

## Abstract

The MAILLARD reaction, also known as non-enzymatic browning reaction, is present in a large number of biochemical systems from food products to our cells. This reaction, whose overall mechanism is well known, is responsible for the formation of several compounds, called MRP (MAILLARD Reaction Products) for food products. Some of them become aromatic compounds but some of them may also become toxic. When they are endogenous, they are called AGE (Advanced Glycation End products).

The effects of those compounds are various and sometimes not very well known. The most used method to compare a maximum of known MRP is the AMES test, which determines the genetic mutations. Many MRP are potentially dangerous, such as the well known heterocyclic amines from grilled meat or fish. In experimental conditions, they showed some mutagenic or carcinogenic properties. To this, we must add the recent discovery of acrylamide, the origin of which could be due to MAILLARD reactions.

The evaluation of risks or the long-term effect on health of those compounds are hard to predict. As far as the AGE are concerned, they are evidently linked to the aging mechanism of the organism. The main mechanisms are based on links and reticulations between proteins which modify their functional properties and increase their resistance to proteolysis.

Key words: Non-enzymatic browning reaction, glycation, heterocyclic amines, acrylamide, mutation, cancer, Advanced Glycation End products, ageing.

## I. INTRODUCTION

"We are able today to individually carry out the condensation of a defined amino-acid on a defined sugar". Thus Louis-Camille MAILLARD shared his surprising discovery with the Academy of Science on January 8, 1912. Whereas he worked on the protein synthesis by heating, he obtained by chance the aromatic and coloured substances which he identified as being melanoïdins, brown polymers responsible for the colour and savour of many foods: crust of the bread, beer, coffee and torrefied chocolate.

The MAILLARD reaction, also known under the name of nonenzymatic browning reaction, is present in a large number of biochemical systems from food to our cells. If the comprehension of its general mechanism started approximately fifty years ago, new intermediaries are regularly discovered.

The succession of reactions, in the food and biological systems, is common for the initial stage. When the nature of the compounds varies, they are called MRP (MAILLARD Reaction Products) for food and AGE (Advanced Glycation End products) for the "endogenous" compounds. They are a lot of effects and consequences of these compounds and sometimes there are not well known. In the food industry, these reactions are required and controlled to upgrade the qualities of some food. At the same time the nutritional consequences can be significant. It was proven that the reaction involved the destruction of the vitamin C and a reduction in the food value of food, because of the transformation of sugars and the essential amino acids.

The MRP presenting a risk are various and the most known are the heterocyclic amines, isolated from meat or roasted fish, which, under experimental conditions, show mutagen and carcinogenic properties. It is also necessary to add the recent discovery of acrylamide which would be due to the MAILLARD reactions. Very current work examines the risks of development of human cancers.

In-vivo, the MAILLARD reaction seems to be an actor in the process of slow degradation of molecules such as the collagen which is found in the constitution of fabrics of the arteries, the tendons, the skin and the crystalline lens. During the aging process, cells such as neurons, hepatocytes, myocytes, fibroblasts, lymphocytes, would accumulate AGE. The principal mechanisms concern connections and reticulations between proteins thus modifying their functional properties and increasing their resistances to the proteolysis. This phenomenon would be more significant for people suffering from diabetes and it would intervene in the development of the cataracts. For MONNIER (1989), MAILLARD reactions are central to the theory of aging.

In this study we will initially look at the general mechanism of this reaction. From what discovered L.C. MAILLARD, some developed a total diagram being used as a basis for all the current studies. We will thus describe the three stages leading to the formation of made up potentially toxic. Then we will examine a large part of MRP present in food, define their toxicity, and study the means of measuring it. We will note their structures and their effects. Finally we will look at the AGE (in particular the pentosidine), their mechanisms of formation and their effects.

#### **IV. CONCLUSION**

We find in our food as well as in our cells a multitude of compounds resulting from MAILLARD reactions. As regards to the PTG, they are clearly related to the aging mechanisms. Today research continues to find effective inhibitors of these compounds formation.

As for food, we saw that it's possible to detect many compounds, whose mutagen or carcinogenic risks on bacteria or in vitro are proven. Evaluation of their long-term effects and risks for public health is a difficult problem. Apart from medical disasters or professional or involuntary intoxications, it is not possible to specifically affect a compound on a part of morbidity or mortality noted in the population. The advanced figures result most of the time, if not always, from a linear extrapolation: knowing animal mortality with a given amount, we deduce human mortality from it. However this extrapolation does not take into account the possible effects of threshold, related for example to the possibilities of DNA repair or the capacity of sophisticated defence from the organism. It is even more difficult to evaluate the cumulative effects on very long periods of human life, the possibilities of synergy or, on the contrary, antagonism between contaminants.

Of all the compounds resulting from the MAILLARD reaction, the heterocyclic amines seem to be the most dangerous. Exposition with a western type of alimentation, estimated on average at  $1\mu\text{g/day}$ , can contribute to the risk of colon, breast and even of prostate cancer. Without being able to determine precise thresholds, the danger is measured by exposition frequency. Meat and roasted fish at high temperature (above  $110^{\circ}\text{C}$ ) are the principal heterocyclic amines sources. All of the biochemical, biological and epidemiologic studies presented in this study alerted public opinion. They also helped convince the food industry to develop new cooking methods, such as microwave pre-cooking for example. The general public should also be made aware of the risks related to large consumption of grilled food in particular.

For all of these compounds the difficulty is the determination of thresholds. For nutritionists, the greatest health risks to humans are more related to frequent imbalances of global alimentation than traces of the multiple compounds that we can now detect.