes between 1995 and 2017. This survey highlights, among its main findings, that although the techniques have varied and there are deficiencies in the processes, the local women maintain their tradition and manage to obtain the colors required for their clothing. These colors, and the dyeing materials from which they come (mainly indigo and cochineal), are closely related to Mazahua women's cultural identity. In the population mentioned above, the use of fermentation vats with human urine for indigo dyeing, a technique that is no longer used in other indigenous communities in Mexico, is still prevalent.

KEYWORDS

Dyeing techniques; local knowledge; Mazahua ethnic group; indigo; cochineal

INTRODUCTION

Knowledge of wool dyeing among Mazahua women used to be transmitted orally from mother to daughter (Liu et al., 2014) and, as has happened in other regions of the world

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(MacFoy, 2004), the use of related techniques has changed over time. The need to rescue this knowledge appears in the context of the erosion of local knowledge of wool dyeing (Mati & De Boer, 2010).

Studies on the use of dyeing materials and wool-dyeing techniques among Mazahua communities are scarce. There are some ethnobotanical surveys, such as that of Farfán, Casas, Ibarra-Manríquez, and Pérez-Negrón (2007) in Francisco Serrato (Michoacán), and of Sánchez-Alejo, Rangel-Villafranco, Cristóbal-Sánchez, Martínez-García, and Pérez-Mondragón (2016) in San Jerónimo Boncheté (State of Mexico), but the use of dye plants and the application of dyeing techniques are not reported. De Ávila (2012) notes the use of some of the former among the Otopamean cultures, Arredondo (2013) describes the processes of dyeing in San Felipe Santiago, and finally, Castillero (2018) mentions aspects related to the dyeing of wool in San Cristobal de los Baños.

In the Mazahua community of Santa Rosa de Lima, State of Mexico, women's traditional clothing consists of three pieces of wool dyed with natural dyes and woven on a backstrap loom. These pieces are the *quechquemitl* (Figure 1), of navy-blue color, made with wool dyed with indigo (*Indigofera suffruticosa* P. Mill.); the *lía* or skirt made of a long band of fabric with thin horizontal lines alternating blue, red, and yellow colors; and the wool band embroidered with traditional Mazahua motifs (Figure 2). Once in daily use, women now wear this clothing as a symbol of their cultural identity only in religious celebrations and socially significant occasions (Franco-Maass, Arredondo-Ayala, Cruz-Balderas, & Endara-Agramont, 2019).

FIGURE 1. *Quechquemitl,* traditional feminine garment, in Santa Rosa de Lima (Photograph: Sergio Franco Maass, 2017; the photograph was obtained and published with the informed consent of the Mazahua woman who owned the garments).

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FIGURE 2. Mazahua women of Santa Rosa de Lima at a political event (Photograph: Yolanda Cruz Balderas, 2018; the photograph was obtained and published with the informed consent of the Mazahua women photographed).

By the middle of the 20th century, the women of Santa Rosa de Lima had mastered all stages of the process of making their traditional clothing. Once the wool was spun with a spindle, it was washed with *sanacoche* (*Cucurbita radicans* Naud). Indigo dyeing was done with the method of fermentation with human urine. In contrast, the direct dyeing with cochineal (*Dactylopius coccus* Costa) was done in hot water with lemon juice, to which oak ashes (*Quercus* spp.) or avocado leaves (personal communication, August 2017) were added as mordants. It should be noted that cochineal has not been produced in the region as far as is known. Furthermore, sunflower (*Helianthus annuus* L.), riatite (*Cuscuta jalapensis* Schlechtendal), bush sunflower (*Simsia amplexicaulis* (Cav.) Pers.), and marigold (*Tagetes erecta* L.) were used.

Dyeing was an exclusive activity of women. They used earthenware pots intended only for this purpose, and the fire had to be of oak wood. The pot was given the sign of the cross with herbs, and pregnant women could not participate in the process, at the risk of having their children born with skin blemishes. Those with bad intentions had to perform a cleansing ritual to avoid the evil eye. To the same end, indigo dyeing was carried out in secret. The donors of the urine had to abstain for 24 hours from drinking alcohol or taking medicines and from having sex; in the case of women, they could not be in their period or pregnant. Today, it is still believed that the urine of children has better results. Such beliefs, a cultural identity product, are present in many other cultures (Junsongduang et al., 2017).

