Chapter 9
Cheddar and Cheddar-Type Cheeses

Stephanie Clark

9.1 Introduction to Cheddar Cheese

Cheddar cheese is generally classified as a hard, internally ripened cheese and is the most widely recognized and produced member of a group of cheeses often called "Cheddar-type." Until 2002, Cheddar was the most plentifully available cheese in the USA. Commodity data from the US Department of Agriculture Economic Research Service show that per capita consumption of Cheddar cheese increased from 5.8 pounds in 1970 to 10.6 in 1987, fluctuated between 9.0 and 10.4 through 2019. Per capita consumption topped out in 2017, at 11.1, and dropped back to 10.1 in 2019 (USDA ERS, 2020). The burgeoning pizza market has led to the emergence of mozzarella cheese as a contender for the honor of most available cheese. During that same period, the per capita consumption of mozzarella has steadily risen from 1.2 pounds in 1970 to 10.0 in 2005 and 12.5 papc in 2019. However, the rapid rise of mozzarella does not diminish the importance of Cheddar cheese, which continues to be strong as a stand-alone product and as an important ingredient for the food industry.

The variations in processes and techniques involved in making cheeses within the Cheddar-type group result in relatively small differences in cheese characteristics when placed in the context of all cheeses. Therefore, Cheddar cheese grading is the primary focal point for discussion in this chapter. An outline of the proper

This chapter is the result of careful work by previous authors of *Judging Dairy Products* (Nelson & Trout, 1934, 1948, 1951, 1964) and *The Sensory Evaluation of Dairy Products* (Bodyfelt et al., 1988; Partridge, 2009), with addition of new materials, deletion of redundancies, and a rearrangement of content.

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sequence of procedures for grading will be followed by a section defining defects and attributes in detail. The use of the Collegiate Dairy Products Evaluation Contest (CDPEC) Cheddar cheese scorecard for the training of students to evaluate body and texture and flavor characteristics will be woven into the general topic of grading.

9.2 Essential Steps of Cheddar Cheese Making

The US government Code of Federal Regulations (CFR Title 21, Part 133.113; US FDA, 2022) defines Cheddar cheese as cheese made by the Cheddar process or by another procedure that produces a finished cheese having the same physical and chemical properties as that produced by the previously described Cheddar process. This cheese is generally made from cow's milk (but milk from goats, sheep or mixed milk is common), with or without the addition of coloring matter (usually annatto bean extract). Common salt (NaCl) is typically added.

The traditional method of converting of milk into Cheddar cheese can be divided into nine essential steps:

1. *Preparation of milk*. Although raw milk may be used if the cheese is aged at >1.7 °C (35 °F) for >60 days prior to sale, cheese milk preparation generally includes pasteurization or thermization. Thermization is a sub-pasteurization heat treatment that reduces bacterial numbers yet retains some indigenous enzyme activity and requires >60 days of cheese aging at >1.7 °C (35 °F) because it is classified as a raw milk cheese. Following heat treatment, the milk is adjusted to the setting temperature of 30–31.1 °C (86–88 °F).
2. *Ripening of milk*. The first addition to the tempered milk in the vat is the appropriate starter culture, followed by the addition of colorant, if used. The starter culture produces the required lactic acid as well as a variety of metabolic enzymes. Often times, adjunct cultures are added along with the primary lactic starter culture to provide unique flavor characteristics and/or to accelerate ripening.
3. *Setting and cutting the curd*. Following 30–60 min of ripening, rennet or another coagulating enzyme is added to induce the formation of the milk gel within 25–35 min. The milk gel (coagulum) is then cut into individual curds using appropriate cheese knives (harps), with wires placed approximately 0.65 to 1 cm (1/4 to 1/2 in) apart.
4. *Cooking the curds*. The curds are allowed to heal for 5–15 min, followed by gentle agitation as the whey syneresis begins, and the individual curds develop a cohesive body and texture. The milk temperature is simultaneously raised with constant agitation to the final cooking (scalding) temperature of 37.8–40.0 °C (100–104 °F) within 30 min, followed by an agitated cooking time that varies with the target characteristics of the cheese.
5. *Cheddaring*. In the traditional Cheddaring stage, whey is drained from the curds, which are allowed to bind together, thus forming mats of curd. The mats are subsequently cut into loaves. Loaves are typically flipped and stacked, approxi-

mately every 15 min and maintained at appropriate temperatures to allow production of additional lactic acid for modification of curd body and texture. The Cheddaring stage is also an important process step for control of the final moisture content of the finished cheese.

6. *Milling*. When the appropriate body and texture and a target acidity have developed, the curd mats are milled into approximately 2 × 2 × 5-cm (¾ × ¾ × 2 in)-sized curds. *Optional substitution for steps 5 and 6*. The make procedures may be modified to eliminate the Cheddaring step (for a stirred curd process) and/or to add a wash step (water is added to the vat after partial whey removal, to reduce the lactose available for fermentation).
7. *Salting*. Salt is added to the properly acidified curd to slow cultures and to help with moisture control, as well as flavor, body, and texture development of the finished cheese.
8. *Molding*. After mixing of the salt and curd, the curd is placed in the mold, which gives the cheese the desired shape. Traditionally, curd is pressed in the mold for about 18 h; however, modern, continuous pressing systems shorten the time required. Proper handling of the curd in the molding process will help provide the desired close-knit texture characteristic of Cheddar cheese.
9. *Packaging and curing*. After extraction of the cheese from the mold, one of several types of coating or packaging materials may be applied to the block as a barrier to oxygen and water, including the option for a natural rind (bandaging, larding, cave aging; Fig. 9.1). Such barriers (except natural rind) have the potential for growth of molds and prevent drying. The Cheddar cheeses are then placed in the aging facility for development of flavor and body and texture. The enzyme activity from rennet and cultures is responsible for the catabolism of cheese curd components resulting in the development of flavor components and body and texture changes.

Fig. 9.1 Vacuum-sealed, rindless Cheddar cheese (left) and muslin bandage-wrapped Cheddar cheese (right). (S. Clark images)

Table 9.1 Code of Federal Regulations for Cheddar-type cheeses (US FDA, 2022)

Cheese variety	CFR, Title 21, Paragraph
Cheddar/Cheddar for manufacturing/low-sodium Cheddar cheese	133.113/114/116
Colby/Colby cheese for manufacturing/low-sodium Colby cheese	133.118/119/121
Washed curd and soaked curd cheese/washed curd cheese for manufacturing	133.136/137
Granular and stirred curd/granular cheese for manufacturing	133.144/145
Monterey and Monterey Jack/high-moisture Jack cheese	133.153/154

Numerous variations and subroutines within each of these general steps make possible the varieties included in the Cheddar-type cheese family. Definitions for Cheddar and similar cheese types may be found in the Code of Federal Regulations (CFR), Title 21, Part 133 (US FDA, 2022) (Table 9.1).

All of the varieties listed in Table 9.1 require a minimum milk fat content of at least 50% by weight of the solids. Given a constant milk fat-to-casein ratio, the hardness of a given cheese is a function of moisture content. The maximum moisture content on a weight basis is 39% for Cheddar and granular/stirred; 40% for Colby; 42% for washed/soaked; and 44% for Monterey/Monterey Jack cheeses.

Moisture content and acidity are regarded as the two most important factors in the control of cheese properties. Generally, a firm, low-moisture cheese will result in a slower rate of ripening, more selective microflora activity, milder flavor, longer product keeping quality, and a cheese more suited for additional aging or maturing.

The salt content, the relative amounts of milkfat above the minimum requirement, and chemical changes that result from the controlled growth of starter and adjunct microorganisms and associated enzymatic activity during manufacturing and ripening processes will also help determine the sensory characteristics of the cheeses between and within varieties. The addition of proteolytic and lipolytic enzymes to the cheese milk before pressing can also modify the sensory characteristics of the cheese. Hence, a combination of factors is responsible for yielding the variety within the Cheddar-type classification.

9.3 Composition and Nutritive Value

In cheesemaking, marked changes in composition of the original cheese milk occur at two distinct stages: (1) during separation of the curd from whey and (2) during cheese ripening. Nearly all water-insoluble and some water-soluble components are retained in the curd. For Cheddar-type cheese, protein, fat, calcium, phosphorus, and vitamin A are concentrated approximately eight- to tenfold compared to the amounts of these constituents found in milk. Most of the water-soluble components, including the water-dispersible whey proteins, are “lost” to the whey. As a result, lactose, whey proteins, and water-soluble salts are not appreciably retained by the

curd, and thus, are present only in small quantities associated with the relatively small amount of moisture (whey) retained in the cheese curd. When using cheese milk concentrated by membrane processing, more of the whey proteins are incorporated into the cheese curd, improving the nutrient profile and yield (Iyer & Lelievre, 1987).

Cheese curd retains the most important nutrients of milk. Most notable are the nutritionally complete protein, casein, calcium, phosphorus, and vitamin A. Cheese is considered to be one of nature's most versatile foods, being simultaneously nutritious and readily digested (Miller et al., 2000).

Some Cheddar cheese is referred to as "full-cream cheese" because it is made from whole milk (~4.0% fat). However, most Cheddar cheese is manufactured from standardized milk, wherein the relative fat and casein proportions are adjusted, usually by adjusting the milk fat content of the cheese milk to approximately 3.8%, thus maintaining a constant casein:milk fat ratio. To produce 1 lb (0.45 kg) of Cheddar cheese requires approximately 10 lb (4.54 kg) of whole milk (almost 5 qt). Nearly one-half of the total solids of whole milk remain in the cheese curd, including about 75% of the milk protein. The milk fat content of Cheddar cheese is about 31–35% of the total weight (>50% of dry matter). Cheddar cheeses meeting the labeling requirements of reduced (25% reduction in fat), low-fat (3 g of fat or less in a reference serving of 28 g), or nonfat (0.5 g of fat or less in a reference serving of 28 g) are available and present many challenges to the cheesemaker due to toughening of the cheese structure and reduction in flavor development.

Cheddar-type cheeses may be made from milk of other sources, such as goats or sheep, and will have different sensory characteristics as a consequence of differences in milk fat and protein composition for each lactating species (refer to Chap. 18).

9.4 Degree of Ripening

Much of the Cheddar cheese made from pasteurized milk is marketed shortly after manufacture (≤ 90 days) as a mild cheese or for use in producing processed cheese (Chap. 12). Historically, the ripening or curing of Cheddar cheese to develop characteristic Cheddar cheese flavor is a slow, complex, bacteriological, chemical, and enzymatic process that requires months, and sometimes years, for extra-sharp cheese flavor. Consequently, Cheddar may be found on the market in various stages of ripeness, or aging. For best results, cheese ripening requires carefully controlled temperature and humidity.

Although not legally defined, unripened Cheddar cheese is often referred to as "fresh," "current," or "green" cheese. Cheese at this stage is characterized as having a flat or weak flavor (compared to a medium or sharp cheese) and a relatively tough, curdy, or corky body. Good-quality Cheddar cheese that has been properly cured for at least 3 months or longer has a moderate, slightly nutty, "Cheddar" flavor and is generally referred to as a "young" or "mild" cheese. At 6–8 months of age, more of

Table 9.2 General[a] Cheddar cheese classifications based on the extent of ripening

Classification	Aging time
Mild	2–3 months
Medium or mellow	4–7 months
Sharp or aged	8–12 months
Extra-sharp	Over 1 year

[a]These are typical aging times for traditionally manufactured Cheddar and may vary slightly among cheese manufacturers. Modern accelerated ripening techniques significantly shorten this timetable

the distinct, aromatic Cheddar flavor should be evident; such cheese is considered as "semi-" or "medium-aged." Generally, a year or longer is required to develop the fully aromatic or robust Cheddar cheese flavor desired in an "aged," "sharp," or "matured" cheese. "Extra-sharp" Cheddar cheese is usually aged in excess of 1.5–2 years (Table 9.2).

The grading of cheese and assignment of extent of ripening designation for labeling is dependent on the organization doing the grading. If the USDA is the contracted grading entity, the grader will designate the cheeses as either fresh/current, medium, or cured/aged. However, outside of USDA grading practices, the assignment of extent of ripening designations is entirely up to the organization with the final approval on the label. Graders may be employed by the manufacturer, formulators, brokers, or the wholesale buyers.

Whether the flavor of Cheddar cheese is mild or pronounced does not depend exclusively on the aging process. The quality of the milk, the bacteriological and chemical control in manufacture, moisture, salt content, and the temperature and method of curing have much to do with the nature and intensity of flavor in the final product. The development of typical Cheddar cheese flavor is highly dependent on age, and it is generally advisable not to evaluate cheeses of various ages within the same class. In educational cheese clinics, exhibits, and/or contests where Cheddar cheese is to compete for awards, the cheese should be entered into different age classes or categories. Young (mild) cheese (under 4 months old), semi-aged (medium) cheese (from 4 to 8 months old), and aged (sharp) cheese (over 8 (or 12) months old) are logical age classifications. Rindless and natural rinded cheeses may also be judged in separate classes.

The use of "accelerated" ripening techniques such as added enzymes, adjunct cultures, and elevated temperature has resulted in many if not most cheeses meeting the sensory equivalent of "sharp" flavor in as little as 6 months. Cheeses that are the product of accelerated ripening are not good candidates for the traditional timeline displayed in Table 9.2, but should be judged by the same set of standards as any Cheddar cheese. The acceleration of ripening will accelerate the development of sensory defects as well as proper character; therefore, milk quality, make procedures, and ripening regime must be followed with great care.

