CHAPTER

46 From Stone Metates to Steel Mills

The Evolution of Chocolate Manufacturing

Rodney Snyder, Bradley Foliart Olsen, and Laura Pallas Brindle

Introduction: The Early Evolution of Chocolate Manufacturing

Although there is no recorded history regarding the first manufacture of chocolate, it is known that natives along the Orinoco River in South America made use of the cocoa tree. Because of the strong bitter flavor of beans straight from the pod, the natives only sucked the sweet pulp surrounding the beans [1]. At some point, the beans may have been thrown in or near a fire, causing the aroma from the roasting beans to fill the air. The seductive aroma and flavor of the roasted cocoa beans would have been just as enticing then as it is now. It might also be that the early use of the cacao bean was associated with medicine, for its bitter and stimulative properties (see Chapter 6).

Whatever the origin of chocolate manufacturing in the Americas, there would have come a time when the roasted beans were ground on stone slabs or *metates* (Fig. 46.1). The resulting chocolate would have hardened into a solid mass or formed into small cakes or tablets. The earliest manufacturing processes would have resulted in chocolate that had quite variable flavor and quality characteristics. But once techniques were developed—whether through planning or accident—on how to avoid burning the beans during roasting and how to grind and mix products with the beans, chocolate manufacturing was born.

The Mexica/Aztec method of chocolate manufacture prior to European contact was simple and basic:

> *The Indians, from whom we borrow it, are not very nice in doing it; they roast the kernels in earthen pots, then free them from their skins, and afterwards crush and grind them between two stones, and so form cakes of it with their hands.* [2]

While basic, this short process summary outlines some of the key process steps still followed today: roasting, winnowing, milling, and molding.

Once the Spaniards became aware of chocolate, they modified the Mexica/Aztec procedure. Early accounts relate that the beans were first cleaned with a sieve to remove dirt, stones, and broken/moldy beans. About two pounds of cacao beans were poured onto the blade of a shovel, and then held over a smokeless fire. The beans on the shovel blade were stirred as

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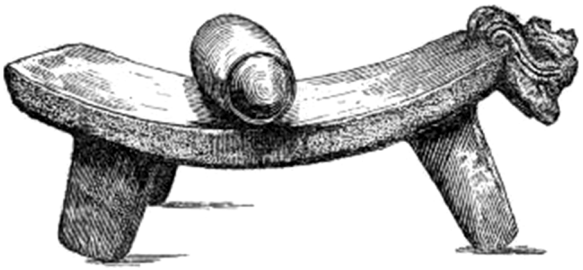

FIGURE 46.1. Stone metate used to grind cacao beans. *Source*: Brandon Head. *A Popular Account of Cocoa*. New York; George Routledge & Sons, 1903; p. 104. Courtesy of Rodney Snyder. (Used with permission.)

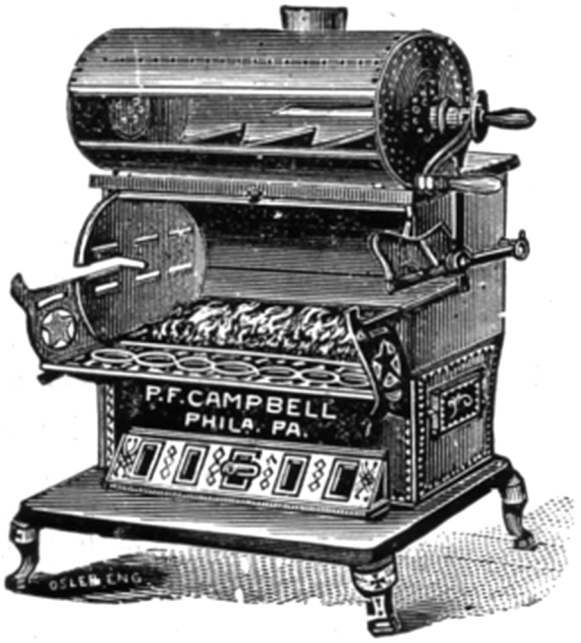

FIGURE 46.2. Hand-turned cylindrical bean roaster. *Source*: P. F. Campbell, 1900. Courtesy of Rodney Snyder. (Used with permission.)

the heat from the fire dried the beans and loosened the shells. After drying, the warm beans were spread on a tabletop, cracked with an iron roller to loosen the brittle shells, and then winnowed with a basket/sieve to separate the cocoa nibs from the shells. The nibs were then roasted to remove the remaining moisture and to develop the flavor. Because the shells were also used to produce a beverage, their removal prior to roasting prevented the shells from burning during the nib roasting process. Underroasted beans were described as having harsh bitter flavors and overroasted beans as having a burnt flavor [3].

The roasted nibs were placed into a mortar and hand-ground into coarse liquor. The liquor was transferred to a heated stone for further grinding with an iron roller with wooden handles to achieve the desired fineness. Stone mills were developed to increase production, although the source of power for such mills is not recorded, that is, whether turned by human, animal, or water power [4]. After grinding, the hot liquor (actually more like a paste) was poured into molds, cooled (sometimes wrapped in paper or vegetable fiber), and stored in a dry place. To produce chocolate, ingredients such as sugar, cinnamon, and vanilla were added during the stone milling step to allow for good mixing with the liquor [5]. The primary use for the chocolate was to produce a beverage. But while it is commonly suggested that "eating chocolate" is a product of the mid-19th century, Richard Brooks commented in 1730 that chocolate also was eaten in solid form:

> *When a person is obliged to go from home, and cannot stay to have it made into drink, he may eat an ounce of it, and drinking after it, leave the stomach to dissolve it.* [6]

Chocolate Manufacturing, 1700–1850

As the basic processing steps of cleaning and roasting the beans, removing the shells, milling the nibs into liquor, and molding the chocolate were adapted to European technologies, they continued to be improved and expanded. Typical early bean roasters were cylinders that were turned by hand to mix the beans while roasting (Fig. 46.2), while later versions were powered by water. Spain and Portugal were the first countries to introduce the process of chocolate manufacture into Europe, but the result was a very coarse chocolate [7]. The Spanish process was described as barely drying the cocoa (powder), producing a less bitter, greasy chocolate, whereas cacao (beans) imported to Italy were roasted at a higher temperature that resulted in a more bitter aromatic chocolate [8]. In France, in contrast to Italy and Spain, the beans were roasted at higher temperatures and for longer periods of time and were described as producing chocolate that tasted like burnt charcoal [9].