Arredondo (1996) states that by the mid-1990s, Santa Rosa de Lima was a small town of 2,003 inhabitants. Based on corn pro-

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duction for self-consumption, its economy was doing badly due to the poor quality of the soil and the conditions then prevailing in the Mexican countryside. Moreover, between 1940 and 1990, it had lost about 20% of its population. Livestock activity in the town was reduced to raising a few sheep for meat and wool production. Under these conditions, women found it difficult to make their traditional clothing.

According to Franco et al. (2019), in 1995, some local women requested financial support from the *Instituto de Investigación y Fomento de las Artesanías del Estado de México* (IIFAEM) for the acquisition of indigo and cochineal. To justify the purchase, the IIFAEM promoted two training courses for thirty women, given by the most experienced woman in the area. Dyeing sessions were held as part of making the clothing. The Arredondo survey (1996) revealed that, in 1995, the same dyeing materials were still being used. However, the use of *sanacoche* had been abandoned, and the wool was washed with Ibis soap. Indigo dyeing remained unchanged, but in direct dyeing, oak ashes and avocado leaves were no longer used and were replaced with tin salt and alum as simultaneous mordants.

In 2016 a first visit was made to Santa Rosa de Lima to identify the women who were still dyeing the wool and who, coincidentally, participated in the 1995 training courses. The main objective of the study was to document the changes that occurred in the knowledge of the dyeing techniques—starting with the one existent in 2017—to identify the possible modifications that occurred, and to contrast the local knowledge with the techniques reported in the literature.

MATERIALS AND METHODS

Santa Rosa de Lima

The Mazahua ethnic group is scattered over the central portion of Mexico, between the states of Mexico and Michoacán. Their language, Mazahua, is part of the Otomanguean language family. The Mazahua town of Santa Rosa de Lima is located in the northwestern part of the State of Mexico, and by 2010 it had a population of 1,533 inhabitants (Instituto Nacional de Estadística y Geografía [INEGI] 2010), that is, 470 less than in the mid-1990s. The community extends along a system of hills with an average altitude of 2850 meters above sea level. The area has a predominantly temperate sub-humid climate with summer rainfall. The hills are covered by low yielding seasonal crops, mainly corn for self-consumption. The

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surrounding mountainous system is covered by temperate forests of pine (*Pinus* sp.) and fir (*Abies religiosa* Kunth Schltdl. *et.* Cham.).

Methods

The research process emerged from previous knowledge of Arredondo's (1996) work and from a series of visits to the town, which consisted of a collection of data on the process of making women's clothing. Exploratory interviews were conducted with eight community members, and several factors that discouraged the manufacture and use of Mazahua clothing were identified. These factors included the scarcity and high cost of raw materials and supplies; the weight of the garments, which makes their daily use difficult with the new roles assumed by the women in the locality; the growing external cultural influence; and the difficulty in making new garments, given the loss of knowledge of the women of the town, particularly concerning the dyeing of wool (Franco et al., 2019). Eleven women with experience in the dyeing of wool were located. In-depth interviews were conducted with the two most experienced women, which revealed that they were applying techniques that demanded large quantities of materials, making them more expensive.

Local knowledge of wool dyeing in 1995

Arredondo's methodology consisted of an ethnographic survey from the perspective of the informants (emic) through observation and in-depth interviews. First, Arredondo carried out an area survey to characterize the economic activities and the spatial organization of the territory, thanks to which it was possible to characterize the socio-environmental conditions in making traditional Mazahua clothing. Arredondo also contacted the person who promoted the training courses, the instructor, and conducted several in-depth interviews. Later, the researcher carried out participant observation in all the course sessions and did in-depth interviews with twenty of the women attending. As part of the fieldwork, she documented the traditional knowledge of wool dyeing, including the procedural part and the connotations of the activity regarding the women's cultural identity.

