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What kind of magic do they put in chocolate, anyway?

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ABSTRACT

Chocolate is the most popular candy in the world. The cocoa tree's seeds are fermented, roasted, and ground, making chocolate the final finished product. The main components of chocolate are carbohydrates, fat, and protein, and it also contains essential minerals like calcium, magnesium, iron, and zinc. The resulting sensory perception of chocolate is linked to many diverse components, making its flavour highly complex. There are different types of chocolate in terms of composition and shape. The cocoa mixture, cocoa bean roasting method, and the ratio of cocoa butter, fat-free cocoa powder, and sugar all play a role in determining the type of chocolate. Chocolate can take different forms, such as bars or sticks, and is often flavored with vanilla, cinnamon, cloves, hazelnuts or almonds. Milk chocolate is the most popular chocolate in the world. Creamy and tender, it melts on the tongue and leaves you wanting more. The second most popular chocolate was dark chocolate, followed by white chocolate. The most popular combinations are soft nougat and crunchy walnuts. Hazelnuts and almonds are also indispensable in the chocolate industry.

Keywords: *chocolate, cocoa butter, anandamide, theobromine, caffeine, types of chocolate*

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Introduction

Chocolate has a fascinating history. The first known cacao plantations were established by the Maya in the lowlands of southern Yucatán around 600 AD. The Maya revered chocolate as divine food, associating the cacao tree with gods and viewing its fruits as a gift to humanity. They held the cacao tree as sacred, often burying dignitaries with bowls of chocolate, symbolizing its importance in the afterlife. The identification of the (Olmec-originated) word ka-ka-w ("cacao") inscribed on those containers was vital to deciphering the Maya's phonetic manner of writing. They believed that the tree belonged to the gods and that the fruits of the cacao tree were God's gift to humans 300. In the new era, the Mayans built castles and temples at the time of the most incredible rise of their empire. They carved images of the cocoa fruit on the "sacred" walls as a symbol of life and fertility. A drink made from cocoa beans was first created in the Mayan Empire. The chocolate drink was so bitter that it was used in drinks known as chocolate or "bitter water". It was the drink of kings and lords to enhance festivities and rituals. Sometimes, chili pepper was added to the bitter drink.

After the mysterious disappearance of the Mayan civilization, this area was inhabited by the Toltecs and later by the Aztecs. The king of the Toltecs, Quetzalcoatl, politically forced to leave the kingdom, sailed away in a small boat, promising to return in a specific year to recover his empire. The legend of his empire became part of mythology. Astrologers of the Aztecs predicted that the year of his return would be 1519.

Before the Europeans reached Central America, the Incas (Peru) and the Aztecs (Mexico) were cultivating cocoa trees (Scholey and Owen, 2013). Precisely, in 1519, the Spanish conquistador Cortez arrived by ship on the soil of the Aztec Empire. The Aztec king Montezuma believed that Cortez was the reincarnation of Quetzalcoatl and welcomed him with the greatest honours. He organized a celebration where a cocoa drink was a tremendous honour. Cortez immediately realized the great potential of cocoa beans. He firmly believed he had found the "gold" he sought. For Cortez, it was also in the literal sense. Namely, according to historical notes, Montezuma drank fifty jugs of cocoa daily. He always drank from a golden cup and threw the cup into the lake. That's how Cortez literally found the "golden lake".

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In the Aztec Empire, a healthy slave could be bought for 100 beans of cocoa, a rabbit for four beans, and a young and beautiful party girl charged for her services for ten beans. Cocoa beans were a "stable currency" for several centuries, and in parts of Central America until the 19th century, cocoa beans remained used as a means of payment.

Cortez, throwing Montezuma in prison, soon organized the establishment of cocoa plantations. The Spanish built plantations in Mexico, Ecuador, and Peru.

Therefore, it is considered that Hernán Cortés, the Spanish conqueror, discovered the secret of making a chocolate drink. However, it should be mentioned that Columbus's crew, returning from a trip to the New World in 1502, brought the first quantities of cocoa beans to Europe, above all out of curiosity and as a souvenir, not recognizing its actual value.

In 1580, the first facility for processing cocoa beans was established in Spain. The Spanish made their version of the chocolate drink by mixing sugar, cinnamon and vanilla with cocoa beans. Soon after, the "chocolate" drink achieved enormous popularity, enjoyed only by the wealthy. Preparing the chocolate drink was a well-kept secret, so it took about 100 years for the preparation process to spread throughout Europe. "Chocolaterias" chocolate houses began to spring up all over Spain. From there, they spread throughout Europe via the Netherlands and Italy as a new fashion among the upper classes of society. Various spices are added, such as chili, cloves, vanilla, and black pepper.

The first chocolate drinking was established in London in 1657. It was mentioned in Pepys' Diary of 1664, where he wrote that "jocolatte" was "very good". In 1727, milk was added to the drink. This invention is generally attributed to Nicholas Sanders. Due to the high costs of cacao and sugar, early consumption of this drink was limited to royalty and the aristocracy. However, with the cultivation of *Theobroma cacao* reducing production costs, chocolate beverage consumption became widespread across all social classes.