Milling of the roasted nibs into liquor was the most labor-intensive activity, and from the beginning efforts most likely were concentrated on improving the process. Early chocolate manufacture often was associated with chemists and doctors because the apothecaries had the necessary mortar and pestle equipment to grind roasted nibs. This method was effective in producing chocolate for personal consumption but could not supply the retail trade with sufficient quantities.

Expanding chocolate production for commercial sale required milling equipment on a large scale. Walter Churchman started manufacturing chocolate in Bristol, England, in 1728. He developed a water engine to power his stone mills and was granted a Letters Patent by King George II in 1729, commending him

on his advanced method of chocolate making. Dr. Joseph Fry began making chocolate by hand in Bristol by the 1750s. When Walter Churchman's son, Charles, died in 1761, the business, water engine, patent, and recipes were purchased by Fry [10]. By 1770, James Watt had perfected the steam engine, which decoupled large-scale chocolate production from the water-driven mill. Fry installed a steam engine in Bristol in 1795 [11].

Although a Boston newspaper carried an advertisement in 1737 for a hand-operated machine for making chocolate, most of the chocolate available in North America was imported until the mid-18th century [12]. James Baker graduated from Harvard in 1760 and, after brief stints in the ministry and medicine, became a storekeeper in Dorchester, Massachusetts. In 1765, he formed a partnership with John Hannon to produce chocolate in a small building attached to a sawmill on the Neponset River. Records showed that they utilized a kettle and a grinding mill [13]. By 1775, importing cocoa beans into North America had become very difficult and John Hannon sometimes traveled abroad to secure supplies. He was reported lost at sea in 1779 while traveling to the Caribbean to obtain sources for importing cocoa beans, although other reports had Hannon returning to Ireland to escape from his overbearing wife [14]. By 1780, Baker had taken over the chocolate business, and while production of chocolate moved from mill to mill over the next 100 years, Baker and the company he expanded developed a sound reputation for high-quality chocolate (see Chapter 26).

Chocolate production started in Switzerland when François-Louis Cailler established a mechanized factory in Corsier on Lake Geneva in 1819 [15]. Cailler learned the art of making chocolate by hand in northern Italy. He envisioned making chocolate with machines to improve the quality and reduce the cost, and designed his own equipment to produce it in Corsier. He was a pioneer in mechanizing individual steps in the chocolate process such as using a stone roller driven by water power [16]. Philippe Suchard started a factory in Serrieres in 1826 with just one worker who could produce about 30 kg of chocolate per day [17]. Suchard also designed his own chocolate-making equipment and harnessed water power to drive the machines [18]. Rudolf Sprüngli followed his father into the Switzerland chocolate business around 1845 using mechanized chocolate-making methods. In 1853, following local wedding traditions, a bride saved some Sprüngli chocolate in its wedding wrapping as a memento. The chocolate was passed down through subsequent generations and finally returned to the company in 1964. The flavor of this chocolate—when tasted in 1964—was more bitter than sweet, with a coarse, sandy texture. Although the flavor and texture failed to meet current-day standards, the 100-year-old chocolate was still edible [19].

Chocolate Manufacturing, 1850–1900

By 1850, the chocolate process was relatively standardized as manufacturers followed the same basic steps. Starting with liquor and sugar, the process began with the mélangeur, which consisted of two heavy, round millstones supported on a granite floor (Fig. 46.3). The millstones remained stationary while the floor rotated to mix the sugar and liquor. When the mixture reached the consistency of dough, it was removed with a shovel and fed into either granite or cast iron roller refiners (Fig. 46.4). The refiners transformed the dough into a

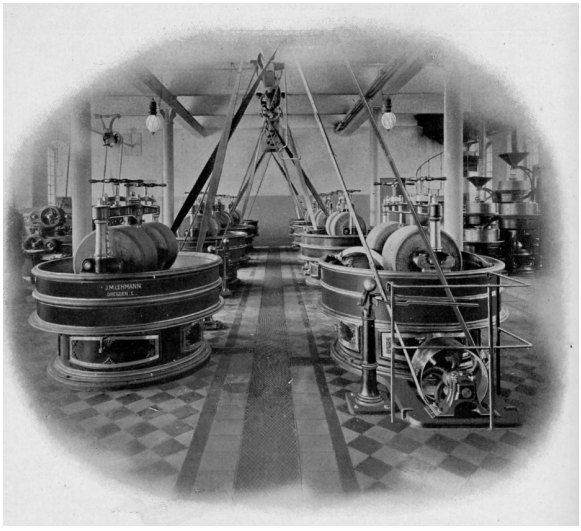

FIGURE 46.3. Mélangeur. *Source*: J. M. Lehmann, undated. Courtesy of Rodney Snyder. (Used with permission.)

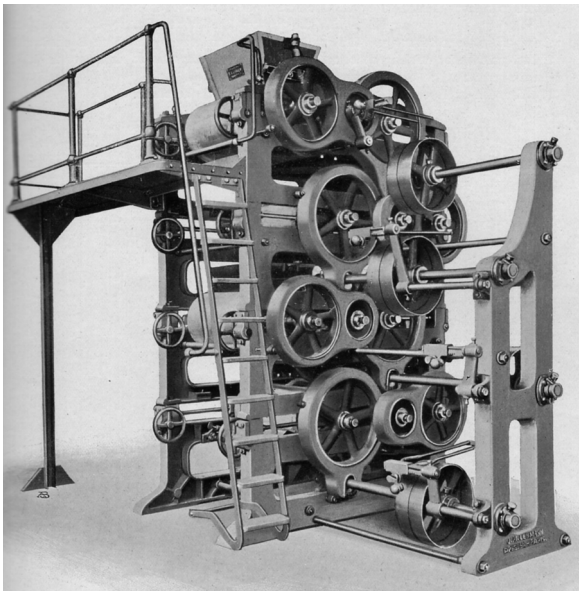

FIGURE 46.4. Roller refiner. *Source*: J. M. Lehmann, undated. Courtesy of Rodney Snyder. (Used with permission.)