Local knowledge of wool dyeing in 2017

Of the thirty women who took the course in 1995, only twenty completed it, and by 2017 nine had died or emigrated. Only eleven

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women had knowledge and experience in wool dyeing. In-depth interviews were applied to all of them based on four fundamental points: the characterization of the informant's experience, knowledge of plants, natural dyes, and the dyeing process; and the use of natural dyes as part of their cultural identity. The above led to a high level of redundancy or saturation in the findings. It is worth mentioning that all the interviews were recorded and that field notes were made.

Work was carried out with two of the eleven women in three dyeing sessions. They were provided with the required materials, and a participant observation was conducted. A detailed record was made that included filming, photography, and recording in stages of processes, materials, quantities, times, temperatures, and pH.

Finally, a comparative analysis was carried out between the processes documented by Arredondo (1996) and the findings derived from the 2017 ethnographic survey. Since the same methodological approach was applied, it was possible to compare the studies of both dates.

Color preferences among local women

Given the concern of some of the women interviewed to know if they could obtain similar results based on other dyeing techniques that they considered "better," four laboratory sessions were held to replicate the processes reported in the literature with the same natural dyes used in Santa Rosa de Lima: indigo, cochineal, riatite, dahlia (*Dahlia coccinea* Cav.), bush sunflower, and marigold. This exercise aimed to determine the possibility of obtaining, through various techniques, color variations from the available dyeing materials. Likewise, it aimed to compare materials and quantities. The research did not seek to evaluate the samples in terms of fixation and fastness when subject to washing, light, and rubbing, which has already been documented by authors such as Zarkogianni, Mikropoulou, Varella, and Tsatsaroni (2011).

A catalog was prepared with thirty samples dyed in the laboratory—five for each dyeing material—using various methods and with samples that used and did not use mordants. This catalog was presented to the women who participated in the interviews so they could express their color preferences and how useful the samples were for the production of their clothing. Once their opinions were obtained, they were informed about the dyeing techniques and materials used in each sample.

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Laboratory processes

Four dyeing sessions were held, without the participation of local women, in which a photographic record was made, and the processes were documented, including times, quantities, temperatures, and pH.

1) Washing

In all cases, samples of 5 g of wool were used, previously washed twice in warm water (35° C) with a neutral soap, and rinsed four times (Furry & Viemont, 1935). Some indigenous communities use specific plants to wash their wool. For example, Comerci (2013) mentions the use of a mountain herb, *tupe*, by women in the western Argentine Pampa; Jaramillo (1989) describes the use of juice from fique plants (*cabuya blanca*; *Furcraea andina* Trel.) as a detergent by communities in the Ecuadorian Sierra; and Contreras (2015) documents the use of the tuber *chicamol* or *chikahmolli* (*Microsechium* sp.) in the Sierra de Zongolica, Veracruz.

2) Pre-mordanting

Three types of samples were used: wool not treated with mordants and wool treated with mordants like alum (potassium aluminum sulfate) ($KAl(SO_4)_2 \cdot 12H_2O$), and potassium dichromate ($K_2Cr_2O_7$). These samples were introduced in a solution of the mordant agent in water and brought slowly to the boiling point for one hour, after which they were left to rest for 24 hours. There are several natural mordants, including avocado leaves(Cedano & Villaseñor, 2006), tickseed sunflower (*Bidens humilis* Kunth) (Jaramillo, 1989), spiny holdback or tara (*Caesalpinia tinctoria* DC.), cow tongue (*Rumex crispus* L.), lemon juice, and *pulque* (Muñoz, 2006). Currently, however, chemical mordants are common, such as metal salts: aluminum salt or potassium aluminum sulfate, chrome salt or potassium dichromate, tin salt, or tin (II) chloride, and copper salt or copper sulfate (Jaramillo, 1989; Mendez, 2009). The mordants are usually prepared in a solution often containing cream of tartar or potassium bitartrate (Rees, 1998) and alum. This combination increases the brightness of the colors, the softness of the fibers, and the uniformity of the colors (Contreras, 2015; Rojas, Mavila & Rojas, 2011). Depending on the type of mordant used, different shades and even different colors can be obtained.

