

The Science of Browning: Useful or Dangerous?

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Abstract

The last few years in India, have witnessed an upsurge in the barbeque culture which draws youngsters towards grilled and browned foods. It is no wonder that teens are attracted to the special charred aroma and flavor along with the appealing golden brown colored layer on the foods. This special attraction could be attributed to various factors such as the preparation and cooking method involved, the chemical components of the food, and the different chemical reactions that occur while cooking. The effect of these foods on health has been a subject of huge debate. On one side, they are promoted to be a healthy cooking method that reduces fat content and on the other hand, the chemical products released from these foods have proven to be carcinogenic. Limiting the frequency of consumption of grilled foods and increasing the usage of other safe methods such as boiling, poaching, or steaming will be more beneficial in improving individual health status.

Keywords: Grilled foods; Browning; Maillard reaction; Carcinogens; Health.

Introduction

There has been an increasing trend in barbeque restaurants and grilled food outlets in India recently. The distinct color and aroma of grilled foods that are released as a result of Maillard's reaction is the reason behind the temptations for these foods. Maillard reaction is a set of reactions that occur when food is cooked at low moisture and high temperature, which results in the release of a distinct aroma and browning of the food. This reaction is named after Louis Camille who investigated it in the early nineteenth century. The occurrence of the Maillard reaction can either

be beneficial or harmful due to the production of various components which are usually not present in food naturally, such as furosine, advanced glycation end products (AGEs), acrylamide, heterocyclic amines, and melanoidins. Research has indicated that the Maillard reaction products have certain beneficial properties such as antioxidant, antimicrobial, antihypertensive properties and can also act as a prebiotic thereby favoring gut health. On the other hand, they also reduce the nutritive quality of foods and are associated with chronic diseases such as diabetes, renal disorders, several types of cancer, and Alzheimer's disease. Hence, the science behind the browning reactions and their pros and cons are discussed in this article to gain a clear understanding of its impact.

What is Maillard's reaction?

There is always a huge difference in the flavor and aroma of boiled or steamed foods when compared to roasted or grilled foods. Maillard's reaction is the reason behind the browning of foods and the appearance of the special aroma and flavor in grilled foods that make it extra delicious. The Maillard reaction is a series of chemical reactions

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that occur simultaneously when the sugars and amino acids present in the foods are exposed to high temperatures. This non-enzymatic browning reaction occurs at temperatures above 285°F/140°C. Important reactions in Maillard process includes three stages. The initial stage includes the production of sugar amine condensation products and Amadori rearrangement products that are colorless.

The intermediate stage includes the production of 5-Hydroxymethylfurfural, reductone, and dicarbonyl compounds that are either colorless or yellow colored. The final stage includes the formation of brown colored compounds called melanoidins. The characteristic color in foods like coffee, malt, bread, cocoa, and other roasted foods is the result of melanoidins, which are brown nitrogen-containing high molecular weight pigments.¹

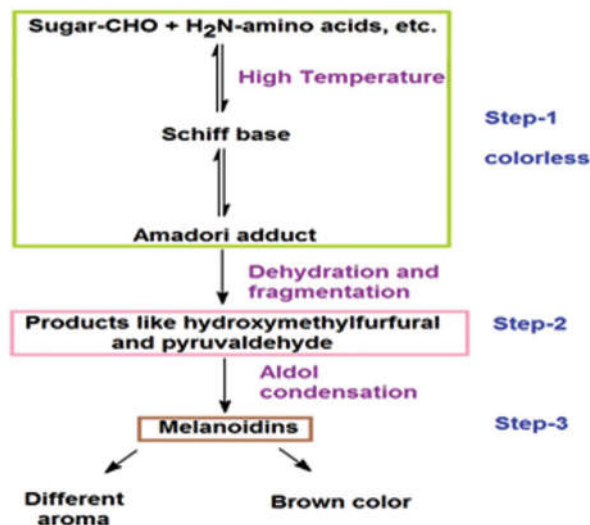


Fig. 1: Diagrammatic representation of "Maillard reaction" in food.²

Even though Maillard reaction occurs in various food stuffs, mainly sugars and amino acids produce a distinct aroma. When temperatures reach above the boiling point, it tends to dehydrate the surface more rapidly. Thus temperature and dryness are the most important factors that play a key role in the Maillard reaction. Maillard reactions can produce different types of flavor compounds based on temperature, time of cooking, presence of air, and the chemical constituents of the food.

