Genuine Mexican cheeses: technological processes and manufacturing parameters

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ABSTRACT

Objective: Provide an overview of the current situation of genuine Mexican cheeses (GMCs), their characteristics, and the conditions of their manufacturing processes (origin of the milk, curdling agent, type of aging, and ripening).

Methodology: We compiled, analyzed, and classified the information available for 20 GMCs in scientific articles, databases, and web pages.

Results: GMCs are mainly classified based on their moisture content in soft or fresh, semi-soft or semi-hard, and hard cheeses. Most of the GMCs are not subjected to ripening processes, which limits their shelf life and large-scale commercialization. Ripened GMCs use their own microbiota, developing characteristic textures and flavors.

Limitations: Few studies have evaluated the manufacturing processes of GMCs and their impact on the physical and sensory properties of the final product. Furthermore, no GMC has a designation of origin, which puts them at a disadvantage in the face of a globalized market.

Conclusions: Most GMCs are handmade, and only a few of them are produced on a semi-industrial scale. A standardized production would allow producers to improve and innovate GMCs and increase their shelf life.

Keywords: Mexican dairy products, texture, cheese ripening, curdling agent.

INTRODUCTION

Cheese is a product derived from the coagulation of milk proteins and represents a high-value source of proteins, vitamins, and minerals. Furthermore, the presence of lactic acid bacteria provides a probiotic effect. The coagulated proteins determine the physical, chemical, and organoleptic characteristics of the cheese (González-Córdova et al., 2016). After its elaboration, the cheese can be subjected to fermentation, ripening, or both processes, promoting the formation of bioactive peptides with beneficial health properties (Hernández-Galán et al., 2016).

Cheese production in Mexico is one of the most important activities in the food industry. In 2019, cheese production amounted to 355 thousand 381 tons, with a market value of more than 18,000 million Mexican pesos (SIAP, 2019). Although most cheese production is concentrated in large national and transnational companies, traditional
cheesemaking has a remarkable market (Mazorra-Manzano, 2019). However, traditional Mexican cheesemaking is still not very competitive due to the lack of technology and standardization of manufacturing processes and, in some cases, the loss of knowledge of production procedures. Therefore, this review aimed to provide a current overview of the production, classification, and particular characteristics of GMCs, in order to spread knowledge and contribute to its preservation.

**Genuine Mexican cheeses and their current situation**

GMCs are considered traditional products of origin and agri-food products with significant economic, commercial, and social potential. These cheeses are part of the tradition, culture, and representative heritage of the Mexican town or region where they are made (FAO, 2010). The importance of GMCs lies in the number of existing varieties in the country, the local economic value of their production, and their economic impact in the international market of dairy products (González-Córdova et al., 2016).

The elaboration of GMCs can be homemade, artisanal, or industrial. Small-scale production often has little technology and poorly standardized processes. In general, the production of GMCs uses raw milk, producing distrust in the consumer. However, there are high-quality raw milks in Mexico that, because of their microbiota, can provide cheeses with unique sensory characteristics (Villegas-de Gante et al., 2016). GMCs are differentiated by the origin of milk, type of rennet, ripening, appearance, and other characteristics (Jiménez et al., 2018). The limited production of certain GMCs is due to the lack of knowledge of this type of product by consumers, the strong competition with industrialized cheeses, and the short shelf life that prevents commercialization (Villegas-de Gante et al., 2016). Furthermore, the migration of producers to large cities and the lack of resources have caused the loss of knowledge on the manufacturing of GMCs. Therefore, it is essential to preserve and communicate the knowledge of the manufacturing processes of GMCs, to train producers in the development of standardized processes, the use of technologies to increase the shelf life of their products, and encourage them to obtain quality and safety certifications for the GMCs to maintain the standards that the consumer needs and demands (Vargas, 2016; Cervantes-Escoto et al., 2017; Villegas-de Gante et al., 2016).