9.5 Form and Style

As market demands are identified, Cheddar cheese may be made in several sizes, forms, or shapes, which are generally called styles. Usually, a judge will not be concerned with cheese style, except to remember that large-sized cheeses are not as prone to drying out as smaller ones; this may slightly affect the texture and flavor of cured cheese.

The Cheddar cheese industry has developed a multiplicity of small sizes and shapes (Fig. 9.2), but it has also recently produced larger, more utilitarian sizes of cheese, as well. The rindless 40-lb block, 640-lb (291 kg) block, and 500-pound (227 kg) barrel cheeses have evolved as the predominant forms and sizes in contemporary cheese manufacture for reasons of economy, ease of handling, and warehousing.

A "mammoth" is a large, oversized, attention-arresting Cheddar cheese. Such cheeses are formed for the express purpose of display, advertising, and a focus of interest for special occasions, such as the opening of a new supermarket or advent of a festival that features cheese or dairy products. The size of a mammoth cheese generally varies from 300 to 13,000 lbs. For many years, the largest cheese on record was the 22,000-pounder made in Ontario, Canada, and exhibited at the Columbian Exposition, Chicago, 1893. However, this one was exceeded by the 34,591-pound Wisconsin Cheese Foundation giant displayed at the 1964 New York World's Fair, followed in 1988 by a 40,060-pound Cheddar named "Belle of Wisconsin," and finally in 1996 by a 57,518-pound turned out by Agropur of Granby, Quebec. Usually, these mammoths have excellent flavor and body and texture quality since the curd tends to cure quite well in a large cheese. In fact, since so much value is at stake, every precaution must be taken, from the selection of milk and curd handling to careful control of curing for such a cheese to be acceptable.

HOOP NUMBER	NAME	Weight of Cheese Pounds	Size of Cheese*	Height of Hoop Less Bandager
1	Longhorn, with one handle only	12	6" x 13"	15⅝"
2	Favorite or ½ Young American	5½	7" x 3½"	5⅜"
3	Young American	10	7" x 7"	9⅛"
5	Daisy	22	13½" x 4¼"	6⅛"
27	Midget	11	9⅜" x 5"	6⅜"
28	Gem	2½	5⅛" x 3¼"	5⅛"
14	20-pound Square Wilson-Style	20	14⅜" x 11⅜" x 3¼"	2⅜"
44	40-pound Square Wilson-Style	40	14⅜" x 11⅜" x 6½"	4¼"
46	60-pound Square Wilson-Style	60	14⅜" x 11⅜" x 9¾"	6"

*First dimension listed for round hoops is diameter, second dimension is height.

Fig. 9.2 Examples of some of the hoops or molds used to form various shapes and sizes of Cheddar and related cheeses. (Bodyfelt et al., 1988)

9.6 Grading of Cheddar Cheese

The practice of "grading" is used to evaluate the potential use and relative value of a cheese as it enters the channels of commerce leading to the consumer. Grading may tell the manufacturer that the cheese in question is suitable for extended ripening or must be moved quickly as young cheese for further processing. The term "judging" is generally reserved for competitions, but the judge uses the same criterion as the grader as appropriate to the contest.

Much can be learned about the quality of a given cheese by its appearance. By careful observation of the external appearance, and the internal body, texture, and color characteristics of a cheese, an experienced judge can often place a given cheese into a quality classification without actually tasting it.

The "ideal" Cheddar cheese should have (1) a clean, delicate, pleasing aroma and, when cured, a nutty flavor; (2) a firm and springy body, showing smoothness and waxiness (if cured) when worked between the thumb and fingers, and slight curdiness if fresh; (3) a texture that reveals a smoothbore or closed appearance (few or no openings); (4) uniform, translucent color, whether colored or uncolored (when fresh, it may be slightly seamy); and (5) a smooth finish that is clean, well-shaped, uniform in dimensions and overall size, with a complete, airtight package, and mold free.

9.6.1 Federal Grading of Cheddar Cheese

The US Cheddar cheese sold in central markets, or on contract, is usually sold on the basis of government grade. If sold on contract, the cheese age and style of package are generally specified. Such cheese is generally graded according to Federal standards by a USDA grader; the cheese price is determined primarily on the "basis of sensory quality." Generally, a college student who has mastered the evaluation of Cheddar cheese by the scorecard system can, after a short apprenticeship with a Federal grader, become proficient in grading cheese according to Federal standards.

The Dairy Grading Branch of the Dairy Programs Division, Agricultural Marketing Service of the USDA, recognizes four grades of Cheddar cheese. The nomenclature for these grades is as follows: (1) US Grade AA; (2) US Grade A; (3) US Grade B; and (4) US Grade C. Cheeses within Grades are also assigned one of three degrees of curing: (1) fresh or current, (2) medium, or (3) cured or aged. Detailed descriptions of the quality grades and US Standards for grades of Cheddar cheese as well as Colby, Monterey (Monterey Jack), and bulk American cheese may be found on the USDA AMS website (USDA AMS, 2022).

9.7 Sequence of Cheddar Cheese Grading Procedures

Following a logical and repeatable set of procedures for the grading of Cheddar and Cheddar-type cheeses will allow the grader/judge to become more proficient and efficient. This section provides a summary of the appropriate procedures for grading and introduces the several example scorecards. The following section describes the defects/attributes of Cheddar cheese in more detail.

9.7.1 Preparation for Evaluation

Appropriate facilities for cheese tempering, sampling, proper disposal of waste cheese, and cleaning of sampling equipment should be provided for evaluators. The facility should be well lit and air conditioned (approximately 65–68 °F) to ensure cheese is neither too warm nor too cold during evaluation. Evaluators should dress in layers, prioritizing cheese quality over comfort. Prior to sampling, one's hands should be washed and dried, since they directly contact exposed cheese surfaces. As soon as the cheese samples to be evaluated are arranged in order and numbered or coded for proper identification, the sensory evaluation process may begin.

Before evaluation, cheese samples should be tempered at l0–15.5 °C (50–60 °F) for a sufficient length of time to ensure a uniform temperature throughout the cheese. This usually requires 1–2 h for the smaller styles (≤5 lb) and 3–5 h for larger ones. Generally, a cheese plug taken from a warm (over tempered) cheese appears weak bodied; by contrast, a cold plug may appear short or corky. Actual body and texture characteristics cannot be determined readily unless cheese samples are properly tempered before evaluation. Flavor and flavor defects can also be more readily assessed at a warmer temperature.

9.7.2 Evaluation of Surface Appearance

The first procedure in grading Cheddar cheese is visual examination of surface finish or packaging material. The judge should note whether the sample appearance is generally clean, neat, attractive, and symmetrical, or whether the surfaces might be uneven, nonparallel, or rounded. Next, the evaluator should look more closely at the surfaces and observe whether the coating of plastic film (or paraffin) or wax or bandage is smooth and free from holes, tears, or wrinkles. Finally, the judge should undertake a close examination of the surface for mold growth; a mental record of all observations of the sample appearance should be made.

Obviously, this technique of evaluating appearance cannot be followed entirely when cheese is encased in opaque wrappers. Laminated paper-Pliofilm or foil wrappers serve to obscure the cheese from the critical eye of the judge. About the only

recourse the evaluator has in noting the appearance of such cheese is to note the cleanliness of the wrapper, the evenness and tightness of adherence, and freedom from breaks and tears.

9.7.3 Sampling

Cheese samples are usually obtained with a double-edged, curved-blade instrument known as a cheese trier (Fig. 9.3). For best service, the edges of a cheese trier need to be sharp. A trier that cuts a larger plug has an advantage over one of a smaller diameter since the extent of "openness" and possible color defects are easier to detect with a larger plug. A cheese trier with a 127-mm (5-in) cutting edge, 15.8 mm (5/8 in) diameter at the base (top), and 14.3 mm (9/16 in) diameter at the tip is recommended.

The trier should be inserted into the top surface of the cheese, preferably about halfway between the center and the outer edge of the cheese sample. After insertion, the trier should be turned one-half way around to cut a sample core. The plug is withdrawn, by twisting and lifting, simultaneously. The process produces a long tapered cylinder of cheese (Fig. 9.4). The back (warm) surface of the cheese trier, with the freshly drawn plug in place, should immediately be smelled to detect any volatile aroma components while at their strongest concentration. The upper 2.54 cm (1 in) of the cheese plug may be broken off and replaced, flush with the surface of the original hole, though this practice is not always followed (Fig. 9.5). This partially protects the cheese from developing mold contamination and retards drying and cracking of the cheese surface surrounding the hole. Various wax-like polymers of plastic or gels have been developed to seal trier holes to restrict the access of oxygen to the center of the cheese.

Fig. 9.3 Cheese triers of various sizes

Fig. 9.4 Removing a cheese plug from a 5-lb block of Cheddar with a 127-mm (5-in) trier. (Stephanie Clark images)

Fig. 9.5 Students in the Collegiate Dairy Products Evaluation Contest try samples of Cheddar cheese. (S. Clark image)

The evaluator should carefully examine the cheese plug and note whether the plug has a clean-cut surface (with no loose particles) or whether it is rough (with a feather-like edge as though the cheese had been cut with a dull knife). The evaluator should make a mental note of these observations as anything less than a clean waxy cut may be an indicator of defects such as short body and acid flavor. To remove the plug from the trier while maintaining its shape, apply moderate pressure to the top of the plug with the thumb of the hand holding the handle. Then, from the top, loosen the plug from the trier by gently grasping and twisting with the thumb and fingers of the free hand.

9.7.4 Evaluation of Color

The evaluator should observe the color of the cheese and determine whether the appearance is bright and clear or dull and lifeless. The cheese should be free from mottled or light and dark portions, curd seams, or faded areas surrounding any mechanical openings. The cheese judge should re-examine the plug and observe whether the cheese appears to be (1) translucent, which is desirable, or (2) opaque (difficult for the eyes to observe beyond the surface), which is undesirable. The evaluator should especially note whether the color is uniform throughout the sample. In quality evaluation, color uniformity is generally more important than the shade of color. Some cheese consumers prefer an uncolored product (no added annatto coloring). Uncolored (or lightly colored cheese) generally results in a light cream shade (sample 7 in Fig. 9.6); this depends on the milk fat and/or carotene content of the cheese milk. Other groups of consumers seem to prefer an intense deep-orange color for Cheddar cheese (sample 5 in Fig. 9.6). A good judge will note any defects in color that may be an indicator of defects in flavor or body and texture.

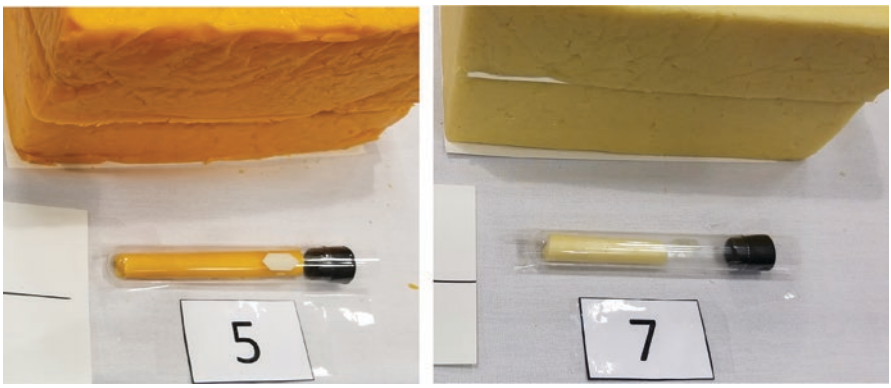


Fig. 9.6 Plugs of Cheddar cheese are placed in glass test tubes for evaluation by student contestants in the CDPEC. (S. Clark images)

9.7.5 Evaluation of Body and Texture

The judge should observe the nature and extent of the mechanical (open) or gassy defects in the cheese plug. Although visual, these defects are considered body and texture defects. In the CDPEC, a single plug is drawn by the lead judge and is placed in a glass test tube, capped, and taped to the table, so all student contestants may observe the same plug (Fig. 9.6). The shape or configuration of openings or gas holes should be examined closely to see whether they are regular, angular, rounded, large, and/or small. For the purposes of the CDPEC, the defects variously identified by USDA graders as either "pinny, sweet holes, gassy and slitty" are all scored as the "gassy" defect. The luster or sheen of the inner surfaces of these openings and whether the surfaces appear dry (preferable) or wet are helpful observations. Free moisture within these openings is sometimes indicative of certain flavor defects (i.e., whey taint, unclean) or potential quality shortcomings. See Fig. 9.7 for examples of gassy and open defects.

After the visual assessment, evaluators should take the ends of the cheese plug by the forefingers and thumbs of both hands and bend the plug slowly into a semicircle, while carefully observing when the sample breaks, as well as the nature of the break. A cheese plug that bends into approximately one-third to one-half of a full circle before breaking apart demonstrates the preferred plasticity. Generally, if the plug shows a definite resistance toward any bending and finally breaks abruptly, a "short" defect is noted (Fig. 9.8); if the plug bends until the plug ends nearly touch (if it breaks apart at all), a "weak" defect is noted.