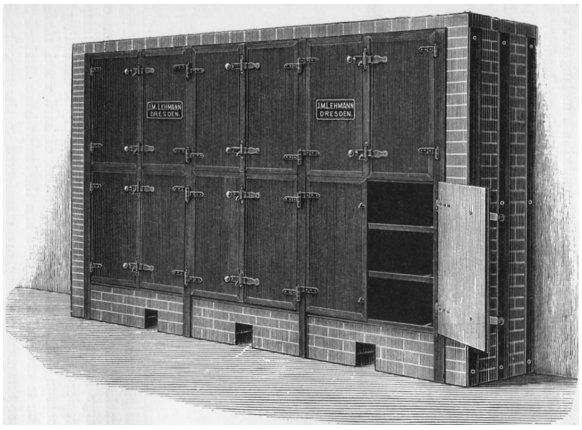

FIGURE 46.5. Holding room for chocolate liquor. *Source*: Paul Zipperer, *The Manufacture of Chocolate*, 2nd edition, 1902; p. 143. Courtesy of Rodney Snyder. (Used with permission.)

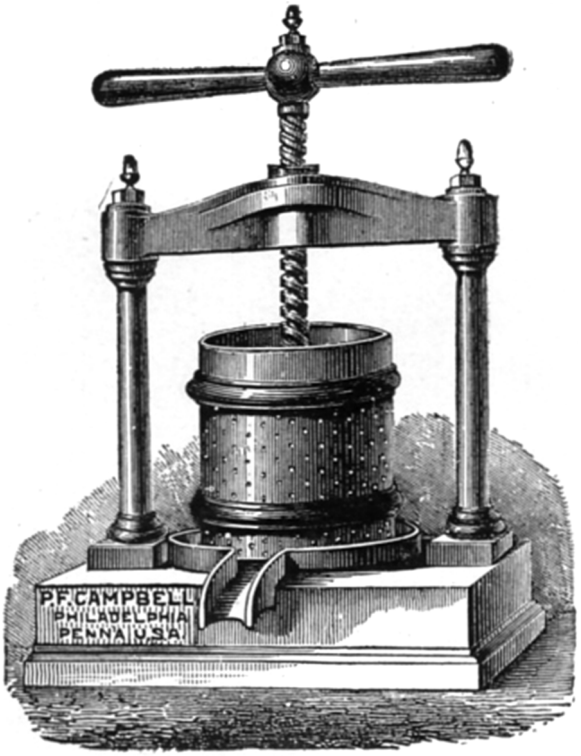

FIGURE 46.6. Hand-operated cocoa butter press. *Source*: P. F. Campbell, ca. 1900. Courtesy of Rodney Snyder. (Used with permission.)

dry powder, as the milled sugar produced more surface area for the cocoa butter to coat. The dry powder was returned to the mélangeur, where the powder was again turned into dough. Grinding alternated between the roller refiner and the mélangeur until the chocolate reached a desired degree of fineness [20]. Manufacturers of the era believed that the thorough mixing of the sugar and liquor was critical to the manufacture of fine chocolate [21]. Since the mixing had to occur at temperatures above the melting point of the cocoa butter (about 35 °C), steam jacketing was added to the holding tanks and the mélangeur. After mixing, the chocolate mass was held at a temperature of about 25 °C for several days to allow a thorough penetration of the flavors into the sugar (Fig. 46.5).

Next, the thick dough traveled through a chocolate kneader, a single granite roller that conditioned the dough so it could be spread on a hard wooden table for placement into molds. Operators filled the molds, pressing the chocolate to remove air bubbles, and transported the molds to a cooling room. As the chocolate cooled, it contracted, which allowed for easier removal. The chocolate then was wrapped in foil and covered with a paper bearing the name and mark of the manufacturer [22].

Although drinking chocolate remained popular into the early 1900s, attempts to resolve some of the inherent difficulties with drinking chocolate identified other chocolate product opportunities. Drinking chocolate was hindered by the high cocoa butter content of cocoa beans. Small-scale methods of extracting butter from liquor, such as the hand-operated butter press (Fig. 46.6), were used throughout the years. Other creative methods also were employed. In 1864, the Ghirardelli chocolate factory in San Francisco solved the problem in a unique way: liquor was poured into a cloth bag and hung in a hot room so the fat dripped through the cloth while retaining the cocoa solids in the bag [23]. This method reduced the fat content of the liquor to produce lower-fat cocoa solids for improved drinking chocolate. The butter was a by-product that found utility elsewhere as a fat or in cosmetics. The reduced-fat cocoa solids were then milled into cocoa powder. Ghirardelli's survival as a company after its bankruptcy of 1870 was attributed to the sales of its Broma cocoa powder [24].

Caspar van Houten built a chocolate mill in Amsterdam in 1815 and started with two pairs of stones driven by manpower. Coenraad van Houten, Caspar's son, developed a mechanical method to press cocoa butter from liquor. Previous methods had mixed water into the liquor to form a stiff paste, which was packed into cloth bags. As the bags were pressed, the cloth retained the cocoa solids while the fat pressed through the cloth. The cocoa solids were compressed into hard cocoa cakes, which turned gray in color and moldy because of the added water. Van Houten developed a process without the added water, producing cocoa cakes that could be milled into reduced-fat cocoa powder. He filed a patent application for a "Method for Pressing the Fat from Cocoa Beans." The patent examiner recommended the application be rejected because he "did not see an invention in the method and . . . even less a useful invention, and . . . because pressing is simple and public knowledge, and the oil from cocoa far from being harmful to health is beneficial; it is