**Classification of genuine Mexican cheeses**

GMCs can be classified by their texture, based on their moisture content. Soft cheeses make up the majority of Latin American cheeses and possess a percentage of moisture in nonfat substance (MNFS) higher than 67%, semi-soft cheeses have a MNFS ranging from 61-69%, semi-hard from 54-63%, hard from 49-56%, and extra-hard less than 51% (NMX-F-713-COFOCALEC-2014). Based on this classification, Figure 1 shows the general manufacturing process of GMCs and the characteristics of each one of them. Table 1 shows the main conditions of the production process of GMCs (origin of milk, curdling agent, type of aging, and ripening) and some final characteristics of these products.

**Description of some genuine Mexican cheeses**

**Soft or fresh cheeses**

**Queso de Bola de Ocosingo** (Chiapas): It consists of a ripened double-cream cheese, lined with a bright yellow rind of cheese made with skim milk to the point of quesillo. It is hard with a spherical form and a diameter between 8 and 12 cm, from 400 g to 1 kg (López et al., 2015; Villegas-de Gante et al., 2014; Sepulveda & Esparza-Chavez, 2016). The core of the cheese has an off-white color and a soft, creamy, spreadable, and crumbly texture with acid aromas and flavors (González-Córdova et al., 2016; Cobo-Monterroza et al., 2019). In 2005, the Instituto Mexicano de la Propiedad Industrial (IMPI) granted the Collective Trademark Registration, thus guaranteeing the consumer the originality of the product (Villegas-de Gante et al., 2014; López et al., 2015). The Bola de Ocosingo cheese was the first Mexican cheese to obtain a Collective Trademark classification and aims for a Protected Designation of Origin (PDO) (López et al., 2015).

**Queso Jarrocho** (Veracruz): This cheese is an artisan creation with a cheesemaking tradition of almost 50 years, native to the tropics, manufactured in the municipalities of Tierra Blanca, Tlalixcoyán, and Ignacio de la Llave in the State of Veracruz (Villegas-de Gante et al., 2014). It is a fresh cheese with a soft texture, white color, and slightly acid aroma and flavor. This cheese has a cylindrical shape (26 cm in diameter and 13 cm in height) and its weight varies between 6 and 8 kg (Cervantes-Escoto et al., 2006). Its production process is considered innovative since it uses ice to better preserve the curd and increase its
Figure 1. Diagram of the manufacturing process of genuine Mexican cheeses. Overall manufacturing process of cheeses (black) and specific processes for soft (purple), semi-soft (blue), semi-hard (orange), and hard (green) cheeses.

in addition to the oral transmission of the production process across generations, Tenate cheese is in danger of extinction (Cruz, 2015).

Semi-soft/semi-hard cheeses

Queso crema (Chiapas): This is a traditional product from Chiapas, it is manufactured in the Norte, Frailesca, and Costa regions (Rangel-Ortega et al., 2012; Villegas-de Gante & Cervantes-Escoto, 2011). It is a unique product, specific and impossible to imitate due to the quality of the milk, its manufacturing process, physicochemical characteristics, salt content, and sensory properties (acidity and strong fruity aromas) that result from fermentation. Shaped as a small flat cylindrical and rectangular prism from 250 g to 1 kg (Agudelo-López, 2015; Cervantes-Escoto et al., 2006; Moreno & Villegas-de Gante, 2016). This cheese is protected by the Collective Trademark “Chiapas Centenario” Queso Crema de Chiapas, which grants it national establishment (Pérez, 2014).