Next, the judge should take one of the broken pieces of cheese between the thumb and the forefingers and attempt to manipulate it into a uniform mass. The relative resistance (or lack of resistance) offered by the cheese to applied pressure from the thumb and fingers should be ascertained. A common procedure is to work

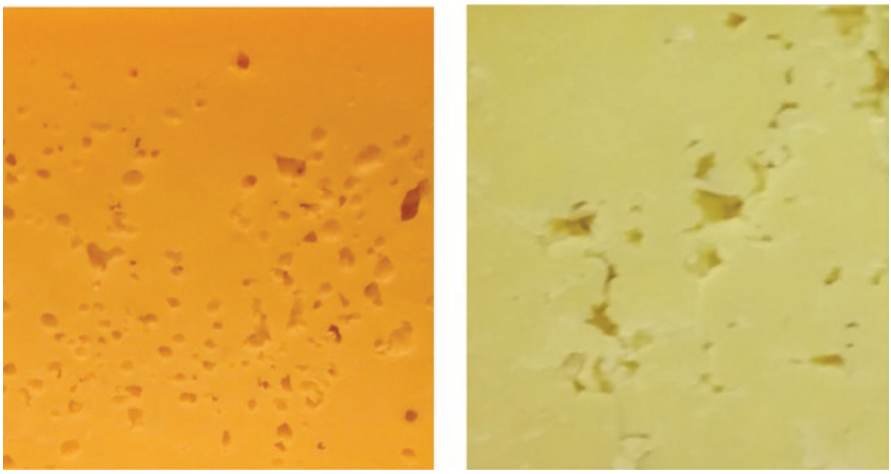


Fig. 9.7 Gassy (left) and open (right) defects evident in sliced cheese. (S. Clark images)

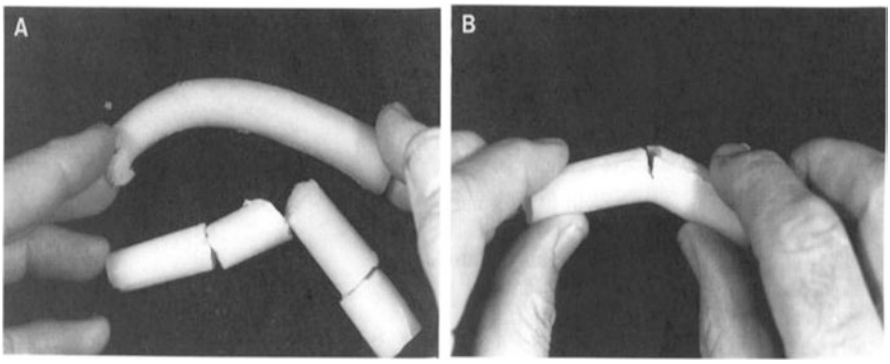


Fig. 9.8 A comparison of a "ideal"-bodied (**a**) and a "short"-bodied (**b**) Cheddar cheese. (Bodyfelt et al., 1988)

the piece of cheese by compressing to about half its original diameter, twisting and pressing the elongated portion to about half of its diameter, and repeating this process 12–15 times. Consistency in piece size and working method allows the evaluator to more objectively compare pieces of worked curd. The evaluator should try to form a small ball or marble of the softened product. Formation of a cohesive sphere of cheese is generally indicative of an appropriate degree of waxiness and elasticity for a typical Cheddar cheese of any age.

Next, the formed "ball" of cheese should be placed into the depression between the tips of the first two fingers, and with gentle to moderate pressure, the evaluator should push the thumb (of the same hand) into the manipulated cheese. Then the thumb should be slowly pulled from the slightly depressed "cheese ball." If the cheese sample adheres or sticks to the thumb or feels tacky or wet to the thumb's touch, the cheese sample is considered to demonstrate the pasty (sticky) defect. In stark contrast, if the cheese sample tends to fall apart in response to thumb pressure, either a curdy or crumbly defect is suggested, respectively, depending on the advancing age of the cheese. The "worked cheese" should remain smooth, waxy, and somewhat pliable for an "ideal" Cheddar cheese. The tempered sample should exhibit a tendency to remain as a solid mass upon gentle finger manipulation.

An optional approach is to spread the cheese mass over the palm of the hand (with the thumb of the opposite hand) and determine whether the thin smear of cheese feels smooth, silky, waxy, and/or fine or whether the sample variously appears to be sticky, pasty, mealy/grainy, or crumbly. The judge should then reassemble (or attempt to reassemble) the cheese particles and try to compress them into a compact "ball" and note the response of the cheese to this form of manipulation. Mealy/grainy may be better determined in the mouth than in the hands.

9.7.6 Evaluation of Flavor

By the time the sample has been worked into a semi-soft ball, the temperature of the cheese mass should have increased from combined pressure and hand warmth and thus enable easier detection of any aroma. The evaluator should place the tempered cheese sample directly under the nose and observe the aroma a second time. The judge should compare the aroma with that noted when the sample first was removed from the cheese. For tasting, the evaluator should place a small portion of an "unworked" plug into the mouth and chew until a semi-liquid stage is reached. The judge should roll the macerated sample about within the mouth for sufficient time to determine both taste and aroma, then expectorate the sample and determine the overall flavor judgment(s). The evaluator should avoid using the previously worked cheese sample due to the possibility of carryover from fingers from previous samples and loss of some volatile flavor components.

As a rule, too many samples tends to dull the sense of taste and smell; ideally, no more than 15–20 samples should be tasted at one scoring, as they may eventually all tend to taste alike. For beginners, about ten samples can be tasted successively with some assurance that the taste sensing nerves are functioning normally or are not overtaxed.

Rinsing the mouth occasionally with tepid water will allow appropriate reconditioning of the mouth for subsequent sampling. After experiencing a particularly poor-quality sample (i.e., rancid, garlic/onion, or intense sulfide/bitter), in a non-contest environment, rinsing with a lukewarm saline solution to cleanse the mouth of previous cheese flavors may be helpful. A pinch of common table salt placed into the mouth and rinsed out with tepid water can be equally effective. Apple slices or grapes are also useful for cleansing the mouth between intense-flavored cheese samples. After any cleansing procedure, a final rinse of water is recommended. Experienced judges find it most helpful to "go back to the best sample in the lot" after evaluating a poor-quality sample.

9.7.7 Scoring

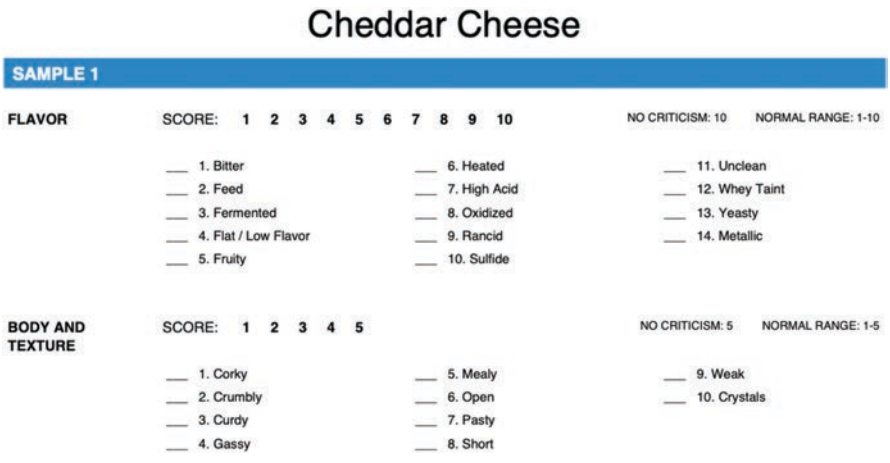
All sensory observations should be recorded on a designated cheese scorecard or a tablet/computer provided for this purpose. The quality score of cheese is determined by comparing the properties or characteristics of each cheese with their accepted standards of perfection or "ideal." These standards of perfection, when assembled, form what is known as a scorecard for Cheddar cheese. The less-experienced judge should strive to follow the aforementioned procedure quite closely. Deployment of a scorecard enhances accuracy when more than two or three samples are evaluated. The judge should strive to keep a mental image of each sample's deviations from the standard. Once this ability is attained, continual re-examination of the various samples becomes unnecessary. The practice of re-examining, reworking, and retasting

cheese is not typically conducive to the best evaluation performance. Such a practice leads to vacillating judgment, which is just as apt to be wrong as to be correct. A confident judgment should be made following the initial sampling, if possible.

9.7.7.1 The Collegiate Dairy Products Evaluation Contest Scorecard

One example of a Cheddar cheese scorecard is the one used by the Collegiate Dairy Products Evaluation Contest (CDPEC). Initially created by the Coaches Committee of the American Dairy Science Association (ADSA), a committee since disbanded, the official CDPEC scorecard was developed for use in training university students in sensory evaluation of Cheddar. The standard of perfection is somewhat arbitrary in origin, and the judge in training should realize that some characteristics listed as defects on the CDPEC scorecard may, in fact, be desirable characteristics for given market segments. The sulfide defect is an excellent example of a sensory characteristic that may also be considered an attribute. A cheese given a score of "6" for definite sulfide may be considered a top-quality cheese if classified and marketed as a New York-style Cheddar. For purposes of research, the use of the cheese lexicon and descriptive analytical techniques or appropriate consumer acceptance testing should be used. A discussion of proper sensory methods for research use is given in Chap. 17.

The scorecard lists some essential factors or items by which a cheese is evaluated; appearance and color are not a part of the scorecard. Each flavor and body and texture attribute is assigned a point weighting that reflects the relative importance of each factor in determining the overall sensory quality. For the novice cheese judge, the scorecard (Fig. 9.9) and associated scoring guide (Table 9.3) can be essential evaluation tools; as such, they should be studied in detail. The evaluator should keep


Cheddar Cheese

SAMPLE 1

FLAVOR SCORE: 1 2 3 4 5 6 7 8 9 10 NO CRITICISM: 10 NORMAL RANGE: 1-10

___ 1. Bitter
___ 2. Feed
___ 3. Fermented
___ 4. Flat / Low Flavor
___ 5. Fruity
___ 6. Heated
___ 7. High Acid
___ 8. Oxidized
___ 9. Rancid
___ 10. Sulfide
___ 11. Unclean
___ 12. Whey Taint
___ 13. Yeasty
___ 14. Metallic

BODY AND TEXTURE SCORE: 1 2 3 4 5 NO CRITICISM: 5 NORMAL RANGE: 1-5

___ 1. Corky
___ 2. Crumbly
___ 3. Curdy
___ 4. Gassy
___ 5. Mealy
___ 6. Open
___ 7. Pasty
___ 8. Short
___ 9. Weak
___ 10. Crystals

Fig. 9.9 The computerized CDPEC contest Cheddar cheese scorecard for sensory defects

Table 9.3 Suggested CDPEC scoring guide for flavor and body and texture of Cheddar cheese for designated defect intensities (ideal = perfect 10 for flavor; 5 for body and texture)

Cheddar cheese			
	Slight	Definite	Pronounced
Flavor			
Bitter	9	7	4
Feed	9	8	6
Fermented	7	5	3
Flat/low flavor	9	8	7
Fruity	7	5	3
Heated	9	8	7
High acid	9	7	5
Metallic Oxidized	8 7	6 5	3 2
Rancid	6	4	1
Sulfide	9	7	4
Unclean	8	6	3
Whey taint	8	7	5
Yeasty	6	4	1
Body and texture			
Corky	4	3	2
Crumbly	4	3	2
Crystals Curdy	4 4	3 3	1 2
Gassy	3	2	1
Mealy	4	3	2
Open	4	3	2
Pasty	4	3	1
Short	4	3	2
Weak	4	3	2

in mind the relative values of the various scorecard items that are considered in the quality grading process. The scorecard does not address issues of finish and appearance, or color; however, these are important considerations when grading cheese for industrial or regulatory purposes and will be discussed later in this chapter. When evaluating cheese, the proper identification of an attribute(s) or a defect(s) is very important in helping the manufacturer identify strengths and weaknesses in the make procedures for the cheese in question.

In using the CDPEC scoring guide, one should keep in mind that if two or more defects are noted, the lowest scoring defect within the flavor or body and texture categories will set the category score for that product. *The defect scores are not cumulative*.

9.8 Defects/Attributes of Cheddar Cheese

9.8.1 Finish and Appearance Evaluation

Cheese should generally exhibit symmetrical, parallel ends, square, and even edges appropriate to the form in which they were made; packaging that is evenly folded, neat, close-fitting plastic film or wrapper free from wrinkles; a clean, thin, uniform, close-adhering coating of paraffin (if used) showing no blisters or scales; and freedom from pinholes, tears, breaks, cracks, undesirable mold, rot spots, or soiled areas.

The finish of the cheese is important during evaluation, as it furnishes an indication of the skill and care taken by the cheesemaker during manufacture of the cheese and of the subsequent handling of the product. An ill-shaped, poorly formed and packaged cheese indicates carelessness in manufacture, which may be correlated with undesirable sensory properties. Untidy, soiled, or moldy cheese does not present a pleasing appearance or full product utility. Defects in package finish are usually quite easy to observe and assess for their significance to maintaining product integrity.

The beginner judge should become familiar with the possible defects in cheese finish, and in turn correlate them, if possible, with other defects. The defects listed in the following paragraphs are closely associated with cheese wrapped with various types of protective coverings. (Common appearance defects, probable causes, and remedies may be found in Table 9.4).