The making of chocolates is the result of long discovery and innovation. In making the drink, enormous problems were caused by some kind of butter because over half of the cocoa bean consists of cocoa butter. The cocoa butter tended to melt in hot water, causing the cocoa particles to clump together and giving the appearance of fat rising to the surface, which was visually unappealing. Van Houten, a Dutch chemist, invented a hydraulic press in 1828, with which he managed to extract cocoa butter from cocoa beans on one side and a dark brown cake

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of cocoa powder. To enhance the dispersion of the powder in hot water or milk and reduce its fat content, the Dutch treated cocoa beans with an alkaline solution during the roasting process, a technique later termed the Dutching process. This method also allowed for the adjustment of cocoa powder colour by varying the alkalizing agent used.

Ten years later, Van Houten sold the patent, and the machine entered general use. Mixing extracted cocoa butter with cocoa beans produces a paste that absorbs sugar, which leads to the production of edible chocolate. It has yet to be discovered precisely who first dissolved cocoa butter and re-combined it with cocoa powder, with the addition of sugar. The result was a smooth, moldable mixture. 1847. Company J. S. Fry & Sons first exhibited this product at the Birmingham Fair under the name "Chocolat Delicieuk a Manger". Daniel Peter in Switzerland. Thus, after the wave of chocolate as a beverage, the wave of "eating" chocolate swept across Europe.

Chocolate must have low moisture content to prevent it from turning into a paste when melted due to water reacting with sugar. Thus, Daniel Peter needed to devise a method to dry the abundant liquid milk in his country. The recent development of a condensed milk formula by Henri Nestle' helped him with this. This meant he had much less water to evaporate and could remove the remaining amount using relatively cheap water-powered machines.

Non-fat particles must be smaller than 30 microns to ensure the chocolate melts smoothly in the mouth. Despite grinding chocolates with granite rollers, those made by Fry and Peter still had a gritty texture due to large particles and agglomerates formed by particle groups. Moreover, inadequate fat coating contributed to this texture, while the presence of acidic chemicals led to bitterness. In 1880, Rodolphe Lindt developed a machine in Berne, Switzerland, producing smoother, better-tasting chocolate. This machine was known as a conche, because its shape was similar to the shell with that name. Employing such a machine enabled the breaking up of agglomerates and some larger particles, coating them all with fat. Simultaneously, moisture and certain acidic chemicals were evaporated, resulting in smoother, less astringent chocolate. Chocolate can be considered a dense suspension of solid particles (sugar, cocoa, and milk mixture, depending on the type) dispersed in a continuous fat phase, chiefly composed of cocoa butter (Khampuis, 2010; Nickless, 1996).

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Swedish botanist Carolus Linnaeus renamed the cocoa tree, giving it the Greek name Theobroma Cacao in the 18thcenturyThe name "theobroma" itself comes from the ancient Greek word θεός (theos), meaning "god, deity", and βρῶμα (broma), meaning "food. The cocoa or cacao tree (*T. cacao* L.) originally came from South and Central America but is now commercially cultivated in suitable climates between 20 degrees north and 20 degrees south. These areas have a high average temperature throughout the year and constant high humidity from plentiful rainfall. In commercial plantations, they are often sheltered by intercropping trees such as coconut and banana. Its leaves are evergreen and are up to about 300 mm in length. Trees begin producing pods within 2–3 years, but reaching total yield takes 6 or 7 years. The cacao tree is notable for its cauliflory, where cacao flowers grow directly from the trunk rather than branches, as is typical. One fruit contains about 20-22 cocoa beans.

There are four types of cocoa (https://barandcocoa.com/pages/varieties-of-cocoa-beans). Criollo has beans with white cotyledons and a mild flavour. The trees are, however, relatively low-yielding. Most cocoa is Forastero, which is more vigorous and often grown on smallholdings (a family's cultivated land smaller than a farm) in West Africa. The third form, Trinitario, is usually considered a hybrid of the other two types. The fourth type is Nacional, which is grown only in Ecuador and probably originates from the Amazonian area of Ecuador. Nacional Cocoa produces beans with a full cocoa flavour and additional floral and spicy flavours.

The cacao tree seeds possess a strong bitter taste and require fermentation to develop their flavour. Fermentation consists of a natural, seven-day microbial fermentation of the pulp at temperatures up to 50 °C (Guzmán-Alvarez and Márquez-Ramos, 2021). Some compounds that give flavour to cocoa are formed during this fermentation. Traditional fermentation is driven by a series of reactions catalyzed by a succession of microorganisms-yeasts, lactic acid bacteria, and acetic acid bacteria-that naturally inoculate cocoa pulp. The end products of fermentation, including ethanol, lactic acid, and acetic acid, kill the beans and generate flavour precursors (De Vuyst 2020).

Free amino acids and peptides also form, and sucrose is inverted to produce reducing sugars (Munoz et al., 2020). After fermentation, the beans undergo drying, cleaning, and roasting. The shells are removed, producing cacao nibs, ground into cocoa mass, the purest form

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of chocolate. When the cocoa mass is heated and liquefied, it becomes chocolate liquor, which can be further processed into cocoa solids and butter. (De Vuyst and Weckx, 2016).

Cocoa butter

The cocoa components used in chocolate are cocoa butter (the fat phase), cocoa powder (the fat-free phase), or cocoa mass (also known as cocoa liquor), which is a combination of cocoa powder and the cocoa butter naturally found in the cocoa bean (Talbot, 2012). Cocoa powder is not used as a component in white chocolate. Cocoa butter, the primary structural material in chocolate, consists of monounsaturated, polyunsaturated, and primarily saturated fats.