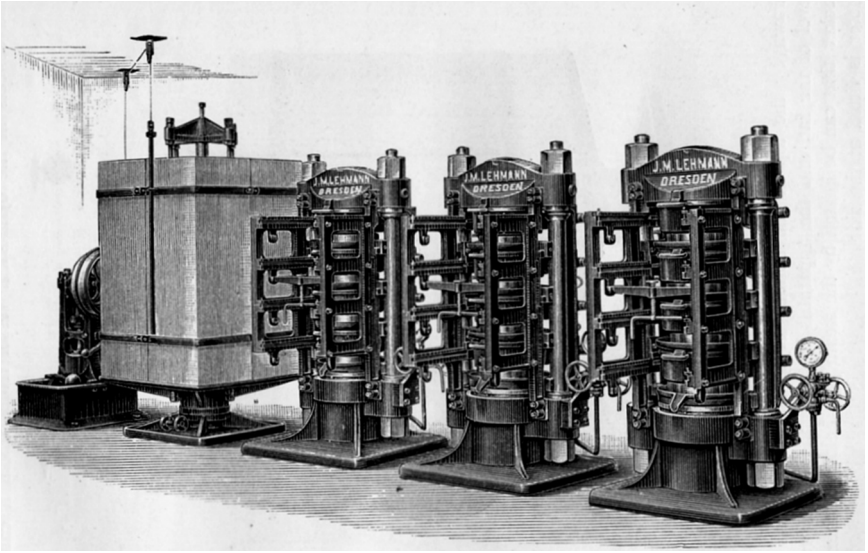

FIGURE 46.7. Four-pot vertical cacao butter press. *Source*: Paul Zipperer, *The Manufacture of Chocolate*, 2nd edition, 1902; p. 186. Courtesy of Rodney Snyder. (Used with permission.)

therefore useful to retain it in the chocolate." Ignoring the examiner's recommendation, the Patent Office awarded the patent on April 4, 1828 to C. van Houten for the duration of ten years [25].

It took many years for the butter press (Fig. 46.7) to become a standard process in the chocolate industry. By 1861, there were about 30 manufacturers of chocolate in England. At the time, Cadbury had a reputation for producing inferior chocolates. To save money, Cadbury reduced the actual cocoa content of their chocolate to about 20 percent, with the remaining 80 percent consisting of potato starch, sago, flour, and treacle. However, Cadbury was not content in producing common chocolate and looked for a way to differentiate its chocolate from competitors. George Cadbury later related the story of how he "heard of a machine in Holland that was necessary for the manufacture of the finer cocoas. I went off to Holland without knowing a word of Dutch, saw the manufacturer, with whom I had to talk entirely by signs and a dictionary, and bought the machine. It was by prompt action such as this that my brother and I made our business" [26]. The addition of cocoa presses at Cadbury produced a reduced-fat cocoa powder that the company named *Cocoa Essence*, which became an immediate success. By the end of 1866, Cadbury had dropped their entire line of chocolates and *Cocoa Essence* became their only chocolate product. Their early slogan—*Absolutely Pure: Therefore Best*—helped to provide the company with a new reputation as *Makers of Quality Goods*. Cadbury *Cocoa Essence* was the first reduced-fat cocoa powder available in England at the time and it launched the long-term success of the Cadbury business [27]. In 1896, Richard Cadbury described *Cocoa Essence* as the most important process since it was a specialty of the Cadbury Company [28].

Because only a few manufacturers had adopted pressing methods to reduce the fat of cocoa powder, the process was considered a trade secret. The pressing process was described as pouring liquor "into round metal pots, the top and bottom of which are lined with pads of felt, and these are, when filled, put under a powerful hydraulic press, which extracts a large percentage of the natural oil or butter" [29]. By the end of the 1800s, presses had increased in size to four pots that held about 88 pounds, and the pressing cycle lasted about an hour. The cocoa solids from the press pots were compressed into hard disks called cocoa cakes. The cakes then were broken into smaller pieces in a cake crusher and ground in a cocoa cake mélangeur to produce cocoa powder [30]. In the United States, the Walter Baker Chocolate Company had presses installed by the 1890s and marketed their cocoa powder as being superior to the dull, brown-colored powder from the competition [31]. By the end of the 1800s, the pressing process was commonplace throughout the industry [32].

Throughout the years, the natural acidity of cocoa beans has also been a manufacturing problem. Even the Aztecs attempted to reduce the acidity by mixing wood ashes into the chocolate [33]. Because of the lack of sophistication of the Aztec method, European chocolate manufacturers did not appreciate the potential of alkalization [34]. In the 1860s, the Dutch company van Houten was the first to capitalize on the alkalization process. Manufacturers in other countries had trouble matching van Houten's process, so initially most alkalized cocoa powder was sourced from the Netherlands [35]. Even today, the alkalization process is referred to as "dutching," based on its origins.

Alkalization produces various flavors and colors ranging from brown to red to black. Many products such as chocolate cakes, puddings, and drinks use alkalized powder to enhance the chocolate color. For example, the distinctive color and flavor of Oreo® cookies is derived from a heavily alkalized black cocoa

powder. By the 1900s, a large proportion of the public preferred alkalized cocoa powder. Cadbury introduced Bourneville alkalized cocoa powder in 1906, and it soon outsold *Cocoa Essence*, Cadbury's flagship brand, by a 50 to 1 ratio [36].

First references to milk chocolate in Europe have been attributed to Sir Hans Sloane and his recipe for a chocolate milk drink. By the 1600s in Jamaica, chocolate commonly was prepared by being grated into a pot, mixed with an egg, sugar, and cinnamon; then either boiling water or milk was added to prepare a chocolate drink [37]. In 1687, while traveling in Jamaica, Sloane complained that the flavor of chocolate was too intense for his taste, but found a local native recipe to be a very pleasant drink. He brought this chocolate recipe back to England, where it was manufactured and sold by apothecaries as a medicine. Cadbury later produced a "Milk Chocolate Prepared after the Sloane Recipe" from 1849 to 1885 [38].

