BEAN-TO-BAR CHOCOLATE PRODUCTION: PROCESSING, PACKAGING AND STORAGE

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ABSTRACT – *Today, Malaysian artisan chocolate companies increasingly focus on handmade, high-quality chocolate made through bean-to-bar processing. This review outlines the small-batch process, from selecting premium cocoa beans from a specific location to producing finished chocolate. The process uses small-scale equipment such as ovens, melangers, marble slabs, and a digital micrometer. Cocoa bean roasting is a crucial step in developing flavour and reducing microorganisms. Then, achieving particle sizes of 20-30 µm and a final tempering temperature of 31-32°C is essential for dark chocolate production. Controlling particle size is important because it affects chocolate texture, with smaller particles creating a smoother mouthfeel and a more refined final product. Careful physical inspections during chocolate moulding help prevent under-filling and trapped air bubbles. Fat crystallisation is maintained by properly cooling the chocolate to 8-12°C, ensuring stable form V β1 polymorphs. This specific fat crystal structure is crucial to chocolate's glossy appearance, snap, and resistance to melting at room temperature. To preserve fine flavours and prevent chocolate bloom during storage, suitable packaging is used. High-barrier aluminum foil protects the chocolate against moisture absorption, light, and odours, while paperboard provides structural support and traceability information. Chocolate storage is carefully controlled, with temperatures kept between 18-22°C and a relative humidity of 50-60%, monitored by wireless thermo-hygrometers to prevent fat and sugar bloom. This approach maintains product quality, enhances consumer appeal, and extends the shelf life of the dark chocolate bar made with premium cocoa beans through bean-to-bar production.*

Keywords: Chocolate, vean-to-bar, processing, packaging, storage

INTRODUCTION

Malaysia's chocolate export volume rose marginally from 80,560 tonnes (2023) to 80,809 tonnes (2024), while export value increased from RM1.66 billion to RM1.92 billion (Malaysian Cocoa Board, 2025a). During this same period, the number of industrial chocolate manufacturers remained steady at 60, while the number of handmade chocolate entrepreneurs expanded from 258 to 270.

According to data from the Regulatory and Quality Control Division of the Malaysian Cocoa Board (2025b), the total volume of single-origin cocoa beans traded across Malaysia (Peninsular Malaysia, Sarawak, and Sabah) tripled between 2022 and 2023, skyrocketing from 27,349 kg to 80,918 kg. Driven by a global preference for fine-flavour, ethically sourced, and artisan chocolate, demand for local premium cocoa beans is rising as buyers show a greater willingness to invest in chocolate produced by bean-to-bar manufacturing. As of late 2024, the market valuation of premium Malaysian cocoa beans was approximately RM45/kg, keeping them highly competitive and on par with commercial rates for imported bulk beans sourced from major producing countries in Africa and South America (Bernama, 2025).

Premium Malaysian cocoa beans must meet strict food safety standards and are characterised by a fine flavour profile and no off-flavours (Suzannah *et al.,* 2021). Under the 12th Malaysian Plan (2022–2025), the Malaysian Premium Cocoa Bean Validation Project analysed over 200 local cocoa bean samples and qualified cocoa farmers to participate in Cacao of Excellence competitions (national and international), showcasing the global potential of the region's premium crops.

Three Malaysian cocoa farmers won international Cacao of Excellence awards, driving up the price of farmers' premium cocoa beans from RM22/kg to RM45/kg (as of October 2024). Nowadays, market demand for chocolate produced through bean-to-bar processing under full production supervision by artisan chocolate companies has increased (Lopes *et al.,* 2024). Several artisan chocolate companies in Malaysia, including Benns Ethicoa, Chocolate Concierge, Amazaque Chocolate, and Artisan Roastery, use these premium Malaysian cocoa beans to produce bean-to-bar chocolate products. Unlike commercial chocolate, which relies on bulk cocoa beans processed on an industrial scale. Meanwhile, premium single-origin chocolate is produced in small batches (the bean-to-bar concept) under close supervision, with oversight at every stage of processing. Furthermore, chocolate

packaging and storage are important because it is susceptible to environmental conditions. Proper packaging protects it from heat, humidity, light, and unwanted odours. At the same time, ideal storage temperatures prevent chocolate bloom, melting, and loss of fine flavour, preserving the product's appearance, texture, shelf life, and overall quality.