Cocoa butter is considered the most important by-product of cocoa due to its physical (rheology and texture), chemical, and organoleptic qualities (Lipp and Anklam, 1998), which produce widely sought-after functional properties in the food industry.

Cocoa butter makes up about half the mass of the cocoa bean. It is obtained using a hydraulic press with the help of high pressures. Cocoa beans contain a large amount of fat. It contains 50-54% fat, 10-15% protein, 4-5% moisture, 1% theobromine and 0.44% caffeine (Afoakwa et al. 2013). These unique characteristics, which cannot be compared with other edible vegetable fats, are very useful in producing many products in the chocolate, cosmetic and pharmaceutical industries. In terms of fat, cocoa butter is the only constant because it is present in the fat phase, regardless of the type of chocolate. Cocoa butter is usually the only fat in dark or plain chocolate. Exceptions to this are when a small amount of milk fat is added to increase the chocolate's resistance to blooming or when low levels of non-cocoa vegetable fat are added in countries that allow these fats in chocolate. In milk chocolate, the fatty phase is then enhanced by milk fat. Some countries allow vegetable fats in chocolate, usually at a defined maximum level. As for the low-fat components in chocolate, the most important for taste is the cocoa powder, i.e., the low-fat part of the cocoa.

Cocoa butter itself has many excellent and exciting properties, as well as significant limitations. The aroma composition of cocoa products is closely related to the unique post-harvest processing conditions and the variety and origin of the cocoa itself (Kongor et al., 2016). Pure-pressed cocoa butter has a flavour that will become part of the chocolate. For some

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products, especially white chocolate, this taste is considered unpleasant. In this case, deodorized cocoa butter is used. This is often produced by steam distillation of cocoa butter under a vacuum (Meursing and Zijderveld,1999).

The growing conditions of the cocoa beans influence the cocoa butter content and fatty acid profiles in chocolate products. Identifying and quantifying fatty acids in cocoa butter is crucial for research, development, processing, and quality control during manufacturing. In cocoa butter, fatty acids form triacylglycerols (TAGs), which are mainly composed of 2-oleyl glycerides (O) combined with palmitic (P) and stearic (S) acids (POP, POS, SOS) (Segall et al., 2005). The TAG composition significantly influences chocolate's production performance and final attributes, including texture, viscosity, melting properties, flavour, and taste (Afoakwa, 2010). The simple composition of glycerides allows the chocolate to melt at a temperature range of 23 to 37°C. The crystalline form of V (β2) lipids is preferred in chocolate production and dominant in well-tempered chocolates.

The cocoa composition and FA profile vary depending on geographical origin. At the same time, only carbohydrates and fat content varied significantly in chocolates due to the effect of origin, with no significant effect observed for processing conditions. Quantitatively, the most essential fatty acids were C16:0, C18:0, C18:1, and C18:2 in all samples (Torres-Moreno et al., 2015). The structure of acids directly influences how chocolate behaves during production and affects the final product's texture, viscosity, melting properties, and flavour (Afoakwa, 2010). High-quality chocolates exhibit slower melting rates due to their higher content of saturated fatty acids, resulting in a desirable mouthfeel as they melt smoothly.

Certain vegetable fats have a triglyceride composition similar to cocoa butter, allowing them to be added to chocolate without altering its texture. Legally, such vegetable fats are allowed up to 5% in the EU for a product sold as chocolate (Regulation on Cocoa and Chocolate Products, 2003). The quantity of cocoa butter and the fatty acid composition in chocolate products are determined by the growing conditions of the cocoa beans. Identifying and quantifying fatty acids in cocoa butter is vital for research, development, processing, and quality control during manufacturing. In cocoa butter, fatty acids form triacylglycerols (TAGs), primarily consisting of 2-oleyl glycerides (O) combined with palmitic (P) and stearic (S) acids (POP, POS, SOS). Cocoa butter alternatives like Caprenin, which have unique fatty acids and

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low absorbability in the intestines, can be used as low-calorie fat substitutes. Cocoa butter can be used with non-lauric fats and tempered like usual.

Sugar and sugar substitutes

Conventionally, chocolate was commonly produced with approximately 50% sugar, predominantly sucrose, and a small amount of lactose in milk chocolate. Sugar adds flavour characteristics to a product, helps keep it moist, and inhibits bacterial growth. Monosaccharides like glucose and fructose are rarely used in chocolate because they are difficult to dry. This added moisture in the chocolate would increase the interaction between sugar particles, leading to higher viscosity. Dextrose and lactose are adequate substitutes for sucrose in milk chocolate. Lactose promotes browning through the Maillard reaction. Recently, sucrose-free chocolates have gained popularity among consumers and manufacturers due to their lower caloric content.

Sugar alcohols (polyols) replace sucrose in chocolate when it is required to make a lower-calorie or sugar-free product. Other common sugar alcohols include sorbitol, mannitol, isomalt and lactitol. Some must be processed into chocolate at relatively low temperatures to prevent them from forming gritty lumps. There is also a big difference in sweetness between the different sugar alcohols. Sugar alcohols, including xylitol, sorbitol, mannitol, erythritol, maltitol, maltitol syrup, isomalt, and lactitol, are used to produce low-calorie and sugar-free products (Grembecka, M. (2015). However, the replacement of sucrose with sugar alcohol affects the rheological properties, as well as the processing conditions and the quality of the chocolate. Maltitol is a suitable replacement for sucrose in chocolate because it shares similar rheological properties. The EU limits the consumption of sugar alcohols to 20 g per day due to the laxative effect (Grembecka, M. (2015).