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3) Dyeing

For direct dyeing, an adjusted procedure was followed for each dyeing material regarding mordants and acidity controllers. This, in general terms, involved dissolving or mixing the dye and mordants in water, bringing them to the boil for ten minutes, trying to maintain a pH of 2.0. The wool samples were added and kept boiling for twenty minutes, stirring periodically. Afterward, it was left to cool down to room temperature, and two washes were applied in warm water (35° C) with a neutral soap, followed by four rinses. The mordants used simultaneously were tin chloride II ($SnCl_2$), common salt (NaCl), oxalic acid ($C_2H_2O_4$), acetic acid (CH_3COOH), vinegar, and cream of tartar ($C_4H_6O_6$). The solution may also include mordants and pH regulators (Kumar & Agarwal, 2009; Kumar & Konar, 2011).

For the human urine fermentation method, finely ground indigo was added to the urine, and the pH was adjusted to 12.0 by adding hydrated lime. The mixture was kept in a water bath at a temperature of 30° C for 48 hours. The wool samples were added, keeping them immersed in the solution, and periodically controlling the pH and temperature. After a week, the samples were extracted from the solution day by day, ensuring their total exposure to the air and verifying the color intensity reached (the maximum was obtained after ten days of immersion). The hydrosulfite method (Furry & Viemont, 1935) consisted of preparing a sodium hydrosulfite solution ($NaHSO_3$) in water and adding a previously prepared reserve solution of indigo hydrosulfite from the mixture of indigo with $NaHSO_3$ and sodium hydroxide. The wool, previously moistened, is immersed in this preparation for thirty minutes. After that time, it is removed, squeezed, and exposed to air for half an hour more. The immersion process is repeated until the desired color intensity is achieved.

RESULTS

With the ethnographic survey, it was documented that, before 1995, the women of Santa Rosa de Lima preserved and transmitted from mother to daughter the knowledge of making their clothing, including the dyeing of the wool. By 2017, no local woman mastered the entire process, and only a few were practicing dyeing. Despite the difficulties, the women continued to make their clothes, trying to preserve the traditional production methods, and always seeking to reproduce the designs and colors that are part of their identity as Mazahuas.

Knowledge of wool dyeing and the use of the backstrap loom had been concentrated in a few women. The use of dahlia was ad-

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opted, and the use of the bush sunflower and sunflower was lost. Despite the environmental threat it represents, the use of tin salt in an acidic medium for direct dyeing became widespread. According to local women, this is the most widely used metal salt because it is easy to obtain and produces more intense colors.

Three dye plants are used to obtain yellow: the women prefer dahlia to combine with cochineal; with riatite, green is obtained from blue-dyed wool; and marigold is used only when it is not possible to obtain dahlia.

Dyeing techniques used today

Washing

As was done in 1995, the women vigorously wash the wool in the laundry room with cold water, using soap bars (of the widely-available Mexican brand Zote), followed by two rinses by immersion in a bucket of cold water. The wool is then drained and lightly squeezed in preparation for dyeing. The women of Santa Rosa de Lima do not treat the wool with mordants, so they proceed directly to the dyeing.

Indigo dyeing

A method of reduction through the fermentation of human urine has been used locally for a long time. For dyeing, urine is collected, preferably from children, since it is believed that its fermentation is more effective. The finely metate-ground indigo is added to the urine and mixed. After two days, the previously washed wool is added and kept completely submerged in the dyeing tub, which is placed in a cool and ventilated area. The wool is taken out daily, exposed to the sun, and aired for a few minutes to evaluate the intensity of the color. The wool is then immersed in the dyeing vat for as long as necessary until the desired result is achieved. Once the required color intensity is reached, the wool is extracted and washed vigorously with soap bars to remove excess dye (Figure 3). When the women cannot obtain the expected intensity of color, the dyed wool is subjected to a second dyeing with the direct method to obtain green tones, using mainly the plant known as riatite.

By 1995, dyers used three liters of urine per 100g of indigo, which made possible the staining of 1kg of wool. In 2017, for the same amount of wool, fifteen liters of urine and 250g of indigo (i.e., six liters of urine per 100g of indigo) were used (Figure 4).

Although the number of materials apparently increased between 1995 and 2017, in reality, the proportional amount of indigo de-

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FIGURE 3. Indigo-dyed wool in Santa Rosa de Lima (Photograph: Sergio Franco Maass, 2017; the photograph was obtained and published with the informed consent of the Mazahua woman who dyed the wool).

