https://doi.org/10.22319/rmcp.v12i2.5230

Article

Traditional ranchero Jarocho cheese: a multidisciplinary study from a typicity approach

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Abstract:

The objective was to integrate the information of the local milk production system, physicochemical and microbiological characteristics of the milk; elaboration process, and physicochemical, microbiological, and sensory characteristics of cheese to establish its typicity. The manufacturing of the cheese in most of the dairies studied has registered the operation of three generations of families. Variability in their chemical composition, microbiological, colour, texture and sensory was related with time and number of turns during the pressing, amount of added salt and vegetal fat. Cheeses with less pressing time had higher moisture content and less protein and fat content. The bacterial counts were related to milk quality tests, training courses and material of containers. These factors also affected the hardness of the cheese. Those with added vegetable fat and with high salt content had the highest hardness. The Hue angle (h°) of the cheeses indicated a tonality close to yellow (90°). Difference in chromaticity (C*) can be related to the use of vegetable fat. Cheeses with higher moisture content were brighter (L*) and had less color saturation. The sensory evaluation showed that the most typical cheeses were perceived in the attributes as salty, milk aroma, and serum and milking smell. Applying sanitation measures of milk collection, good cheese manufacturing practices and avoiding the addition of vegetable fat, it could be possibly getting a legal-commercial protection of the ranchero Jarocho cheese.

Key words: Raw milk, Traditional cheese, Typicity, Milk production systems.

Received: 26/01/2019

Accepted: 05/08/2020

Introduction

Traditional foods express the individual identity of a society and seemed to look as a symbol of heritage. Transmission of knowledge of traditional food occurs between the older and the younger generation(1). The typicity approach allows analyzing traditional foods that are linked to a territory as the result of a social trajectory of manufacturing techniques, where a collective knowledge is developed from the interaction between physical-biological and human factors. The present study starts from the premise that the typicity is established when the information about the milk production system, milk characteristics, processing parameters, physicochemical, microbiological, and sensory characteristics are integrated(2). Generally, the information that is integrated is previously obtained from a multidisciplinary study in which the different disciplines that serve a common objective concur, but the interaction between them does not modify the disciplines individually(3). This integration is important because an incomplete characterization prevents getting some type of intellectual property right(4) since it is necessary to ensure that there is a connection between the extrinsic attributes of the *terroir* and intrinsic attributes of this product(5).

In Mexico, traditional cheeses linked to a region are manufactured[6] however, the available information includes the chemical and microbiological quality and production process[7] leaving aside production systems sensory characteristics of the product. Mexican cheeses face a serious problem related to current regulations, since on the one hand it emphasizes the use of standardized and pasteurized milk so that a cheese can be classified as such and on the other hand it allows the addition of milk in powder and other dairy ingredients or not, favoring the proliferation of imitation cheeses[8]. In addition to the regulatory problems, there is the lack of experience in the legal framework for Mexican cheeses to obtain commercial protection. In this regard, Cotija cheese is a cheese with a strong link with the territory and the society that produces it, which has been established by various studies that define its typicality integrating the physicochemical, microbiological and sensory aspects. These cheese are the pioneer for the recognition and protection of traditional Mexican food products since, despite not having obtained the designation of origin, it has been granted the collective mark, which has translated into growth for producers and opens the door for other Mexican cheeses[9].

The ranchero Jarocho cheese is a traditional cheese made from raw bovine milk, produced in the cattle areas of Veracruz and her production represents the major source of income for some families. The objective of this study was to apply the typicity approach to integrate the information about the local milk production system, physicochemical and microbiological characteristics of the milk; elaboration process, physicochemical, microbiological and sensory characteristics of the cheese in an interdisciplinary way to generate information that will eventually allow obtaining trademark protection.

Material and methods

Study area and characterization of the bovine milk production system

The rural development district 008 in the State of Veracruz, Mexico (18º 11´ to 18º 45´ N and 95º 09´ to 96º 37´ W) was explored including the municipalities of Tierra Blanca, Tres Valles, Cosamaloapan, Ixmatlahuacan, Acula, Chacaltianguis and Tlacotalpan, which produce 90.5 % the bovine milk of the district[10]. A semi-structured questionnaire to obtain information about livestock approach, feeding and supplementation was applied. The sample size using the data available from INEGI[10] regarding the number of production units as sampling frame was determined ($N= 5,924$ $\sigma^2= 8.0$). The following formula was used, considering a confidence level of 95% ($Z = 1.96$) and a maximum permissible error (B) of 0.5.

$$n = \frac{\frac{N\sigma^2}{(N-1)B^2}}{Z^2} + \sigma^2$$

The result was n= 120 UP, however, in practice, 124 production units were accessed.