It is sometimes found in unique chocolates for people with diabetes, as, unlike saccharose, it does not raise blood sugar when eaten. However, it does need special processing conditions, especially regarding temperature and humidity.

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Milk

Around 13.5% of the liquid milk is composed of anhydrous components. Lactose makes up the most considerable portion, accounting for nearly 5%. Minerals account for about 0.7 % of the total (Haylock and Dodds, 1999). Milk fat, however, has a limited shelf life as it can be oxidized or attacked by enzymes (lipolysis). The enzymes speed up the decomposition of the acids into shorter chain free acids, resulting in a rancid off-flavour and rendering the chocolate unsuitable. However, when this reaction occurs with cocoa butter, the acids formed are largely tasteless, so the chocolate remains acceptable. When milk is dried, it can produce a wide range of different powders (Fowler, 1999).

Skim milk and full cream milk powder are the most commonly used powders in chocolate making. Both powders can make chocolates with the same overall milk component content. Milk proteins add to the chocolate's nutritional content. They also determine its flavour, texture, and liquid flow properties. If the proteins are subjected to water and heat, they can participate in the Maillard (browning) reaction. Milk powder added as spray-dried skimmed milk powder or whole milk powder contributes to flavour, texture, and flow properties, depending on heat treatment and drying conditions.

There are two very different types of protein, namely caseins and whey proteins. There are four to five times as many caseins as whey proteins. Caseins act as emulsifiers. As water binds the sugar particles, adding powdered milk to liquid milk to chocolate in about 12-25% is better. Milk contains about 5% lactose, 5% milk fat, 3.5% protein and 0.7% minerals. Triglycerides of milk fat, dominated by saturated fatty acids, show different crystal structures. However, adequate amounts of palmitic, stearic, and oleic acids are the primary fatty acids in cocoa butter. Milk fat is mostly liquid (15-20% solid) at room temperature and softens the texture of the chocolate, slows down settling, and uses up to 30% of the total fat, preventing the ripening of the fat (greying). Milk fat is prone to oxidation and affects shelf life with 80% casein and 20% whey protein. The casein fraction acts as a surfactant and reduces the viscosity of chocolate, while whey proteins, on the contrary, increase the viscosity (Sadiq, Gill and Chandrapala, 2021).

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Emulsifiers

Emulsifiers have been used in chocolate for a long time for several crucial reasons: texture enhancement, stabilization, flow properties, reduced viscosity, and cost efficiency. Emulsifiers are critical in guaranteeing a desirable texture, stability, and workability of chocolate, enhancing the general quality of the product (McClements, 2004). Emulsifiers contribute to chocolate's smooth texture, stability, and overall consistency, ensuring it tastes delightful and has a visually appealing appearance. Several common emulsifiers used in chocolate production include:

Polyglycerol Polyricinoleate (PGPR, E476) reduces the viscosity of chocolate, facilitating smoother processing during various production stages like moulding and enrobing. PGPR contributes to chocolate's overall quality and appeal by promoting easy handling, texture refinement, and stability maintenance. It substitutes cocoa butter, ensuring economic efficiency without compromising the delectable texture and stability of the final chocolate product.

Sorbitan Esters are indispensable emulsifiers in chocolate production because they prevent ingredient separation, creating a stable emulsion. They also ensure the homogeneous blending of cocoa solids and fats, inhibit fat crystallization, and preserve the desired texture over the product's shelf life.

Distilled Monoglycerides (DMG) are vital contributors to the art of chocolate making. These emulsifiers are essential for creating a stable emulsion, guaranteeing the seamless incorporation of cocoa solids and fats. DMG inhibits fat crystallization, preserving the chocolate's desired consistency over time and enhancing the overall texture for a creamy and delightful mouthfeel.

Highly complex chocolate

The resulting sensory perception of cocoa is linked to many diverse components, making its flavour highly complex. Both non-volatile and volatile compounds contribute to the overall flavour profile of cocoa and cocoa-derived products. Over 600 odour compounds have been reported to be found in cocoa and chocolate (Aprotosoaie et al., 2015). The aroma composition

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of cocoa products is tightly related to the unique post-harvest processing conditions and the variety and origin of the cocoa itself.

Among the non-volatile compounds in cocoa, alkaloids and polyphenols arguably have the highest impact on flavour perception, as they are linked to bitterness. The polyphenols in chocolate, derived from cacao beans, are believed to contribute to cardiometabolic health benefits by modulating blood pressure and lipid profiles. (Tan et al., 2021). Additionally, polyphenols are associated with astringent sensations and contribute to green and fruity flavours (Noor-Soffalina, 2009). Moreover, proteins and carbohydrates are non-volatile compounds essential in forming volatile aroma compounds during the drying, roasting, and conching processes through Strecker degradation and a Maillard reaction (Guzmán Penella et al., 2023).

On the other hand, volatile aroma compounds found in cocoa products include esters, alcohols, acids, and phenols, mainly derived from the fermentation and drying processes. These compounds tend to be linked to sweet, sour, fruity, and floral notes, except for phenols, which may convey smoky and other undesirable hints (Jinap et al., 1998).

