

The Maillard Mystery

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THE year 2019 was like no other. Space exploration reached new heights everywhere. In India, Chandrayaan-2, developed by ISRO (Indian Space Research Organization), was successfully launched. In the USA, EHT (Event Horizon Telescope) made history by capturing the first-ever image of a black hole, cheekily described by an astrophysicist as: ‘feels like looking at the gates of hell’. Ironically, this statement ended up describing the year 2019 quite well.

It started with a video that appeared on social media. The haunting images of empty streets and home-confined people in the video seemed to be lifted from a disaster-movie set. Although the video was initially taken seriously by very few, it sent shock waves across the world. The shock soon turned to fear when scenes from it materialised in different parts of the globe and the COVID-19 pandemic shook the world.

Other than the people directly affected by the coronavirus, many have suffered from secondary infections. Only laboratory testing can conclusively identify a patient, but there are many symptoms to look out for.

The traditional flu indicators of fever, fatigue and cough are the primary symptoms of this infection. Among the other indicators, a very useful one is the loss of smell and taste. Since this is not an influenza symptom, it is considered a good indicator of COVID-19. Although there are a few theories, such as swelling inside the nose to cause loss of smell and subsequently taste, the exact mechanism of action is essentially unknown. This is not surprising, since the vast realm of taste is still under constant research and discovery.

After arranging for the basic needs of survival, humans crave to satisfy more refined desires, and what can be more satisfying than a flavourful wholesome meal? The science of satisfaction, which is beyond the mere fulfilment of the body’s calorie requirement, is still an active area of research.

Studies indicate that the hypothalamus in the brain is the antenna that sends off signals indicating the desire to eat and also signalling satisfaction. Endorphins and Serotonin are the molecules that act as the efficient messenger-boys, carrying these signals. They are triggered into action primarily by nutrient imbalances in the body, but also by hormonal fluctuations. The beautifully complex human body, with its numerous sensing mechanisms, is truly a masterpiece of nature.



A dish with ‘browned’ cheese

The neurotransmitter dopamine which is associated with a feeling of well-being is generated in the body both by the opposing actions of sugar consumption and also vigorous physical activity. As indicated by chemical, physiological and social experiments, the link between tasty food and happiness is undeniable. The next frontier is to have a better understanding of what makes food tastier.

In 1912, the French physician Louis Camille Maillard, attempting to solve a complex biochemical puzzle of the time, opened up the door to a completely different mystery: the taste of food. He was experimenting to understand biological protein synthesis. The brown solution produced by heating a mixture of amino acids and sugar in water had a distinct smell — one we associate with the ‘deliciousness’ of freshly baked bread, condensed milk and roasted coffee. The subtle factors which influence our sensory perception of food: its flavour, colour, aroma and taste were being observed in the scientific laboratory for the first time.

A chemical explanation for the enhanced attractiveness of food items after ‘browning’ could now be attempted. The discovery of this set of chemical changes, called the Maillard reaction, marked the first step in an interesting scientific journey involving the human senses, which was until then



A cup of hot coffee



Freshly baked cupcakes

considered to be a more artistic rather than scientific pursuit. So, the distinct paths of science and arts were successfully merging, making way for a better understanding of humans with all their mental and physical complexities.

The cooking of food increases its taste, digestibility and nutritional content. It also destroys harmful plant poisons. Evolution helped

plants survive over-consumption by animals through the development of poisonous anti-nutrients, forcing the animal kingdom to adapt or perish. Dinosaurs, consuming this vegetation were already on the path to extinction much before any geophysical disaster. Birds evolved stronger beaks to remove seed shells, which contain most of the plant poisons. Humans, on the other hand, got saved by the discovery of fire and roasting food before consumption.

A mechanism for the Maillard reaction was published by John E. Hodge, a chemist with the US Department of Agriculture in 1953, but there is still a lot about it that remains unexplained. The Hodge model divides the reaction into three major steps: the Early, Advanced and Final Maillard reactions.

The first step involves a sugar-amine condensation and the Amadori rearrangement to produce amino-ketose compounds. In the second step, the colour of the reaction mixture begins to darken, ultraviolet light is absorbed, and the degradation of

amino acids and sugar takes place. A series of condensation reactions (aldol, aldehyde-amine), polymerisations and formation of heterocyclic nitrogen compounds occurs in the last stage. The large number of sub-reactions taking place in each step leads to the formation of a brown melanoidin-rich solution containing hundreds of compounds, many of which are yet to be characterised.

The study is made even more challenging by the wide range of products possible just by varying simple reaction conditions such as temperature and duration of heating. This chemical cocktail is the holy grail for flavour scientists who carry out experiments to capture the essence of what tickles our taste buds and try to recreate it in the laboratory. The reaction is also of great importance while considering the integrity and nutritional content of heat-treated or cooked food which is stored before use.

The processes of caramelisation, lipid oxidation also take place in the same conditions and cannot be completely ruled out while considering the effect of the Maillard reaction on food. In recent years it has been found that the Maillard reaction is responsible for certain carcinogenic compounds like acrylamide being present in deep-fried and roasted food items. Studies are being carried out to find alternative treatment methods, storage conditions and food items which have a similar flavour but lack harmful Maillard products.

As we often hear, one's gain is another's pain. The Maillard reaction which creates magic in food does the exact opposite in the human body. Ageing, the one natural process which has captivated people down the ages, can be linked to the Maillard reaction.

In 1980, scientists Monnier and Cerami proposed the 'glycation hypothesis of ageing' based on the *in vivo* study of this reaction. Many protein modifications due to the Maillard reaction keep accumulating in the body with time, leading to lower elasticity of cartilage tissues. This can be linked to 'body stiffness' and increased fatigue of old age. Also, higher blood sugar levels in diabetics indicate a greater occurrence of the Maillard reaction explaining a host of problems ranging from cataracts and cardiovascular defects to body inflammation.

Unravelling the Maillard mystery could be exciting in many ways. In food, we could be subjected to unique and yet-undiscovered tasting experiences. In human health, ageing could be understood better. The enhanced satisfaction of eating roasted food compared to the raw counterparts has saved us once in the evolutionary race, maybe it will now help us stay in the race longer. With rapid progress in science and technology and a big dose of optimism, we might even be able to get close to the development of the alchemists' legendary elixir of eternal health and youth!

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