Method: fermentation vat	Amount of indigo (Grams)	Amount of human urine (Liters)	Required pH
1995	*100*	*3*	*12*
2017	*250*	*15*	*12*

Source: Own elaboration based on what was reported by Arredondo (1996) and the findings of the field work in 2017.

FIGURE 4. Table of materials used for indigo dyeing in Santa Rosa de Lima in 1995 and 2017 (Source: created by the authors based on Arredondo's (1996) reports and the findings of the fieldwork carried out in 2017).

creased by half (from 33.3 g/l to 16.6 g/l). According to the dyers, the increase in materials seeks to guarantee results. This is sometimes not achieved in practice, even though the wool is kept in the fermentation vat for more than two weeks. The high price of indigo and the difficulty of getting it prompt women to decrease the amount used. There is not enough understanding of the fundamental principles involved in fermentation, which are essential to understand the factors that induce reduction/oxidation. However, the lack of success is often attributed to the poor quality of the urine and mainly to the amount of indigo used.

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Direct dyeing with cochineal

While direct dyeing can be done in either a basic or acidic medium (pH of 2.0) (Kumar & Konar, 2011), only the latter is used in Santa Rosa de Lima. The dyeing materials are mixed directly in hot water, to which tin salt and large quantities of lemon juice are added to increase the acidity of the medium. Unlike what is recommended in the literature, mordants are never applied in procedures before dyeing, and no cream of tartar is used during the process (Figure 5).

FIGURE 5. Wool dyed with cochineal in Santa Rosa de Lima (Photograph: Sergio Franco Maass, 2017; the photograph was obtained and published with the informed consent of the Mazahua woman who dyed the wool).

The women demonstrated more significant control over direct dyeing. This is a series of subsequent processes with the addition of various materials to achieve different colors and shades. In the first stage, a dyeing vat is prepared with hot water, tin salt, and abundant lemon juice. The wool is immersed for at least an hour to obtain what the women identify as "pink," which is a color valued for the making of traditional clothing (first dyeing). Subsequently, the water level of the vat is adjusted, and two handfuls of dried dahlia petals are added, giving the color red (second dyeing). Again, the water levels are adjusted, and more tin salt, lemon juice, and cochineal are added to get the orange color (third dyeing). Finally, two

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handfuls of dried dahlia heads are added to produce the yellow (fourth dyeing). Thus, by increasing the dissolution of the cochineal and the amount of dahlia, it moves from red to yellow. It is important to note that the addition of dyes and mordants is done intuitively, based on the dyer's own experience.

Figure 6 presents the materials and quantities used for dyeing wool reported in the specialized literature and those used in Santa Rosa de Lima in 1995 and 2017. It is evident that the quantities used in the latter year, including dyeing and mordant materials, increased in relation to the former. However, these quantities are less than those recommended in the literature. Although the dyeing process in the locality shows significant deficiencies and is based exclusively on the use of tin salt as a mordant and lemon juice as an acidic medium—the lack of control over quantities and processes leads to unpredictable results—the women achieve, according to their particular requirements, satisfactory results.

COMMON NAME	Color	Reported amounts[1]					Reported amounts in 1995[2]			Reported amounts in 2017[3]		
		Amount (g)[1]	Pre-mordating	Simultaneus mordent	pH controller	Additive	Amount (g)[1]	Simultaneus mordent	Lemon juice (L)	Amount (g)[1]	Simultaneus mordent	Lemon juice (L)
Cochineal *Dactylopius coccus Costa*	Red	*128*	*No*	*Sn (250 g)*	AO *(250 gr)*	CT *(62 g)*	*100*	*Sn (30 g)*	*1*	*192*	*Sn (35 g)*	*3.5*
	Pink	*62*	*Al*	*No*	*No*	*No*						
	Purple	*156*	*Cr*	*No*	*V (5 ml)*	*No*						
Riatita *Cuscuta jalapensis Schlechtendal*	Dark yellow	*1000*	*No*	*Sn (200 g)*	*No*	CT *(208 g)*	*50*	*Sn (30 g)*	*0.5*	*60*	*Sn (35 g)*	*3.5*
Dahlia *Dahlia coccinea* (Cav.)	Bright yellow	*1020*	*Al*	*Sn (70 g)*	*No*	CT *(208 g)*				*65*	*Sn (35 g)*	*3.5*
Marigold *Tagetes erecta* L.	Medium yellow	*1060*	*Al*	*Sn (70 g)*	*No*	*CT (208 g)*				*65*	*Sn (35 g)*	*3.5*
Bush sunflower *Simsia amplexicaulis (Cav.) Pers.*	Yellow						*75*	*Sn (30 g)*	*0.5*			