Characterization of the cheese-making process and sampling

A dairy in each municipality was selected based on processed milk per day (at least 500 L). Semi-structured questionnaire considering the variables in Table 1 was applied. Five samples of milk and five samples of cheese were taken weekly in each of the seven dairies (35 samples of milk and 35 samples of cheese) for five weeks, collecting 175 samples of milk and 175 samples of cheese in total. For milk, 500 ml from the storage tank were taken before starting the cheese processing using borosilicate sterile glass bottles. At the end of the production process, 500 g of cheese was taken in sterile bags with hermetic sealing. The samples at 4 ± 1 °C were transported for analysis. All samples were taken in triplicate.

Chemical and microbiological analysis of the milk and cheese

The fat, protein and lactose content in milk were tested with ultrasonic equipment Lactoscan S (Milkotronic Ltd., Nova Zagora, Bulgaria). The fat, moisture and protein content of cheese samples were determined(11). For microbiological analysis 10 ml (milk samples) or 10 g (cheese samples) were diluted in 90 ml of sterile peptone and homogenized one minute at 265 rpm in a homogenizer Stomacher™ model 400 (Seward Limited, UK). Dilutions of 10^{-1}, 10^{-2} and 10^{-3} were obtained. Total Bacterial Count (TBC) and Total Coliform Count (TCC) were determined to milk. The TBC, Fungi and TCC were determined to cheese(11). To comply with the normality assumption, the values expressed as Colony Forming Units (cfu) were subjected to a logarithmic transformation and expressed as Log_{10} of cfu to perform the statistical analysis.

Texture and color of the cheese

The hardness and adhesiveness on cylindrical samples 2.5 cm in diameter and 3.0 cm in height were evaluated. A texturometer TA-XT (Stable Micro Systems, Surrey, UK) with an acrylic disk 35 mm in diameter (A/BE35) at the compression rate 5 mm/s was used. A colorimeter

UltraScan™ Vis (HunterLab, Hunter Associates Laboratory Inc., Virginia, USA) was used to measure the colour parameter as L* (Luminosity), a***** (red/green coordinates (+a indicates red, -a indicates green) and b* (yellow/blue coordinates (+b indicates yellow, -b indicates blue). The Chromaticity or saturation (C*) and Hue angle (hº) were calculated. The samples were analyzed in triplicate and at three different points of the cheese surface.

Sensory analysis of cheese

A panel of eight trained judges was formed. The Bright (BR), Porous in view (PV), Serum presence (SP), Hardness to the touch (HT), Creamy to the touch (CT), Milk smell (MS), Serum smell (SS), Milking smell (MKS), Salty (SA), Hardness in mouth (HM), Plastic aroma (PA), Milk Aroma (MA), Serum aftertaste (SAT) and Milk aftertaste (MAT) attributes were evaluated. An unstructured scale from zero (low intensity) to nine (high intensity) was used. The "Typical" (TY) attribute was evaluated using an unstructured scale (right and left anchors were “good example” and “bad example” of a typical cheese)(12). Eight sessions with a replication were conducted to obtain the sensory profile by QDA™. Only samples with bacterial counts within the official Mexican standard were used.

Statistical analysis

The experimental data were analyzed using an analysis of variance (ANOVA), and a minimum significant difference test with a confidence level of 95% was used. The correlation among some variables and the effect of the manufacturing process on the cheese characteristics using SAS version 9.3(13) were determined. The instrumental, sensory and manufacturing process data were integrated by Multiple Factorial Analysis (MFA) and vectorial correlation coefficient Rv using XLSTAT version 1.0(14). The stabilities of the sensory map, confidence ellipses (95%) and Hotelling’s test T^2 using SensoMineR with language R version 2.15.3 (R Development Core Team) were determined.