The first milk chocolate designed for eating was invented by Daniel Peter in Vevey, Switzerland, in 1876. Peter believed manufacturing food products gave the best prospects for business success, and chocolate was becoming more and more popular. His job as an ordinary worker in a chocolate factory in Lyons, France, helped him to learn the art of chocolate making. After returning from Switzerland, he intended to continue the operation of the family candle business while diversifying into chocolate manufacture. The presence nearby of his friend Henri Nestlé gave Peter the idea of producing a milk-based form of chocolate. While working on a method of preserving fresh milk, Nestlé had developed powdered milk. Since milk was plentiful in Switzerland, adding milk to the chocolate recipe also added volume and replaced some of the expensive, imported cocoa beans. This process both supported the local milk industry and lowered the ingredient costs for the chocolate [39].

Peter ran his candle/chocolate factory with one employee and his wife while experimenting at night to discover a way to combine milk with chocolate [40]. Because of the high water content of milk, he found that milk did not form a stable emulsion with cocoa butter and resulted in rancid chocolate. He also found that using the coarse milk powder from Nestlé resulted in gritty chocolate. The Anglo-Swiss Condensed Milk Company—Nestlé's competitor—had developed condensed milk in 1867, and after experimentation Peter concluded that a recipe that incorporated condensed milk, cocoa powder, sugar, and cocoa butter produced a very smooth chocolate. A key step to his recipe was the precise regulation of temperature. Peter's *chocolat au lait* was an immediate success, and soon the chocolate manufacturing industry adopted the new process [41].

Much as Starbucks redefined the public's expectations of quality coffee starting in the 1990s, a similar opportunity in the late 1800s occurred with chocolates suitable for eating. As eating chocolates appeared in the marketplace, they typically were characterized as having a coarse and gritty texture. While achieving a measure of popularity, eating chocolate was not perceived as a viable alternative to chocolate beverages. Development of the manufacturing process called conching and the subsequent introduction of *chocolat fondant*, or melting chocolate, would lead to a redefinition of the word "chocolate."

Conching started in 1879 in Berne, Switzerland, originating with Rodolphe Lindt, son of a local pharmacist. Lindt had trained as a confectioner apprentice and bought two fire-damaged factory buildings and some roasting machinery from a bankrupt mill to manufacture chocolate. In the beginning, the roasters were unable to sufficiently dry and roast the cocoa, and grinding the damp nibs produced a very coarse chocolate. When put into molds, his chocolate developed a whitish coating that was unappealing to consumers. He enlisted the assistance of his brother, August, also a pharmacist, to help investigate the source of the white coating. August determined that the cause was too much water in the chocolate, which allowed the migration of fat to the surface of the product. He advised Rodolphe to heat his roller grinder and let the chocolate mix longer to drive the excess water from the chocolate. Rodolphe modified an old water-powered grinding machine developed by an Italian named Bozelli, by embedding iron troughs in granite with the upper edges curved inward. A vertical profile of the trough resembled a shell, and Lindt called his invention a *conche* from the Spanish word for shell, *concha*.

The curved edges allowed for more chocolate mass to be added to the trough without splashing out. At the end of each stroke of the roller, the chocolate broke like a wave, incorporating air into the mass. Rodolphe added some cocoa butter to reduce the viscosity of the chocolate so it flowed more efficiently over the rollers in the trough. After three days of uninterrupted rolling, the chocolate did not resemble regular chocolate. The aeration reduced the bitter and sour flavors and helped to develop the chocolate aroma. Instead of pressing chocolate paste into the molds, the new chocolate could be poured into molds. When eaten, this new chocolate melted on the tongue and possessed a very appealing aroma. In this way began the production of *chocolat fondant* [42].

History does not record why Lindt let the chocolate mix for three days. Perhaps it was part of an experimental plan developed with his brother. One anecdote related to the process involved Lindt leaving for a long weekend and forgetting to turn off the machine, which was powered by water from the Aare River [43]. Regardless of the reason for the discovery, Lindt realized this new process had to be maintained as a trade secret. A separate conching building was built, with access limited only to authorized personnel. In 1899, the German magazine *Gordian* published a

discussion entitled: "Why does this chocolate taste so different from all the others?" The magazine received many ideas from readers speculating on the Lindt process, ranging from using a new kind of grinding machine, to adding peppermint oil, even to the addition of more cocoa butter. Their conclusion was Lindt's secret could not be cracked. Lindt was able to maintain the secret of his conching process for more than 20 years and eventually sold his company (and the conching secret) to Rudolf Sprüngli [44].

One of the ingredients needed to produce *chocolat fondant* was cocoa butter. About 50 percent of a cocoa bean is cocoa butter, which has been extracted from cocoa beans since they were first discovered for food and cosmetic applications. The Aztecs put liquor into a pan of boiling water until almost all of the water evaporated. They then re-filled the pan with water and the butter floated to the surface of the water. Cocoa butter was stable, and even 15-year-old butter could be substituted for olive oil [45].

The original purpose for the van Houten butter press was to remove the excess cocoa butter from the liquor to produce reduced-fat cocoa powder. While considered a by-product at the time, it was still regarded as an expensive fat as compared to other available alternatives. However, it possessed a unique characteristic of having a melting point very similar to body temperature. Because many other fats did not mix well into chocolate, cocoa butter became a key ingredient for eating chocolate and milk chocolate.

Chocolate Manufacturing in the 1900s

By the beginning of the 1900s, machines developed for each step in the process prompted the Walter Baker Chocolate Company to describe the chocolate-making process as "modified and greatly improved by modern science" [46]. Richard Cadbury regarded the development of chocolate processing machines as "an interesting study, for we are apt to forget, in this age of luxuries, the years of toil and thought that it has taken to perfect them." Cadbury also believed that the production of chocolate required great experience, skill, and special knowledge [47].

As demand for chocolate increased, companies were consolidated to gain market share and production efficiencies. In 1902, it was observed that "the art of chocolate making is no longer the same as it was some twenty or thirty years ago; but it has for the most part passed from small operators into the hands of large manufacturers" [48]. As economies of scale required larger investments in equipment, specialized machinery was developed to optimize the process.

France was credited with developing a better system of roasting, grinding, and mixing chocolate and Germany was noted for producing the best chocolate-making equipment [49]. Companies investing in improving the efficiency of their processes to meet consumer expectations had lower costs and higher profit margins than companies maintaining the status quo. Companies that failed to modernize were purchased by larger and more efficient companies. As companies increased the scale of their operations, they became more concerned with keeping their process advancements secret. Although many companies such as the Walter Baker Chocolate Company continued to offer factory tours to visitors, areas with proprietary processes were off-limits [50].

