Chapter 18
Goat and Sheep Cheeses

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18.1 Introduction

Legend has it that cheese was discovered by nomads who carried milk in pouches made of goat or sheep stomachs. It is likely that goats and sheep were domesticated before cows and water buffaloes because of their manageable size and that the very first cheeses were made from goat and sheep milk. Although the first livestock species domesticated (Pereira et al., 2009), goat (and sheep) milk products have not been studied or utilized quite as extensively as cow milk products (Salles et al., 2002). Goat milk is reportedly the most consumed milk in the world (Gillingham, 2008) and is often a popular replacement for cow's milk for people (especially children) with allergies. The higher proportion of small fat globules and natural fat globule homogenization makes goat milk easier to digest and a popular alternative for infants and children (Golinelli et al., 2014; Clark & Mora Garcia, 2017).

In the United States, goat and sheep milk represent less than 1% of annual milk production, and 75% of the goat milk and 95% of the sheep milk produced are made into cheeses (Milani & Wendorff, 2011). Although the United States is better known for making cheeses from cow milk, goat and sheep milk cheeses predominate in other countries. As of January 1, 2020, U.S. sheep and lamb inventory was 5.2 million head, and goat and kid inventory was 2.3 million head (NASS, USDA, 2020). Dairy goats and kids made up 440,000 of that number, with highest counts in WI, CA, IA, and TX. It has been reported that approximately 21% of all goats and sheep in the world are dairy animals and produce 3.5% of the world's milk; about 8% of the total agricultural output in Greece and 0.9–1.8% of the total agricultural output in France, Italy, and Spain (Pulina et al., 2018). The island of Sardinia is the source

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S. Clark et al. (eds.), *The Sensory Evaluation of Dairy Products*,
https://doi.org/10.1007/978-3-031-30019-6_18

of about 65% of the total Italian production of sheep milk, most of which is processed into the primary dairy product of Sardinia: Pecorino Romano (Idda et al., 2018). More than 50 varieties of goat cheese are made in France alone, at least nine of which have Protected Designation of Origin (PDO) status.

18.2 Composition of Goat and Sheep Milk

Before elaborating on goat and sheep milk cheeses, some general information about goat and sheep milk will help lay the groundwork for what makes these cheeses unique. From a proximate analysis standpoint, milk from goats and sheep (in particular), on average, contain more fat and protein than cow milk (Table 18.1). As a result, during cheesemaking, there is potential for higher cheese yield since fat and protein predominate cheese. However, the higher proportion of solids does not always translate to a higher yield. For example, goat milk contains less alpha$_{s1}$-casein than cow or sheep milk, which partially explains the softer body and lower yield of goat cheese compared to cow and sheep cheeses (Clark & Sherbon, 2000). Sheep cheese yield, on the other hand, is typically higher than that of either goat or cow milk.

The milk and products made from the milk of goats, sheep, and even water buffalo are naturally more white in appearance (Fig. 18.1) than products made from cow milk (Kosikowski & Mistry, 1997a). This is because when goats and sheep consume feeds rich in beta-carotene (a pigment yellow to orange in color), they convert the nutrient to vitamin A, which is colorless (Fedele, 2008). Cows do not convert beta-carotene to vitamin A, so the color of products made from cow milk tends to be more yellow, particularly if they eat feeds rich in beta-carotene (e.g., organic or grass-fed).

Naturally, goat and sheep milk contain more short-chain-length volatile fatty acids (VFA) and branched-chain fatty acids (BCFA) than cow milk (Ha & Lindsay, 1991). Sheep milk naturally contains more butyric acid (C:4) than goat or cow milk, while goat milk naturally contains more caproic (C:6), caprylic (C:8), and capric (C:10) acids than sheep or cow milk (Clark & Mora Garcia, 2017). Volatile

Table 18.1 Mean percent of components and Cheddar cheese yield from milk of cows, goats, and sheep

	Cow	Goat	Sheep
Water	87.4	86.9	83.6
Protein	3.3	3.7	5.2
Fat	3.8	4.2	6.1
Lactose	4.8	4.4	4.2
Ash*	0.7	0.8	0.9
Cheddar cheese yield	10.0	9.8	14.8

Adapted from Clark and Mora Garcia (2017)
*Calculated by subtraction

Fig. 18.1 The interior of goat (left two) and sheep (right) cheeses naturally appear more white than cow milk cheeses (S. Clark images)

compounds are aromatic, so they can be smelled. The 4-methyloctanoic acid of sheep milk fat gives sheep milk products a mutton-like aroma and flavor, and the 4-ethyloctanoic acid in goat milk gives goat milk products a "goaty" flavor (Ha & Lindsay, 1991).