Note: The use of bush sunflower is not reported in the consulted literature.
1 – Amounts to dye one kg of wool based on Furry & Viemont (1935), updated based on Zarkogianni et al. (2011).
2 – Data reported by Arredondo (1996).
3 – Data obtained in field work in 2017.
Mordants
Cr – Potassium dichromate (K2Cr2O7)
Al- Alum (potassium aluminum sulfate) (KAl(SO4)2·12H2O)
Sn – tin chloride (SnCl2)
pH controllers
AO – Oxalic acid (C2H2O4)
AA – Acetic acid (CH3COOH)
V - Vinegar
Fixative
CT – Cream of tartar (C4H6O6)

FIGURE 6. Table of materials and quantities used for the dyeing of wool in Santa Rosa de Lima in 1995 and 2017, compared with those recommended in the literature (Source: created by the authors based on reports by Furry & Viemont (1935), updated based on Zarkogianni et al. (2011), Arredondo (1996), and fieldwork carried out in 2017).

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As the table demonstrates, the sources recommend, in many cases, first treating the fibers with a mordant, which would guarantee better fixation and durability of dye, and using cream of tartar to obtain brighter colors.

Laboratory dyeing to identify the preferences of local women

The application of dyeing procedures in the laboratory made it possible to create a sample catalog using some techniques reported in the literature. Unlike the traditional practices in the locality, this one involves applying pre-mordanting procedures, mainly with alum. According to the women interviewed, this past practice fell into disuse with the introduction of tin salt. This, according to the review of documentary sources, is not always necessary, and in some cases, other mordants, such as potassium dichromate, are recommended instead. Similarly, dyeing in an acidic medium is unnecessary in all cases, and when this is required, other compounds such as vinegar can be used. This is important since large quantities of lemon juice are expensive and usually demand a long extraction process. Finally, local women are unaware of the method of addition of cream of tartar to the dyeing tub, which would make it possible for them to obtain, as mentioned above, softer fibers and brighter colors.

Two methods were tested for indigo dyeing: the traditional method, which is common in the locality (Figure 7), and the chemical one, with hydrosulfite baths, used for many years (Figure 8). Despite not being known by the women of Santa Rosa de Lima, the latter has become more common in the Mazahua region, given its

FIGURE 7. Wool dyed in the laboratory using the human urine fermentation method (Photograph: Sergio Franco Maass, 2017).

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FIGURE 8. Wool dyed in the laboratory using the hydrosulfite bath method (Photograph: Sergio Franco Maass, 2017).

greater speed and effectiveness. It is essential to point out that at no time were hydrosulfite baths promoted among local women because they cause serious environmental problems.

For the direct dyeing method, three samples for each of the natural dyes were used. These natural dyes, except for cochineal, are used to obtain yellow. While Mazahua women perform the cochineal dyeing in an acidic medium with wool without mordants, it was possible to obtain three different colors in the laboratory. These were the so-called "pink," which is, as has been said, the one preferred by the women of Santa Rosa de Lima, obtained with wool without mordants (Figure 9); fuchsia, obtained with wool processed with alum mordant (Figure 10), and purple, from wool with potassium dichromate mordant (Figure 11).

FIGURE 9. Wool without mordants dyed in a laboratory with cochineal in an acidic medium (Photograph: Sergio Franco Maass, 2017).

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FIGURE 10. Wool processed with alum mordant and dyed in a laboratory with cochineal in an acidic medium (Photograph: Sergio Franco Maass, 2017).

FIGURE 11. Wool processed with potassium dichromate mordant and dyed in a laboratory with cochineal in an acidic medium (Photograph: Sergio Franco Maass, 2017).