As eating chocolate increased in popularity, the flavor of the chocolate became a major selling point. Most cocoa bean shipments arriving in Europe were damaged by seawater, mold, or infestation; the use of moldy and inferior beans had to be minimized to avoid off-flavors in the chocolate [51].

Some manufacturers roasted their beans without removing the trash and extraneous materials. The recommended practice was to store the beans in a dry warehouse and turn them at regular intervals to dry them in order to prevent damp and mold [52]. For cleaning the beans, the method of hand-picking foreign materials from rotating casks was soon replaced by rotary cylindrical screens driven by either steam or water power (Fig. 46.8) [53]. By the 1930s, the beans were automatically metered into the cleaning machines, automatic brush sieve cleaners were added to keep the screens open, and variable air-blowing capabilities were added to remove the dust. A machine to separate stones was developed that used differences in density to separate the lighter beans from the heavier stones [54]. As late as the 1950s, manual picking of trash after cleaning was still required [55]. Modern cleaning

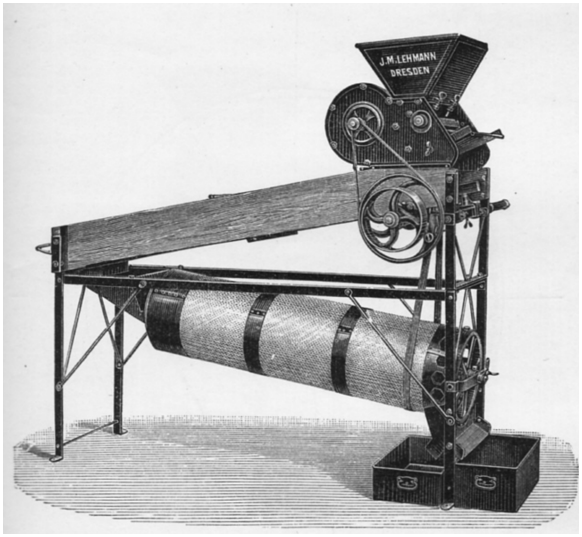

FIGURE 46.8. Cacao bean cleaner. *Source*: Paul Zipperer, *The Manufacture of Chocolate*, 2nd edition, 1902; p. 113. Courtesy of Rodney Snyder. (Used with permission.)

processes use screens with air aspiration capabilities to separate the light trash and vibrating density tables to remove heavy impurities such as stones. Powerful electromagnets ensure that metallic objects are removed prior to roasting and milling.

Nib roasting required a separate step of drying the beans prior to winnowing and roasting; to improve the process, manufacturers invented a bean roasting method that dried and roasted in one step. To develop the desired color and taste, the roasting process was viewed as "one of the most delicate processes from beginning to end" [56]. Roasters increased in capacity to one-ton rotating drums heated by high-pressure steam. However, the roast level depended on the roasting operators. The operators monitored the sound of the falling beans and the smell of the beans to judge the degree of roast. Experience in the art of roasting was critical: "[It is] . . . impossible to give any technical explanation of this; only practice can give this knowledge, which is the first condition to manufacture of the highest class" [57]. Drinking chocolate and eating chocolate required different roast levels. Some beans were partially roasted over a low fire to about 85 °C to dry and loosen the shells. Others were completely roasted to about 130 °C until almost all of the moisture was driven off through evaporation. Great care was taken to prevent overroasting due to the flavor impact of burnt and ashy flavors in the finished products [58].

By 1920, it was observed that "although attempts were being made to replace the æsthetic judgment of the operator, the complexity of variables associated with roasting cocoa made the application of science to the roasting process difficult" [59]. By the 1950s, better instruments were available to monitor the temperature, moisture, and color of the roasted beans [60]. By the 1970s, roasting was controlled more by science than art: "Science has given us close automatic control of time, temperature, motion, and air flow in roasting; but skill is still needed to bring cocoa beans from the roaster with just the flavor needed for any given purpose" [61]. By the beginning of the 21st century, manufacturers had increased the capacity of a roaster to five tons per batch, they had the ability to roast either beans or nibs, and they had the ability to automate the process to repeatedly produce the same roast level. The art of roasting had transitioned from the operator to the research scientists who developed the optimal roasting recipes for beans from each country of origin.

Even from the beginnings of cocoa processing, it always has been difficult to effectively separate shells from nibs. In the late 1800s, the association of German Chocolate Manufacturers offered a prize to anyone who could develop an effective and economical machine to separate shells from nibs while minimizing the amount of nibs in the discarded shells. Equipment manufacturer J. M. Lehmann subsequently developed a winnower to improve separation and nib yield [62]. These winnowing machines were described as having an "ingenious arrangement and fine divisions of the cylindrical sieves" [63]. Warm nibs were fed into crushing cylinders to crack the shells and then fed into the winnower. Operators adjusted the airflow over the screens to minimize the loss of small nibs carried into the shell stream. Winnowing machines evolved into a rectangular shape that vibrated a set of stacked screens to separate the nibs and shells by size. Since shells were much lighter, air aspiration was utilized to blow the shells away from the nibs. Because of the constant shaking of the screens, the body of the winnower was changed from wood to steel to improve stability and durability. Despite all of the advances in winnowing technology, about one percent of the shell still remains with the nibs regardless of the winnowing equipment utilized.

