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## Evidence of *terroir* in milk sourcing and its influence on Cheddar cheese

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### ABSTRACT

The concept of local food is rapidly gaining importance within the United States. The foundation of local food is *terroir*, which links a food to its production environment. The purpose of this study was to investigate evidence of *terroir* in milk sourcing and its influence on Cheddar cheese flavor. Specifically, the study was designed to assess if consumers could differentiate between Cheddar cheeses made with milk from different dairy farms. Milk from 5 locations, including single dairy farms and commingled sites, was collected from around the state of Oregon. Using raw and pasteurized counterparts of the milk, Cheddar cheese was made and aged. At 5 and 9 mo into aging, Cheddar cheese consumers were asked to group the samples based on perceived similarity/dissimilarity of cheese flavor. Grouping data were subjected to multidimensional scaling and subsequent cluster analysis. Results at 5 mo into aging revealed that cheeses made by milk originating from different farms (80 km apart) within the same region were perceived as different, whereas cheeses made with milk from neighboring farms (5 km apart) were grouped together, irrespective of heat treatment (i.e., raw vs. pasteurized). Cheeses made with commingled milk from different regions grouped together. At 9 mo of aging, in contrast, a clear separation of perceived flavor was present between the pasteurized and raw cheese samples, whereas the effect of milk sourcing was less pronounced. These data suggest that the geographical location of the milk source has an effect on the flavor of Cheddar cheese, but that the practices of milk commingling and heat treatment likely reduce the effect of geographical location, particularly as cheese ages.

**Key words:** Cheddar, flavor, pasteurization, commingling

### INTRODUCTION

*Terroir* is a French term referring to the conditions in which a food is grown or produced that give the food its unique sensory characteristics (Barham, 2003). The term is also defined as “local area with homogeneous environment and production systems” (Brunschwig et al., 1999). The concept of *terroir* has served as the basis of the European Union’s geographic indications, known as protected designation of origin (PDO), which promote and protect the names of agricultural products (e.g., Champagne, Camembert). The term *terroir* also has a cultural dimension that ties a product to local community and lifestyle through traditional production and local knowhow.

The effect of *terroir* on differences in flavor has mostly been studied in wine. The *vini-terroir* relates these differences as a direct result of the natural environment of the vine (Moran, 2006). The natural environment, specifically the macro-, meso-, and micro-climate, geology and pedology, water availability, native microbial populations, and harvest time all independently have the ability to affect the final sensory characteristics of wine (Jackson and Lombard, 1993; Van Leeuwen and Seguin, 2006; Gilbert et al., 2014). In addition to wine, other plant-based products, such as coffee and olive oil, have demonstrated sensory characteristics linked to the territory of production. Costa Rican coffee beans have been shown to produce beverages with different aroma, acidity, and body based upon the slope exposure and altitude of the growing region (Avelino et al., 2005). Similarly, olives of the same cultivar, but grown in different regions, produce oils with particular volatile compounds and sensory profiles (Kalua et al., 2007).

Dairy products, such as cheese, have a more complex relationship to the area of production. Just like wine, soil and climactic conditions serve as the base of *terroir* by selecting for certain pasture and forage characteristics. It is known that when different plants are included in the cow’s diet, they influence the chemical composition of and thereby sensory qualities of milk (Carpino et al., 2004a; Coulon et al., 2004; Martin et al., 2005; Rapisarda et al., 2013). Further, it has also been

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shown that variations of homogenous edaphic regions correspond to the variations in sensory characteristics of alpine cheeses (Monnet et al., 2000; Povolò et al., 2013). The dairy farm environment also contributes to the native microflora of the milk (Kagkli et al., 2007) that ultimately affects the cheese (Pintado et al., 2008).

In addition to the natural environment, the animal presents an additional intermediary step between the raw commodity and the final product. The breed of the animal is an important aspect of the final sensory characteristics of the cheese. Different bovine breeds can produce different protein and fat levels, which influence the final sensorial characteristics of the cheese. Furthermore, a genetic variation within a single breed can cause differences of specific milk proteins resulting in modifications in sensory profile of cheese (Coulon et al., 2004). Therefore, popular PDO cheeses, such as Parmigiano-Reggiano and Comté, have strict local foraging and animal criteria, thus serving as the first direct link to area of production (Bertoni et al., 2001).