Results and discussion

Characterization of the bovine milk production system

Only dual-purpose systems were observed, Swiss×Cebu crosses were predominant (85 %), used to obtain acceptable levels of milk production with animals resistant to tropical conditions[15]. The herd feeding consists in *Cynodon nlemfuensis* (Vanderyst) (23.4 %), *Brachiaria humidícola*, (Rendle) (18.2 %), *Digitaria eriantha* (Stent) (17.3 %), and undefined mixtures (41.1 %). The supplementation with protein concentrates in 20 % of cases only in the dry season was observed, which, as mentioned by some producers, is carried out with the objective of maintaining production levels and not increasing production costs. The dairy herd consists an average of 63 cows milked once daily by hand (98.4 %). An average milk production of 4.4 $L \cdot cow^{-1}$, that in 32 % of cases do not sell it because they use it to produce cheese.

Characterization of the cheese making process

The production process of ranchero Jarocho cheese registers three generations in 57.2 % of the dairies; The process consists of (a) raw milk is coagulated (32-34 °C/2-3 h) with commercial rennet (Cuamex, México Industries); (b) the curd is cut; (c) the serum is drained by decanting; (d) salt is added manually by crumbling to reduce the curd size; (e) the curd is pressed in plastic molds. The variables of the cheese making process are presented in Table 1. The used milk is not standardized or homogenized and calcium chloride and starter culture is not used. It was observed that in 28 % of dairies vegetable fat was added to the milk to increase the yield[16] which is considered an adulteration[17]. The pressing was similar to that reported in Caciocavallo cheese[18] and fresh cheese from Croatia[19]. A distinctive manufacturing feature is a rotation during the pressing so that the moisture is homogeneously distributed.

Table 1: Description of variables involved in the manufacturing process of ranchero Jarocho cheese

Variable	Levels	Cheese dairies (%)
Quality tests are performed to milk received	Yes	28
	No	72
Amount of added salt (%)	5	57
	6	28
	7	15
Pressing time (hours)	2.0	14
	3.0	29
	3.5	14
	4.0	29
	4.5	14
Number of rotations during pressing	0	72
	2	14
	3	14
Addition of vegetable fat	Yes	28
	No	72
Cheese yield (%)	10	57
	11-15	28
	16	15
The material of the containers used	Plastic	28
	Stainless steel	72
Antiquity of the process (Generations)	1	42
	3	58

Chemical composition and microbiological analysis of milk

The main chemical parameters are shown in Table 2. The milk of Acula and Cosamaloapan presented the lowest fat content, possibly due to rainy season which is presented high moisture and low fiber content on the forage. The milk of Chacaltianguis and Ixmatlahuacan presented physiologically improbable values associated with the addition of vegetable fat. The protein content was low possibly caused by the high yield of *Bos Taurus* component[(20)]. The lactose content was lower than the reported in dual-purpose systems[(15)]. The milk composition was characterized by low solids content; this is related to genetic, technological, environmental and dairy herd variables[(21)]. The main indicators microbial of contamination of milk are presented in Table 2. The TBC indicated an inadequate hygiene in the milking and post-milking management[(22)] since they were higher than 100,000 cfu ml^{-1} (23). For TCC only the milk of

Tierra Blanca and Cosamaloapan fulfilled the regulatory count which sets a lower count of 750 cfu ml^{-1}[23] related to failures in the removal of residual water or milk from the deposits or containers[22].

Table 2: Chemical composition and microbiological analysis of milk in different cheese dairies (Mean±SD)

Municipality	Fat (g L^{-1})	Protein (g L^{-1})	Lactose (g L^{-1})	TBC (log$_{10}$ cfu mL^{-1})	TCC (log$_{10}$ cfu mL^{-1})
Ixmatlahuacan *	84.50 ± 0.30^{e}	32.0 ± 0.80^{c}	43.3 ± 1.20^{b}	5.72 ± 0.11^{e}	4.35 ± 0.00^{c}
Chacaltianguis *	73.35 ± 0.10^{d}	27.1 ± 0.38^{a}	44.3 ± 2.57^{b}	5.54 ± 0.01^{b}	4.20 ± 0.02^{b}
Tierra Blanca	35.00 ± 0.10^{c}	26.2 ± 0.04^{a}	38.6 ± 0.54^{a}	5.34 ± 0.01^{a}	ND
Tres Valles	34.20 ± 0.30^{c}	29.8 ± 0.32^{b}	42.6 ± 0.49^{b}	5.61 ± 0.00^{d}	4.10 ± 0.01^{a}
Tlacotalpan	32.20 ± 0.40^{b}	31.6 ± 1.80^{c}	39.1 ± 0.05^{a}	5.74 ± 0.01^{f}	4.12 ± 0.01^{b}
Cosamaloapan	31.75 ± 0.20^{b}	26.9 ± 0.87^{a}	38.2 ± 1.20^{a}	5.57 ± 0.01^{c}	ND
Acula	24.75 ± 0.50^{a}	30.4 ± 1.40^{b}	43.2 ± 0.10^{b}	5.76 ± 0.00^{g}	4.35 ± 0.00^{c}
SEM	4.877	2.408	0.578	0.032	0.427