18.3 Goat and Sheep Milk Cheeses

Just about any cheese that can be made from cow milk can also be made from goat (and sheep) milk. An exception is *pasta filata* (stretched curd) cheeses like mozzarella; the different protein composition makes goat cheeses more difficult to stretch (Niro et al., 2014; Faccia et al., 2015). Cheeses resulting from goat and sheep milk have some different appearance, flavor, and body and texture characteristics than cow milk cheeses, which are discussed elsewhere in this book.

Some cheeses require very specific making conditions in order to be labeled as the cheese type. In the United States, cheese definitions are found in the Code of Federal Regulations, Title 21, Chapter 133 (USFDA, 2019). The Appellation d'origine controlée (AOC, primarily for wines), Protected designation of origin (PDO), Appellation d'origine protégée (AOP) notation in French-speaking countries, Denominacion de origen (DOP) in Spanish-speaking countries, and Denominazione d'origine controllata (DOC) in Italian speaking countries (or Italy), systems protect the names of products throughout the European Union (Harbutt, 2009). The AOC, AOP, PDO, DOP, or DOC designation means a product has undergone all production stages according to recognized expertise in the same geographical area, which provides its characteristics. The designations embrace the concept of terroir, wherein interactions between a physical and biological environment influence food produced in the region (NAOQ, no date). Many goat and sheep cheeses have PDO, AOP, or DOP status.

In the United States, on the other hand, most goat and sheep cheeses are not defined in federal standards of identity. However, 21 CFR 133.184 defines

"Roquefort cheese, sheep's milk blue-mold, and blue-mold cheese from sheep's milk" as being made from pasteurized or unpasteurized sheep milk, aged at least 60 days, "characterized by the presence of bluish-green mold, *Penicillium roqueforti*, throughout the cheese" and containing a minimum milk fat content of 50% on a dry weight basis and maximum moisture of 45% by weight (USFDA, 2019). This description does not comply with French regulations, which require that, to have the name "Roquefort," the cheese must be made exclusively from whole raw milk of Lacaune ewes, pastured in southern France, and made and aged in caves only in the Roquefort Causses region of Auvergne, France (Kosikowski & Mistry, 1997a). The first AOC cheese, Roquefort cheese has held that status since 1925 (Harbutt, 2009). The reader is referred to Chapter 17 for additional discussion of mold-ripened cheeses.

Cheeses made from sheep milk include but are not limited to: Manchego (DOP), Idiazábal (DOP), Pecorino Romano (PDO), Fiore Sardo (DOP), and Serra da Estrela. Up to 30% goat milk is allowed to be added to sheep cheeses in traditional Greek cheeses (Litopoulou-Tzanetaki, 2012). Manchego has been a PDO/DOP cheese since 1985. Made only in the La Mancha region of Spain from the milk of Manchega ewes, it is enzymatically coagulated, cooked at about 40 °C, pressed, dried or brine salted, and cured for 1–10 weeks (Kosikowski & Mistry, 1997b). The hard cheese is the most popular cheese variety in Spain (Poveda et al., 2014). Manchego can be made either from raw or pasteurized milk, but if the latter, a commercial mixed-strain starter culture, typically composed of *Lactococcus lactis* subsp. *lactis* and *Lactococcus lactis* subsp. *cremoris* is used. Manchego has a traditional dry grass mold or basket-weave rind. The dry blonde to straw-colored interior of Manchego cheese may have mechanical openings. It is buttery and nutty in flavor with lanolin notes and gains caramel and/or piquant flavors with age. Idiazábal (DOP) originated in the Basque Mountains of Spain. It is an aged, hard, and chewy cheese with tiny mechanical openings and a smoky flavor, obtained from beech wood smoke (Harbutt, 2009).

Pecorino Romano (PDO since 2009) is a semi-cooked (68 °C for at least 15 s) hard cheese made from whole ewe's milk in specific regions of Italy: Sardinia, Lazio, and the Province of Grosseto (Idda et al., 2018). Aged 5–12 months, and cylindrical in shape, it has a somewhat sweet, nutty flavor with a salty tang and hints of lanolin (Harbutt, 2009). Several similar varieties exist in Italy, including Pecorino Sardo (PDO; drum-shaped; aged 1–2 months for dolce, 8 months for maturo), Pecorino Siciliano (PDO; wheel-shaped; aged 4–12 months), and Pecorino Toscano (PDO; drum-shaped; oil-rubbed rind; aged 1–6 months) (Harbutt, 2009).