In addition to how the milk is produced, treatments applied to milk may also affect the expression of *terroir* in cheese. Milk is pasteurized to kill pathogens and extend shelf-life by significantly reducing overall levels of spoilage bacteria. Unfortunately, thermal treatment also affects other potentially beneficial native flavor-producing microflora, the nonstarter lactic acid bacteria (Shakeel-Ur-Rehman et al., 2000). Thus, cheeses made using raw milk have a more heterogeneous microbial population and are often more strongly flavored than their pasteurized counterparts (McSweeney et al., 1993; Muir et al., 1995). These adventitious microbial populations have been shown to vary between raw milk sources and manufacturing sites and thereby may play an important role in *terroir* in cheese (Berthier et al., 2001; Crow et al., 2001; Poznanski et al., 2004).

Most *terroir* research pertaining to cheese is focused on European cheese made from raw milk, where specific appellations are already in place. In contrast, research dealing with the *terroir* effect in popular American-style cheese is lacking. Several studies have investigated flavor differences in Cheddar cheese from various US regions and consumer perception of those cheese samples (Drake et al., 2005, 2008, 2009). However, these studies were not meant to investigate *terroir*, but rather to provide information on the diversity of commercial US Cheddar cheese. Therefore, these studies did not attempt to control for milk source, make procedures, milk pretreatment, manufacturing environment, and age of cheese, which would all be confounding factors in the study of *terroir*. It could be argued that each dairy processing plant constitutes its own *terroir* due to resident nonstarter lactic acid bacteria, processing capabilities,

and equipment, all of which would significantly affect cheese characteristics. Conducting a milk sourcing study will therefore require that either the processing plant is kept constant or the effect of the processing plant is determined separately. For the purpose of this study, the processing plant was kept constant.

The potential expression of *terroir* of Cheddar cheese in a localized US landscape was explored in this study. More specifically, the study was designed to assess if consumers could differentiate between Cheddar cheeses made with milk from different dairy farms. In addition, we explored if consumers' ability to differentiate cheeses was affected by commingling, geographical distance between farms, pasteurization of cheese milk, and aging of the cheese. Milk was collected from distinct regions as well as localized farms around Oregon, and manufactured into raw and pasteurized Cheddar cheese. The cheese samples were tested at 5 and 9 mo into aging. Although there are no legal definitions for designations (Drake et al., 2009), 5- and 9-mo-old cheeses are considered as "medium" and "sharp" Cheddar.

## MATERIALS AND METHODS

### *Milk Collection*

Milk was collected from 5 locations around the state of Oregon (Figure 1) over the course of early fall (October 2–24). Locations were strategically selected based upon individual ecoregions, or microclimates, delimited based upon geology, physical geography, vegetation, climate, soils, land use, and hydrology (Thorson et al., 2003). Milk was received from individual dairies in the Willamette Valley (**F1**, **F2**, and **F3**), and commingled from 2 additional regions: Coastal Range (**R1**), and Columbia Plateau (**R2**). All 5 locations had predominantly Jersey herds on pasture-based diets. The F1 and F2 dairies with pure Jersey herds are separated by 5 km, with the F3 dairy (86% Jersey herd) located about 80 km away. Milk was collected at 2 different times from the F3 location (F3.1 and F3.2) as a blind duplication to validate consistent cheese making and testing procedure. Milk from the R1 and R2 locations came from independent regions, and each sample was commingled from 2 to 3 local dairy farms.

All raw milk was collected directly from the bulk tank (F1, F2, and F3) or tanker truck (R1 and R2) after being stored on site for less than 48 h. The milk was kept below 4.4°C during transportation to the Arbutnot Dairy Center (Oregon State University, Corvallis, OR) and stored at 2.2°C for no greater than 24 h before manufacture.

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