

# NUS scientists make caffeine-free ‘chocolate’ with non-cocoa plant

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With cocoa getting more costly and being threatened by climate change, food scientists from the National University of Singapore (NUS) have found ways to make cocoa-free chocolate alternatives taste more like the real deal.

Cocoa alternative from a plant known as carob (*Ceratonia siliqua*) has been touted as a substitute for cocoa chocolate for several reasons, including how it is naturally sweet and also mimics some chocolate-like notes.

This comes amid price surges in cocoa that are reportedly caused by severe supply disruptions in West Africa that account for about 70 per cent of global cocoa production. The disruptions could be due to extreme weather events such as drought, as well as plant diseases.

Carob, in comparison, is a hardy, climate-resilient plant that can thrive in hot and arid climates. It is also caffeine-free and rich in a compound that has been shown to have anti-diabetic effects.

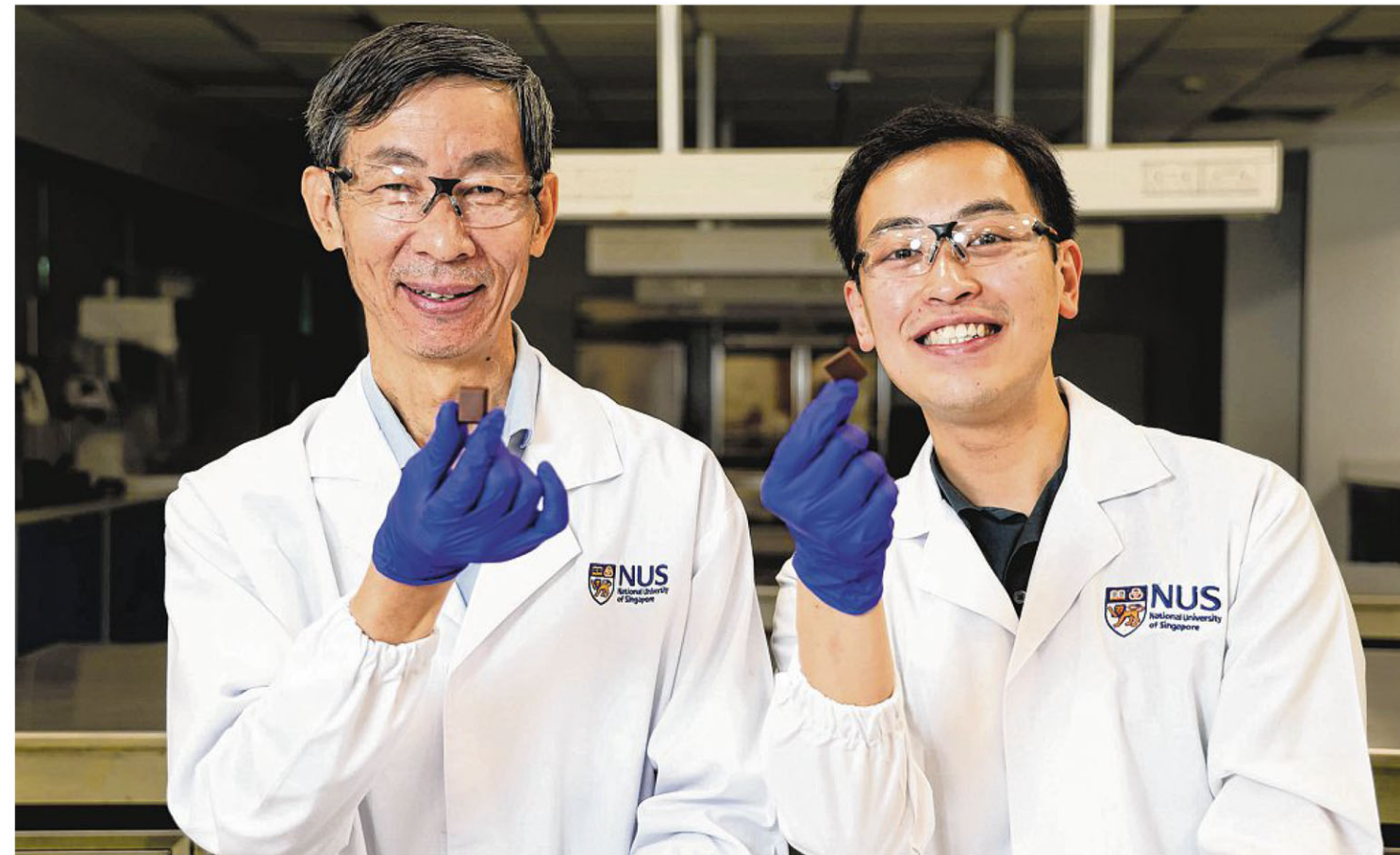
But a major hurdle for its wider adoption lies in its flavour, which mostly still falls short of the cocoa taste. While carob is naturally sweet and has a caramel-like taste, it lacks other flavours such as the bitterness found in cocoa, said the NUS researchers.

“There’s a big gap between current carob-based chocolate alternatives and cocoa chocolate, with missing notes such as cocoa’s bitter, nutty and roasty flavours,” said Associate Professor Liu Shao Quan from the Department of Food Science and Technology (FST) at the NUS Faculty of Science.