* Milks with added vegetable fat. ND= Not detected (<1 log$_{10}$ cfu mL^{-1}). TBC= Total bacterial count; TCC= Total coliform count. SEM= Standard error of the mean.

^{a} Values followed by different letters in superscripts in each column are significantly different at P<0.05.

Chemical composition and microbiological analysis of cheese

The chemical composition of cheeses is shown in Table 3. According to the moisture content, ranchero Jarocho cheese was classified as a fresh and soft cheese[24]. The protein content was lower than to that reported in the Mihalic cheese[25]. The heterogeneity in the chemical composition was related to making process. The cheeses with less pressing time had higher moisture, less protein, and fat (Figure 1a). This effect has been explained to be a solid concentration effect when the moisture is removed[26]. The main indicators microbial of contamination of cheeses are presented in Table 3. The values for all parameters were higher than reported for the Dill cheese made from pasteurized milk[27] and similar than reported for the tropical cream cheese, attributing to the use of raw milk[28]. A correlation between the microbial counts of the milk and the microbial counts of the cheeses (TBC: R=0.64, P<0.05;

TCC: R=0.98, P< 0.001) was observed. The cheeses had values of TBC and TCC higher than the milk due to the physical retention of microorganisms in the curd and the microbial growth during coagulation and whey removal(29). Some of the manufacturing process variables affected the microbial counts of the cheese (Figures 1b, 1c and 1d). The dairies where quality tests were performed and stainless-steel vessels were used had the lowest TBC, TCC and Fungi counts. These results occur because the stainless-steel vessels are made can be maintained in a sanitary condition(27). In dairies where training courses were held the TBC, TCC and Fungi counts were the lowest. The high microbial counts in cheeses can be related to the use of unpasteurized milk. The pasteurization can reduce the microbial count(30) however; can eliminate bacteria responsible for the typical flavors(29) and specific sensory characteristics of the cheese(31).

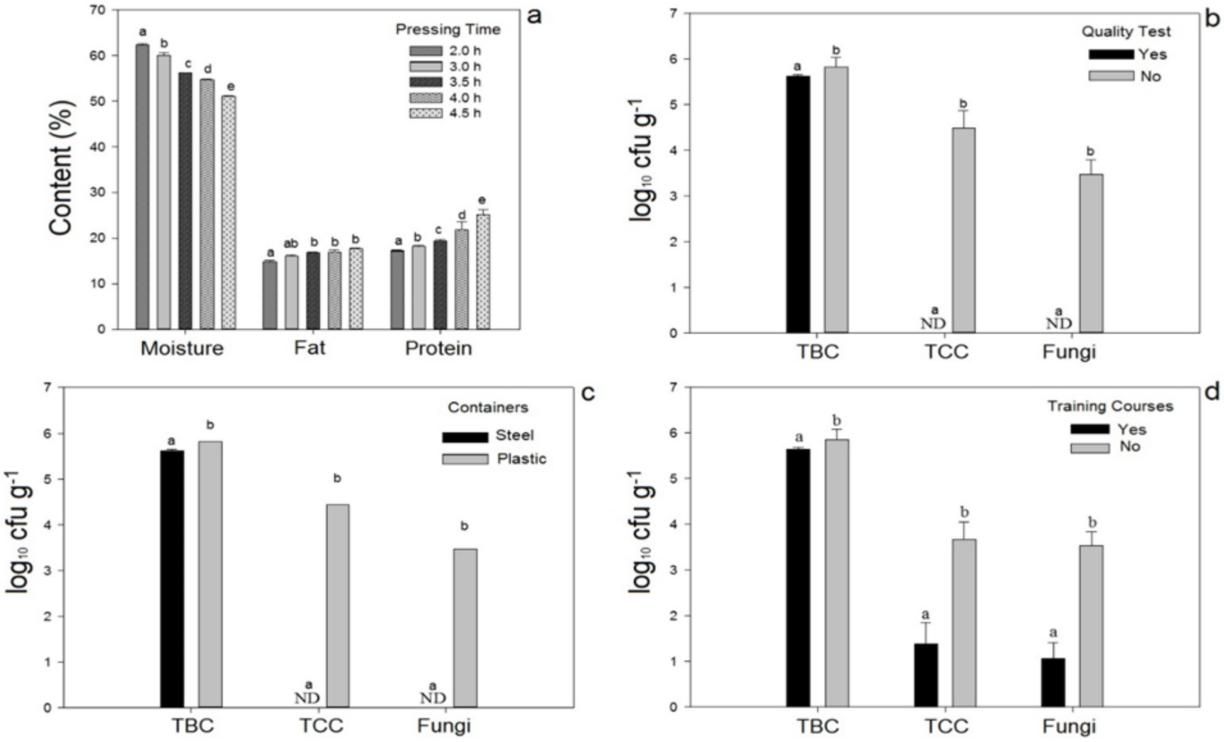
Table 3: Chemical composition and microbiological analysis of ranchero Jarocho cheese made in different cheese dairies (Mean±SD)