The nibs were ground into liquor using a variety of stone mill designs by the 1900s (Fig. 46.9). Cadbury used three lines of millstones that fed granite millstones to further reduce the particle size [64]. The heat generated during the milling process liquefied the butter in the nibs, reducing the viscosity of the liquor. Double or triple stone mills, able to grind up to 140 pounds per hour, were introduced to increase milling capacity [65]. Cadbury employed hundreds of circular stone mills with one stationary stone and one revolving stone. The nibs were fed through a hole in the center of the top stone, and grooves cut into the stones allowed the nibs to gradually be reduced in particle size. The liquefied mass was used for either cocoa powder or chocolate production [66]. The standard for stone mills gradually evolved into the triple stone mill. By the 1950s, impact mills such as disk mills, hammer mills, and pin mills were introduced. These mills relied on impacting the nibs with the

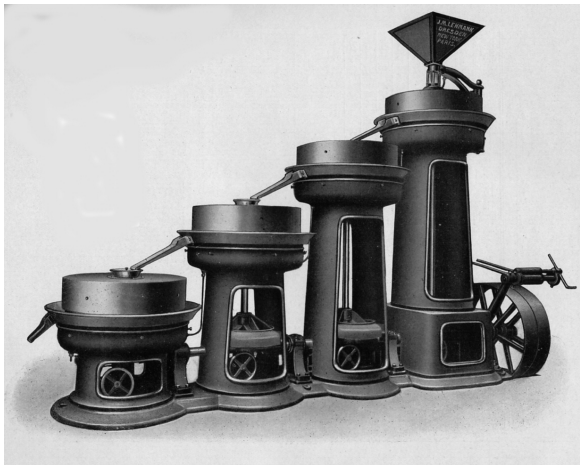

FIGURE 46.9. Set of four stone mills for grinding nibs. *Source*: J. M. Lehmann, undated. Courtesy of Rodney Snyder. (Used with permission.)

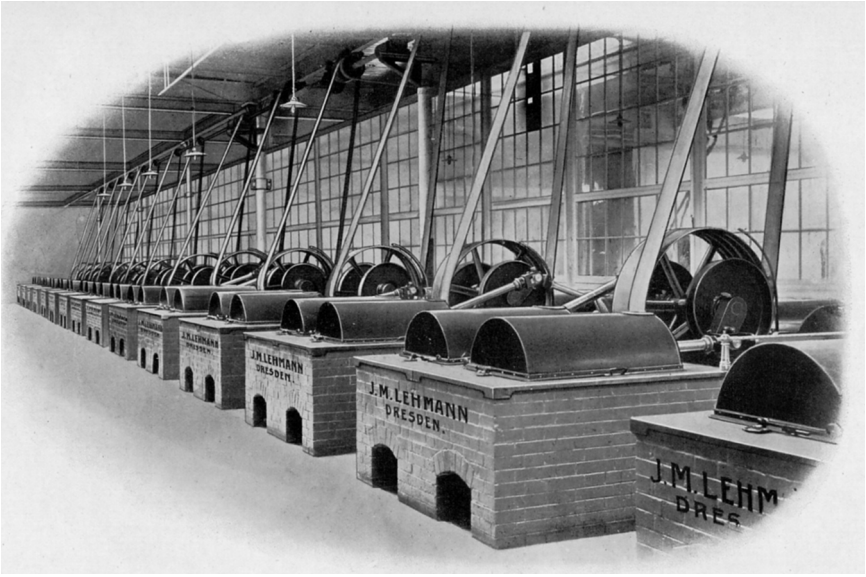

FIGURE 46.10. Conching room. *Source*: J. M. Lehmann, undated. Courtesy of Rodney Snyder. (Used with permission.)

disks, hammers, or pins until the particles were small enough to pass through a screen or grate. For fine grinding of the liquor, agitated ball mills were introduced that pumped the liquor through a cylinder filled with steel balls. The impact of the liquor particles between the agitated balls reduced the size of the particles.

Due to the mystery surrounding the production of melting chocolates and the additional equipment needed to produce it, drinking chocolate continued to form the backbone of the chocolate trade into the beginning of the 1900s. Melting chocolates were considered a high-class chocolate only preferred by a certain class of consumers, and could "only be produced in factories which are fitted up with special machinery of modern construction, and their manufacture not only consists of a series of operations of extreme delicacy, but also requires the attendance of an experienced person who has made a special study of such preparations" [67]. By 1900, it was predicted that "chocolate creams are, from the gastronomic point of view, the finest pure chocolate preparations that are made, and there is reason for believing that this branch of chocolate manufacture will soon be very much extended" [68].

The Swiss were renowned for their high degree of perfection in the quality and manufacture of *chocolats fondant*. The Swiss production methods were imitated by most manufacturers, but lack of understanding and failure to pay attention to the details of the Swiss methods often did not lead to success [69]. To make Swiss chocolates, the chocolate had to be ground very fine and additional cocoa butter needed to be added to allow the chocolate to be in a liquid form when warm. Conching lasted up to 48 hours at a temperature of around 55 °C. But for many imitators, by the beginning of the 1900s, it was still unclear how Swiss chocolates were produced. It was first believed that additional cocoa butter had to be added to the chocolate. However, high levels of fat in the chocolate were objectionable in flavor and texture, so the melting characteristics of the chocolate were then attributed to the chocolate process itself [70].

To replicate the caramel-like taste of *chocolat fondant*, experiments over many years were conducted to discover the method of imparting this flavor to the chocolate. Some manufacturers poured boiling sugar into the cacao mass and others added caramelized sugar. None of these experiments was successful in replicating the flavor of Lindt chocolate. Unknown to others, the secret was not in the form of the sugar added, but the subsequent processing of the chocolate.

Conching (Fig. 46.10) was described as an extraordinary process of which the science behind the effects was unknown: "There is no general agreement as to exactly how the conche produces its effects—from the scientific point of view the changes are complex and elusive" [71].