Fiore Sardo (PDO) is an uncooked and long-ripened hard cheese that is made from the raw whole milk of Sardo sheep, produced in Sardinia, Italy (Zazzu et al., 2019). Serra da Estrela (PDO status since 1985) is a traditional soft (or hard if aged over 6 months) Portuguese cheese made from raw milk of Churra Mondegueira and Bordaleira Portuguese autochthonous breeds, coagulated with wild thistle flower (Lima et al., 2019).

Cheeses typically made exclusively of goat milk include but are not limited to, Chevre, Crottin de Chavignol (PDO), Sainte-Maure de Touraine (PDO), Valençay

(AOP), and Banon (AOP). Chevre is a soft, fresh "lactic" cheese made from pasteurized milk, typically with the aid of chymosin. It is a fairly simple cheese to make. As in the making of most cheeses in the United States, the goat milk is first pasteurized and then cooled to a favorable temperature for mesophilic cultures to grow in, often around room temperature or a bit higher. Culture and/or rennet is added and the cultured milk is left to sit for between 6 and 24 h as the curd forms in response to the lactic acid production by the bacteria. The product is then drained for 6–24 h (depending on method and desired outcome), shaped, and salted. Herbs, spices, flowers, fruits, and other condiments are often added internally and/or to surfaces. Chevre may be served fresh or ripened. Oftentimes, the surface is dusted with food-grade ash to reduce surface acidity, and a rind is allowed to form. The cheese is often dried and aged (Hooper, 2009). For more on soft-ripened cheeses, see Chapter 17. Chevre is generally acidic with a pH around 4.2–4.5, with at least 55% moisture (Santos et al., 2016).

Crottin de Chavignol (PDO since 1986) is a soft-ripened cheese made from raw Alpine goat milk in the Loire and Chavignol regions of France. It is slightly renneted, and the lactic coagulation lasts about 2 days (Rubino et al., 2004). After draining, the cheese is salted (1–2% of the weight of the cheese) and then aged for 10 days and allowed to form a white surface mold (Litopoulou-Tzanetaki, 2012) (Fig. 18.2). It has a nutty flavor, which gets more robust with age, along with a texture that becomes more dry and crumbly with age.

Sainte-Maure de Touraine (PDO) is made by a slow curdling, molding in a long log shape (16–17 cm), and transferral onto pyroengraved rye straw (Rubino et al., 2004; Litopoulou-Tzanetaki, 2012). The cheese is then salted and aged for at least 10 days, but generally 3–4 weeks (Harbutt, 2009; Le Jaouen, 1987). The cheese has a white, soft paste under a grayish-blue, moldy rind from *Penicillium candidum* (Harbutt, 2009; Rubino et al., 2004).

Fig. 18.2 Crottin de Chavignol style cheese made in the United States (S. Clark image)

Valençay (AOP) is a soft, blue-veined cheese made from raw goat milk in the shape of a pyramid with a flattened top (Fig. 18.3). Originating in the Berry and Loire Valley regions of France, the rustic blue-gray cheese (because it is typically dusted with ash) develops during the 4-week ripening in caves (Le Jaouen, 1987).

The origin of Banon (AOP) is north of the Haute-Provence Alps. Pure goat milk or a mixture of goat, sheep, and even cow milk may be used to make the small round (6- to 7-cm diameter, 2-cm height) cheeses. Several varieties of Banon are available in France (fresh, flowered rind), but the most famous is wrapped in chestnut leaves (Fig. 18.4). After drying and ripening for 4–6 weeks, the ball is wrapped in dried chestnut leaves and tied with raffia (Le Jaouen, 1987).

Several popular cheeses may be made from both goat and sheep milk, and sometimes cow milk is added. Feta, Kaseri, and Halloumi are examples. Feta, likely the most famous white brined cheese (WBC), is in the most important class of cheeses (brined cheeses) of the east-Mediterranean and neighboring countries (Alichanidis & Polychronidaou, 2008). The WBC, characterized by their white color that results from the use of goat and/or sheep milk, include but are not limited to Feta and Teleme (Greece), Beyaz peynir (Turkey), Iranian white (Iran), Brinza (Israel), Akawi (Lebanon), and Domiati (Egypt).