Food products using Maillard reactions

Maillard reaction occurs in various foods that are prepared using cooking methods such as grilling, roasting, barbecuing, baking, frying, sautéing,

broiling, searing, and toasting. Color of beer, coffee, chocolate, maple syrup, baked foods like biscuits, brownies, cakes and cookies, grilled meat, chicken, eggs and vegetables, and roasted peanuts are due to the occurrence of the Maillard reaction.

Important Maillard reaction products

Maillard reaction produces certain end products that are not naturally present in foods. The combination of factors such as time, temperature, and composition results in the production of certain end products that can have beneficial properties such as antimicrobial, anti-inflammatory, antioxidant, and antihypertensive or destructive properties such as carcinogenic, mutagenic, or cytotoxic properties.

Important end products of maillard reaction includes

- Acrylamide
- NεFructoselysine (furosine)
- Melanoidins
- Heterocyclic amines
- 5-Hydroxymethylfurfural (HMF)
- Advanced glycation end products (AGE)

Beneficial effects of Maillard reaction

Certain MRPs such as HMF and melanoidin have been proven to have antioxidant properties. Experimental studies too proved the effect of melanoidin on antimicrobial and antihypertensive properties.³ The in vitro and in vivo studies observed the prebiotic activity of melanoidins from bread crust and coffee. Reviews on the current state of knowledge of MRPs on health emphasized the need to improve the knowledge on the impact of MRPs in gut microbiota and the metabolites that are derived from the fermentation of MRPs.⁴

Detrimental effects of Maillard reaction

Glycated Maillard products are associated with metabolic diseases including type 2 diabetes mellitus, Alzheimer's disease, acute renal failure, allergies, polycystic ovary syndrome and oral health. The advanced glycation end products which are also called glycotoxins can increase oxidative stress and its impact on neurodegenerative disorders and early aging is also being explored.⁵ Yamagishi et al. 2015⁶ studied the impact of AGEs and RAGE receptors in cancer. Increased risk of pancreatic cancer was found to correlate with dietary CML-AGE consumption, particularly in male pancreatic cancer patients.⁷ A study conducted with rodents proved that different

levels of acrylamide exposure increase the risk of developing cancer in the pancreas, skin, lung, and thyroid⁸. Maillard reaction products also tend to alter the nutritive quality of the foods by reducing the protein digestibility of the foods.

Control of Maillard reaction

Several studies have attempted the inhibition of Maillard reaction through methods such as modification of reducing sugars and amines and the use of enzymes. Ohmic heating, encapsulation of metal ions, and high-pressure processing are some of the emerging non thermal processing technologies that help in controlling the Maillard reaction in food. Combination of these methods can be a promising strategy in controlling the Maillard reaction products.⁹ Uribarri et al. 2010,¹⁰ reinforce that AGE formation in food occurs with high temperature and low moisture while reducing temperature and heating time, increasing water content and pretreatment of foods with acid tend to reduce these products.

Conclusion

The different Maillard reaction products have proven to be either beneficial or detrimental to health. There is still a need for further research regarding the maillard reaction products in content of Indian foods and the frequency of consumption of these Maillard products. The safe level of intake of these foods to prevent diseases and the level of intake needed for having the beneficial effects need to be established.

To limit the negative effects and benefit from the positive effects of Maillard reaction products, it is essential to maintain a balance and variety not only in the food but also in the method of cooking. Owing to the increase in chronic diseases in India and to improve the overall health status, it is always advisable to use other safe cooking methods such as steaming, boiling, poaching, simmering, etc. which do not produce any harmful toxic compounds. There is an impending need for creating awareness to the public regarding the effect of Maillard reaction products on health and disease.

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