Inside Cocoa

Factors affecting aroma development and characteristics, and potential for health claims in applications

Sophie Rochard and Gerard George, Cargill Flavor Systems; photos courtesy of Cargill

Cocoa (*Theobroma cacao*) taste is one of the most elementary and lovable flavors worldwide. The flavor character of this so-called "food of the gods" depends on the basics: origin and genetic makeup of the cocoa bean, and how it is handled first in the fields (fermentation and drying) and later in industrialization (roasting and extraction). Beyond the subtlety of the flavor, like most ingredient superstars, cocoa is now also linked with health benefits from antioxidants and, more specifically, polyphenols.

Specifying, developing and using cocoa for use in the food/flavor industry requires deep ingredient knowledge and chocolate flavors expertise. This includes experience in producing regions. At-origin access provides crop analysis and farmer training to ensure that the best methods of growing, harvesting and fermentation are applied. Back in the principal consuming regions, extensive applications counsel can aid in advising where to source cocoa beans to produce the most suitable flavors for different applications. The authors of this review will herein draw upon this type of expertise.[a]

Flavor Development

Flavor potential starts at the very beginning—by growing trees with the best genetics, combined with optimum growing conditions. Cocoa trees take about four to five years before they bear fruit.

The three major genotypes of cocoa are:

- Forastero: A native of the Amazon basin which represents 70% of commercially grown product worldwide, mainly grown in West Africa, South America and Asia.
- Criollo: Considered the most aromatic—but also the most expensive—cocoa. It is native to Central America and accounts for only 5–10% of world production.
- Trinitario: A natural hybrid of Criollo and Forastero.

Pods grow on the branches and trunk of the tree and take about six months to ripen. Inside each pod are between 20 and 40 beans topped with a syrupy pulp consisting of 85% water and 10–12% combined glucose, fructose and citric acid (**T-1**).

After harvesting, the beans, which are at this stage covered with pulp, are fermented for three to seven days. This stage is vitally important to flavor development. The most common method is wild fermentation—covering heaps of cocoa beans with banana leaves, or putting them into wooden boxes for fermentation. The biochemical processes that occur during fermentation develop the rich flavor precursors of chocolate. Variations in fermentation can affect the flavor potential of the bean—duration, the process applied, volume of beans processed at any one time and temperature. Of course if the process is not carried out correctly there are negative consequences. For example, the incidence of "slaty" beans that have little chocolate flavor is a direct result of poor fermentation practice.

The beans produced from the fermentation process are known as merchantable beans and are mainly aimed at the European market, whereas nonfermented beans find their way into the North American market. After fermentation,

[a]Cargill's flavors business in the foothills of Grasse has been extracting the essence of cocoa taste since the 1800s.

Typical cocoa bean composition **T-1**

Triglycerides	50–55%
Phenolic compounds	5–10%
Starch	8–10%
Protein	8–10%
Pulp	4–6%
Minerals (iron, magnesium, potassium, phosphorus, calcium)	2–3%
Theobromine	1–2%
Caffeine	0–0.2%
Vitamins	Trace*
Methylxanthines	Trace
Tannins	Trace
Phenylethylamine	Trace
Phytosterols	Trace
Organic acids (acetic, citric, oxalic)	Trace

*Trace = < 0.2%

Volatile components identified in cocoa aroma **T-2**

Acids	55	Pyridines	10
Acohols	27	Oxazoles	150
Aldehydes	27	Thiazoles	8
Ketones	25	Phenols	10
Esters	58	Pyrones	2
Furans	19	Quinoleines	1
Hydrocarbons	50	Sulfur mol.	16
Pyrazines	97	Nitrogen mol.	12
Pyrroles	21	Lactones	6
Quinoxalines	10	Ethers	13

the beans are roasted for 15–40 minutes at 100–135°C. Roasting provides the traditional opportunity to create flavor compounds by Maillard reaction during processing. Roasted cocoa beans are ground into a paste called cocoa liquor, which is then further processed to remove most of the fat (cocoa butter). This resultant solid material is called cocoa press cake. These cakes are crushed to form cocoa powder. The processing can be altered to produce cocoa powders of different compositions and with different levels of fat.

Cocoa powder and cocoa nibs (roasted broken cleaned cocoa beans) are the principal raw materials used to make cocoa extracts as flavor preparations. Like most extracts, cocoa powder or nibs are mixed with an extraction solvent at temperature and sometimes pressure to produce a liquid syrup that is first filtered and then concentrated to different levels. The concentration level of these extracts is normalized by the determination of the cocoa equivalent based on the content of some specific constituents, e.g. caffeine, theobromine or dried matter. For specific applications, and in order to promote better solubility, an additional supporting solvent such as propylene glycol (PG) or glycerol can

*UTZ (*www.utzcertified.org*) certified cocoa beans; the UTZ program works to "achieve a more sustainable cocoa sector."*

A cocoa powder cake used for cocoa extracts.

be added as a carrier after concentration. The end result is a polished raw material that meets the needs of food and flavor customers.