Queso de Poro (Tabasco): This is a fresh ripened cheese of semi-hard and pressed paste (Alejo-Martínez et al., 2015; Díaz-Ramírez et al., 2016) and artisan manufacture in the Ríos region of Tabasco, specifically in the municipalities of Balancán and Tenosique. An important characteristic of this cheese is its 7-day ripening. Due to the microbiota present in the whey used for its manufacture, small holes or pores develop, attributed to the production and accumulation of gas. This cheese has a rectangular shape and its weight ranges from 250 g to 1 kg. It has a characteristic intense aroma, an acid-salty flavor, and a humid texture (Cervantes-
<table>
<thead>
<tr>
<th>CHEESE NAME, ORIGIN</th>
<th>MOLK ORIGIN</th>
<th>COAGULATION AGENT</th>
<th>RIPENING TIME</th>
<th>PASTE PROPERTIES</th>
<th>FERMENTATION / RIPENING</th>
<th>FAT CONTENT (FDE %)</th>
<th>MOISTURE CONTENT (MNFS %)</th>
<th>REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adobera de la Sierra de Amula, Jalisco</td>
<td>Brown-Swiss, Simmental, Zebu, and their crosses</td>
<td>Liquid rennet</td>
<td>21-30 days</td>
<td>Soft, sliceable, and unpressed</td>
<td>Medium fat (29.31 %)</td>
<td>Full fat (48.27 %)</td>
<td>Semi-hard</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
<tr>
<td>Ahumado de la Joya, Veracruz</td>
<td>Holstein, Jersey, Swiss, Zebu, and Holstein-Swiss crosses</td>
<td>Liquid rennet</td>
<td>21-30 days</td>
<td>Soft, sliceable, and unpressed</td>
<td>Medium fat (29.31 %)</td>
<td>Full fat (48.27 %)</td>
<td>Semi-hard</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
<tr>
<td>Aro de Etla, Oaxaca</td>
<td>Guernsey, Holstein, Jersey, Swiss and their crosses</td>
<td>Renin or microbial rennet and acetic or lactic acid</td>
<td>4-6 weeks</td>
<td>Flala and meltly</td>
<td>High fat (73.52 %)</td>
<td>Semi-hard</td>
<td>Semi-hard</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
<tr>
<td>Asadero, Aguascalientes</td>
<td>Brown Swiss and Brown Swiss crosses</td>
<td>Renin or microbial rennet and acetic or lactic acid</td>
<td>4-6 weeks</td>
<td>Firm or sliceable</td>
<td>High fat (65.6 %)</td>
<td>Medium fat</td>
<td>Soft</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
<tr>
<td>Bola de Ocosingo, Chiapas</td>
<td>Zebu-Brown Swiss and their crosses</td>
<td>Mixed: rennet and microbes with ripened milk</td>
<td>1-6 days</td>
<td>Soft, sliceable, and unpressed</td>
<td>High fat (67.77 %)</td>
<td>Medium fat</td>
<td>Semi-hard</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
<tr>
<td>Chapingo, Estado de Mexico</td>
<td>Holstein and Jersey-New Zealand</td>
<td>Enzymatic</td>
<td>1-4 weeks</td>
<td>Soft, sliceable, and unpressed</td>
<td>High fat (67.77 %)</td>
<td>Medium fat</td>
<td>Soft</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
<tr>
<td>Chihuahua menonita de Cuauhtémoc, Chihuahua</td>
<td>Holstein</td>
<td>Enzymatic</td>
<td>1-6 days</td>
<td>Soft, sliceable, and unpressed</td>
<td>High fat (71.52 %)</td>
<td>Medium fat</td>
<td>Semi-hard</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
<tr>
<td>Chipilo, Puebla</td>
<td>Zebu-Brown Swiss and their crosses</td>
<td>Mixed rennet and natural acidification</td>
<td>1-3 days</td>
<td>Soft, sliceable, and unpressed</td>
<td>High fat (67.77 %)</td>
<td>Medium fat</td>
<td>Semi-hard</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
<tr>
<td>Chilhuahua</td>
<td>Holstein</td>
<td>Enzymatic</td>
<td>1-3 days</td>
<td>Soft, sliceable, and unpressed</td>
<td>High fat (67.77 %)</td>
<td>Medium fat</td>
<td>Semi-hard</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
<tr>
<td>Chiltepec, Estado de Mexico</td>
<td>Holstein and Jersey-New Zealand</td>
<td>Enzymatic</td>
<td>1-3 days</td>
<td>Soft, sliceable, and unpressed</td>
<td>High fat (67.77 %)</td>
<td>Medium fat</td>
<td>Semi-hard</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
<tr>
<td>Chipila, San Luis Potosi</td>
<td>Zebu</td>
<td>Enzymatic</td>
<td>1-3 days</td>
<td>Soft, sliceable, and unpressed</td>
<td>High fat (67.77 %)</td>
<td>Medium fat</td>
<td>Semi-hard</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
<tr>
<td>Guaje de Tanquian, San Luis Potosi</td>
<td>Zebu</td>
<td>Commercial calf rennet and 3-day whey</td>
<td>1-3 days</td>
<td>Soft, sliceable, and unpressed</td>
<td>High fat (67.77 %)</td>
<td>Medium fat</td>
<td>Semi-hard</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
<tr>
<td>Hoja de la Costa Chica, Oaxaca</td>
<td>Zebu</td>
<td>Natural rennet / commercial liquid rennet</td>
<td>1-3 days</td>
<td>Soft, sliceable, and unpressed</td>
<td>High fat (67.77 %)</td>
<td>Medium fat</td>
<td>Semi-hard</td>
<td>Villegas-de Gante et al., 2014</td>
</tr>
</tbody>
</table>