Conventional carob-based chocolate alternatives are first made by directly roasting the carob pulp, followed by grinding, refining and conching, keeping the original taste of roasted carob pulp powder mostly intact, said the team led by Prof Liu.

But this “natural original taste” is different from conventional cocoa, and does not appeal to chocolate lovers at large who like the rich chocolatey taste, said Mr Manfred Ku, who is part of the team and a PhD student at NUS FST.

To tackle this, the food scientists



Associate Professor Liu Shao Quan (left) and PhD student Manfred Ku are part of a team from NUS’ Department of Food Science and Technology which has found ways to make chocolate alternatives using carob, a naturally sweet plant that mimics some chocolate-like notes, taste more like cocoa chocolate. ST PHOTOS: HESTER TAN

came up with two techniques to better mimic the taste of cocoa, creating two types of cocoa alternatives of different profiles – bitter and sweet. This is done by using enzymes to alter the profile of substances that affect the flavours of the carob pulp, the main ingredient from the carob plant used to make the chocolate alternative.

The techniques were documented in two research papers – both of which Mr Ku is the first author of – published in June and July separately.

To make the carob chocolate alternative taste more bitter, the NUS team mixed soya protein powder with water and an enzyme, before putting the mixture in a water bath of 50 deg C for six hours to promote the rate of reaction.

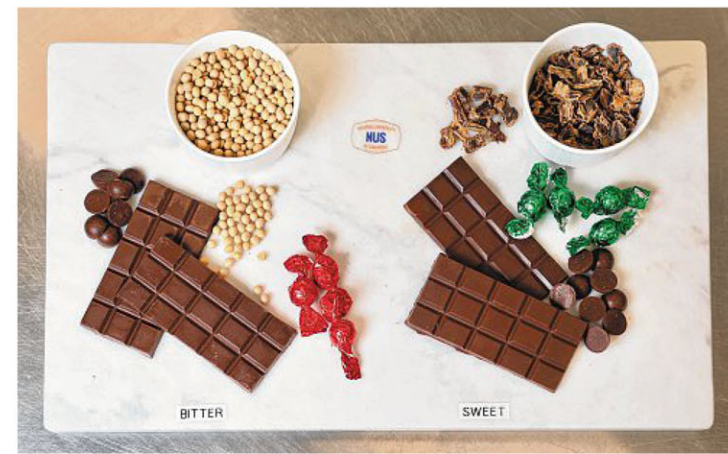
“This is where the enzyme will do its work. Through a process called hydrolysis, the soya proteins

are broken down into smaller fragments,” said Mr Ku. This technique can also balance some of carob’s less desirable odour, which can smell woody to some, he added.

The insoluble parts of the mixture will be removed and the remaining liquid portion is mixed with carob pulp powder. The liquid mixture is subsequently placed in the oven for 24 hours to dry, then roast. Once that is done, sugar and fat are added to the roasted powder before it is placed in a melanger – a stone grinding machine commonly used to turn cocoa nibs and sugar into a smooth paste.

The mixture will then go through tempering – a controlled heating and cooling process that organises the paste into a stable crystal form – before it is left in the refrigerator for 30 minutes to achieve the final product.

To create the sweet cocoa alter-



The food scientists came up with two techniques to create two types of cocoa alternatives of different profiles – bitter and sweet.

native, the NUS team uses a second technique to enhance the sweetness of the carob-based chocolate

alternative. Instead of adding the enzyme to the soya protein, like in the first method, the enzyme is di-

rectly added to the carob pulp powder and water.

The mixture is then placed in a water bath of 50 deg C for 1½ hours to promote the rate of reaction.

Through hydrolysis, the sugars in the carob are broken down into smaller fragments, said Mr Ku. “This will also allow the carob to react differently during roasting to be sweeter and more caramel-like.”

Prof Liu said that while these techniques are not new in biochemistry and science, what is novel is the application of such techniques in transforming the carob into an alternative that tastes more like cocoa chocolate.

The researchers are also looking into other techniques, such as fermentation, to further enhance the flavours of carob during roasting.

Cocoa prices soared in 2024 and early 2025, with the International Cocoa Organization recording a monthly average of US\$10,709.30 (S\$13,880) per tonne in January. While the price has fallen to a monthly average of US\$5,591.21 in November, it is still more than twice the price of US\$2,382.32 in November 2022.

Meanwhile, according to Tridge, a global online platform for the food and agriculture industry, carob was priced at US\$3,170 per tonne in November.

As carob pulp is also a by-product of locust bean gum production – a common thickening agent in the food industry – using the pulp to make a cocoa alternative can also reduce agricultural waste, and help bring down costs for both manufacturers and consumers, said the researchers. The NUS scientists are looking to collaborate with industry partners and commercialise the products.

“By improving carob pulp’s flavour profile, these techniques could encourage confectioners to incorporate carob into food products that require cocoa, such as chocolate bars, cocoa powders, malt drinks, and other cocoa-based products,” said Prof Liu.

“If adopted at scale, this could significantly reduce the chocolate industry’s dependence on cocoa, making supply chains more resilient to climate change and crop disease outbreaks.”

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