WBC production generally follows the same steps (Alichanidis and Polychroniadou 2008), including:

1. Filtration and (maybe) standardization of cheese milk (C:F 0.72–0.75 for sheep and/or goat milk or 0.75–0.8 for cow milk)
2. Pasteurization or thermization
3. Addition of $CaCl_2$ and starter cultures (30–35 °C)
4. Renneting (commercial or artisanal chymosin)
5. Ripening (50–60 min)
6. Cutting (1–3-cm cubes)

Fig. 18.3 Valencay-style cheese made in the United States (S. Clark image)

Fig. 18.4 Banon-style cheese made in the United States (S. Clark image)

7. Healing (10–15 min)
8. Molding (rectangular/square or cylindrical molds)
9. Draining (usually under pressure, some without pressure)
10. Cutting (to final cheese dimensions)
11. Salting (mostly in brine, some with dry salt)
12. Packaging (with or without brine)
13. Ripening (16–18 °C for 5–15 days; until pH ≤4.6)
14. Sealing of the containers and storage (≥4 °C)

Feta has been a European Union protected (PDO) name since 2002, and can only be made in the mountainous regions of Macedonia, Thrace, Epirus, Thessaly, Sterea Ellada, Peloponnesus, and Mytilini from goats and sheep that graze freely in those areas (Harbutt, 2009). However, many U.S. producers make products they call Feta. Feta is traditionally made in Greece from raw ewe milk with no starter and rennet from lamb abomasa, or in large factories from pasteurized ewe milk with culture and rennet (Bozoudi et al., 2018). In addition to being characterized as pure white, feta has no rind, no eyes (gas holes), some mechanical openings, and a smooth, soft, and crumbly body. The flavor is salty, acidic, and piquant, often reflecting the fatty acid flavors representing the source of the milk. The flavors of WBC range from very mild to very piquant, which is, in part, influenced by native or added lipase.

Kaseri (DOC), produced in Greece using a mix of goat and sheep (at least 80% sheep) milk, is reportedly one of the oldest cheeses in the world (Harbutt, 2009). A pasta filata cheese, Kaseri is stretched in hot brine; it is stringy when melted, slightly sweet, and pungent in flavor.

Halloumi, a traditional cheese of Cyprus, is made from non-cultured raw milk from goats and sheep and sometimes combined with cow milk (Harbutt, 2009; Papademas & Robinson, 1998). The renneted coagulum is cut into grain-sized curds

(as with other low-moisture granular cheeses), allowed to rest (heal), then cooked in whey with continuous stirring for about an hour prior to draining and pressing into blocks. The pressed curd is cut into 10 × 15 × 3 cm blocks, then scalded in hot whey (94–96 °C) for about 30 min (Alichanidis & Polychroniadou, 2008). Blocks are allowed to drain, then surface-salted and sometimes sprinkled with crushed mint leaves (Alichanidis & Polychroniadou, 2008; Papademas & Robinson, 1998). Blocks are folded in half, kneaded, and chilled overnight, or salted whey is poured into containers of halloumi for sale (Harbutt, 2009; Papademas & Robinson, 1998). Halloumi has a mild flavor and is good for grating or frying (Papademas & Robinson, 1998).

The by-product of cheesemaking, whey, can be made into several popular whey cheeses: Gjetost (goat), Manouri (PDO, predominantly goat), and Mizithra or Myzithra (predominantly sheep). Gjetost is a caramelized whey-and-cream cheese of Norweigan origin. Dark brown in color and sweet in flavor, Gjetost is unlike any other cheese except Mysost, the cow-whey-based version.

Manouri (PDO) and Mizithra are Greek heat- and/or acid-coagulated cheeses produced predominantly from caprine (manouri) or ovine (mizithra) whey, but they are not caramelized, so they appear white to cream-colored. Mizithra may have up to 70% moisture, while Manouri may only have up to 60% moisture and a minimum fat in dry matter of 70% (Kaminarides et al., 2013). Manouri and Mizithra have no rind, a closed texture, a firm, granular body, and a mild flavor. Manouri is only produced from sheep or goat whey and whole sheep and goat milk and/or cream (Kaminarides et al., 2013). The whey-based cheeses are made by first filtering whey to remove curd particles, then heating to 88–92 °C for 40–45 min, under continuous stirring (Alichanidis & Polychroniadou, 2008). If whole milk or cream is added (to improve yield and quality), it is added early in the process (when the whey reaches 65–70 °C); salt is added to the whey at 73–75 °C. After curd particles start floating, part-way through the heating process (at about 80–82 °C), heating is sped up and stirring is slowed. A citric acid solution (100 g/L) is added at the rate of 6 mL/L at approximately 90 °C, just before stirring is stopped. The curds are allowed to float on the whey surface for about 15–20 min, then scooped into molds for drainage over a period of 3–5 h (Alichanidis & Polychroniadou, 2008).

A summary of goat and sheep cheese composition is shown in Table 18.2.