Table 1. Conditions of the manufacturing process of genuine Mexican cheeses and their main characteristics.
<table>
<thead>
<tr>
<th>CHEESE NAME, ORIGIN</th>
<th>MILK ORIGIN</th>
<th>COAGULATION AGENT</th>
<th>FAT CONTENT (FDE %)</th>
<th>MOISTURE CONTENT (MNFS %)</th>
<th>PASTE PROPERTIES</th>
<th>REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jarocho, Veracruz</td>
<td>Zebu, Zebu and European crosses</td>
<td>Rennet</td>
<td>Medium fat (29.5 %)</td>
<td>Soft (51.5 % WB)</td>
<td>High moisture, sliceable, and lightly pressed</td>
<td>Villegas-de Gante et al., 2016</td>
</tr>
<tr>
<td>Poro, Tabasco</td>
<td>Zebu and European crosses</td>
<td>Microbial rennet and/or calf rennet</td>
<td>Medium fat (27.13 %)</td>
<td>Semi-hard (69 %)</td>
<td>Semi-hard, low moisture, and small pores</td>
<td>Diaz-Ramirez et al., 2015, Alejo-Martinez et al., 2015</td>
</tr>
<tr>
<td>Quesillo de Reyes Etla, Oaxaca</td>
<td>Holstein, Zebu and Brown Swiss crosses</td>
<td>Commercial or natural rennet</td>
<td>Medium fat (29.9 %)</td>
<td>Semi-soft (48 % WB)</td>
<td>Filata</td>
<td>Centeno-Rodriguez et al., 2020</td>
</tr>
<tr>
<td>Cotija región de Origen</td>
<td>Holstein, Zebu-Swiss, and Zebu-Holstein</td>
<td>Rennet</td>
<td>Medium fat (29.9 %)</td>
<td>Semi-hard (69 %)</td>
<td>Semihard, sliceable, and evenly ripened</td>
<td>Villegas-de Gante et al., 2014, 2015</td>
</tr>
<tr>
<td>Enreatado de Nuevo Morelos, Veracruz</td>
<td>Holstein, Zebu-Swiss, and Zebu-American, Zebu-Swiss and Zebu-Holstein</td>
<td>Rennet</td>
<td>Medium fat (28.5 %)</td>
<td>Semi-hard (69 %)</td>
<td>Extra-hard, pronounced taste, and hard aroma</td>
<td>Villegas de Gante et al., 2014, 2015</td>
</tr>
<tr>
<td>Añejo de Zacazonapan, Estado de México</td>
<td>Holstein (low genetic quality)</td>
<td>Liquid rennet</td>
<td>Medium fat (28.5 %)</td>
<td>Semi-hard (69 %)</td>
<td>Crumbling (friable, crumbly, friable)</td>
<td>Díaz-Ramirez et al., 2015, Hernández et al., 2009, Villegas de Gante et al., 2011</td>
</tr>
<tr>
<td>Tenate de Tiulcoxco, Tlaxcala</td>
<td>Holstein (low genetic quality)</td>
<td>Enzymatic</td>
<td>Medium fat (28.5 %)</td>
<td>Soft (67 %)</td>
<td>Full fat (44.55 %)</td>
<td>Villegas-de Gante et al., 2016</td>
</tr>
<tr>
<td>Tenate, Hidalgo</td>
<td>Holstein (low genetic quality)</td>
<td>Liquid rennet</td>
<td>Medium fat (28.5 %)</td>
<td>Soft (67 %)</td>
<td>Full fat (44.55 %)</td>
<td>Villegas-de Gante et al., 2016</td>
</tr>
<tr>
<td>Seco (añejo) de Chihuahua de la Sierra, Puebla</td>
<td>Holstein (low genetic quality)</td>
<td>Enzymatic</td>
<td>Medium fat (28.5 %)</td>
<td>Soft (67 %)</td>
<td>Full fat (44.55 %)</td>
<td>Villegas-de Gante et al., 2016</td>
</tr>
</tbody>
</table>