BEAN-TO-BAR CHOCOLATE PRODUCTION

"Bean-to-Bar" refers to a meticulous chocolate-making process that begins with sourcing cocoa beans from a single location and extends through every stage of production in small batches. By maintaining complete control over production, chocolate makers produce single-origin bars with unique flavour profiles (fresh fruit, browned fruit, vegetal, floral, woody, spicy, nutty, and caramel) (Cacao of Excellence, 2023; Leissle, 2018).

Selection and Sorting of Cocoa Beans

Dried cocoa beans were obtained from the Cocoa Research and Development Center, Jengka, Pahang, Malaysia. The chocolate manufacturing process begins with selecting and sorting dried cocoa beans. When the beans arrive at the processing facility, workers open the gunny bags (Figure 1a) and spread them on a clean, stainless-steel surface for inspection. At this stage, workers remove beans showing signs of germination, mould, or insect damage (Figure 1b), as these defects can negatively affect the quality of the finished chocolate product (Beckett, 2018; Afoakwa, 2016). This careful selection ensures that only suitable beans proceed to the roasting stage.



Figure 1: a) Cocoa beans in a gunny bag; b) Germinated, mouldy, and insect-damaged cocoa beans are discarded (source: own author)

Cocoa Bean Roasting

After sorting, cocoa beans are roasted in an oven (Memmert, Germany). Roasting is essential in chocolate production because it develops the beans' flavour and aroma. During roasting, the moisture content decreases from 7–8% to about 2%. To achieve even heating, beans are placed in a single layer in stainless steel baskets (Figure 2a). Roasting is carried out at 110°C to 160°C for 20 to 50 minutes (Figure 2b), with adjustments based on the size and initial moisture content of the beans (Cacao of Excellence, 2023; Beckett, 2018). After roasting, beans are cooled to room temperature on a marble slab or stainless steel table (Figure 2c).



Figure 2: a) The cocoa beans are placed in stainless steel baskets before roasting; b) Cocoa beans are placed in an oven for roasting; c) The roasted cocoa beans are placed on a marble slab (source: own author)

Crushing and Winnowing of Cocoa Beans

After roasting, the cocoa beans are crushed and winnowed. As shown in Figure 3, the roasted beans are first broken into smaller pieces using a breaker (Cocoatown, USA), preparing them for separation. These pieces are then processed in a winnower (Cocoatown, USA), which separates the cocoa nibs from the outer shells (Figure 4). The cocoa nibs (Figure 5a), the inner part of the bean, contain cocoa liquor and cocoa butter, the main ingredients in chocolate production. The separated shells are collected and used as organic compost fertilizer (Figure 5b).



Figure 3: Cocoa beans are crushed into fragments using a breaker (source: own author)

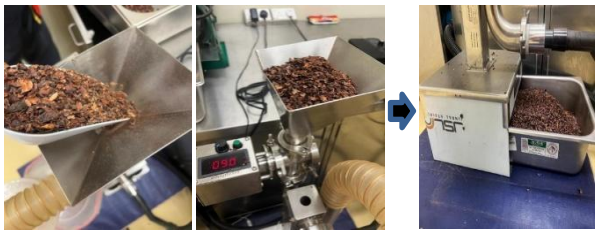


Figure 4: The crushed cocoa bean fragments are then fed into a winnowing machine (winnower) (source: own author)



Figure 5: a) Cocoa nibs for chocolate manufacturing; b) Cocoa bean shells are used as compost fertilizer (source: own author)

Grinding Cocoa Nibs into Cocoa Liquor

Prepare cocoa nib powder by pre-grinding the cocoa nibs in a blade grinder (Zhong Gu Xiong An, China) for 5-10 seconds. Limit the grinding time to 10 seconds or less to avoid excessive extraction of cocoa butter from the powder. After grinding, the powder is collected using a silicone spatula (Figure 6) and subsequently transferred to a chocolate melanger (Premier, India). The melanger processes the powder for 5 to 6 hours, producing a smooth cocoa liquor for chocolate production (Figure 7). The melanger, also known as a stone refiner, uses two granite rollers that rotate over a granite base within a stainless steel drum to mechanically reduce the particle size of cocoa nibs and sugar, producing a uniform and smooth chocolate paste (Ibadullah *et al.,* 2024; Beckett, 2018).