Regarding the samples dyed with dyeing vegetables of the region, bush sunflower and sunflower produced dull and brownish tones. This, together with their scarcity, explains the fact that they have fallen into disuse. On the other hand, Marigold (Figure 12) produced results similar to those of the dahlia (Figure 13), which also explains the fact that, in case this wild-flower becomes scarce, it can be used as a substitute. Finally, with riatite, an intense amber yellow was obtained (Figure 14), which, in a second dyeing with indigo, tends to produce olive green.

Once the sample catalog was prepared, it was presented to eleven local women to indicate their preferences. It is important to note that they were not informed about the dyeing methods ap-

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FIGURE 12. Wool not treated with mordants and dyed in a laboratory with marigold petals and heads (Photograph: Sergio Franco Maass, 2017).

FIGURE 13. Wool not treated with mordants and dyed in a laboratory with dahlia petals and heads (Photograph: Sergio Franco Maass, 2017).

FIGURE 14. Wool not treated with mordants and dyed in a laboratory with riatite (Photograph: Sergio Franco Maass, 2017).

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plied to each sample until they gave their opinion on the entire sample. In all cases, the women expressed a clear preference for samples that had not been previously treated with mordants. Particularly for cochineal, the sample closest to the color "pink" was obtained with wool not treated with mordants and with the lowest proportion of dyeing material to the amount of tin salt. Regarding the dyeing samples with dahlia and marigold, the women preferred, in addition to the samples that did not use mordants, those that used alum as a mordant. They also expressed a clear preference for the wool sample that was not treated with a mordant and was dyed with riatite. In the case of those dyed with indigo, the color that was closest to that used in the *quechquemitl* was the one obtained by immersion for ten days in the human urine fermentation vat.

DISCUSSION

Wool dyeing is part of an oral tradition among Mazahua women, who used to pass on their knowledge to their descendants, mainly the women of the house (Liu et al., 2014; Méndez, 2009). More than half of the eleven women interviewed learned to dye from their mothers. Currently, however, this is no longer the case. There are no written documents that preserve local knowledge, except for some scattered notes that the dyers use to remember some aspect of the process. Thus, the transmission of knowledge depends, to a large extent, on daily practice, but young women and girls no longer participate in it. Although dyeing is no longer seen as an activity only for women, men show little interest. The research revealed that not only are scarcity and high cost of materials affecting dyeing, but there is also a gradual loss of local knowledge, reflected in both the abandonment or alteration of traditional techniques and the loss of beliefs and taboos associated with such practices.

Although there are studies that explore the meaning of color among Mazahuas as a form of visual language (Maldonado, Serrano, & Sandoval, 2014), as part of a cosmogonic vision based on a universe of symbols (Vázquez, 2009) or as a form of expression of gender and community cultural identity (Gilsdorf, 2015), from an emic perspective the women do not attribute explicit meaning to colors, materials, and designs. The above seems to have been lost over time, but it is an essential part of their identity as Mazahuas and a distinctive element of belonging to their locality.

There is an inextricable link between the color of the garments and the dyeing material from which it is derived. The garments of the Mazahuas must be made with dyed wool, mainly with indigo and

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cochineal, and the women have a very clear idea of the color they expect for each garment. The laboratory work made it possible to obtain a wide range of colors; the women, however, chose those that are associated with their clothing and that were obtained with techniques similar to those they apply. There are dyeing materials in the area, such as the capulin cherry, blackberry, or purple cabbage, which, if used correctly, could produce colors similar to those obtained with indigo. Indigo and the technique of fermentation of human urine, however, are assumed as an essential identity symbol.

Similarly, cochineal can generate a wide range of colors and tones. However, women take the color pink as a feature of identity. It was evident in the research that in the clothing of the women of Santa Rosa de Lima, navy blue, and red or pink are prevalent. The appropriation of indigo and cochineal in traditional dress denotes elegance and status and is part of indigenous women's identity (Contreras, 2015). Cochineal is one of the most common dyes used by indigenous communities in other countries such as Peru (Rojas, Mavila, & Rojas, 2011), Ecuador (Jaramillo, 1989), Chile, and Argentina (Méndez, 2009).