18.4 Sources of Sensory Attributes of Goat and Sheep Cheeses

Variability in goat and sheep milk and cheese quality arises, at least in part, from variability in lactation stage, feeding system, and diet (Inglingstad et al., 2014). Feeding systems have an impact on milk and cheese profiles due to the molecular compounds in the feedstuffs. Feed nutrient composition is influenced by soil nutrients, water quality, season, climate, maturity, and variety of species, among other

Table 18.2 Typical composition of goat and sheep cheeses

Cheese	Milk source	Fat (%)	Total solids (%)	Salt (%)	pH
Camembert	Goat, sheep, cow, mixed	23	47	2.5	6.9
Cheddar	Goat, sheep, cow, mixed	28	62	1.5	5.5
Chevre (fresh)	Goat	6–16	15–35	1	4.4
Chevre (ripened)	Goat	18–32	51–58	1.5	4.5
Crottin de Chavignol (AOP)	Goat	20–23	40 – 41	1.5	4.6
Feta	Goat, sheep, cow, mixed	22 - 31	37 - 50	4.5	4.4
Gjetost	Goat	30	77	0.5	6.5
Gouda	Goat, sheep, cow, mixed	28	59	2	5.8
Halloumi	Goat, sheep, cow, mixed	30	>54	<3	4.6
Manchego (DOP, semi-mature)	Sheep	30–40	65–70	2.2	5.8
Manouri (PDO)	Goat, sheep, mixed	25	>40	1.5	5.0
Myzithra/Mizithra	Goat, sheep, mixed	25	56	1.6	5.0
Ricotta	Goat, sheep, cow, mixed	18	30	<0.5	5.9
Pecorino Romano (PDO)	Sheep	24–30	65–77	5.5	5.4
Roquefort (AOC)	Sheep	31–33	57–60	3.5	6.4
Valencay (AOP)	Goat	20–23	40–41	1.5	4.6

Fox et al. (2000), Bozoudi et al. (2018), Kosikowski and Mistry (1997a), Le Jaouen (1987), Papademas and Robinson (2000), Raynal-Ljutovac et al. (2008), Papademas and Robinson (1998), and Park (1999)

factors (Hooper, 2009). This implies that different feeds or pasture species can be used to diversify product flavor (Fedele, 2008). Compounds that give flavor to cheese include fatty acids, volatile organic compounds, amines, ketones, free amino acids, phenols, alcohols, aldehydes, lactones, and sulfuric compounds, all of which affect the cheese-making and ripening process and all of which can be attributed to feed type (Tilocca et al., 2020). Branched-chain fatty acids give goaty flavor to chevre, in particular 4-ethyl-octanoic acid, which is fairly specific to goat milk. It is found in very low concentrations or not at all in cow milk but is curiously found in some plants, such as tobacco. Scientists speculate that it is released during the aging process of cheese as lipolysis occurs (Salles et al., 2002).

Concentrates and forages each contribute different qualities to milk and can be used to manipulate characteristics of the end product. A dry lot system with a very consistent ration of dry hay and grain yields milk and cheese with different sensory characteristics compared to a variable pasture-based system or a silage-based ration (Fedele, 2008). Indoor feeding systems generally involve a higher feed intake of

good-quality feeds but may also lead to overfeeding concentrates, which leads to milk high in protein but comparatively low in fat (Morand-Fehr et al., 2007). As concentrates become a larger portion of the ratio (>60%), milk fat drops due to a lack of dietary fiber (Morand-Fehr et al., 2007).

Natural pasture leads to milk high in fat, fatty acids, vitamins, and volatile compounds such as terpenes, which give milk grassy flavors (Morand-Fehr et al., 2007). Terpenes are unsaturated hydrocarbons built of isoprene units that are volatile liquids with strong odors found in plant flowers, leaves, and fruit (Fedele, 2008). When grass is at an early growth stage, goat milk production and fat content may both be higher, as well as having higher levels of polyunsaturated fatty acids (PUFAs) and conjugated linoleic acid (CLA) due to the higher feed quality (Morand-Fehr et al., 2007). Early grazing season has more favorable rennet coagulation properties that result from α_{s2}-casein and calcium concentrations, prompting a shorter firming time and higher curd firmness (Inglingstad et al., 2014). Pastured goats have more protein (α_{s1}-casein and κ-casein) and milk yield, and thus a better cheese yield, than hay-fed goats (Inglingstad et al., 2014).