Figure 6: Grinding the cocoa nibs using a blade grinder (source: own author)



Figure 7: The cocoa nib powder is processed in a melanger to produce cocoa liquor (source: own author)

Mixing of Ingredients for Chocolate Production

Dark chocolate ingredients typically include cocoa liquor, cocoa butter, sugar, and lecithin (Figure 8). The cocoa content ranges from 47% (bittersweet) to 70%, 80%, or even 99% for very dark chocolate (Izzreen *et al.,* 2025; Jaćimović *et al.,* 2022). During initial processing, all ingredients except for the lecithin are introduced into the melanger for preliminary mixing. The lecithin is reserved and added later during conching. At this stage, only half of the total cocoa butter is gradually introduced into the melanger, and the remaining half is held back for addition during conching. This mixing phase is carried out in the melanger at approximately 40–50°C for 10-20 minutes (Figure 8), primarily to ensure that all ingredients are uniformly blended (Izzreen *et al.,* 2024; Ishak *et al.,* 2024a).

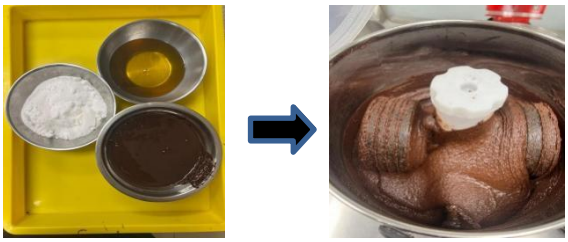


Figure 8: Mixing the ingredients of the dark chocolate in the melanger (source: own author)

Conching the Chocolate Mixture

Conching is a critical stage in chocolate production, essential for developing the flavour profile by evaporating volatile acetic acids and eliminating off-flavours. This process also reduces moisture content and refines texture, ensuring a smooth and glossy final product (Figure 9). The chocolate mixture in the melanger is conched at 50–60°C for 12 hours to enhance its rich flavour and aroma. A stone grinder in a melanger automatically generates heat through friction and mechanical shear as the granite rollers crush the chocolate ingredients against the bowl base. Specifically, the remaining cocoa butter is introduced into the melanger at

the second hour of conching, after which the process continues for an additional 8 hours. Finally, lecithin is incorporated during the last two hours of the conching. It serves as an emulsifier to bind the key ingredients, which are cocoa liquor, cocoa butter, and sugar, while optimising the final viscosity of the chocolate (Ishak *et al.,* 2024a; Beckett, 2018; Afoakwa, 2016).



Figure 9: Chocolate with a shiny appearance has been processed in the melanger for 12 hours (source: own author)

Particle Size of the Chocolate

After conching, the ideal particle size of chocolate ranges from 20 to 30 µm. Traditionally, continental European chocolate has been described as having a particle diameter of 15–22 µm, while North American chocolate has a particle diameter of 20–30 µm (Afoakwa *et al.,* 2007). This target range is essential for optimal mouthfeel and excellent flavour release. A grindometer (Biuged Instrument, China) and a digital micrometer (Mitutoyo, Tokyo) are the standard instruments used to measure the chocolate's particle size (Figure 10). Chocolate in this range is perceived as exceptionally smooth on the palate, with no trace of grittiness. Conversely, if the particle size is reduced below <18 µm, the chocolate exhibits a powdery and pasty texture, causing it to stick unpleasantly to the palate in the mouth (Izzreen *et al.,* 2022; Beckett *et al.,* 2018; Afoakwa *et al.,* 2007).



Figure 10: a) Grindometer; b) Digital micrometer (source: own author)

Chocolate Tempering

All equipment (polycarbonate mould, stainless steel bowl, stainless steel chocolate scraper, digital thermometer, and plastic spatula) used for chocolate making is food-grade, and the marble slab must be thoroughly cleaned and completely dry before tempering chocolate (Figure 11). The chocolate is tempered using the traditional tabling technique. This method involves pouring a portion of the melted chocolate onto a marble slab, where it is continuously agitated and worked with a scraper (Afoakwa, 2016). This rapid movement promotes the crystallisation of stable fat crystals in chocolate until it reaches the required target temperature for dark chocolate (29–30°C). Tempering chocolate on a marble slab takes about 2 to 5 minutes to prevent it from hardening as cocoa butter crystallises, depending on the volume of chocolate and the ambient room temperature.