Municipality	**Moisture**	**Fat**	**Protein**	**TBC**	**Fungi**	**TCC**
	(g kg^{-1})			**(log$_{10}$ cfu g^{-1})**		
Acula	510.01 ± 0.25^{a}	170.6 ± 0.50^{d}	250.10 ± 1.06^{e}	5.97 ± 0.00^{c}	3.91 ± 0.01^{c}	4.94 ± 0.00^{d}
Chacaltianguis	540.52 ± 0.31^{b}	150.5 ± 0.54^{b}	230.11 ± 1.58^{d}	5.61 ± 0.01^{ab}	3.39 ± 0.01^{a}	4.26 ± 0.03^{c}
Ixmatlahuacan	540.75 ± 0.15^{b}	180.5 ± 0.54^{e}	200.43 ± 0.40^{c}	6.15 ± 0.11^{d}	3.64 ± 0.36^{b}	4.95 ± 0.00^{d}
Tres Valles	560.24 ± 0.01^{c}	160.7 ± 0.43^{c}	190.35 ± 0.37^{bc}	5.68 ± 0.00^{b}	3.20 ± 0.00^{a}	4.16 ± 0.01^{a}
Cosamaloapan	590.36 ± 0.22^{d}	130.3 ± 0.41^{a}	180.23 ± 0.27^{ab}	5.66 ± 0.01^{ab}	ND	ND
Tlacotalpan	600.54 ± 0.01^{e}	160.1 ± 0.41^{bc}	180.16 ± 0.19^{ab}	5.78 ± 0.01^{b}	3.20 ± 0.03^{a}	4.15 ± 0.01^{b}
Tierra Blanca	620.2 ± 0.26^{f}	160.0 ± 0.0^{bc}	170.1 ± 0.27^{a}	5.5 ± 0.02^{a}	ND	ND
SEM	8.099	3.272	6.087	0.044	0.355	0.459

TBC= Total bacterial count; TCC= Total coliform count. ND= Not detected (<1 log$_{10}$ cfu mL^{-1}). SEM = Standard error of the mean.

[abcdef] Values followed by different letters in superscripts in each column are different (P<0.05).

Figure 1: (a) Effect of (a) pressing time on the moisture, fat and protein content, (b) milk quality testing to receive it in the cheese dairies, (c) material of the containers used, (d) training of producers, over total bacterial count (TBC), total coliform count (TCC) and Fungi in analyzed cheeses