9.8.1.1 Rindless, Flexible-Wrapped, or Non-paraffined Cheese

Modern processing and merchandising has led to the introduction of new styles and packaging materials for Cheddar cheese. Twenty-pound (9.1 kg) and 40-pound (18.2 kg) blocks and 500-pound barrels and 640-pound blocks have displaced the time-honored round “daisy” and “Cheddar,” which were covered with a cotton bandage (cheese cloth) and paraffin. Taking the place of cotton and paraffin are a wide variety of flexible wrappers constructed of multiple polymer, laminated films that provide better oxygen and vapor barriers, greater tensile strength and bonding properties. In Cheddar cheese operations, these packaging materials are generally applied directly to the pressed “wet curd” immediately after de-hooping, with vacuum treatment, followed by heat sealing of the wrapper. The film-packed cheese may be placed in a fitted fiberboard box with a veneer reinforcement liner or other suitable container for storing and shipping. The cheese judge should be alert to possible flexible-wrapper defects listed in the following paragraphs.

Damaged Coverings Torn or punctured wrappers readily permit air access and microbial contamination of bulk cheese and thus must be prevented. Careless handling contributes to the “damaged” package defect. Hopefully, for economic reasons, damaged wrappers occur infrequently, but all wrapped bulk cheese warrants close inspection in this respect.

Table 9.4 Common color and appearance, body and texture, flavor defects of Cheddar cheese, their probable causes, and remedial measures

Appearance and color defects	Probable causes	Remedial measures
Acid-cut: bleached or faded, or dull looking (portions or entire cheese surface)	1. Excessive acid developing in the whey or at packaging stage 2. Nonuniform moisture distribution in the cheese	1. Monitor acid development carefully 2. Take precautions to insure consistent and uniform moisture retention in curd
Crystals or white specks: Granules or small hard mineral or protein deposits	1. If young cheese, results from calcium lactate complex formation (not desired) 2. If in aged cheese, derived from proteolysis and crystallization of tyrosine	1. Use make procedures that limit the levels of lactic acid and calcium in the serum of the cheese 2. Limit the fermentation of lactose through selection of appropriate cultures (pasteurized milk cheese only) 3. Reduce the level of lactose available in cheese milk by using ultrafiltration/diafiltration 4. Minimize post-packaging acid development
Mottled appearance: Irregularly shaped light and dark areas on cheese surface	1. Combining curds of different colors, batches, or moisture content 2. Uneven acid development in curd 3. Unwanted microbial growth: (a) H_2O_2 production, and/or (b) fruity off-flavor and (c) pasty body	1. Avoid adding starter culture after color incorporation 2. Attempt to cut the curd into uniform-sized particles 3. Handle all curd carefully to avoid drying during matting, Cheddaring, or "holdovers"
Pinking: Develops a pink color on the surface	Oxidation of annatto color	1. Avoid storing cheese under fluorescent lighting 2. Allow proper development of acid to develop during cheesemaking 3. Package the cheese using a good oxygen barrier
Seamy: Shows light colored lines around curd pieces	1. Exudation of milkfat from curd pieces due to excessive forking, too-warm temperatures, and lack of salt dissolution 2. Over-stirred set	1. Wash "greasy" curd at 32 °C (90 °F) and thoroughly drain 2. Avoid over-forking of the curd 3. Allow all of the salt to dissolve completely 4. Press curd at 30–32 °C (86–90 °F)
Moldy appearance	Growth of mold on cheese surface	1. Insure airtight seals on cheese packages 2. Avoid O_2 in the packages by vacuum or CO_2 or N_2 gas flushing

(continued)

Table 9.4 (continued)

Body and texture defects	**Probable causes**	**Remedial measures**
Corky, dry and hard	1. Lack of acid development 2. High salt in moisture phase 3. Not enough coagulant 4. Use of too much calcium chloride	Follow standard or recommended procedures for cheesemaking
Crumbly, mealy/grainy	Excessive acid production and low moisture retention in cheese	1. Avoid ripening at higher temperatures 2. Control acid development and moisture level in curd
Curdy or rubbery	Inadequate curing conditions	Optimize ripening temperature and time
Pasty, sticky or wet	1. High moisture retained by curd 2. Excessive acid development	Control acid development in relation to time and temperature parameters
Weak or soft	1. Excessive fat content 2. High moisture in cheese 3. Failure to develop "body" in cheese during cooking 4. Low salt in moisture phase	1. Standardize fat in cheese milk 2. Cook curd to desirable firmness (higher temperature, longer time) 3. Avoid piling curd slabs too high or too soon while Cheddaring curd
Flavor defects	**Probable causes**	**Remedial measures**
Bitter	1. Excessive moisture 2. Low-salt level 3. Proteolytic starter culture strains 4. Microbial contaminants 5. Excessive acidity 6. Poor-quality milk 7. Plant sanitation problems	1. Use carefully selected cultures 2. Reduce amount of starter 3. Monitor salting levels and method of adding 4. Upgrade milk quality 5. Improve sanitation 6. Control acid and rate of development
High acid	1. Development of excessive lactic acid 2. Excessive moisture 3. Use of too much starter 4. Use of high-acid milk	1. Reduce ripening time 2. Reduce starter amount 3. Monitor milk acidity 4. Cook to slightly higher temperature 5. Follow a standardized procedure for cutting, cooking, draining, Cheddaring and salting steps
Fermented (vinegar-like)	Heterofermentative *Lactobacilli*	1. Improve cooling 2. Short wash pasteurizer every 8–12 h 3. Review milk quality

(continued)

Table 9.4 (continued)

Flat (lacks flavor)	1. Lack of acid production 2. Use of milk low in fat 3. Excessively high cooking temperature 4. Use of too low a curing temperature 5. Too short a curing period	1. Check starter activity 2. Increase starter amount 3. Increase curing temperature 4. Lengthen curing period 5. Standardize cheese milk for fat content
Fruity	1. Certain strains of *S. lactis* or *S. diacetylactis* 2. Low acidity 3. Excessive moisture 4. Low-salt level 5. Poor milk quality	1. Eliminate lactic strains that produce ethanol 2. Monitor starter activity 3. Check salting procedures 4. Upgrade milk quality
Rancid	1. Milk lipase activity 2. Microbial lipases from contaminants 3. Homogenization of raw milk 4. Late lactation or mastitic milk	1. Standardize the Cheddaring process. 2. Avoid excessive agitation, foaming, and severe temperature fluctuations. 3. Improve sanitation 4. Monitor milk quality
Unclean	1. Poor-quality, off-flavored, or old milk 2. Unwanted microbial contaminants 3. Allowing off-flavored cheese to be "aged" 4. Improper technique of Cheddaring	1. Upgrade milk quality 2. Improve sanitation 3. Market marginal quality cheese as mild 4. Standardize the Cheddaring process
Whey taint	1. Poor whey expulsion from curd 2. Improper Cheddaring techniques 3. Failure to drain whey from piles of curd slabs (especially between pieces)	1. Standardize the Cheddaring process. 2. Constantly make sure expelled whey is free to drain away from Cheddaring curd 3. Wash curd with 32 °C (90 °F) water to remove excess whey

Sources: Compiled from Blake et al. (2005), Chandan (1980a, b), Johnson (2004), Van Slyke and Price (1979), Wilson and Reinbold (1965), Wilster (1980), and Wendorf (2007)

Loosened Coverings For maximum protection against mold growth, air (oxygen) must be excluded insofar as possible from under the wrapper of cheese coverings. Some wrappers are bonded so tightly to cheese surfaces that loosening and removing of wrappers in cheese cutting and packaging operations may be difficult. All non-bonded wrappers must be pressure- or vacuum-sealed to void as much oxygen as possible. Usually, these wrappers cling to the cheese as though they were bonded. "Loosening" and "ballooning" of the wrapper is generally undesirable, as mold growth may occur within the air space provided if the integrity of the covering is lost. Loosened wrappers may be noted by sight, or by stroking the cheese surface with the hand. Cheese package edges and ends should be closely examined for any unnecessary looseness and/or air pockets.

Soiled Coverings A "soiled (or greasy) wrapper" often denotes extreme carelessness in packaging, handling, and storage. Such a condition may suggest a general lack of concern for both cleanliness and good housekeeping. This defect is even more serious when accompanied by damaged wrappers.

9.8.1.2 Pliable, Wax-Coated Cheese

Microcrystalline paraffin and a variety of polymers yield adhesive, flexible, plastic-like protective coatings when surface-dried cheeses are dipped into the melted wax. These appealing, thick coatings may be produced in a wide variety of colors and may be semi-transparent to opaque. The cheese must be handled with reasonable precautions so that the coating will not chip or flake. This type of flexible wax is often used as a cheese covering for any cheese that is subsequently cut into retail portions, or for small units cut from bulk cheese to be cured and sold as miniature-sized cheese. This coating is relatively free of defects if the proper form of wax is used.

9.8.1.3 Paraffined Cheese

Although paraffin (wax) currently finds limited use as a covering material for cheese, the cheese judge should be aware of the following defects, which may rarely appear with poorly applied pliable wax coating but are often related to the use of paraffin.

Blistered This defect manifests itself by areas of thin, loose paraffin, usually on the end of the cheese where cheesecloth may be absent. Such a condition readily lends itself to the possible entrance of mold and/or harboring cheese pests (see Cheese Mites and Skippers in Sect. 9.8.1.6); therefore, blistering is quite objectionable for paraffin-coated cheese.

Checked A "checked" or cracked paraffin is denoted by breaks or formed cracks in the cheese covering. Applying a heavier-than-necessary paraffin coating usually causes this defect. Checked paraffin offers an opportunity for mold and pests to gain entrance to the cheese.

Rough Rough paraffin is manifested by a lack of surface smoothness or paraffin finish. The paraffin surface seems to contain small hard particles; this leaves the impression that the surface of the cheese may have been covered with tiny particles of foreign matter prior to coating. Although not usually that serious, this defect is somewhat undesirable as a surface blemish for what may otherwise be a high-quality cheese. Roughness may be detected either visually or by running the hand over the surface.

Scaly Loose or scaly paraffin offers poor protection for cheese; it permits moisture to escape and mold to gain entrance; hence, this represents a serious packaging defect. In cutting cheese, particles of paraffin often become intermixed with the cheese itself, and thus produce an untidy, unappetizing cheese slice. Scaly-like paraffin should seldom occur if the cheese surface is pre-dried sufficiently, then completely dipped into hot paraffin (not lower than 104.4 °C (220 °F) for at least 10 s). The paraffin is then allowed to completely harden and solidify via allowing it to cool to near ambient temperature before subsequent handling occurs.

9.8.1.4 Workmanship

High Edges Cheese showing this defect lacks square or symmetrical edges, such as desired in well-finished cheese. Sometimes, edges of the cheese may be so long that they tend to bend over (curl under) onto the end of the cheese, and thus form a protected area for mold growth or pests. These undesirable long edges are usually dry, do not cure properly, and thus represent waste.

Lopsided, Misshapen Nonparallel ends or sides, a result of uneven distribution of curd in the hoops, possibly coupled with unequal pressure in the press, characterize a misshapen cheese. Such defects detract from a neat appearance of the cheese unit(s) under evaluation. This unwanted configuration may sometimes be correlated with weak-bodied cheese.

Uneven Edges Heavy pressure against followers or press boards that are too small for the hoop may cause the curd to squeeze out around the edges and form a narrow raised edge or rim around the outer edge of the cheese, generally up to about one-half inch thick. The presence of these raised, uneven edges not only detracts from cheese appearance but additionally results in a waste of curd. The raised edge dries out and does not cure properly. Cheese should be pressed in a manner that ensures that the bottom edge of the cheese meets evenly with the sides.

Uneven Sizes Cheese of a designated style should be well within a specified weight tolerance for that style of cheese; lack of size uniformity may result in an unattractive appearance. Carelessness in assuring even distribution of the curd among the various hoops is often correlated with other finish and/or appearance defects. An "uneven size" of cheese also may result in excess trim losses when blocks are cut subsequently into retail-sized pieces.

9.8.1.5 Surface

Bruised Slightly depressed areas over which the paraffin is broken indicate a bruised surface. Cracks may radiate from the center of the break. Obviously, a bruised surface permits mold contamination and pest infestation.

Light Spots A cheese that exhibits "light spots" has more or less irregular light- and dark-colored areas over the flat surfaces. Though this defect is quite noticeable, it is not a particularly serious one, as far as product protection is concerned.

Moldy "Mold growth" on cheese may occur on portions where the cheese covering has been penetrated by a cheese trier, or from holes or tears in the packaging material. The presence of even a slightly moldy portion not only substantially detracts from the appearance but also may jeopardize the flavor and consumer acceptance of the entire cheese. As soon as the cheese is cut, mold mycelia usually have the opportunity to disperse across the entire cheese. Moldiness is considered a serious product finish defect and is a constant problem; annually it results in considerable waste and economic losses for the US cheese industry.

Additionally, some mold contaminants can pose public health problems due to production of certain mycotoxins (carcinogenic aflatoxins). No absolutely successful method has as yet been found and applied to prevent regrowth of mold from bulk forms of cheese onto cut and rewrapped cheeses. Even cheese that has been thoroughly cleaned, scraped, and repackaged, and possibly treated with approved mold inhibitors, may develop surface mold during extended storage or distribution.

Open Short depressions on or near the surface are referred to as an "open" surface. This openness usually stems from insufficient curd pressing or a too-cold curd at the time of pressing. This open surface typically reflects an open-textured cheese; there tend to be many mechanical openings. Defects of surface openness are objectionable because these surface depressions and openings serve to (1) increase the amount of cheese trimmings and (2) provide sites for mold and/or cheese pests to establish themselves.