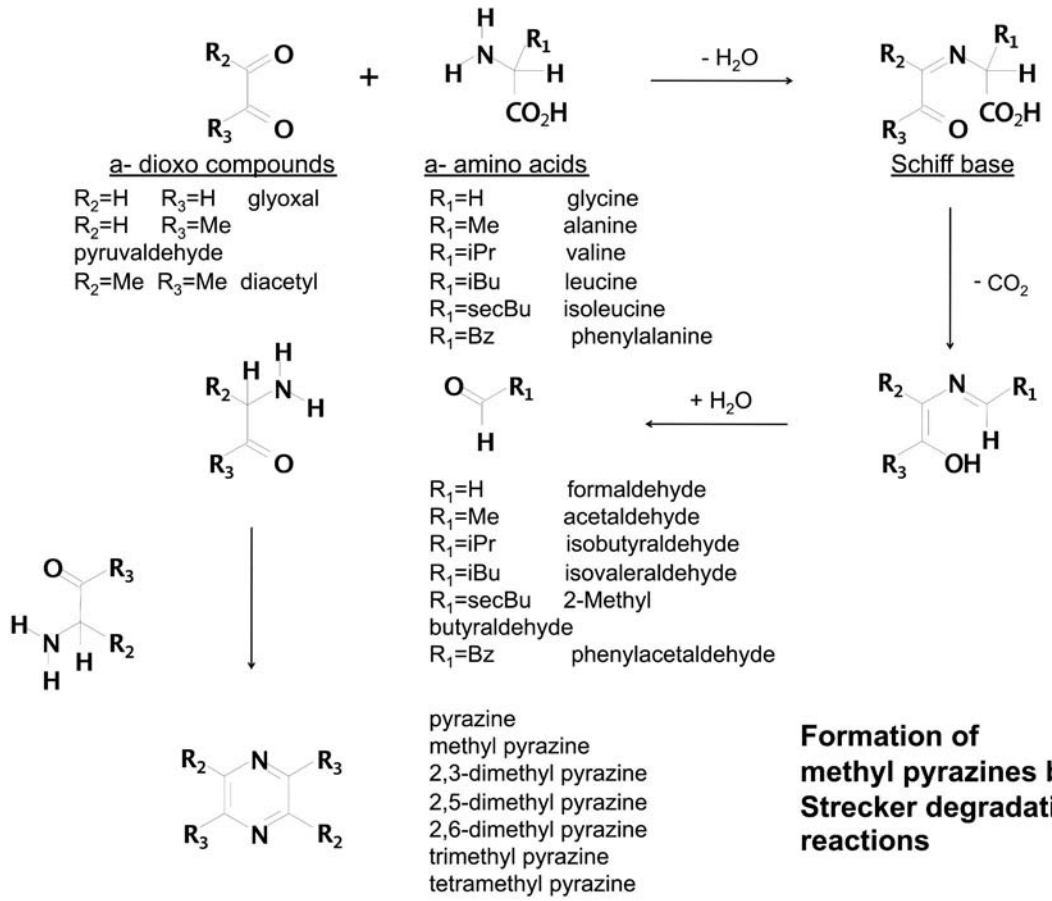
Cocoa Flavor Constituents

Almost 500 volatile components have been identified in the aroma of cocoa (**T-2**). Character impact compounds such as aldehydes and pyrazines are produced through a complex pathway involving non-enzymatic browning reactions, specifically Strecker degradation reactions. First, during fermentation, proteins are degradated into amino acids by an enzymatic proteolysis. The main amino acids found in fermented cocoa beans are: alanine, glycine, valine, leucine, isoleucine, threonine, phenylalanine, thyrosine and methionine. Then, in roasting, these amino acids react through Strecker degradation reactions with α-dioxo compounds resulting from sugar fragmentation and dehydration reactions (**see F-1**).

The aldehydes produced during these Strecker degradation reactions react through cross aldolization-crotonization reactions to form a set of α-substituted, α,β-insaturated aldehydes. These are extremely powerful, with a characteristic cocoa flavor sometimes described as "cocoa aldehydes." The two most important of these aldehydes result from the aldocondensation of the phenylacetaldehyde with the acetaldehyde and the isovaleraldehyde (**F-2**).