Chocolate also contains the following compounds

- Aldehydes (2-methyl butanal, 2-methyl propanal, 2-phenylacetaldehyde, 3-methyl butanal acetaldehyde, benzaldehyde)
- Esters (1,3-diacetoxypropane, diethyl butanoate, ethyl acetate, isoamyl acetate, propylene glycol diacetate) alcohols and phenols (3-methyl butane-1-ol pungent, 2,3-butanediol (isomere A), 2,3-butanediol (isomere B), 2-methyldopa-1-ol, 2-phenyl ethanol aetoin buttery, ethanol - furfuryl alcohol, pentan-2-ol
- Ketones (acetoin acetate, acetol, acetophenone, butane-2,3-dione)
- Pyrazines (2,3,5,6-tetramethylpyrazine, 2,3,5-trimethyl pyrazine, 2,3-dimethyl pyrazine)
- Other (2,2,4,6,6-pentamethylheptane, 2-acetyl pyrrole, acetic acid, butyrolactone, decane, dimethyl sulfide, toluene (Guzmán Penella et al., 2023).

Pyrazines, aldehydes, and ketones products resulting from Maillard reactions are other volatile compounds of interest.

Pyrazines are aromatic compounds with the formula C_4H_4-n$R_n$$N_2$ (where R represents an alkyl group). Pyrazines bearing methyl substituents, such as 2,3-dimethylpyrazine, exhibit a

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nutty aroma. At the same time, trimethylpyrazines and tetramethylpyrazines are associated with cocoa and coffee scents, respectively. Additionally, particular ketones and aldehydes significantly influence chocolate's flavour profile; for instance, 2- and 3-methyl-butanal contribute to a malt or chocolate aroma, and phenylethanal imparts a honey-like scent. Still, pyrazines are usually associated with the expression of nutty, earthy, roasted, and green notes (Rodriguez-Campos et al., 2012).

Chocolate includes chemicals like – phenylethylamine (PEA), anandamide, theobromine, caffeine, serotonin, phenolics, xanthenes, histamine, thyphylline etc.

Phenylethylamine (PEA) is an organic compound with the chemical formula $C_8H_{11}N$. The phenylethylamine structure is also integrated into more complex ring systems, such as the ergoline system in LSD and the morphinan system in morphine.

It acts as a neurotransmitter in the human central nervous system. Phenylethylamine has pharmacological properties similar to those of amphetamine. It is often called a Love drug because the brain releases this natural alkaloid when people fall in love. PEA is a kind of amphetamine with a very short half-life. It helps the production of serotonin, the neurotransmitter dopamine and norepinephrine, a neurotransmitter and a hormone. However, it acts mainly as a neurotransmitter), and generates optimistic and pleasurable feelings (DeLisi et al., 1984). Chocolate contains PEA, but chocolate cannot make someone fall in love because blood levels of phenylethylamine do not increase after eating chocolate, as most of this enchanting compound is metabolized during digestion. PEA is likely to be broken down by monoamine oxidase during digestion, and the trace amounts that survive are too small to affect the brain. Phenylethylamine is present in relatively high concentrations in chocolate (0.4-6.6 micrograms per gram).

Caffeine (theine, methyl theobromine) is a bicyclic molecule derived from the purine ring system. The chemical composition is 1,3,7-trimethyl-1H-purine-2,6-dione. It is an alkaloid drug found in chocolate at low levels (0.1%). Under the guidelines issued by the Food and Drug Administration (FDA), daily intake of up to 400 milligrams of caffeine is safe. Caffeine offers a plethora of health advantages. It stimulates the central nervous system, improves blood circulation in the brain, facilitates serotonin release, reduces fatigue, enhances mood and alertness, and fortifies respiratory and cardiovascular functions. However, owing to different

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metabolisms, caffeine may lead to various side effects, including headaches, jitteriness, restlessness, increased heart rate, or other reactions (Reyes and Cornelis, 2018).

The amount of caffeine in chocolate can vary depending on the type, the cocoa beans' growing conditions, and the source of cocoa. Darker chocolates (bittersweet and semi-sweet) typically contain the most caffeine. Milk chocolate contains less caffeine because it contains fewer cocoa solids, while white chocolate has no caffeine. The interaction between caffeine and theobromine in chocolate affects the psychoactive effects by relieving unpleasant side effects such as jitters, midday crashes, and sleep disturbance. The effect described is commonly referred to as the "entourage effect."

Theobromine's earlier name is Xantheose, a bitter alkaloid of a cacao plant (Jain et al., 2020.) whose chemical formula is $C_7H_8N_4O_2$, which comprises 1.5-2.7% chocolate. Interestingly, theobromine does not contain bromine in its composition. The name is derived from the cacao tree, Theobroma, which translates to 'god drink' in Greek ('theo' meaning 'god' and 'broma' meaning 'drink'). The Mayan people believed chocolate was their gods' preferred beverage. The main methylxanthines in cocoa, chocolate, and certain plant foods are bitter alkaloids, theophylline, and caffeine.

Theobromine and caffeine differ by only one methyl group but have comparable stimulant effects on the human brain. It is highly fat soluble, with levels peaking in the plasma 1–2 h after ingestion. Recognized (Scholey and Owen, 2013) as an antagonist of the adenosine receptor and inhibitor of the phosphodiesterase, this white crystalline powder has multiple uses, including bronchodilation, antitussive, neurostimulation, cardiac stimulant, vasodilation, muscle relaxation, diuretic properties, anti-inflammatory effects, antitumoral activity, and cardiovascular protection (Carbajal-Valenzuela et al., 2020). The content of theobromine is around 200 mg per 100 g of milk chocolate, and the darker the chocolate, the higher the concentration.