Rough A "rough-surfaced" cheese exhibits severe irregularities of surface finish. This defect may result occasionally from (1) the use of unclean press cloths to which particles of dried curd have adhered; (2) insufficient or improper pressing of "hooped" cheese; or (3) rough and uneven shelving. Cheese that has this defect lacks the preferred neat and attractive appearance that facilitates marketing the product.

Soiled, Unclean Most unfortunately, cheese takes on an untidy "soiled" or "unclean" appearance when dirt or soil adheres to various cheese surfaces. Usually, soiled surfaces are due to carelessness on the part of the cheesemaker and production team. This defect should not be tolerated in the manufacture of high-quality cheese.

9.8.1.6 Miscellaneous Factors

Huffed, Bloated The so-called huffed or bloated cheese results from gassy fermentation (Fig. 9.10). A cheese suffering from this defect usually becomes rounded on the sides and ends, producing a somewhat oval shape to the cheese unit. In occurrences of the huffed defect, the lower edges of the cheese may be raised slightly above the top plane of the shelf. Occasionally, a gassy condition within the cheese wrapper may develop to the extent that the general symmetry of the cheese unit is distorted and the packaging material may be ruptured. A huffed cheese usually yields a sample plug that is dominated by obvious gas holes. Plugs pulled from some bloated cheese may exhibit openings in the shape of narrow slits; these openings are commonly called "fish eyes" or "slits." Huffed cheese generally portrays poor sensory qualities; serious off-flavors frequently accompany gassy fermentations.

Ink Smears Occasional "ink smears" from careless cheese branding often detract from the appearance of cheese. Generally, this is a relatively minor defect that is not correlated with other defects, other than careless workmanship.

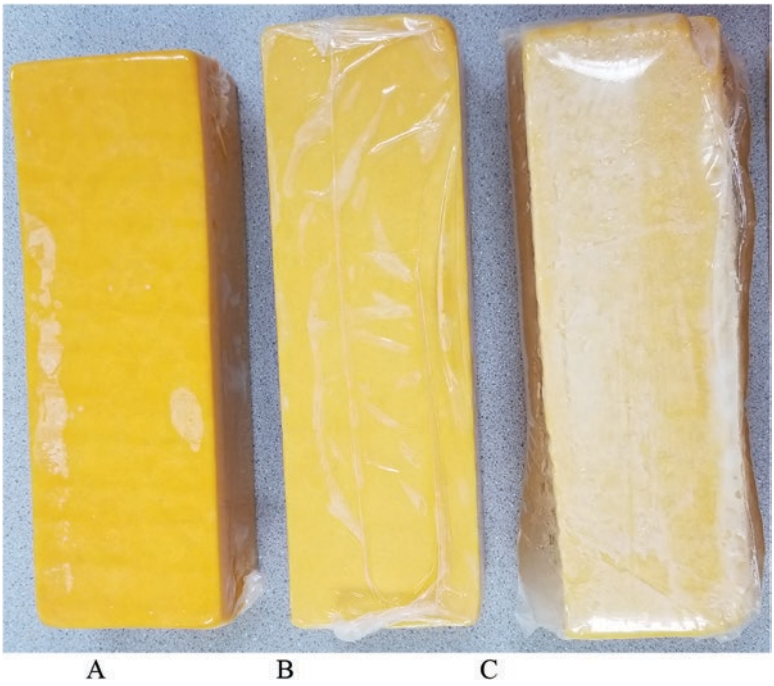


Fig. 9.10 A lineup of Cheddar cheeses exhibiting vacuum-sealed plastic ((**a**) a tight seal with no apparent defects; (**b**) loose packaging; (**c**) huffed or bloated cheese exhibiting extensive crystal formation). (S. Clark images)

Cheese Mites and Skippers Fine, loose, brown dust on the surface of aged cheese, cheese wrappers, or on the shelving usually manifests the presence of "cheese mites." Microscopic examination has revealed this brown dust to consist of live and dead mite bodies, molted skins, excreta, and minute particles of cheese. In badly infested cheese (which has not been moved for some time), the brown dust may appear over extensive areas of the cheese; however, it is more generally localized in favorable harboring places (such as cracks, under a folded edge or under loose paraffin). Evidence of mites is often found on natural rinded Cheddars. Skippers, the larvae of the cheese fly, are infrequently noted; they only occur as the result of poor sanitation practices.

9.8.2 Color

The color of Cheddar cheese, regardless of the chosen intensity, should always be uniform throughout the cheese. American Cheddar cheese may be uncolored, light to medium colored, or high in color. For uncolored cheese, the most desired color is a light cream shade; for medium-intensity-colored cheese, a deep cream color or a pleasant yellow-orange hue is acceptable. Deep, intense shades of yellow-reddish hues are generally discriminated against. Not only should the shade of color be appropriate and uniform for the given cheese, but the color should exhibit some luster. The cheese surface color should be slightly translucent – appearing as if one could actually see into the cheese interior for a short distance. The "translucent" quality of Cheddar cheese is closely associated with desirable body and texture.

Not only is cheese color one of the items capable of being most accurately evaluated, but when carefully observed and correlated, may also serve as an index to defects in body, texture, and flavor. Some color defects that may be associated with Cheddar cheese, and associated body and texture attributes, are discussed in detail below. Common color defects, probable causes, and remedies may be found in Table 9.4.

Acid-Cut (Bleached, Faded) The color of "acid-cut" cheese generally appears dull and lifeless, with an opacity that allows little light to be transmitted through even a thin slice. Quite often, a degree of bleaching may be noted more or less uniformly throughout the entire cheese (Fig. 9.11). In some cheese, acid-cut color may occur only within close proximity to mechanical openings. In such instances, the cheese may have a "mottled" appearance. Of these two defects, a uniform acid-cut color is less objectionable than a mottled one; however, neither is desirable. Evaluators should readily recognize the acid-cut color defect and be on the alert for the possible association with a given body and texture or a specific flavor defect. Generally, the faded color of acid-cut may be associated with high-moisture and high-acid development in cheese, but it also may occasionally be observed in cheese with a dry body and a crumbly texture. Cheese showing this defect nearly always has a distinctive high acid or sour flavor. The acid-cut color defect is becoming less common due

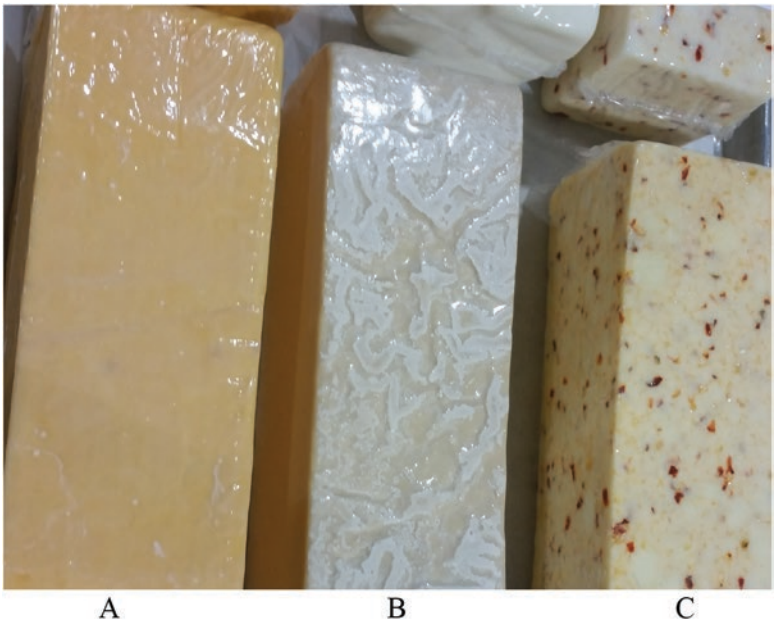


Fig. 9.11 A lineup of Cheddar-type cheeses ((**a**) Cheddar with faded appearance; (**b**) Cheddar with extensive crystals; (**c**) pepper Jack with typical appearance. (S. Clark image)).

to better control of acid development by cheesemakers, improved lactic cultures, and better monitoring and control of the manufacturing process. However, the resurgence of pasture-based feeding has resulted in the fading defect appearing in cheeses as a result of higher natural color content resulting from these feeding practices (Wendorf, 2007).

Atypical Color Specks Atypical color specks take the form of occasional white or black specks, rust spots, and/or red blotches. While there may be little or no association between foreign specks and a specific off flavor, the presence of atypical color deposits generally reflects carelessness in the manufacturing process. White specks may result if addition of color to milk is made prior to addition of starter culture due to small clumps of starter not getting colored. Other potential sources for specks may include water condensation on pipes dripping into the vat, poor filtration of milk, or lack of good environmental cleaning and sanitation procedures.

Color Too High (Unnatural) This defect is characterized by high yellow-orange color intensity, especially when precut cheese is warmed to room temperature or higher. There is generally no association between this defect and flavor, since the defect stems from the use of an excessive amount of added colorant to the cheese milk. More intensely colored Cheddar cheese may be preferred in some specific markets, but in others it is often discriminated against.

Mottled The "mottled" color defect appears as rounded, irregularly shaped areas of contrasting light and dark color, with one shade gradually blending into the other. This defect may result either from certain physical causes during cheese manufacture or be due to atypical microbiological activity during the curing process. Chief causes often ascribed to this defect are the combining of curd from two different lots of cheese or nonuniform development of acidity within the curd. When a mottled color results from unusual microbial growth, an associated yeasty, fruity, or acid off-flavor, and/or pasty body may sometimes accompany this appearance defect. However, the mottled appearance is intended with Colby-Jack cheese.

Pinking A "pink" discoloration of cheese occurs when the water-based colorant annatto is exposed to intense lighting (Fig. 9.12b) This defect is most often found in cheese packaged for retail sale and subsequently subjected to extended exposure to fluorescent lighting in display cases. The pinking reaction can be intensified if the cheese has an atypical pH around 5.4 instead of the typical range of 4.8–5.1, or if the packaging used does not present an effective barrier to oxygen (Hong et al., 1995a, b).

Seamy (Uneven or Wavy) The appearance defect "seamy" is portrayed when the cheese appears interlaced with dark- or light-colored lines around each original piece of curd (Fig. 9.12a). This is particularly noticeable when one directly examines the block or the surface appearance of freshly cut cheese. The seamy appearance defect may be seen in very young cheese, when proteolysis has not yet progressed. The slight degree of seaminess that is occasionally noted in fresh or young Cheddar cheese is not particularly objectionable, since this form of seami-

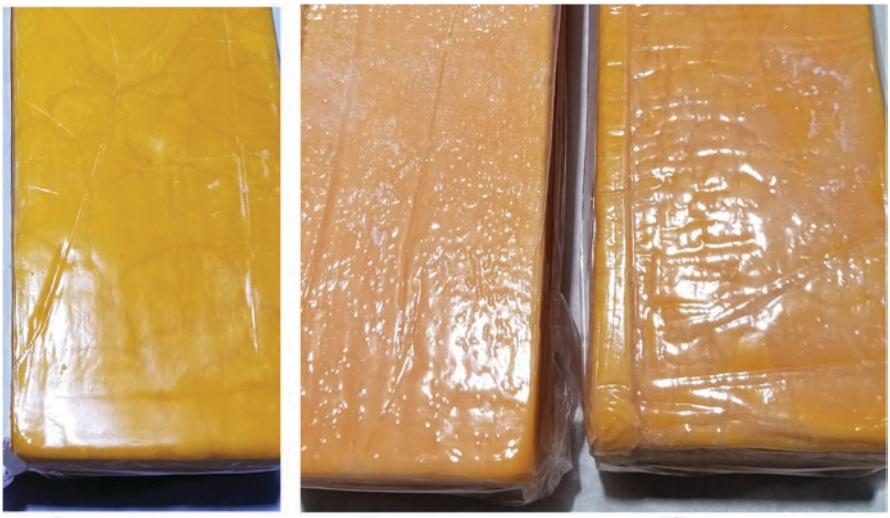


Fig. 9.12 A selection of Cheddar cheeses with appearance defects ((**a**) very slight seamy; (**b**) pinking and crystals; (**c**) seamy, pinking, and crystals). (S. Clark images)

ness generally disappears with additional aging. Seamy can result from improperly pressed cheese, or curd surfaces being physically altered by exuded or crystallized milkfat, uneven or over-salting, or moisture evaporation that probably occurred prior to curd pressing. Cheese exhibiting this color defect not only tends to lack color uniformity but may also demonstrate a short-bodied, crumbly, and/or friable texture. Occasionally, wider bands of discoloration may occur in cheese (without the seaminess lines); this condition may be described as uneven or wavy color. The wavy color character may be a result of inadequate dilution of the coagulant prior to addition or excessive agitation or vibration after setting the milk.

9.8.3 Body and Texture

Cheddar cheese with the most desirable body and texture displays a full, solid, close-knit plug (see Fig. 9.4) that is entirely free from gas holes or mechanical openings, and possesses smoothness, meatiness, waxiness, and silkiness. Cheddar cheese with the above-described quality attributes lends itself to uniform slicing into thin, intact pieces.

The term "body," as applied to cheese, usually refers to various physical attributes that primarily affect the relative firmness or softness of the cheese. By contrast, the term "texture" refers particularly to the structure and arrangement of the various parts that make up the whole cheese. Thus, texture in cheese is observed visually by the quantity, size, shape, and distribution of openings and by the sense of touch to uncover internal particles. Common body and texture defects, probable causes, and remedies may be found in Table 9.4. The more common descriptors of cheese body defects are listed below and are described in the following sections.