By 1923, it was recorded that the "crunchy chocolates which sold in quantity only five to ten years ago have gone, the public now demanding a chocolate with a smooth velvet feel. This is most effectively obtained by means of a machine peculiar to chocolate, called a conche, in which the chocolate is worked continuously for three of four days. Along the concave bottom of the conch a heavy roller is thrust backwards and forwards under the chocolate. Many clever attempts have been made to supersede this tedious and costly process, but, in spite of local secessions, it still holds the field" [72]. Although mélangeurs were still in common use in the 1950s, further refining and conching were the standard accepted practice [73]. Highly polished five-roll steel refiners were used to reduce the

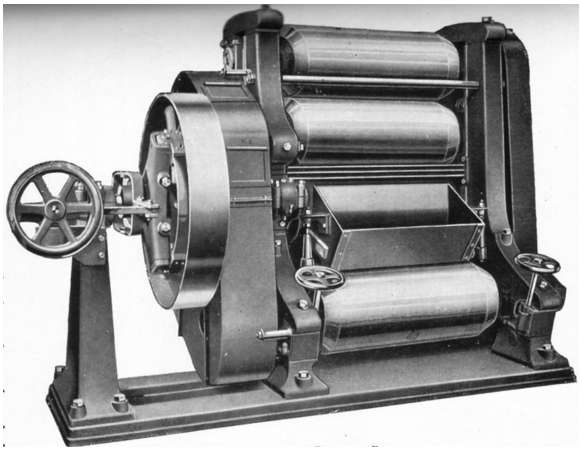

FIGURE 46.11. Five-roll steel refiner. *Source*: J. M. Lehmann, undated. Courtesy of Rodney Snyder. (Used with permission.)

particle size of the chocolate, and many new conche designs were being developed (Fig. 46.11).

Although the concepts of chocolate tempering and fat bloom were still unknown in 1852, their effects on the appearance of chocolate were noted: "A little while after it is made the surface grows dull, and is covered with an efflorescence of cacao-butter; but this slight alteration should not cause it to be rejected" [74]. The introduction of melting chocolate required a process to cool the chocolate to ensure that the finished chocolate had a glossy appearance and crisp snap when broken. In 1902, it was believed that the "more rapidly the molded chocolate is cooled the finer is its texture and the more uniform is the appearance of the fractured surface" [75]. By 1931, the tempering process was developed to control bloom in chocolate molding but the underlying principles were not fully understood [76]. By the 1950s, to produce proper temper to avoid fat bloom, the chocolate was cooled to about 30 °C until "mushy," then raised to 33 °C prior to molding [77]. The effects of tempering on the crystal forms of the cocoa butter in the chocolate were better understood by the 1970s. Raising the temperature slightly during tempering to melt out the unstable crystal forms produced a chocolate with a glossy appearance and good snap.

Although Cadbury's Milk Chocolate dates from 1897, their first milk chocolate was not as sweet and milky as consumers preferred. It took the company until 1902 to have operational equipment for condensing the milk, refining the chocolate, and conching it. By 1911, Cadbury opened its first subsidiary factory to condense the milk. The liquor and sugar were shipped to the condensing factory to be mixed and dried in large ovens to produce a product called *crumb*. Milk in *crumb* form could be stored for long periods of time without turning rancid, allowing surplus milk produced during the summer to be stored and manufactured into chocolate in the winter months.

Milton Hershey was manufacturing caramels in Lancaster, Pennsylvania, when he visited the World Colombian Exposition in Chicago in 1893 (see Chapter 16). He saw the new mechanized chocolate-making equipment displayed by the Lehmann Company of Germany. Lehmann had set up a display showing a working chocolate-making process, including roasting, winnowing, milling, mixing, and molding. After tasting the chocolate, Hershey bought the entire Lehmann display and had it shipped to Lancaster. He then hired two chocolate makers from the Walter Baker Chocolate Company to learn how to make melting chocolate. In 1900, he made headlines across the state of Pennsylvania when he sold the Lancaster Caramel Company for one million dollars [78].

After tasting many European milk chocolates and touring some of their factories, Hershey decided to manufacture his own milk chocolate. Although he had seen the equipment used to produce milk chocolate, he did not understand how to make it. He sent William Klein, one of his most trusted workers, to work at the Walter Baker Chocolate Company to discover the methods used by the Swiss. However, Baker had not yet learned how to make milk chocolate either, and Hershey struggled to develop a milk condensing method. According to Anne Klein, daughter-in-law of William Klein, Hershey hired a German chemist who claimed to know how to make milk chocolate and assigned Klein to assist him since he also spoke German. After this attempt failed, Hershey finally called on a worker from the Lancaster Caramel Company, who demonstrated in one day how to add the sugar to the milk, then boiled the milk at low heat under vacuum to remove the moisture. The finished sweetened and condensed milk was smooth like taffy and blended easily with the other chocolate ingredients [79]. After a falling-out with Hershey in 1913, Klein moved 10 miles south to Elizabethtown and started the Klein Chocolate Company, which produced chocolate until 1970.

By 1912, the process of making milk chocolate was known to the entire industry and a turnkey milk condensing plant could be purchased for £275 [80]. Milk chocolate began to be conched to help develop its special flavors, and by the 1930s, milk chocolate had become the most popular chocolate type [81].

The basic concept of pressing has remained constant since it was patented in 1828. The equipment to pulverize the cocoa cakes into cocoa powder transitioned from stone rollers on wooden frames to steel hammer mills. The presses were manufactured in a vertical configuration through the 1950s. By the 1960s, the presses were converted to a horizontal configuration to allow for more capacity and higher pressures. Current presses can have up to 18 horizontal pots with

a total pressing capacity of five tons of liquor per hour. Cocoa powder has between 10 and 12 percent fat remaining from a starting fat content of about 54 percent in the liquor. The cocoa butter is filtered from the presses to remove any entrained cocoa solids. While in early presses the cocoa butter was filtered through horsehair or camelhair bags, today continuous centrifuges and paper filters produce the clear yellow cocoa butter [82].

Conclusion

After almost 400 years of innovations in chocolate manufacturing, the captivating aroma and seductive flavor of chocolate still entice scientists to discover new advances in both technology and product development. The evolution from stone metates to automated steel mills has resulted in a variety of new products. Today, the health benefits of dark chocolate are well known, and a trip through local grocery stores provides evidence that chocolate has infiltrated a diverse selection of edible products. Some new trends can be connected to the past. The recent popularity of chocolates made from a single origin is reminiscent of the early years of chocolate production, and the *American Heritage Chocolate* from The Historical Division of Mars, Incorporated uses authentic recipes from the Colonial era of America (see Chapter 49). The blending of old and new will continue, but, unlike the Aztec's methods that were described as "not very nice" [83], modern techniques are sleek and efficient. In other words, very nice indeed.

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