Texture and color of cheeses

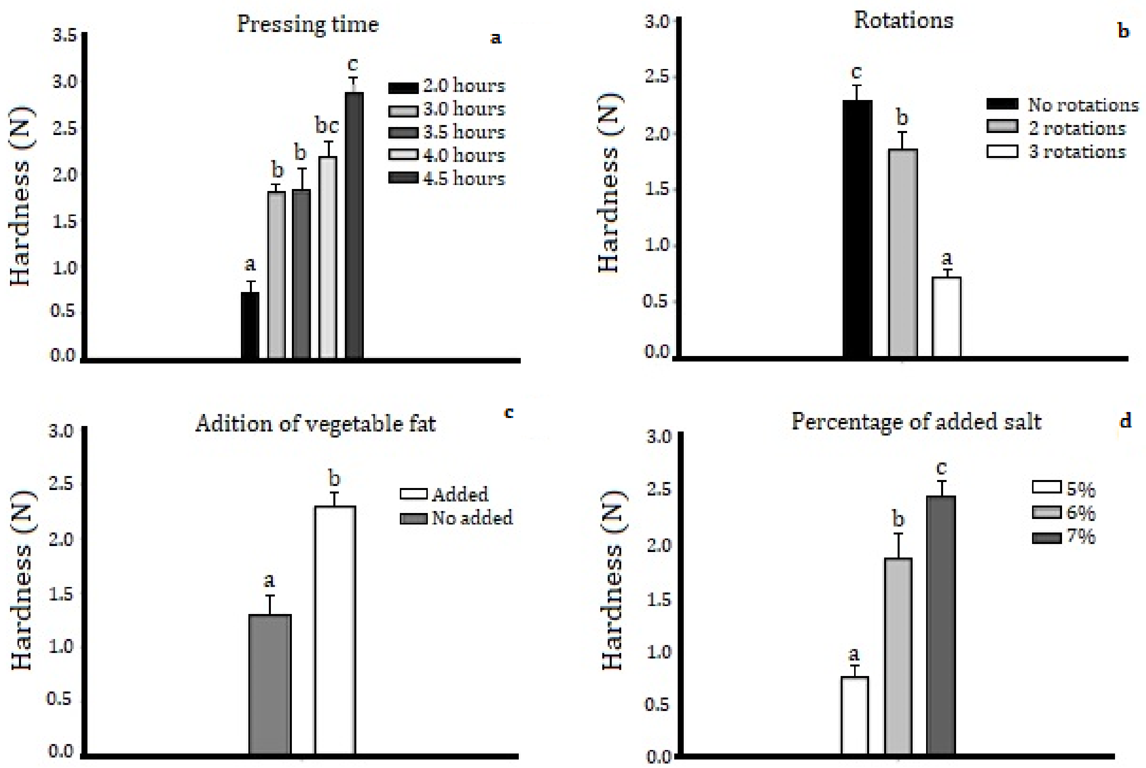
The texture analysis results of the cheeses are shown in Table 4. The hardness and adhesiveness were lower than the fresh cheeses with added canola oil[32]. The pressing time, a number of rotations, the addition of vegetable fat and percentage of salt parameters affect the cheese hardness (Figure 2). A longer pressing time allowed a more water transferred out of the cheese, which increased the fat and protein concentrations and the hardness[33]. The number of rotations during pressing affected the water removal, where the cheese that is rotated more times retains more moisture and has the lowest hardness. The cheeses with added vegetable fat had the highest hardness (P<0.05) because the larger diameter of the vegetable fat globules enables the interaction with more protein per unit area and causes greater resistance to deformation of the protein matrix[16,32]. A higher percentage of added salt increases the hardness of the cheese, probably due to a decrease in the degree of proteolysis[34]. The color parameters are shown in Table 4. L* indicates high brightness and is consistent with the observed in the fresh cheese of Minas Gerais in Brazil[26]. The Hue angles indicate a tonality close to yellow (90°) with differences in saturation (C*). The yellowing of cheeses made from cow's milk is characteristic because cows can transfer dietary carotenoids to the milk[25]. The moisture content is correlated with the values of L* (R= 0.38, P < 0.001) and C* (R= -0.43, P<0.001): the cheeses with higher humidity were brighter and had less color saturation because higher water content increases the ability to reflect or transmit light[26]. The difference in color saturation can be related to the use of vegetable fat, which was previously reported[16].

Table 4: Texture and color parameters for the ranchero Jarocho cheese made in different cheese dairies (Mean±SD)