Body defect descriptors	Texture defect descriptors
Corky (dry, hard, tough)	Crystals
Crumbly (friable)	Fissures
Curdy (rubbery)	Gassy (holes or slits)
Greasy	Mealy/grainy
Pasty (smeary, sticky, wet)	Open (mechanical openings)
Short (flaky)	
Spongy	
Weak (soft)	

9.8.3.1 Desirable Body and Texture Characteristics

As a general rule, a "closed" (few or no openings in the cheese mass) texture is desired; however, a slightly open texture is not objectionable, providing the body possesses such properties that the open texture does not give rise to a weak-bodied,

curd, or crumbly cheese. Worked plugs exhibiting various cheese body and texture characteristics are shown in Fig. 9.13.

Firm Body A plug of Cheddar with desirable "firm" body feels solid and offers some resistance to applied pressure. Firm-bodied cheese yields a clean-cut plug that generally tears apart slowly on bending, rather than breaking suddenly. The preferred texture is closed; the curd particles should be well matted or fused together in a high-quality cheese. A slice of firm-bodied cheese tends to tear apart somewhat like a thoroughly cooked chicken breast. A firm-bodied cheese should not be confused with either a dry, corky, or curdy body; the latter cheese body products often resist pressure and seem excessively springy or quite rubber-like.

Waxy Body A desirable "waxy body" is exhibited when a cheese plug responds to the combined pressure of thumb and fingers as would cold butter, tempered candle wax, or modeling clay. In "breaking down" a waxy-bodied sample by finger manipulation, little resistance is offered other than the normal force required to mold the cheese into a cohesive "cheese ball" (Fig. 9.13a). Preferably, a "malleable" cheese shows little tendency to "spring back" to the original position, but rather assumes or retains a new configuration as a result of applied finger pressure. A waxy body is generally associated with either medium-aged or aged (sharp) cheese. A pliable or waxy body is a good indicator of desired slicing properties and proper flavor development.

Silky, Smooth Body A "silky, smooth-bodied" cheese exhibits fineness of grain and a continuous, slightly oily, silky smooth film when the mass, worked between the thumb and fingers, is spread over the palm of the hand. The "worked cheese" usually spreads evenly without forming irregular patches in the hand. The spread-

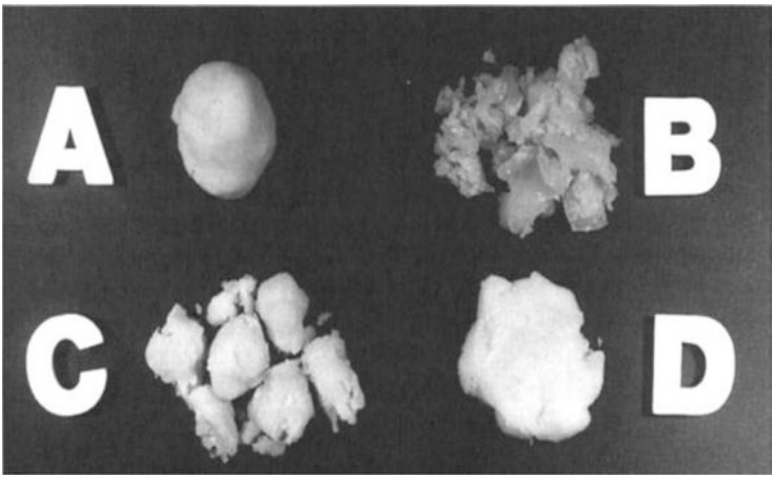


Fig. 9.13 "Worked" Cheddar cheese samples showing: (**a**) "ideal" body; (**b**) Corky; (**c**) Crumbly and possibly Curdy; (**d**) Pasty. (Bodyfelt et al., 1988)

out cheese sample should readily reassemble into a small intact ball. The smooth, silky-like property of the cheese sample is generally indicative of proper cheese breakdown, flavor development, and desired mouthfeel.

9.8.3.2 Body Defects

Corky (Dry, Hard, Tough) This defect is generally associated with a low-moisture, low-fat, and/or young cheese or a particularly dry aged cheese. Difficulty is sometimes encountered in trying to sample dry, tough cheese, due to initial resistance against the trier during penetration. The drawn plug resists any form of pressure; when sufficient finger pressure is applied, the plug may resist breaking down and/or exhibits a distinct tendency to recover its original shape. The plug is stiff or rigid upon bending; it seems to have a rubber-like consistency. When a portion of a so-called corky cheese is worked between the thumb and forefingers, the desired smooth, silky, even distribution of cheese particles is notably lacking (Fig. 9.13b). The worked mass of cheese tends to curl up under sliding pressure of the thumb over the forefingers and is usually distributed in irregular patches. This defect may be associated with other body defects of which dryness is a closely related factor. A dry-bodied cheese generally has an opaque appearance. This defect sometimes appears to be associated with curd mealiness (a texture defect). Appearance defects of seamy or acid-cut color may also be exhibited.

Crumbly (Friable) A "crumbly bodied" cheese is one that tends to fall apart when tried, sliced, and/or worked (Fig. 9.13c). A plug of such cheese may be extremely friable (Fig. 9.13c). This defect sometimes appears to be associated with curd mealiness (a texture defect) as well as with acid-cut and seamy color defects. A crumbly cheese may sometimes be quite dry, but more often will be normal in this respect. A crumbly, friable body is more likely to occur in aged cheese (~10 months of aging) than in young cheese.

Curdy (Rubbery) This body defect is quite characteristic of freshly made, "green," or uncured cheese. Such cheese usually seems firm, almost hard or rubbery, but not as dry or firm as corky. The plug resists finger pressure; when it does yield to pressure, there is a tendency for the cheese to spring back to its original shape but to less of an extent than corky. Additionally, when worked into a ball, if the cheese is curdy, the ball will commonly display curds that were not adequately warmed or broken down by body temperature to make a smooth ball (Fig. 9.13c). A cheese exhibiting a curdy, rubbery body will likely exhibit a fresh, "green," flat, or undeveloped flavor. Since curdiness is primarily a characteristic of young, uncured cheese, before the curd has had an opportunity to break down (undergo proteolysis), the defect is not usually considered objectionable in mild-aged cheese. Such cheese should eventually develop the desired body and texture characteristics upon additional aging. A curdy cheese that breaks along a seam between curds should not be confused with a short-bodied cheese (see below).

Greasy A "greasy" cheese is one that has free fat on the surface, as well as in and around openings within the cheese or surfaces of individual curds. The defect is easily recognized by an almost oil-like appearance or feel. Greasy cheese often exhibits marked seaminess or may develop it upon additional aging.

Pasty (Smeary, Sticky, Wet) Cheese showing the "pasty" defect is usually characterized by the presence of high moisture. There is often difficulty in securing a full, well-rounded plug; the cheese shape is easily distorted. Upon compression between thumb and forefingers, the cheese breaks down easily into a pasty, sticky mass that tends to adhere to the fingertips as the product is manipulated (Figs. 9.13d and 9.14b). This defect is often associated with a weak body and/or high acid, fruity, and/or fermented off-flavors.

Short (Flaky) A "short," "brittle," or "flaky" body is characterized by a lack of meatiness, waxiness, or overall homogeneity; the consistency of the cheese may appear loose-knit (it takes a "short" time to break). The plug will break easily on bending a short distance rather than tearing apart and will show a distinct lack of elasticity. The break will occur at any point along the length of the plug and should not be confused with a break occurring at the seam between curd particles, which is

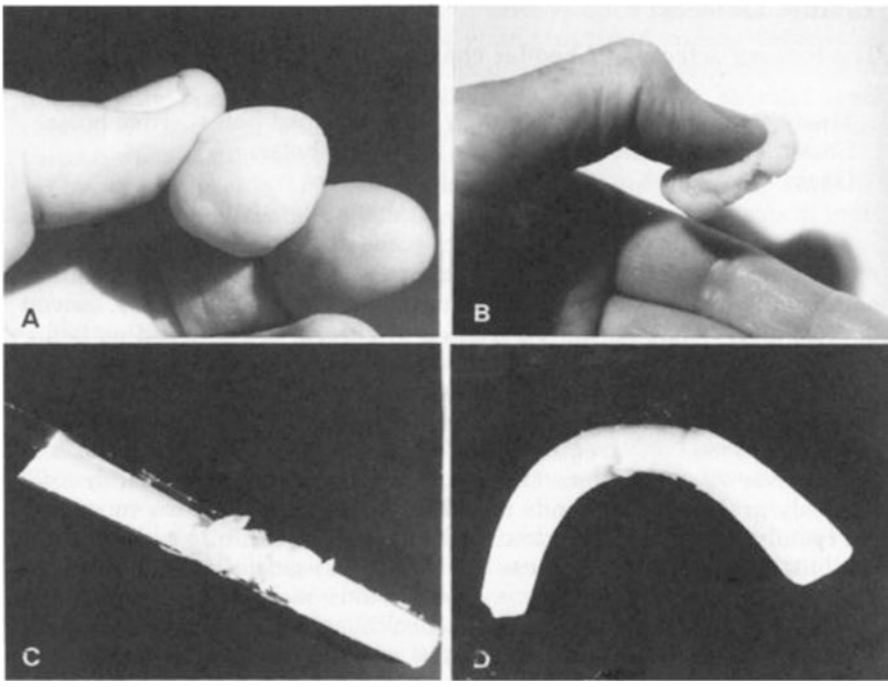


Fig. 9.14 Examples of some common body characteristics (defects) of Cheddar cheese: (**A**) An "ideal" waxy body (practically forms a marble); (**B–A**) distinctly "pasty" or "sticky" body; (**C–A**) "crumbly" plug; (**D–A**) "weak" body. (Bodyfelt et al., 1988)

more indicative of a curdy cheese. The sample piece may appear dull in color, but in many cases, may exhibit a fairly even and somewhat glistening surface. A cheese having this body defect may be too acid and/or dry to exhibit more desirable body properties. Sometimes a short-bodied cheese is inclined to be mealy when a piece of a plug is worked between the thumb and forefinger (or by mouthfeel).

Spongy A spongy bodied cheese fails to yield a full, continuous plug, due to the presence of excessive gas or mechanical openings that prevent an adequate degree of firmness in the body of the cheese. When a spongy cheese is plugged, it tends to sink immediately next to the trier. Such cheese is distinctly springy when pressure is applied to the surface. This defect is commonly associated with gassy, high-moisture, weak-bodied cheese.

Weak (Soft) A weak-bodied cheese is noted particularly by the ease of cheese trier penetration, and/or by the relatively small amount of finger pressure necessary to crush the structure. Weak-bodied cheese is soft and is closely associated with high-moisture content. An aged, weak-bodied cheese may demonstrate fruity/fermented, whey taint, and/or unclean flavor defects, enhanced presumably by relatively high whey (moisture) content. When bent between the thumbs and index fingers of opposite hands, weak-bodied cheese tends to approach touching end to end (Fig. 9.14d). However, bending end-to-end is not always indicative of weak cheese. Consider Swiss cheese, for instance; a plug can be bent end-to-end without breaking, but the body is more firm/rubber or even corky-like.

9.8.3.3 Texture Defects

A closed textured cheese should yield a solid plug with practically no visible openings (Fig. 9.4). The plug, however, may gradually break apart along a curd seamline, especially in a young cheese. Mechanical openings may be a sign of insufficient matting (Cheddaring) or pressing of the curd, or both. An "open" cheese yields a plug that may contain numerous small or large irregularly shaped openings, referred to as "mechanical openings." This is in contrast to Cheddar cheese that exhibits "gas holes" or "slits" as the result of CO_2 formation from microbial activity; these openings tend to be more symmetrical and are usually spherical or elliptical, in shape, and shiny. The so-called late gas defect may occur in closed-textured cheese, but in this instance, the plug will exhibit a split appearance.

Crystals or White Specks Small "white specks" interspersed throughout a cheese's mass and/or on its surface most commonly occurs in mature cheese; however it may occasionally be a problem in young- and medium-aged cheeses. These white particles (Fig. 9.15) are generally assumed to be an admixture of calcium lactate, tyrosine, and other components. Sometimes these specks are so small that they may be only noticeable when viewed from a close distance.