Figure 11: Equipment and marble slab used for chocolate tempering (source: own author)

The chocolate is first tempered using the tabling technique (Figure 12a). This method involves pouring a portion of the melted chocolate onto a marble slab and rapidly working it with a scraper to induce stable fat crystallisation until the target cooling temperatures are achieved (29–30°C for dark chocolate). Once this crystallisation step is complete, the sub-cooled chocolate (Figure 12b) is scraped back into the stainless-steel bowl to mix with the remaining untempered chocolate (Afoakwa, 2016).

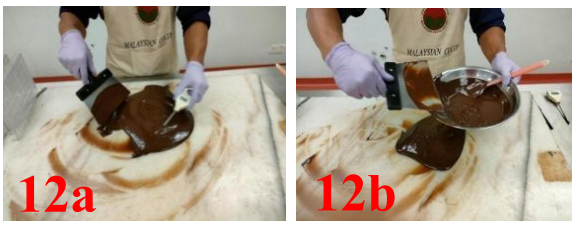


Figure 12: a) The chocolate undergoes tempering using the tabling technique; b) Once the tabling process is complete, the sub-cooled chocolate is scraped back into the stainless-steel bowl containing the remaining chocolate (source: own author)

This blending step raises the overall batch to its final working temperature—ideally 31–32°C for dark chocolate (Beckett, 2018; Hartel, 2018). At this stage, the chocolate is properly tempered and ready for molding. Meanwhile, keep the chocolate tempering workspace dry at a strictly controlled room temperature of 21–22°C, with relative humidity not exceeding 50% (Figure 13).



Figure 13: Chocolate tempering workspace (source: own author)

Chocolate Moulding

After tempering, the chocolate is poured into a bar-shaped mould on a weighing balance to achieve a target weight of ±60 g (Figure 14a). Next, the chocolate is levelled evenly in the mould before cooling (Figure 14b). Accurate weighing is critical to maintaining uniform product specifications. Underfilling not only violates labeling standards but also results in overly thin chocolate bars prone to breakage (Cocoa Runners, 2025). At the same time, tap or vibrate the mould filled with tempered chocolate firmly against a hard surface to release trapped air. Before transferring the moulded chocolate to the chiller for cooling, visually inspect the bottom of the mould (Figure 15) to confirm the chocolate has filled the mould and all air bubbles have been eliminated.

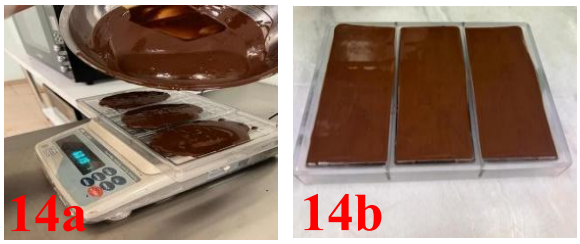


Figure 14: a) The chocolate must be weighed into the mould; b) The chocolate is evenly levelled within the mould prior to cooling (source: own author)

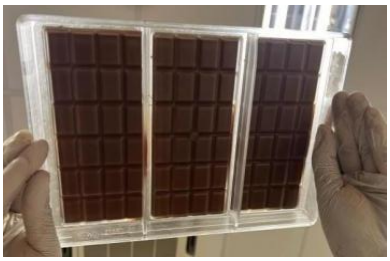


Figure 15: The chocolate must completely fill the mould and have no air bubbles before being placed in the chiller for cooling (source: own author)

Chocolate Cooling

As shown in Figure 16, the chocolate must undergo a cooling process in a chiller (Berjaya, Malaysia) at a temperature of 8–12°C for an appropriate duration (20–30 minutes) (Afoakwa, 2016).