Municipality	Hardness (N)	Adhesiveness (N)	L*	C*	h°
Tierra Blanca	0.72 ± 0.10^{a}	-0.26 ± 0.27^{a}	91.5 ± 5.46^{ab}	14.7 ± 1.10^{bc}	89.4 ± 0.29^{a}
Tlacotalpan	1.72 ± 0.17^{b}	-0.11 ± 0.11^{a}	92.5 ± 0.70^{b}	12.0 ± 2.91^{a}	87.2 ± 3.05^{a}
Tres Valles	1.81 ± 0.61^{b}	-0.18 ± 0.14^{a}	92.1 ± 0.64^{ab}	14.2 ± 0.62^{ab}	88.3 ± 0.70^{a}
Cosamaloapan	1.85 ± 0.41^{b}	-0.03 ± 0.04^{a}	91.9 ± 0.73^{ab}	13.0 ± 0.66^{ab}	89.3 ± 0.40^{a}
Acula	2.18 ±0.64^{bc}	-0.08 ± 0.10^{a}	91.0 ± 0.42^{ab}	16.4 ± 1.04^{c}	89.4 ± 0.47^{a}
Chacaltianguis	2.56 ± 0.59^{c}	-0.16 ± 0.18^{a}	90.5 ± 0.67^{a}	16.1 ± 0.89^{c}	89.0 ± 0.37^{a}
Ixmatlahuacan	3.18 ± 0.60^{c}	-0.14 ± 0.10^{a}	90.7 ± 0.79^{ab}	15.6 ± 0.53^{c}	89.3 ± 0.38^{a}
SEM	0.182	0.031	0.423	0.418	0.281

L*= Luminosity; C*= Chromaticity or saturation; h°= Hue angle. SEM = Standard error of the mean.
[abc] Values followed by different letters in superscripts in each column are different (*P*<0.05).

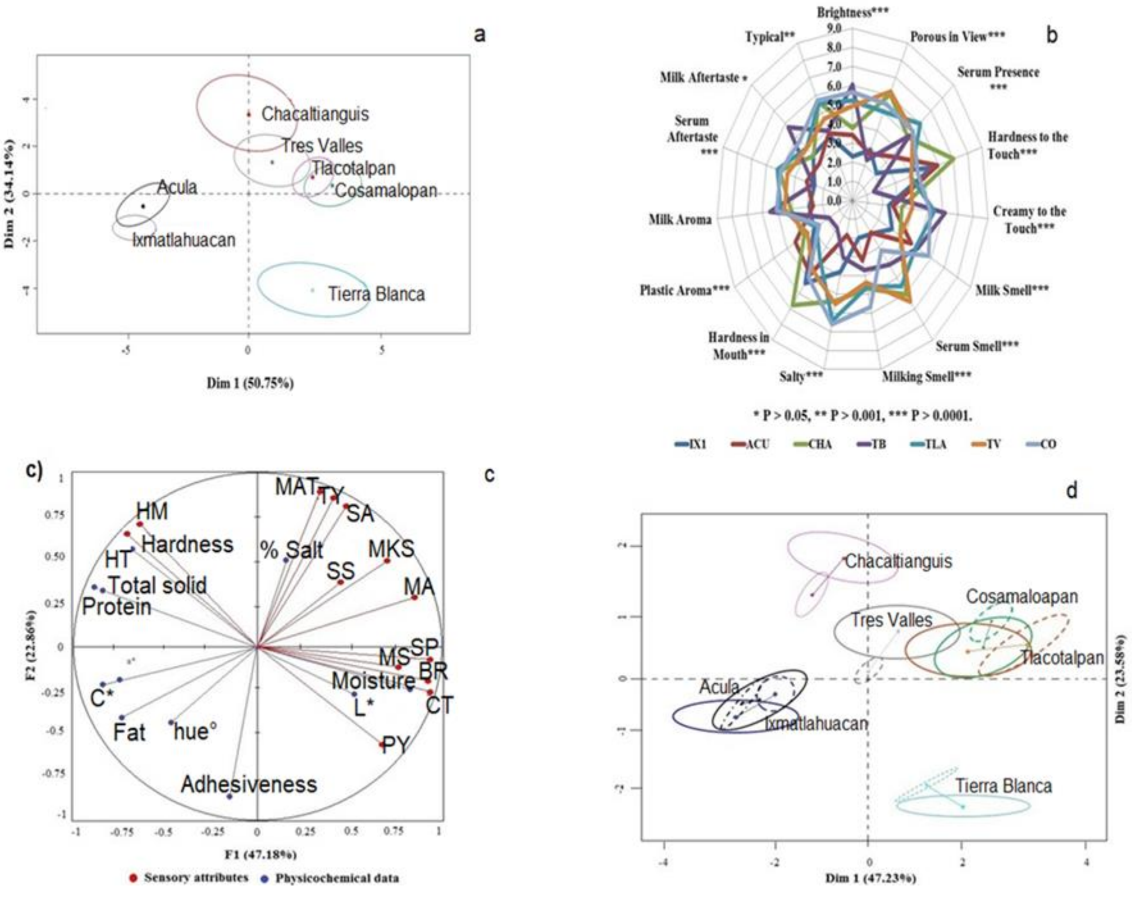
Figure 2: Effect of a) pressing time, b) rotation, c) addition of vegetable fat and c) percentage of added salt on the hardness of ranchero Jarocho cheese