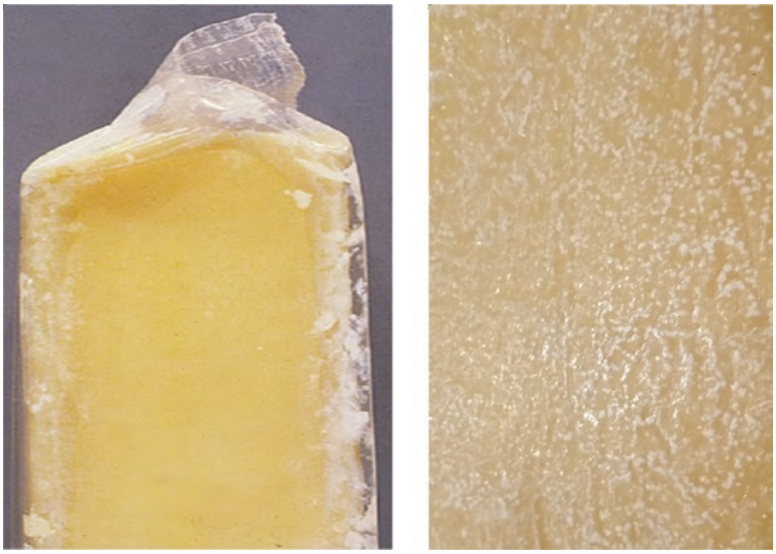


Fig. 9.15 The color/appearance defect of "white specks" or "surface precipitate" of calcium lactate crystals evident along loose edges of a package of mild Cheddar cheese (left); tyrosine crystals evident on surfaces of aged Cheddar cheese (right). (S. Clark images)

Curing of cheese that contains nonstarter lactic acid bacteria at elevated temperature, then followed by lower storage temperature, tends to favor accumulation of calcium D-lactate, which is an insoluble complex. The formation of calcium lactate crystals (CLC) is the most frequent cause of white specks in younger cheeses, and results when the level of lactic acid in the cheese, combined with available calcium, results in calcium lactate concentrations in excess of its solubility in the serum phase. The prevention of CLC formation is not guaranteed by manufacturing practices that reduce available lactose or limit production of excess lactic acid, but the current level of knowledge accepts these particular practices as appropriate procedures for limiting the defect (Johnson, 2004; Blake et al., 2005). Accumulation of tyrosine, on the other hand, may indicate to the evaluator that the cheese has been aged long enough for protein to partially break down and yield this amino acid. Some aged cheese that exhibits the combined appearance/texture characteristics of white specks also frequently exhibits a desirable "buttery"-like body.

Even an inexperienced judge should be able to associate the presence of crystals (and the possible associated mouthfeel) with an aged cheese; the cheese sample will most likely also have a fully developed intense flavor. Crystals in a younger cheese may be associated with a high-acid flavor. White specks, on their appearance alone, should not be considered a serious color defect. Their presence may be noted, but a deduction in score should not be made unless an excessive grainy or objectionable gritty mouthfeel is present.

For the CDPEC, crystals are only considered a defect when detected during mastication. It should be noted at this point that a "defect" from one person's perspective may be considered an attribute from another person's perspective. For instance,

for aesthetic judges in the American Cheese Society Judging and Competition, tyrosine crystals are often considered a delightful "crunch" in aged Cheddar.

Fissures A fissured texture is characterized by an elongated slit or extended separation of the curd particles. The curd lacks cohesion, and such defects may be associated with seaminess. This defect is not serious, but such an affected cheese often lacks the desired meatiness of body.

Gassy (Pin Holes, Sweet-Curd Holes, Swiss Holes, Shot Holes, Slits, Fish Eyes, Yeast Holes) Gas holes in cheese vary in size but may be fairly uniform in distribution and shape. They are formed from gas produced by undesirable microorganisms within the cheese. The seriousness of these gas holes depends on the kind of organisms that form the gas and the relative size and frequency of the gas holes. As related earlier, all of the gas-related defects are lumped into the gassy category on the CDPEC scorecard.

Gas holes are referred to as "pin holes" when they are about the size of a pinhead, symmetrically rounded, evenly distributed, and/or show a tendency to be concentrated near the center of the cheese. Pin holes may result from the growth of undesirable bacteria from cheese milk, or a contaminated culture, or a "gassy" culture (formed CO_2) that contains *Lactococcus lactis* ssp. *diacetylactis* or *Leuconostoc* species. Formed gas may also affect the flavor of the cheese; occasionally an objectionable fruity flavor may occur. The development of numerous pin holes and other gas holes may lead to a "huffed" cheese, especially if the cheese is cured at higher temperatures. If there are sufficient gas holes in the cheese to weaken the overall body structure, it is termed "spongy" cheese; undesirable flavor(s) is (are) often associated with excess gas formation.

Slits, fish eyes, and yeast holes may be found in cheese made from poor-quality milk or starter culture that has been contaminated with yeast (or possibly coliform bacteria). The round, glossy-surfaced gas holes are the result of abnormal fermentation (Fig. 9.7a). Cheese that contains numerous yeast holes usually has a "spongy" body due to excessive gas production. During plugging, the cheese tends to sag immediately adjacent to the inserted trier. Such cheese usually yields a honeycomb-like plug. Yeast holes in cheese may flatten out as the cheese is cured, forming long narrow slits known as "fish eyes."

The large, uniformly distributed gas holes found occasionally in Cheddar cheese are usually the result of a particular bacterial growth. There is often a correlation between their occurrence and the flavor (or off-flavor) of the cheese. Large gas holes are often associated with a peculiar sweetish, flavor reminiscent of Swiss cheese; consequently, they are sometimes referred to as "Swiss holes," "sweet holes," or "shot" holes. The specific flavor defect that often develops may not be highly objectionable, but it is not typical of Cheddar cheese.

Mealy (Grainy, Gritty) A cheese that is worked between the thumb and forefingers and shows a lack of uniformity and smoothness, as well as irregularly shaped, hard particles of cheese, is criticized as being mealy (grainy, gritty), depending on the

particle size. This physical condition often may be correlated with a dry, corky-bodied cheese. When the manually worked cheese feels like cornmeal, and the cheese tends to spread in irregular patches under sliding pressure of the thumb over the forefingers, the texture is described as mealy. A mealy cheese tends to exhibit dryness and seems to release fat readily. Often, a mealy textured cheese also exhibits a short body with little elasticity. Mealiness is most often associated with sharp or aged cheese. The cheese judge should be able to detect a corn meal-like mouthfeel when the cheese sample is masticated and pushed against the roof of the mouth. Mealy should not be confused with crystals.

Open (Mechanical Holes) An "open," porous, or loose texture is traceable to the physical aspects of handling and pressing the cheese curd. Mechanical openings are characterized by their asymmetrical, angular shape and size and by the dullness of their surface linings (Fig. 9.8b). These irregular-shaped holes are derived from various conditions during the matting and pressing of the curd. There is little or no relationship between their presence and cheese flavor. In Cheddar cheese, as long as mechanical openings are not connected and are neither so numerous nor so large as to weaken the body or interfere with the integrity of the plug or slice, they should not meet with serious objection.

9.8.4 Flavor

Once the physical properties of the cheese have been assessed, the flavor characteristics should be evaluated. This is accomplished by (1) first noting the odor of the freshly drawn plug as it is passed slowly under the nose; (2) then smelling the warm, semi-soft cheese that results from the quick kneading of a portion of the plug between the thumb and forefingers; and (3) finally tasting a small piece of the cheese. The novice judge, however, should taste the sample not only to verify the odors previously noted but also to perceive the nonvolatile taste sensations – bitter, salty, sour, umami and sweet, which would otherwise go undetected. When a larger number of samples are being tasted, an occasional rinse of the mouth between samples is helpful. This prevents any non-liquefied portions, which may lodge between the teeth, from obscuring the flavor characteristics of subsequent samples.

High-quality Cheddar cheese should possess the characteristic "Cheddar flavor," which is best described as clean, moderately aromatic, nut-like, and pleasantly acidic. While the same general flavor qualities are desired in fresh, medium-cured, and aged cheese, the intensity of the characteristic Cheddar flavor will primarily depend on the extent of curing and curing conditions. Usually, aged cheese has a sharp, aromatic, intense flavor that is entirely lacking in young cheese. The flavor of high-quality Cheddar cheese has been likened to that of freshly roasted peanuts or hazelnuts by various investigators (Kosikowski & Mocquot, 1958; Van Slyke & Price, 1979; Wilson & Reinbold, 1965; Wilster, 1980).

The flavor of Cheddar cheese is ascribed to a complex mixture of compounds, produced by bacteriological and enzymatic action during aging. Singh et al. (2003) published an excellent review of the chemical and sensory aspects of Cheddar cheese flavor. The Cheddar flavor originates from (1) protein breakdown to simpler and more volatile organic compounds; (2) acid developed in the curd; (3) milk fat and milk fat breakdown products; and (4) the small amount of salt added before the curd is pressed. Due to the relatively high degree of solids and the nature of the organic constituents, Cheddar cheese has a distinct, desirable flavor when the appropriate bacteriological, enzymatic, and chemical changes have occurred during controlled manufacturing and curing. When the components of Cheddar flavor get out of balance, one or more distinct flavors may dominate and result in a distinctive flavor profile that may be described alternately as a defect or an attribute.

The beginner judge should try to appreciate that the finish, appearance, color, and body and texture characteristics reveal much regarding the flavor quality of the cheese. The evaluator should carefully study both the desirable and undesirable aspects of these quality criteria and note the flavors that may be associated with them.

9.8.5 Flavor Defects and Their Characteristics

Off-flavors in Cheddar cheese show wide variation. Descriptive terms are listed below and are described in subsequent paragraphs (see Table 9.4 for probable causes and remedial measures). Other descriptive terms such as brothy, nutty, diacetyl, etc. are incorporated in the discussion of the Cheddar cheese lexicon in Chap. 17, but are not included here due to lack of common use by graders and judges (Drake et al., 2001).

Flavor defect descriptors

Bitter
Feed
Fermented
Flat/low flavor
Fruity
Garlic/onion (weedy)
Heated
High acid
Malty (“Grape Nuts®”)
Metallic
Moldy (musty)
Oxidized
Rancid
Sulfide
Unclean
Whey taint
Yeasty

Bitter Bitterness is a basic taste noted only by the sense of taste on the tongue, and not from aromatic compounds perceived by the sense of smell. Bitter taste may occur in mild cheese but is found more frequently in aged cheese as an aftertaste. Certain lactic cultures, coagulating enzymes, and salt levels have been implicated in the development of this troublesome defect. Bitterness has been observed to develop in cheese made from both excellent-quality and poor-quality milk. "Sharpness" and the high flavor intensity of aged cheese should not be confused with a bitter taste. Sharpness gives rise to a temporary peppery sensation, whereas true bitterness is somewhat distasteful to most individuals, resembling the taste of quinine or caffeine. The bitter sensation is somewhat delayed in terms of its initial perception and tends to persist for some time after sample expectoration. Bitterness in cheese is observed by a taste sensation that typically occurs at the base or back of the tongue. Bitterness will normally intensify with maturation. If detected in a young cheese, the cheese should not be kept for sale as a sharp or extra-sharp cheese. Bitter is one of the most common off-flavors in Cheddar cheese.

Feed Some feeds, especially high volume roughages, may impart aromatic taints to cheese if fed to cows within a critical time frame prior to milking. The 0.5–3-h time period is the most critical. This is especially true of succulent feeds, silage, some commodities, brewery wastes, and some of the hays. A "feed" off-flavor is characteristic in that it is aromatic, sometimes pleasant (e.g., alfalfa), and can usually be readily detected by the sense of smell. A characteristic note (and mild aftertaste) of "cleanliness" is associated with most feed off-flavors, when the cheese sample is expectorated. Feed off-flavors usually "disappear" rather quickly and thus leave the mouth in a clean state of condition.

Obviously, the characteristic odor/taste of feed off-flavors varies with the type of feed consumed by lactating animals. The odor of a given raw milk supply is generally characteristic of a particular feed. In some US dairy regions, a severe feed defect is often observed early in the spring when the all-dry winter ration is terminated and changed to one that includes fresh green pasture. Also, severe feed off-flavors are likely to occur when there is a sudden change to a new, more odorous form of roughage, such as from alfalfa hay to corn or grass silage. The current trend for some producers to return to a seasonal, pasture-based feeding system or the requirement of organic production practices to include access to pasture may also contribute to feed off-flavors.

Fermented The fermented off-flavor in Cheddar cheese is suggestive of acetic acid (vinegar-like). Some nonstarter lactic acid bacteria (NSLAB), such as heterofermentative lactobacilli, may produce significant amounts of acetic acid in cheese during ripening. Acetic acid is one of the myriad of components making up cheese flavor that can exhibit an off-flavor when out of balance with other components.

Flat/Low Flavor Cheese exhibiting this defect is practically devoid of any Cheddar flavor. A flat flavor is particularly noticeable when the sample is initially tasted. Likewise, little odor is detectable. When associated with fresh or young cheese, the

defect is not serious or objectionable, since full cheese flavor may eventually develop with additional aging. In an aged cheese, flatness (lacking flavor) represents a more objectionable defect. A cheese with a defect such as bitter or high acid should not be scored as a flat/low flavor sample.

Fruity The "fruity" off-flavor is peculiarly sweet and aromatic; it resembles the odor of fermenting or overripe fruit, such as an apple or pineapple. At low levels it may be considered complexity and appealing. At high levels, this flavor defect may be associated with high-moisture cheese, and a weak, pasty body. The fruity defect intensifies as the cheese ages and may eventually lead to an unclean or combined fruity and unclean off-flavor. The fruity defect is attributed to the presence of ethanol-forming microorganisms in the cheese milk or certain cheese cultures. Esters formed from available ethanol and organic acids are responsible for the fruity note (Bills et al., 1965; Vedamuthu et al., 1966; Bodyfelt, 1967).

Garlic/Onion This flavor defect is relatively easy to detect because the off-flavor resembles that of garlic, onions, or leeks. Defective cheese usually shows a moderate odor, unless the sample has been stored at a high temperature. When the sample is tasted, the off-flavor is often quite pronounced and usually requires a thorough rinsing of the mouth prior to tasting additional samples.