Figure 16: The chocolate is cooled in a chiller at a temperature of 8–12°C for 20 to 30 minutes (source: own author)

This step is critical for forming stable polymorphic fat crystals (specifically Form V β1) in dark chocolate, thereby preventing fat bloom, maintaining a glossy surface, and achieving optimal textural firmness (Lonchampt & Hartel, 2004). After cooling, keep the chocolate cool at room temperature of 20-22 °C for 30 minutes. Then examine the bottom of the mould (Figure 17) to confirm the chocolate has fully contracted and released from the mould, ensuring a clean demoulding process (Pastry Arts Magazine, 2023).

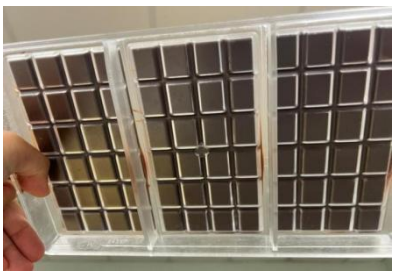


Figure 17: Ensure the chocolate has completely detached from the mould following the cooling process in the chiller (source: own author)

Chocolate Demoulding

Once the chocolate has been released from the mould, carefully invert the mould to release the chocolate bars onto parchment paper lined in a clean tray (Figure 18). (Greweling, 2012; International Culinary Center, 2016). After demoulding, neatly trim and scrape off any excess chocolate along the bar's edges (Beckett, 2018; Afoakwa, 2016).

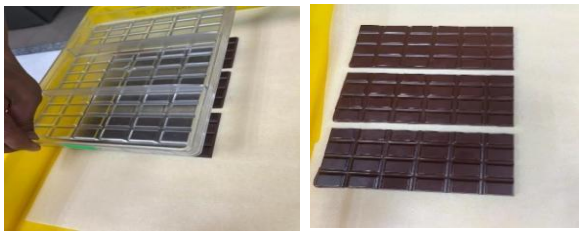


Figure 18: Gently and carefully invert the mould to release the chocolate bars (source: own author)

Characteristics of properly tempered chocolate (Beckett, 2018):

- Properly tempered chocolate solidifies rapidly and evenly during cooling.
- It displays a smooth, glossy, and visually appealing surface.
- A distinct and clean snap is observed when the chocolate is broken, indicating proper tempering.
- The surface remains free of both fat and sugar bloom, reflecting the stability achieved through proper tempering.
- Properly tempered chocolate can be easily released from the mould.

CHOCOLATE PACKAGING

Single-origin chocolate bars processed via the bean-to-bar technique emphasise the distinct organoleptic and unique flavour profiles inherent in cocoa beans harvested from specific geographical regions. Consequently, the primary and secondary packaging materials must reflect this authenticity, artisanal craftsmanship, and premium value (BioPack, 2025).

Aluminium foil provides a hermetic barrier against light, oxygen, and moisture (Figure 19), which is vital for preserving the flavour profile, mitigating lipid oxidation, and preventing fat or sugar bloom during storage (ZPTAI Aluminum, 2026; Thompson *et al.,* 2009). Concurrently, an artcard paperboard folding carton serves as secondary outer packaging, providing space for brand storytelling, flavour profiles, cocoa percentages, and regulatory certifications while also providing the structural rigidity needed to prevent mechanical damage and enhance retail shelf presence (Silver Edge Packaging, 2026).



Figure 19: a) Aluminium foil for chocolate packaging; b) front outer packaging of chocolate; c) back outer packaging of chocolate (source: own author)

CHOCOLATE STORAGE

Chocolate bars with packaging require specific storage protocols to maintain quality. Proper storage conditions (optimal ambient temperature and relative humidity) are vital to ensure microbiological and chemical safety throughout the product's shelf life and to keep it in good shape and structurally intact (Figure 20) (Škrabal *et al.,* 2019; Afoakwa, 2016; Lonchampt & Hartel, 2004).