*Cuerito: dry and salty calf abomasum that is soaked in whey or milk to obtain an aqueous extract for curdling; *WB %: Wet basis percentage; *FDE %: Fat in dry extract; *MNFS %: Moisture in nonfat substance. NR: Not reported.
Escoto et al., 2006; Díaz-Ramírez et al., 2016). Queso de Poro has the Collective Trademark ‘Queso de Poro de Balancán, Región de Origen’, granted by the IMPI (Cervantes-Escoto et al., 2017; Díaz-Ramírez et al., 2016).

**Queso Chihuahua (Chihuahua):** This product is of Mennonite origin and has been produced since 1992 in various regions of Chihuahua, being Cuauhtémoc municipality the one with the greatest market presence (Sánchez-Carlos & Bautista-Flores, 2017; Villegas-de Gante et al., 2014). Queso Chihuahua, also known as Mennonite or Chester cheese, has a flat cylindrical shape and is characterized by aromas of milk and melted butter (López-Díaz & Martínez-Ruíz, 2018; Villegas-de Gante et al., 2016).

**Queso Adobera de la Sierra de Amula (Jalisco):** This cheese has been manufactured for more than 100 years in the regions of Los Altos (Arandas, Tepatitlán, Lagos de Moreno, and other municipalities) and Sierra de Amula (Atengo, Tenamxatlán, Tecolotlán, and other municipalities) in Jalisco (Flores & Villegas-de Gante, 1990). In Sierra de Amula, the queso adobera of Soyatlán is manufactured in two modalities: “adobera de mesa” and “quesadilla”. It can be fresh, aired (semi-ripened), or ripened (Flores & Villegas-de Gante, 1990). It is named for its characteristic rustic clay brick (adobe) shape. Its aroma, acidic-salty flavor, and ivory yellow color provide remarkable characteristics to this artisan product (Flores & Villegas-de Gante, 1990).

**Queso Chapingo (Estado de México):** This product is characterized by its cylindrical shape and weights from 4 to 5 kg (Villegas-de Gante et al., 2014). This cheese has a golden-yellow color, is creamy and has a characteristic hazelnut aroma. It is produced by the Universidad Autónoma de Chapingo (Cervantes-Escoto et al., 2006).

**CONCLUSIONS**
Most GMCs are handmade. Only a few of them are produced on a semi-industrial scale, such as the Oaxaca, Chapingo, and some fresh cheeses. The standardization of the manufacturing processes would allow improvements and innovations; it would also increase the shelf life of GMCs. Moreover, obtaining a Protected Designation of Origin by the IMPI would contribute to the differentiation of GMCs from imitations, highlighting their identity, quality, and originality. This added value would also benefit local cheese producers, making their products known at a national and international level.

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