Heated (Cooked) The heated (cooked) off-flavor of cheese differs from the clean, distinct cooked flavor of pasteurized milk; in cheese, this defect more resembles the odor of old or spoiled milk, or the odor exhibited by melted Bakelite® forms of plastic. This off-flavor is somewhat suggestive of the unclean odor, in addition to whey taint. "Heated whey" is probably a more appropriate term to describe "heated" or "cooked" off-flavor in cheese. A related group of products that demonstrate the heated flavor are pasteurized process cheese, cheese food, and cheese spreads.

High Acid (Sour) Lactic acid is a normal component of Cheddar cheese flavor; however, an excessive acid or sour taste is undesirable. Depending on age, the normal pH range of Cheddar cheese should be 5.15–5.45. The "high-acid" (sour) defect generally results from a too rapid or excessive lactic acid production in the curd. High acid is by far the most frequently encountered flavor defect of Cheddar cheese. When a portion of high-acid cheese is placed into the mouth, a "quick" taste sensation is noted on the top and front sides of the tongue. This taste soon disappears (usually), leaving the mouth free of any off-flavor sensations. High-acid flavor may sometimes be associated with a dull, faded, or acid-cut color defect. For some individuals, the high-acid off-flavor is sharp and puckery to the taste, suggestive of lactic acid. Numerous other off-flavors and bitterness may occur in conjunction with a high-acid note.

Metallic The call for sodium reduction in the diets of some consumers has led to development of reduced-sodium Cheddar cheeses. Some "salt substitutes" replace sodium with potassium or other salts. One result of sodium reduction is the off-

flavor metallic. Additionally, in recent years, some cheesemakers have incorporated sea salt into cheesemaking practices. The ions in sea salt sometimes provide metallic tastes. Metallic may be described as copper penny-like or prickly and is most readily noted at the gumline. Occurrence of a metallic (oxidized) off-flavor from metal-oxidized milk is quite rare, due to the reduction-oxidation potential of the cheese interior.

Malty ("Grape Nuts®") The growth of malty *Lactococcus lactis* strains in cheese milk, and a subsequently produced malty flavor compound (3-methylbutanal), is responsible for this off-flavor (Tucker & Morgan, 1967). When this compound is present in young (fresh/current) cheese at too high concentrations, malty flavor is the outcome. However, when present in appropriate concentrations and with other appropriate background compounds, 3-methylbutanal is the source of a pleasing "nutty" flavor in Cheddar cheese (Avsar et al., 2004; Carunchia Whetstine et al., 2006).

Moldy (Musty) A moldy or musty flavor defect often resembles the odor of a damp, poorly ventilated (potato) cellar. This defect is easily recognized by a characteristic smell. A slightly unclean off-flavor tends to persist after the tasted sample has been expectorated. The most frequent cause is mold growth on cheese surfaces, due to lost integrity of the cheese package and the admittance of air. In some cheeses where extensive mold contamination has occurred, a *Penicillium*-like mold (blue-green) growth may appear in the interior of the cheese, especially when it is open-textured. Serious economic losses, consumer dissatisfaction, and potential toxicological and allergenic consequences may occur from severe mold contamination of cheese.

Oxidized (Light-Induced) This off-flavor is characterized by a flat, cardboard-like taste, and a puckery (mouthfeel) sensation may linger. The sense of smell is of little or no value in detecting its presence. Oxidized cheese milk or light exposure in the dairy case is the probable source for this cheese off-flavor.

Rancid (Lipase) A "rancid" off-flavor in cheese is characterized by (1) a relatively slow or delayed reaction time; (2) a prominent odor that may be still noted after sample expectoration; and (3) an unpleasant, persistent aftertaste. The off-flavor is typically bitter, soapy, and usually somewhat repulsive. A rancid off-flavor in Cheddar cheese can usually be detected by the sense of smell. Rancidity is caused by activity of the enzyme lipase on milkfat; this yields volatile, unpleasantly flavored short-chain free fatty acids and their respective salts (or soap). When the concentrations of the free fatty acids from butyric (C_4) to lauric (C_{12}) exceed levels desired for a balanced Cheddar cheese flavor, they impart an off-flavor variously described as goaty, (cowy is ketone-like) unclean, bitter, or rancid. Rancid cheese usually results from abusive handling of cheese milk prior to pasteurization; however, the production of lipases by contaminating bacteria or the lipase activity inherent to raw milk may also contribute to rancidity, especially in aged cheese.

Sulfide (Skunky) The "sulfide" off-flavor of cheese is distinctive; it is similar to the odor of water with high-sulfur content or boiled eggs. The cheese judge should keep in mind that a low to modest level of sulfide is an important component of aged Cheddar cheese flavor and aroma; it provides complexity and appeal to aged Cheddar. However, when the sulfide note becomes dominant, to the point of obscuring other flavor characteristics, this is perceived as an off-flavor and a serious defect. In some regions of the world that produce Cheddar cheese, a moderate sulfide flavor note is considered essential or highly desirable in sharp or extra-sharp cheese; hence, it is not criticized when it appears. Sometimes an offensive sulfurous (skunky) or spoiled egg odor may be noted in aged cheese. Frequently, there is an associated bitter aftertaste, and/or a burning sensation within the mouth. Sulfide cheese often has a related sticky, pasty body. Usually, sharp or extra-sharp cheese is involved when this flavor attribute is incurred. Numerous sulfur-containing compounds can be formed during the aging process.

Unclean (Dirty Aftertaste) An "unclean" off-flavor is difficult to describe, since it often varies in intensity and lacks a definitive sensory description. Some describe unclean as, simply, "complex." At higher levels, this defect may suggest to the taster a general lack of cleanliness in producing the product, given the dirty, lingering, unpleasant aftertaste. This off-flavor persists long after the sample has been expectorated, and the mouth fails to "clean-up." An unclean off-flavor may occur in conjunction with other flavor defects such as high acid, bitter, and/or whey taint. Poor-quality or "old" milk used for cheese manufacture is a principal cause of the unclean flavor defect. Proteolytic and/or lipolytic enzymes, derived from psychrotrophic bacteria or nonstarter lactic acid bacteria, may cause undesirable chemical reactions to occur within the cheese and hence, result in an unclean off-flavor.

Whey Taint (Sour Whey) These terms describe various intensities of off-flavors in cheese associated with retained cheese whey. The slightly dirty-sweet/acidic taste and odor is characteristic of fermented whey. Ordinarily, the taste reaction of "whey taint" is perceived rapidly and is of short duration; whey taint is the early stage of unclean. The mouth tends to clean up soon after sample expectoration, unlike the unclean defect. Some cheese authorities liken whey taint to the occurrence of a "fermented/fruity" off-flavor, with an "unclean" off-flavor superimposed over it. Whey taint cheese often has the body (rheological) characteristics of a high-moisture cheese. Also, whey taint is sometimes found in young Cheddar cheese that exhibits a seamy defect. Some judges may confuse whey taint and high-acid off-flavors; however, only the former defect exhibits the distinctive aroma of fermented whey.

Yeasty This off-flavor may be identified by its sour, bread dough, yeasty, or somewhat "earthy" taste and characteristic aroma. Yeastiness in cheese may be detected immediately after the sample has been put into the mouth. Since this defect is caused by yeast growth, the cheese will usually have numerous medium- to large-sized gas holes, which may be readily identified by their surface sheen, spherical or fish eye shape, and frequency. Yeasty is a rare and serious defect.

Other Off-Flavors The off-flavors discussed above should be considered as the more common or frequently encountered ones in Cheddar cheese. However, the cheese judge should be alert to other possible flavor defects that may occur occasionally. Examples are an "atypical Cheddar flavor" and a "catty" (or cat-box odor) attribute; the latter is possibly caused by low concentrations of mesityl oxide in cheese reacting with sulfides to produce this aroma.

9.9 Grading Fresh or Current Cheddar Cheese

Cheddar cheese can be graded at any stage between the time at the end of pressing and the time of consumption. Experienced cheese graders agree that Cheddar cheese ranging from only a few days to a few weeks old is more difficult to grade than a more mature product. In grading a young or "green" cheese, the grader should pay close attention not only to the flavor but also to those conditions that might precede undesirable flavor development during ripening. There are occasions when a cheesemaker, cheese buyer, or processor would like to have fresh or "green" cheese graded, in order to (1) sell it on a quality basis; (2) determine the best use of the cheese; (3) determine whether cheese quality will withstand storage; or (4) monitor the day-to-day quality of the cheese. Different cheese-producing areas of the USA often grade cheese independently of each other; consequently, those assigned grades may differ slightly from Federal (USDA) cheese grade standards. Considering the purposes for which cheese is graded in different geographical regions, the variations in scorecards or grading forms and the wide interpretation of standards, there is little wonder that there is lack of uniformity existing in grading Cheddar cheese. Conversely, remarkable agreement exists in what constitutes high-quality or low-quality cheese, regardless of the geographical region or the grading agency involved.

Grading of Young Cheese for Storage Some Cheddar cheese is bought and sold when "green," or only a few days after removal from the press. Fresh, uncured cheese lacks the typical Cheddar flavor and body and must be graded on the basis of predicted quality development during early to mid-stages of the curing period. There is merit in grading fresh Cheddar cheese, in order to utilize the product to best advantage. However, some differences of opinion exist as to the value of judging "green" cheese to determine its future or "aged" potential. Since certain flavor, body, texture, and workmanship qualities have a bearing on the curing of cheese, a qualified cheese grader usually can reliably project or predetermine how a graded young cheese will develop with additional storage (curing time). Careful sensory evaluation of immature cheese (prior to storage) and records of manufacturing, moisture content, and of the relative quality of cheese milk are helpful factors in determining the probable success of cheese curing.

In grading young cheese for subsequent commercial use, Price (1943) suggested dividing Cheddar cheese into the following categories:

Long hold – The quality level necessary for the most particular or discriminating use of the cheese.
Short hold – Minor defects (slightly apparent), which will permit, short storage periods without loss in commercial value.
Immediate use only – Distinct defects (easily detected, obvious) which require careful sorting of the cheese according to given markets; immediate utilization of the cheese is perhaps mandatory.
Limited use – *Major* defects (quite serious faults), which restrict use of the cheese to a few markets, i.e., grinding purposes, process cheese, or immediate consumption as a "cooking cheese."
Culls – Inedible cheese not to be used for human consumption.

The specific product defects that necessitate placing cheese in the above respective classes are usually obvious and involve many of the defects listed on the cheese scorecard. Flavor is usually considered more critically than other factors, although body and texture, color, and appearance features of the cheese should not be overlooked.

9.10 Colby, Monterey Jack, Colby-Jack, and Flavored Cheese

In as much as the general manufacturing procedures and bacterial fermentations occurring in Colby and Monterey Jack cheeses closely parallel those of Cheddar cheese, these three related varieties tend to share common defects. Generally, due to higher moisture content, lower acid and salt content, which facilitate higher microbial and enzymatic activity, some sensory defects may reach greater intensity and frequency in Colby and Jack cheese than in Cheddar. The above factors tend to limit the keeping quality of Monterey Jack and Colby cheese, compared to Cheddar.

Flavor For cheeses 2–3 months of age, an acid flavor may be more apparent in Jack and Colby cheeses than in Cheddar. The likelihood that a typical, nutty, Cheddar flavor will develop in Colby or Jack cheese within several months is unlikely. The "acid flavor" tends to be more obvious in the two stirred curd cheeses, since there is no partial masking effect from a "Cheddar flavor." A notable exception is certain dry or low-moisture Monterey Jack cheeses, which can be aged 9 or more months and often develop a distinct, full, nutty flavor. Frequently, when conventional Colby or Monterey Jack cheese exceeds 100 days of age, a distinct bitter taste may develop, which reflects a possible limitation for aging of these cheese types beyond 3 months.

Body and Texture Defects Colby and Monterey Jack cheeses tend to have a weak body, due to their higher moisture content. This characteristic is anticipated and

tolerated, up to a certain point. With respect to cheese texture, mechanical openings are expected and more tolerated in these two stirred curd forms of cheese, than in Cheddar. Occasionally, solid or "blind spots" occur in Colby and Monterey Jack cheese. These are usually related to the formation of curd lumps that developed before or during curd washing, cooling, or salting. The typical remedy is to try to continuously maintain the curd in a granular form by applying adequate agitation of the curd and uniform distribution of the salt. Applications of higher pressure to cheese hoops during pressing also account for the production of closed or blind Colby and Monterey Jack cheeses. Solid or blind cheese of these two types has apparently gained consumer acceptance; an open, granular, or stirred curd appearance gradually has become a less common feature of Colby and Monterey Jack cheese.

Flavored Cheese Cheddar and Cheddar-type cheeses are excellent carriers for a variety of added flavors (e.g., sun-dried tomato, caraway seed, sage, horseradish, dill) 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 complimentary flavor and body and texture characteristics of the flavoring component. An excellent example results from the addition of jalapeño peppers during the salting step of any of the Cheddar-type cheeses. A properly manufactured cheese will age well and present an, evenly distributed flavor of the jalapeños. 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.

9.11 Conclusion

Cheddar and related cheeses present a delightful but daunting task to the cheese grader/judge. However, learning how to evaluate this extensive class of cheeses provides judges with wide array of sensory skills to apply to many cheese styles. Students dedicating time to training in the use of the CDPEC scorecard for Cheddar cheese will find themselves well prepared to continue training as full-fledged judges/graders of Cheddar and Cheddar-type cheeses, with skills to apply to other categories of cheeses. Coupled with good cheesemaking record-keeping, learning to observe the fine balance of flavor, body, and texture and to detect defects in cheeses enables cheesemakers to produce the most consistent high-quality products to consumers.

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