Sensory analysis

The confidence ellipses showed the discriminant effect of the panel which formed three groups, according to Hotelling's test T^2 (0.205, 0.39 and 0.14) (Figure 3a). The sensory profile revealed that the cheeses of Tierra Blanca were characterized by the higher intensity in attributes BR, CT, MA and MAT. The cheeses of Acula and Ixmatlahuacan had lower intensities of BR, MA, and SA. The cheeses of Tlacotalpan, Cosamaloapan, Chacaltianguis, and Tres Valles showed more intensity in SAT, MA, MKS and SS (Figure 3b). Figures 3c and 3d show 70 % of the total inertia of the data in the two principal components. The cheeses of Tres Valles, Tlacotalpan and Cosamaloapan were grouped according to the percentage of added salt and considered the most typical with highest intensities of MAT, SA, SS, MKS and MA (Figure 3c). The attributes SA and SS were established to differentiate Mihalic cheeses(25) because the salt content affects the aroma intensity of cheeses(35). The attributes BR and CT were associated with higher moisture content and greater L*. The attributes HT and HM were associated with higher protein content, total solid and more hardness. Figure 3d shows that the sensory and physicochemical data are near at midpoint among all cheeses, confirmed with the Rv coefficient (RvSE-FQ = 0.74).

Figure 3: (a) Confidence ellipses around of cheeses, (b) sensory profile of the cheeses, (c) sensory-physicochemical correlation, (d) Overall and partial representation of cheeses in the MFA (solid line: sensory data, dashed line: physicochemical data)



“Through the integration of the information, it was observed that the ranchero Jarocho cheese has a high potential to obtain commercial protection, however, it presents the following difficulties: The high variability in milk quality is a consequence of the inequality in which the local milk systems of dual purpose are developed, therefore, originates a high heterogeneity in the quality of the cheeses. Therefore, at the production system level, it is necessary to train producers to maintain a more stable and homogenous milk quality. Another important problem is the addition of vegetable fat as a strategy to increase cheese yield. In this regard, it is preponderant to convince the producer that this practice must be eradicated since it discards the product to obtain commercial protection.

Finally, the lack of pasteurization of milk for the production of cheeses is perhaps the most worrisome problem since it firstly violates current local regulations and also represents a high risk of contamination with pathogenic bacteria such as *Salmonella*, *E. coli*, *Listeria*, *Campylobacter* and others that cause disease in humans. This problem may seem simple; however, the sensory attributes of cheeses are strongly related to some specific microorganisms and although pasteurization eliminates pathogenic bacteria, it also destroys bacteria related to the development of aromas and flavors. Therefore, it is necessary to carry out more studies focused on correlating specific bacteria in milk with the development of sensory attributes that make ranchero Jarocho cheese be perceived as “typical” with the aim of isolating the milk microbiota so that it can be added after the pasteurization process. These studies must be carried out so that the developed technology can be transferred later to the producers”.

Conclusions and implications

This study revealed that the ranchero Jarocho cheese is manufactured with milk from local dual purpose systems and the making process reflects the traditional empirical knowledge and is associated with the cultural practices that have maintained these biological resources over several generations. The multivariate integration revealed that the cheeses with greater intensity in the sensory attributes as serum and milking smell, milk aroma intensified by a higher percentage of salt were perceived as the most typical ranchero Jarocho cheese. Likewise, some aspects of this study revealed that the use of raw milk and lack of sanitation could compromises the safety of consumers. On the other hand, the heterogeneity in composition of ranchero Jarocho cheese related to differences in the production process in some cheese factories, as well as, the addition of vegetable fat in milk could classified it as an analogous cheese. However, the multidisciplinary approach allowed to appreciate the potential of this cheese for obtaining its typicity, for that purpose, applying sanitation measures during milk collection, good cheese manufacturing practices and avoiding the addition of vegetable fat, it could be possible get a legal-commercial protection of the ranchero Jarocho cheese.

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