Figure 20: Chocolate bars must be stored under optimal temperature and humidity conditions (source: own author)

Temperature

The climate control system in the chocolate bar storage facility must maintain 18–22°C (the optimal storage temperature) (Machálková *et al.,* 2015). Monitor chocolate storage temperature and humidity using a wireless thermo-hygrometer (Figure 20) to ensure accurate, real-time data tracking. Avoid fluctuations greater than 6°C from the controlled temperature, as sudden spikes can induce fat bloom during storage. Ideal storage temperature prevents fat bloom, a dull, grayish-white coating on the surface of chocolate caused by cocoa butter melting, migrating to the surface, and recrystallising unevenly (Figure 21). Even though harmless, it significantly degrades the product's visual appeal, texture, flavour, and overall consumer acceptance. This is typically triggered by improper tempering or unsuitable storage temperatures (Škrabal *et al.,* 2019; Afoakwa, 2016; Lonchampt & Hartel, 2004).

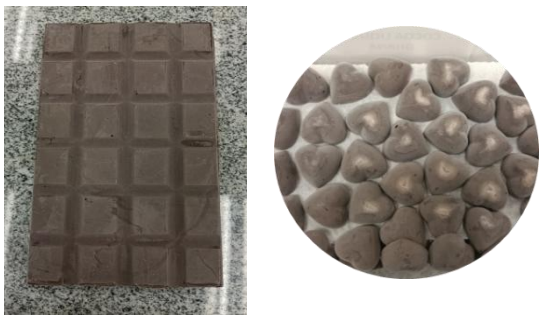


Figure 21: Fat bloom is a whitish or grayish layer completely covers the surface of the chocolate during storage (source: own author)

Relative Humidity

Store chocolate at a relative humidity of 50–60% and monitor it continuously with a wireless thermo-hygrometer to prevent moisture absorption (Figure 20) (Afoakwa, 2016). Using a dehumidifier is necessary to prevent sugar bloom, mould, off-odours, and oxidative degradation (Moiswell, 2026). Sugar bloom creates a sandy surface texture when high humidity dissolves internal sugar, which then recrystallises on the surface as water evaporates (Figure 22) (Barry Callebaut, 2025; Lindt USA, 2025). This defect is mainly caused by condensation or extended exposure to high humidity.



Figure 22: The formation of the sugar bloom on the surface of the chocolate during storage (source: own author)

Light and Air

Store chocolate in a dark, airtight environment, using opaque packaging such as foil or high-barrier films, to prevent lipid oxidation (Robertson, 2012). These protective measures are particularly critical for milk and nut-filled chocolate varieties, which are highly susceptible to lipid oxidation, staling, and rancidity when exposed to light and atmospheric oxygen.

Odour

Store chocolate away from strong external odours, including spices, coffee, and detergents, because its fat matrix readily absorbs volatile compounds from the surrounding environment. This process can especially affect the quality of milk chocolates, as milk fats absorb these odours strongly. Therefore, using opaque, high-barrier packaging is necessary to maintain chocolate quality during storage (Afoakwa, 2016; Robertson, 2012).

STORAGE STABILITY OF CHOCOLATE

Chocolate products generally remain stable when stored at 15-18°C (Afoakwa, 2016). Among these, dark couverture has a notably longer shelf life of 18 to 24 months, which can be attributed to its very low moisture content (1-2%) and high antioxidant levels (Ishak *et al.,* 2024b; Beckett, 2018). In comparison, milk couverture typically lasts only 6 to 12 months. This shorter shelf life is mainly due to the milk solids in its composition, which increase the rate of lipid oxidation and make the product more sensitive to temperature changes. As a result, the long-term quality and structural stability of milk couverture are more easily compromised.

CONCLUSIONS

Malaysia's artisan chocolate industry depends on careful bean-to-bar production, which requires small-batch processing from selecting raw materials to producing the final chocolate. Malaysian artisan chocolate makers typically select premium cocoa beans that comply with strict food safety standards and offer a unique flavour profile. Each stage of the bean-to-bar process must be managed with precise parameters to ensure the resulting chocolate is both high-quality and safe for consumption. Effective packaging and storage are also essential to maintain microbiological and chemical safety throughout the product's shelf life and preserve its physical integrity. To support further industry growth, research should prioritise optimising microbial control during cocoa bean fermentation, which is necessary to standardise flavour precursor levels before drying and roasting. There is also a need to investigate sustainable, bio-based packaging solutions with high barrier properties as alternatives to aluminium foil to prevent bloom formation during storage and transport in Malaysia's tropical climate.

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