Anadamide is a lipid. The origin of the name anandamide might be a clue to its effects - Ananda is Sanskrit for "bliss". Anandamide is an N-acylethanolamine 20:4 resulting from the formal condensation of the arachidonic acid's carboxy group with the ethanolamine's amino group. This endocannabinoid has a role as a neurotransmitter, a vasodilator agent and a human blood serum metabolite. Anandamide is an endogenous cannabinoid receptor agonist. Anandamide works on two cannabinoid receptors, provoking euphoria, increased appetite, and

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short-term memory deficits. The two most abundant endogenous cannabinoids, N-acyl ethanolamines (NAEs) found in chocolate (N-oleylethanolamine and N-linoleylethanolamine), inhibit the degradation of anandamide without activating brain cannabinoid receptors (Beltramo and Piomelli, 1998.) This observation suggested that these compounds might enhance the pleasurable properties of chocolate by causing non-metabolized anandamide to accumulate at its action sites. Di Marzo and co-workers (Di Marzo et al., 1994) have tested the role of endogenous cannabinoids in chocolate. Based on their findings, they deduce that the levels of NAEs and other cannabinoid-related compounds in cocoa are significantly lower than what would be needed if ingested orally to reach the bloodstream and induce noticeable cannabis-like effects. Therefore, tiny amounts of anandamide in cocoa could be explained as processing artefacts.

Types of chocolate

There are many types of chocolate, which can be classified into various groups depending on their color, composition, uses, and flavor potential.

Milk chocolate

Milk chocolate is sweet chocolate that contains milk powder or condensed milk. Milk chocolate is light brown in colour, has a creamy texture, and has a sweet flavour. It is widely regarded as the most popular type of chocolate (Minifie, 1989). Renowned for its smooth and velvety texture, milk chocolate is known for its mild, sweet, and creamy flavour. It is crafted by blending chocolate liquor (cocoa solids and cocoa butter) with sugar and milk. An emulsifier like soy lecithin is occasionally included to augment its smooth consistency. FDA defines milk chocolate composition as at least 10% chocolate liquor, 3.39% milk fat, and at least 12% milk solids. Milk chocolate is milder and sweeter. The cacao % (amount of actual cocoa bean used) is between 35% to 55% cocoa mass, 20% milk powder, and 20% to 25% sugar. Milk chocolate typically offers a flavour profile characterized by sweetness and chocolate richness, with hints of cooked milk and caramelized sugar, followed by a subtle vanilla undertone. It is notably sweeter and possesses a softer texture compared to dark chocolate. However, it falls slightly short in sweetness and softness compared to white chocolate (The Chemistry of Chocolate).

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When stored properly, milk chocolate maintains its quality for approximately 16 months. It is an excellent choice in baking when a milder chocolate flavour is desired, as demonstrated in recipes such as chocolate waffles. Due to its higher sugar and milk solid content, milk chocolate should not be substituted for semi-sweet chocolate in recipes. Milk chocolate is optimal for crafting dipping and drizzling sauces, pastry creams, and confectionery delights.

White Chocolate

White chocolate comprises a minimum of 20% cocoa butter and 14% milk, with a sugar content not exceeding 55%, along with vanilla and lecithin. These components contribute to the sweet vanilla fragrance associated with white chocolate. Its flavour profile is typically characterized by pronounced sweetness, underscored by rich, sweetened condensed milk and vanilla notes. High-quality white chocolate exhibits a luxurious, velvety texture thanks to its cocoa butter base and elevated sugar and milk concentrations. Notably, white chocolate stands out for its absence of cocoa solids, which are integral to the composition of traditional chocolate varieties. It's dark brown and has a chocolatey taste that we all know and love (Glicerina et al., 2016). White chocolate qualifies as chocolate because the cocoa bean ingredients are derived from the cacao bean. It should not be confused with white-flavored or vanilla-flavored coatings commonly found in lower-quality products. Cocoa butter is an essential constituent of white chocolate. It is relatively expensive due to the high demand for products such as lotions in the cosmetics industry. Consequently, some companies substitute cocoa butter with other vegetable fats to reduce costs. However, these substitutes often fail to meet the FDA's requirement of at least 20% cocoa butter content, preventing them from officially being labelled as white chocolate.

When stored correctly, white chocolate maintains its quality for approximately four months. Besides being delicious, white chocolate is versatile in cooking and baking and a decorative element for drizzling or coating. It is well-suited for creating dipping and drizzling sauces, mousses, pastry creams, and various confectionery delights.

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Blonde chocolate

Blonde chocolate was, for all intents and purposes, a happy accident! It is produced by slowly heating white chocolate, which gives it a golden colour and triggers Maillard reactions. These reactions create a range of flavour compounds, contributing to its caramel-like flavour (Liu et al., 2022). It was discovered by chance in 2004 in Valrhona by a pastry chef, Frédéric Bau when he accidentally left some white chocolate in a bain-marie for a few hours. The chocolate went through a Maillard reaction. Both the Maillard reaction and caramelization involve a chemical reaction that causes browning. However, while caramelization only impacts sugars, the Maillard reaction involves amino acids. Bau found that his white chocolate took on a pale brown colour with irresistible butterscotch, toffee, and shortbread-tasting notes, unlike any chocolate he had eaten before. Because Bau’s blonde chocolate had been created by mistake, it took chocolatiers eight years to reproduce the treat and master its nuanced flavour profile. Although blonde chocolate undergoes the Maillard reaction, it is often mistakenly called 'caramelized chocolate' or even 'toasted chocolate'. And it's not hard to see why. With its golden caramel colour and depth of flavour, brimming with toasted notes, it has a fuller taste than traditional white chocolate, which tends to be subtle and delicate.