Valdivielso et al. (2016) evaluated changes in the volatile composition and sensory profile of raw milk cheeses made on farm from the milk of six commercial flocks of Latxa sheep in the Basque region of northern Spain in different feeding seasons throughout lactation. From a sensory standpoint cheeses made from milk of mountain grazing sheep had lower overall intensity, buttery, toasty and nutty aroma, salty taste, and elasticity and moisture in the mouth than cheeses made from milk of indoor-feeding ewes (Valdivielso et al., 2016). Barlowska et al. (2018) conducted a related study in Poland, with four farms (two mountainous areas; two upland areas) raising Saanen goats and making artisan cheese during two production seasons. From a sensory standpoint, mountain cheeses were more firm, aromatic, less goaty, less sour, sweeter, and saltier than upland cheeses (Barlowska et al., 2018). Upland milk is also generally higher in PUFAs and MUFAs (Coppa et al., 2019). In a study done regarding the ability to differentiate feeding systems based on goat cheese aroma, 100% of the testers could distinguish both the taste and odor of 20-day-ripened cheese from a grazing herd compared to a hay/concentrate system. The fact that fewer testers could distinguish the same two systems in 1-day-ripened cheese highlights how aging generally increases the taste and odor of cheese (Fedele, 2008).

Vitamins and minerals also have an important role in milk and cheese quality. Potassium and calcium chloride contribute bitterness to chevre, while free amino acids, organic acids, and naturally present mineral salts all contribute to taste as well (Salles et al., 2002). In addition to influencing flavor, vitamins and minerals are important for milk quality. Deficiencies of zinc, selenium, manganese, and iron, as well as vitamin A, vitamin C, and beta-carotene, have all been shown to impact the health of the mammary gland and SCC (Nudda et al., 2020), thereby influencing cheese quality and yield.

18.5 Evaluating Goat and Sheep Cheeses

Understanding the source of the milk, making procedures, and intention of cheesemaker can all help during the evaluation of goat and sheep milk cheeses. At a minimum, it is essential for evaluators to know if the source of milk is from a sheep, a goat, or a mixture. With that base information, expectations for certain appearance and flavor characteristics come to mind. As noted previously, goat and sheep cheeses should be white in color. If goat milk is used, the caproic, caprylic, and capric acid "goat notes" should be observed but not be overbearing (dirty buck). Lanolin (woollike) aroma/flavor should be noted in sheep cheeses but not remind the eater of old mutton. Evaluating additional appearance, body and texture, and flavor quality characteristics relies on some knowledge of intended cheese style. For instance, while a fresh chevre would be expected to have a closed body and a soft, smooth paste; mechanical openings and firm, crumbly body, and grainy texture would be more typical in an aged Romano. The present document summarizes some of the common flavor defects and body and texture defects that might be observed in goat and sheep cheeses (Tables 18.3 and 18.4). An example scorecard for evaluation of goat and sheep cheeses is included in Fig. 18.5. The reader is encouraged to view additional references for detailed appearance, body and texture, and flavor notes about goat and sheep cheeses. For instance, Talavera and Chambers (2016) further refined an existing lexicon (language) to describe flavor characteristics of artisan goat cheeses made in the United States. They worked with five highly trained descriptive sensory panelists to establish a lexicon of 39 flavor attributes to represent sensory characteristics for 47 artisan goat cheeses produced throughout the United States

Preparation of Cheese for Evaluation

When evaluating goat and sheep cheeses, tempering to room temperature is typically advised, as volatile components will become more prominent. An exception is ricotta and chevre, which may be served on the cooler side of room temperature. The cheeses should be sampled with tools that are appropriate to the style. For instance, ricotta is often spread, feta may be sliced or crumbled, and Manchego is commonly thinly sliced. For firm, large-format goat and sheep cheeses, triers should be used to penetrate the cheese and extract a representative sample to observe for mechanical openings or eyes. Cheese body can be examined by breaking the plug and working between the thumb, index, and middle fingers. Surface-ripened, mold-ripened, or washed-rind cheeses should be sliced open.

How to Evaluate

Similar to evaluation of all other cheese types, evaluation of goat and sheep cheeses begins on the outside with appearance, color ,and rind development, and moves inward. Since product evaluation typically involves comparison to a standard, any shortcoming characteristic or "out-of-balance" attribute is characterized as a defect. With respect to defects, the term "slight" refers to attributes that are only detectable upon critical examination, while "definite" is not intense but is detectable; "pronounced" defects are immediately noticeable and typically objectionable to most

Table 18.3 Common flavor defects in goat or sheep cheese, identification and their probable causes