Based on the fermentation of human urine, the indigo dyeing technique is a legacy of the processes used in Europe during the pre-industrial period to reduce indigo in an alkaline medium. According to Gonzalez, Bernal, Linares, and Crown (2012), it is an unreliable method that can generate, if the pH is not adequately controlled, inconsistent rates of fermentation. The experience with Mazahua women contradicts this statement, as they usually obtain good results from their empirical knowledge. It is true that there is a lack of understanding of the reduction-oxidation process and that the women do not control the physicochemical conditions during the process (Gilbert & Cooke, 2001). However, the intuitive application of the technique yields products that are satisfactory to them. The fundamental criteria that guide them are the indigo/urine ratio and the quality of the latter (the women insist on the need to use the urine of children). This was confirmed in the laboratory, as the urine method produced a color more in line with Mazahua women's preferences.

The human urine fermentation method is no longer used in many indigenous communities in Mexico (Contreras, 2015) and among indigenous women in Argentinean Patagonia (Méndez, 2009). The case of Santa Rosa de Lima is especially significant because it has managed to maintain an ancient, economical, and more environmentally friendly tradition and because it is part of the local cultural tradition. The use of garments made from indigo-dyed wool using the urine fermentation method is part of the local Mazahua women's cultural identity.

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As for the process of direct dyeing based on the use of cochineal and other natural dyes in order to obtain the red-yellow range and green tones in second dyeing with blue wool, the method used is always done in an acidic medium (with large amounts of lemon juice to achieve a pH close to 2.0). Invariably, tin salt is used as a simultaneous mordant. The amount of this substance, used by women intuitively, is similar to that reported by Türkmen, Kirici, Özgüven, Nan, and Kaya (2004). Despite the interest that several women showed in learning other traditional dyeing techniques, much of the knowledge has been lost and is dispersed among local women. The use of tin salt began around the 1990s and is well established. Thus, faced with the uncertainty of achieving optimal dyeing results, larger quantities of dyeing materials and mordants are often used.

Several authors state that the use of alum and cream of tartar as a pre-treatment for wool can yield more satisfactory results. Therefore, it has been gradually introduced in other indigenous communities, mainly because it results in brighter colors and softer fibers (Contreras, 2015). In Santa Rosa de Lima, however, they are not used. One of the women acknowledged that alum was used many years ago, but during simultaneous dyeing. She "believed," however, that it did not yield good results. The above could lead to the possibility of promoting more complex dyeing techniques locally. Zarkogianni et al. (2011), however, showed that the use of mordants in wool is not very significant since it is a fiber with a high absorption capacity that, even when dyed without mordants, presents excellent color fixation and very high fastness when subject to both washing and light exposure. Promoting, therefore, a change in the techniques used by Mazahua women would only mean an increase in the costs and complexity of the dyeing process.

As in other communities, knowledge of wool dyeing techniques is restricted to a few women (Trillo, Demaio, Colantonio, & Galetto, 2007). However, during the dyeing sessions in Santa Rosa de Lima, it was possible to corroborate that there is no control in the processes to facilitate obtaining the desired colors. A possible solution lies then in documenting and making the local knowledge of the women transmissible, according to their system of knowledge and beliefs, and correcting the significant technical limitations.

FINAL REFLECTIONS

The study of local knowledge does not mean documenting ancestral knowledge that is facing extinction. Rather, it offers the opportunity to bring it to light for its recovery and to give it its just value.

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In this sense, the work done in Santa Rosa de Lima acquires particular relevance. It was possible to document knowledge of extraordinary anthropological value that has almost been forgotten. This work made it possible to record the use of the indigo fermentation vat with human urine in detail. It is not merely a matter of describing an ancient technique but of measuring its intrinsic cultural value as a feature of a community's cultural identity. It also opens the possibility of recovering an almost lost knowledge regarding plants used in the past in the dyeing process.

DECLARATIONS

The authors acknowledge the contribution and support of the Mazahua women of Santa Rosa de Lima who participated in the study. The research was conducted following the guidelines of the International Society of Ethnobiology (ISE) code of ethics. In a spirit of respect for the cultural diversity and autonomy of the Mazahua people of Santa Rosa de Lima, the local authorities were informed and their authorization was sought before initiating the fieldwork. Once this was done, the project was presented to the local women who, having been informed about the objectives of the project, gave their consent for the publication of the audiovisual material and the findings.

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