Dark chocolate

Dark chocolate is crafted by adding fat and sugar to the cacao mixture. Dark chocolate encompasses a variety of cocoa contents, ranging from 35% to over 85%. With higher cocoa content, chocolate has less sugar and a more pungent, bitter taste. This kind of chocolate, characterized by its distinctive dark brown colour, is in second place in popularity among consumers. Frequently, it is called black or semi-sweet chocolate because it is significantly less sweet than milk chocolate (Glicerina et al., 2016). Recently, dark chocolate has gained popularity due to numerous articles highlighting its health benefits. Its composition is relatively simple, typically comprising two primary ingredients: chocolate liquor and sugar. Occasionally, small amounts of vanilla and soy lecithin, an emulsifier, are added. Most high-quality dark chocolate is free from added dairy, making it an excellent choice for vegans. The absence of

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dairy and reduced sugar content contributes to its firmer texture than milk and white chocolate, resulting in a satisfying snap when adequately tempered.

The flavour profile of dark chocolate varies widely depending on its cocoa content. It often boasts a slightly sweet and chocolatey taste, accompanied by hints of baked brownie, red fruit, and brown spice like cinnamon or allspice. Its robust chocolate-forward flavour makes it perfect for baking, particularly when a rich, chocolatey flavour is desired, as showcased in recipes like classic brownies or decadent chocolate bourbon maple pecan pie.

Dark chocolate has been rediscovered because of its health benefits, making it a preferred snack choice among health-conscious consumers. Dark chocolate is recognized as a functional food due to its anti-diabetic, anti-inflammatory, and anti-microbial properties. Additionally, it provides protection against cardiovascular diseases, certain cancers, and brain-related disorders such as Alzheimer's and Parkinson's (Samanta et al., 2022). When stored correctly, it maintains its quality for approximately 20 months. In contrast to other chocolate varieties, dark chocolate exhibits a more pronounced and bittersweet flavour profile. It is typically classified into two primary types: bittersweet chocolate and semi-sweet chocolate. The FDA stipulates that dark chocolate must contain a minimum of 35% cacao and less than 12% milk solids, leaving manufacturers accountable for categorizing their products as either bittersweet or semi-sweet. Bittersweet chocolate typically contains a higher cocoa percentage than semi-sweet and tends to be less sweet.

Dark chocolate is especially well-suited for recipes where chocolate takes centre stage, such as ganache, mousses, truffles, and puddings.

Bittersweet chocolate

Bittersweet chocolate is mainly composed of chocolate liquor (about 33% of the final mass), cocoa butter, vanilla, and sometimes lecithin. The sugar content is less, and the liquor content is more than semi-sweet chocolate. People are increasingly interested in bittersweet chocolate as they learn about cacao and cocoa percentages (https://www.lakechamplainchocolates.com/types-of-chocolate/). The rise in popularity of this type of chocolate, also known as extra-dark chocolate, occurred when people started advocating for dark chocolate with a cocoa content of over 70% for maximum health benefits. The high

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cacao content gives the chocolate a rich flavor profile, reducing sweetness and imparting a slightly dry or crumbly texture. Bittersweet chocolate is darker than milk and semi-sweet chocolate on the chocolate spectrum. Still, it is less dark than authentic dark chocolate. Bittersweet baking chocolate is excellent for balancing sharp and sweet chocolate notes.

Semi-sweet chocolate

Semi-sweet chocolate typically contains approximately 50-60% cocoa solids, with the remaining portion comprising sugar and potentially small amounts of lecithin, vanilla, or other flavourings. (https://www.lakechamplainchocolates.com/types-of-chocolate/)

Although semi-sweet chocolate contains less sugar than milk chocolate, its sugar content is higher than most dark chocolates. Cocoa butter is mainly responsible for semi-sweet chocolate's smooth texture and glossy appearance. Lecithin is an emulsifier that smoothly blends cocoa and cocoa butter. Vanilla is often added to enhance the chocolate's flavour, offering a moderate level of sweetness that strikes a balance between the inherent bitterness of cocoa and the added sugar. Semi-sweet chocolate has a more robust, less sweet taste than milk chocolate, making it well-suited for desserts that do not require an overpowering chocolate flavour.

When baking, bittersweet and semi-sweet chocolate can be swapped depending on the recipe and personal taste preferences.

Raw chocolate

Unprocessed chocolate, commonly known as raw cacao, is consistently dark and contains at least 75% cacao content. Raw chocolate has not undergone processing, heating, or blending with other ingredients. In its production process, the "raw" chocolate is not exposed to high temperatures, cocoa beans are not subjected to roasting, and the chocolate conching temperature does not exceed 45 °C, which enables preserving its valuable traits. It is available in countries where cocoa is cultivated and, to a lesser extent, in other regions. Raw chocolate is often promoted as a healthier alternative. Raw chocolate includes numerous essential antioxidants, minerals, and vitamins- proteins, iron, and fibers (Urbańska et al., 2019). Improperly tempered chocolate may exhibit whitish spots on its dark surface, referred to as chocolate bloom. This

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indicates that sugar and/or fat have separated due to inadequate storage. While unappealing in appearance, chocolate bloom is not harmful and can be consumed safely.