Flavor	Identification	Probable cause
Bitter	A basic taste sensation, commonly on the back of the tongue, similar to the taste of quinine	Breakdown of proteins by proteolytic starter culture or microbial contamination
Flat/lacks flavor	Lacks characteristic piquant, lactic acid, or "goaty" free fatty acid aroma/flavor for goat or lanolin for sheep cheeses	Lower than typical level of short-chain volatile fatty acids in milk
Foreign	Atypical aroma or flavor for goat or sheep cheese	May be chemical (e.g., cleanser, sanitizer), enzymatic, or bacteriological in origin
High acid	Unbalanced, overly sharp, and puckery to the taste, characteristic of lactic acid	Excess lactic acid production; may be coupled with low salt
High animal flavor	Goaty, "buck", or mutton flavor is out of balance	Mishandling of milk promotes lipolysis that releases butyric, caproic, caprylic, and/or capric acid
High salt	Salt is out of balance, too high, off-putting	Over-salting
Lacks freshness	Staleness or "refrigerator aroma" noted in product	Stored improperly or too long
Low salt	Cheese lacks salt; may be coupled with high acid or goaty flavor	Under-salting
Metallic	A flavor having qualities suggestive of metal, imparting copper taste or a puckery sensation	Oxidation of ingredients (milk), contamination with free metals, or use of sea salt (certain minerals)
Musty	Atypical aroma of basement or mold	Contamination with mold spores; poor packaging
Oxidized	Wet cardboard aroma and/or mouth-drying sensation or aftertaste	Exposure to light and oxygen facilitates autoxidation of unsaturated fatty acids to produce aldehydes and ketones
Unclean	An undesirable dirty gym socks or dirty dishwater aroma/flavor; fecal aroma, flavor, aftertaste in extreme cases	Volatile compounds coming from fecal material or bacterial contamination
Yeasty	A flavor indicating yeast fermentation, may be appearance of gas eyes or slits	Contamination by yeast; poor packaging

observers. Each plant may determine and evaluate cheese quality based on methodology appropriate to the setting. To assist in the process of developing an evaluation criteria, an example scorecard is included in Fig. 18.5.

Appearance, Color, and Rind Development

Unripened goat cheeses are expected to be white; any discoloration in the form of yeast, mold, or bacterial spoilage should result in downgrading. Sheep cheeses may range from white to cream to slightly blonde color if aged. Surfaces of ripened cheeses or washed-rind cheeses should be properly colored (light browns, pinks, oranges) and uniform. A toad skin or rippled appearance is not unheard of. Blue-green mold-ripened cheeses should exhibit vivid blue-green well-veined interiors. Cheeses with ash may range from gray to black and must not be slimy or wet.

Table 18.4 Common body defects in goat and sheep cheeses[a], identification and probable causes

Body/Texture	Identification	Probable cause
Crumbly	Falls apart while cutting, working, or spreading	Low moisture retention; may be associated with high acid or high salt
Gassy	Eye or slit formation within body of cheese or packaging	Contamination with yeast or gas-producing microorganisms
Grainy	Atypical rough, mealy, gritty, or sandy feeling	Overcooking of curds
Pasty	Sticky and smears when worked or rubbed between the thumb and fingers	Excessive acid production, high moisture content, poor drainage of whey
Too firm	Atypical resistance to mastication or manipulation between thumb and fingers	Excess use of chymosin, too high cooking temperature and/or time, low moisture
Weak/Soft	Cheese compresses very easily between thumb and forefingers; may be difficult to plug cheese	Excess moisture or proteolysis
Weepy/Wet	Whey syneresis from cheese body	High moisture; poor drainage of whey; improper storage

[a]Defects are style-dependent (e.g., a brined white cheese would be expected to be crumbly; a fresh or soft-ripened cheeses would be expected to be weak/soft)

Aroma and Flavor

Goat and sheep cheeses should have pleasing and desirable aroma and flavor characteristics consistent with the source of the milk and the age of the cheese and should be free from undesirable aromas and flavors. A term that should come to mind is balance. Soft goat cheeses such as chevre are expected to be refreshing (fresh) with a slight tang (lactic acid), have recognizable goat flavor (characterized by caproic, caprylic, and capric acids), and be free from excessive goatiness or "dirty buck" notes. Talavera and Chambers (2016) reported that the most common attributes shared in U.S. goat cheeses included overall dairy (especially buttery, dairy fat, and dairy sour), goaty, astringent, biting, pungent, sharp, salty, sour, and bitter.

Goat cheeses should be downgraded if they lack typical goaty flavor, but goat flavor should not overwhelm. The same can be said for sheep milk cheeses (lanolin vs. mutton). A summary of the common off-flavors in goat and sheep cheeses is included in Table 18.3.