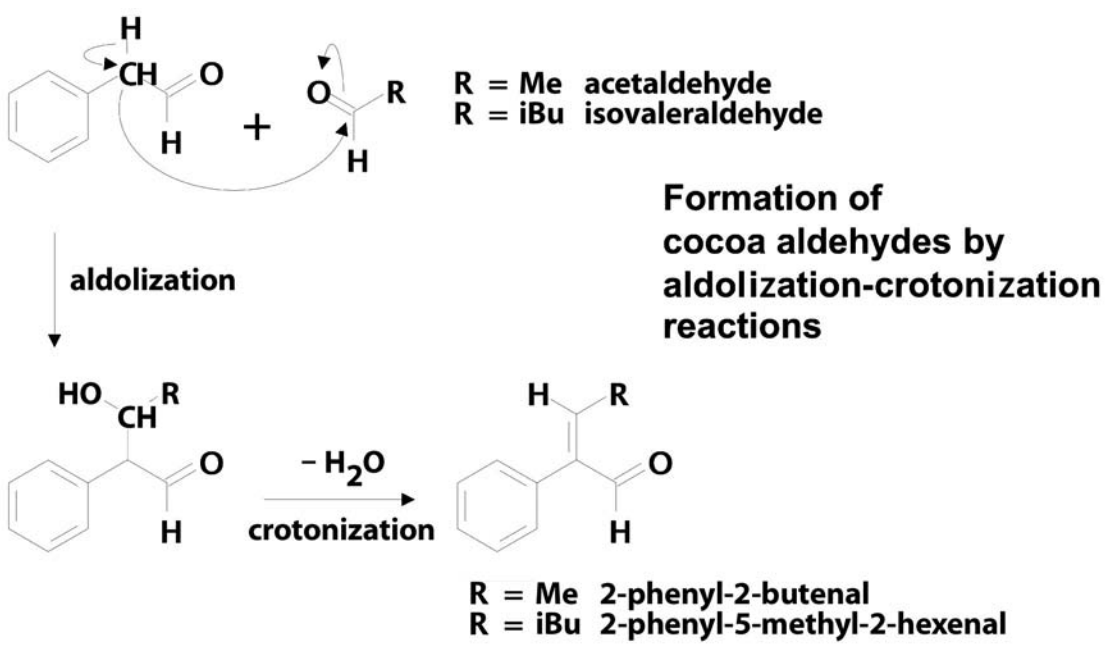
Formation of methyl pyrazines by Strecker degradation reactions

F-1



Formation of cocoa aldehydes by adolization-crotonization

F-2



The Alkalization Process in Cocoa

A cocoa powder-producing process known as Dutching was developed in the nineteenth century in the Netherlands—hence the name—and is permitted under most food regulations. The process produces cocoa powder with:

- A milder taste, mainly resulting from the neutralization of the light acidity of fermented cocoa beans.
- Reduced astringency and a darker color, mainly due to the polymerization of the flavonoids (epicatechin). The increased chromophoric groups in so polymerized molecules generates darker colors.
- An enhancement of flavor aspects (cocoa and bouquet).

Different variant methods can be used, but generally raw beans—known as nibs once they are fermented—are treated with an alkali ingredient (potassium carbonate/potash) towards a standardized pH-level at temperatures > 90°C. The so-obtained alkalized nibs are then processed following the traditional method: grinding of the nibs, refining of the paste, pressing of the cocoa liquor, blending and pulverizing of cocoa cakes.

For more on cocoa flavor, see **The Alkalization Process in Cocoa.**

Application and Organoleptic Descriptors

The start of a cocoa or chocolate flavor is a cocoa extract. Concentrated extracts aim to enhance and bring uniqueness in cocoa based fillings, chocolate ice cream or dairy products. Their complexity, richness and longevity is also appreciated in soy-based products or protein mixes in combination with cocoa powder. In the beverage and fragrance industries for which clear soluble solutions are mandatory, cocoa distillates and absolutes provide distinctive and full impact. Lastly, PG or glycerol cocoa extracts at low dosage with infusions can broaden the sensory wheel.

Procedures for organoleptic evaluations differ between cocoa producers, chocolate manufacturers or flavor companies. Basic properties all feature sweet, bitter, acid and astringent. More detailed organoleptic descriptors might include malty, honey, vanilla, dried fruit, alcoholic, cocoa powder, roasty, smoky, woody and earthy.

The Future of Cocoa

In addition to its organoleptic character, there are known and potential health benefits relating to cocoa. These benefits derive from its significant content of polyphenols. The polyphenol content of cocoa has received much press. Polyphenols are mainly constituted by catechin and epicatechin which are known for their antioxidative properties. Thus, polyphenol-rich cocoa extracts have the potential to deliver powerful health benefits.

In fact, cocoa can be regarded as a micro psychoactive cocktail as a result of traces of other minor constituents:

- Two alkaloids:
  1. Caffeine, present only in modest quantities.
  2. Theobromine.
- Anandamide: A cannabinoid neurotransmitter also found in the brain.
- Vitamins A, B, Niacin (Vitamin B3 or PP) and E.
- Phenylethylamine: This is perhaps cocoa's key ingredient. Related to amphetamines, this molecule—also known as the "love chemical"—raises blood pressure and blood glucose levels. For this reason it can be regarded as a psychoactive drug with stimulant effects, which explains why it can initiate migraine attacks. Its concentration in some cocoa extracts can reach 50 ppm.

Simple cocoa taste has been popular since the time of the Mayas and Aztecs. At current price levels that encourage reinvestment by farmers in the sourcing countries, the future is bright for cocoa taste as a staple of the gods—and consumers—for future generations.

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