Ruby Chocolate

Belgian chocolate maker Barry Callebaut discovered Ruby chocolate. This variety developed in 2004 and was introduced to the public in 2017. The exact production process of ruby chocolate has yet to be discovered. However, in 2012, Callebaut obtained a European patent for a specific "process for producing cocoa-derived material". Unlike traditional white chocolate, it obtains its colour from a particular type of cocoa bean known as the ruby cocoa bean, typically cultivated in regions such as Ecuador, Brazil, and the Ivory Coast. As opposed to regular chocolate production, either under fermented cocoa beans, not fermented for more than three days, or preferably, unfermented cocoa beans, the so-called “Lavados” beans, meaning “washed” beans, are used (Tuenter et al., 2021). This chocolate stands out among its counterparts, featuring a distinctive red-pink hue. With a 47.5% cacao content composition and 26.3% milk, ruby cacao boasts intense fruity flavours and refreshing sour notes. Ruby chocolate's flavour profile is sweet and fruity with fresh, tart notes and a red-pink colour despite having no added colours or fruit flavourings. This trendy new type of cacao is great for creating bold, fruit-forward chocolate treats and colourful chocolate confections. Rubbery cacao can have a shelf-life of about 12 months (https://www.lakechamplainchocolates.com/types-of-chocolate/).

Gianduja

Gianduja refers to European-style chocolate crafted from a chocolate and nut paste blend. While hazelnut paste is the most prevalent, almond paste can also be used. It is available in both milk and dark chocolate variations. The history of Gianduja starts during a Napoleonic lockdown. During the Napoleonic wars, Napoleon and Nelson's battle led to a European-wide lockdown. Nelson and the British Navy enforced a blockade on European ports in response to Napoleon's trade war called the "Continental System". This lockdown put an enormous strain on cocoa supplies. Michele Prochet, a chocolatier from Turin, blended his limited chocolate with hazelnuts from Piedmont's hills to make it go further. Due to limited resources, he had to rely on easily accessible, regional ingredients to extend his chocolate production. The birth of Gianduja

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during the Napoleonic lockdown was a response to the high demand for chocolate from customers (https://meltchocolates.com/gianduja-carnival-what-is-gianduja-and-its-connection-to-carnival/).

Gianduja chocolate is a versatile ingredient, suitable for flavouring or as a replacement for milk or dark chocolate. Like conventional chocolate, it is produced in plain and milk versions. It may include other nuts, such as almonds.[18] In bar form, Gianduja resembles conventional chocolate, albeit noticeably softer because of the hazelnut oil content. It maintains a smooth consistency at room temperature, allowing it to be rolled or cut. Yet, it is too soft for moulding chocolates (Medrich, 2015).

Couverture Chocolate

Couverture chocolate is a quality chocolate favoured by professional bakers and confectioners; it is renowned for its superior quality. It boasts a high cocoa butter content comprising at least 30 percent and a significant proportion of chocolate liquor. The abundance of cocoa butter imparts a glossy appearance to the chocolate and ensures a firm snap when expertly tempered. Couverture chocolate melts smoothly, making it ideal for coating, dipping, and enrobing. It is the preferred chocolate for tempering and enrobing candies. It is not recommended for baking. Couverture chocolate is offered in dark, milk, and white chocolate options. It is commonly found in drop form but can also be purchased as a bar or slab.

Couverture chocolate's composition must meet specific criteria. Both couverture and milk chocolate must contain identical amounts of cocoa butter and cocoa solids. Still, couverture chocolate requires at least 31% cocoa butter and 2.5% fat-free cocoa solids. (https://www.valrhona.com/en/l-ecole-valrhona/discover-l-ecole-valrhona/chocolate-terminology/couverture-chocolate). The importance lies in cocoa butter, which provides couverture chocolate with its glossy appearance and smooth consistency.

Chocolate bloom

Chocolate bloom is a white or greyish coating that can form on chocolate. Although it may appear and feel unappealing, chocolate that has bloomed is typically safe for consumption. There are two forms of chocolate bloom: fat bloom and sugar bloom.

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Fat bloom occurs when chocolate undergoes fluctuations in temperature. The process of fat bloom involves the separation of cocoa butter from cocoa solids when it melts. As cocoa butter solidifies, it migrates to the chocolate's surface, producing grey streaks or white blotches, known as fat bloom. Poor storage conditions, particularly temperature fluctuations, often contribute to fat bloom. Chocolate is sensitive to temperature changes and should be stored in a cool, dry environment (Indiarto et al., 2021). While fat bloom can alter the chocolate's colour and sometimes its texture, typically making it soft and crumbly, it remains safe to consume and usually does not affect the taste.

When fat bloom occurs, the chocolate can be safely remelted and tempered. Conversely, sugar blooms arise when chocolate encounters moisture, resulting in water, either in dampness or condensation, impacting the chocolate. This causes the sugar to segregate and form a sugar bloom, giving the chocolate a white and grainy appearance. Preventing sugar bloom necessitates keeping chocolate shielded from moisture and storing it in a cool, dry location, refraining from refrigeration or freezing.

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