Body and Texture

The body and texture of most goat and sheep cheeses vary depending on cheese style, so a judge must be familiar with the intended style of the cheese to be a fair evaluator. Deviations in body and texture often result from improper acidification, moisture, salt balance, and/or proteolysis in aged cheeses. A summary of the common body and texture defects in goat and sheep cheeses is included in Table 18.4.

GOAT/SHEEP CHEESE
Iowa State Fair Judging Score Sheet
Judges: 0.5 to 1 point deduction for each defect (note that the minimum total score is 76 and maximum is 100)

Product identity: _____

Packaging Appearance & Condition: 8 pt. min. 10 pt. max. total _____
Positive features:
Intact □ Factually informative □ Positive dairy image □ Protects product □ Visually appealing □
Deviations from ideal:
Cracked or disturbed □ Loose □ Confusing or misleading information □ Uneven shape/color □

Product Appearance: 12 pt. min. 15 pt. max. total _____
Positive features:
Consistent/Homogeneous □ Evenly firm □ Evenly moist □ Rustic, hand-made appearance □
Proper eye development □ Typical of product □ Visually appealing □
Deviations from ideal:
Atypical □ Cracked or disturbed □ Rough surface □ Uneven shape/color □ Excessive rind □ Free whey □
Mottled/Seamy □ Uneven mold □ Unexpected yeast/mold □

Aroma: 12 pt. min. 15 pt. max. total _____
Positive features:
Appealing □ Buttery □ Fresh □ Typical of product □ Earthy □ Nutty □ Pleasantly fruity □
Deviations from ideal:
Atypical □ Ammoniated □ Cooked □ Chemical □ Flat □ Fruity/fermented □ High goat/sheep □ Unclean □

Flavor: 22 pt. min. 30 pt. max. total _____
Positive features:
Appealing □ Fresh □ Nice balance of flavors □ Nice salt content □ Typical of product □
Deviations from ideal:
Atypical □ Bitter □ Cooked □ Chemical □ Flat □ High acid □ High goat/sheep □ High salt □ Fermented □
Fruity □ Lacks freshness □ Overly flavored □ Oxidized □ Rancid □ Unclean □

Body & Texture: 22 pt. min. 30 pt. max. total _____
Positive features:
Crumbly (feta) □ Firm but delicate □ Pleasant mouthfeel □ Smooth □ Spreadable □ Typical of product □
Deviations from ideal:
Corky □ Crumbly (atypical) □ Curdy □ Gassy □ Mealy/grainy □ Open □ Pasty/Sticky □ Short/Brittle □
Too firm/rubbery □ Weak □

Specific comments:

Fig. 18.5 Example scorecard, used in the Iowa State Fair Dairy Products Contest for the evaluation of goat or sheep cheese

Potential Defect Sources

Defects come from a variety of sources. Along with originating in the milk, defects may occur during harvesting, storing, or processing the milk or cheese. Animal nutrition contributes to flavors because consumed compounds can enter the mammary gland and be absorbed into the milk. Microbes produce distinct aromas and flavors by releasing enzymes that alter fats or proteins. If milk is stored too long before processing, cheese quality may suffer due to oxidation or hydrolysis of fatty acids. Despite pasteurization, microbes originally present in the milk or introduced during processing may contribute to defects prior to pasteurization; some spoilage microorganisms and their enzymes survive pasteurization and can cause degradation (defects) later. Cheese may experience oxidation if it is not stored properly. If utensils are unclean or if chemicals such as sanitizing agents are present on

equipment, the cheese may exhibit chemical off-flavors. Probable causes of common flavor and body and texture defects of goat and sheep cheeses are included in Table 18.3 and 18.4, respectively.

18.6 Flavored Goat Cheeses

Goat cheeses are excellent carriers for a variety of added flavors (e.g., herbs, fruits, flowers) that are only limited by the imagination of the cheesemaker. The flavor and body and texture characteristics of a good cheese should be enhanced by characteristic and complementary flavor and body and texture characteristics of the flavoring component. Even distribution of condiments is essential and should effectively represent the name on the package without detracting from the underlying high-quality cheese flavor that should be noted by the judge, and ultimately the consumer.

18.7 Conclusion

Goat and sheep cheeses have unique appearance and flavor attributes which differentiate them from other types of cheeses. Understanding these characteristics, as well as the intention of cheesemakers, enables fair judgment of goat and sheep cheese to encourage consistent, high-quality cheesemaking. Using consistent lexicons and scorecards for the evaluation of cheese will enable processors to optimize products' body and texture, flavor, and appearance to not only monitor product quality but attract and keep consumers.

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