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Review

# Analysis and biological properties of amino acid derivates formed by Maillard reaction in foods

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**Abstract**

Maillard reaction products (MRPs), especially early stage MRPs and melanoidins, are currently gaining a lot of attention due to their reported health-promoting properties and their potential to be used as functional food ingredients. It is often not clear which specific biological function is assigned to which MRP, due to the large amount of MRPs formed during the reaction and difficulties in their purification and identification. This paper provides an overview of amino acid derivatives such as Amadori compounds, carboxymethyllysine, pyrraline, cross-linking products and melanoidins, which can be formed by Maillard reaction in foods, their biological properties and the analytical tools commonly employed for their determination.


*Keywords:* Maillard reaction products (MRPs); Biological functions; Analytical tools; Amino acid derivates; Melanoidins

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## 1. Introduction

The phenomenon that foods turn progressively brown during thermal processing (e.g. baking, roasting and frying) or storage is the result of the well-known Maillard reaction [1]. This reaction, also called non-enzymatic browning or glycation, is of outstanding importance for the formation of colour, aroma and flavour precursors in foods. The majority of literature considers the Maillard reaction as a series of subsequent and parallel reactions, which can be divided into three stages: the early, advanced and final Maillard reaction steps. All these reactions can occur simultaneously, affected by each other as well as by reaction

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parameters [2,3]. The compounds involved in these reactions are carbonyl and amino compounds, which include reducing carbohydrates and the free amino groups of amino acids, peptides or proteins [4].

The Maillard reaction can cause both deterioration or enhancement of food quality [3,5–8]. In the past, many scientific works focused on the negative biological effects of the Maillard reaction. The formation of antinutritional and toxic Maillard reaction products (MRPs) has been reported frequently. In vitro studies revealed some harmful effects including mutagenic, carcinogenic [9,10] and cytotoxic effects [11]. Excessive glycation has also been stated to cause the destruction of essential amino acids, decreased digestibility, inactivation of enzymes, inhibition of regulatory molecule binding, cross-linking of the glycated extra-cellular matrix, decreased susceptibility to proteolysis, abnormalities of nucleic acid function, altered macromolecular recognition and endocytosis and increased immunogenicity [12].

The formation of beneficial compounds during the Maillard reaction has also been found and is currently gaining a lot of attention. MRPs containing antioxidant, antiallergenic, antimicrobial and cytotoxic properties are amongst others mostly detected [13–18]. Many studies focussed on the high antioxidant capacity of MRPs in model systems and foods such as beer [19], coffee [20] and bakery products [17]. In those studies it was shown that MRPs can contribute greatly to the shelf-life of heat-treated foods [21]. In vitro studies demonstrated that MRPs may offer substantial health-promoting activity as they can act as reducing agents [22], metal chelators [23] and radical scavengers [24]. It appears that especially low molecular weight MRPs exhibit antioxidant effects in the organism after they get absorbed by the small intestine [13,25,26].

Both consumers and regulatory organisations demand high quality, healthy and safe food (ingredients) while food scientists attempt to develop new processes to obtain these. In addition, there is a great interest in novel healthy food ingredients with a large number of works published in this area. Several papers indicate that the Maillard reaction can be a good means of producing functional food ingredients also since they can be obtained without the use of harmful chemicals and tedious purification procedures. The determination of MRPs with their beneficial or harmful properties is thus of key importance for the production of safe foods and for the development of novel functional food ingredients.

Most of the work focussing on the biological properties of MRPs demonstrate the formation of a large pool of compounds without knowing accurately which one is responsible for a particular biological activity. The analysis of known indicators, as described in this review, can help understand at what stage of the Maillard reaction the health-promoting compounds are produced. Those indicators may then be employed to control the industrial production of these health-promoting MRPs, which

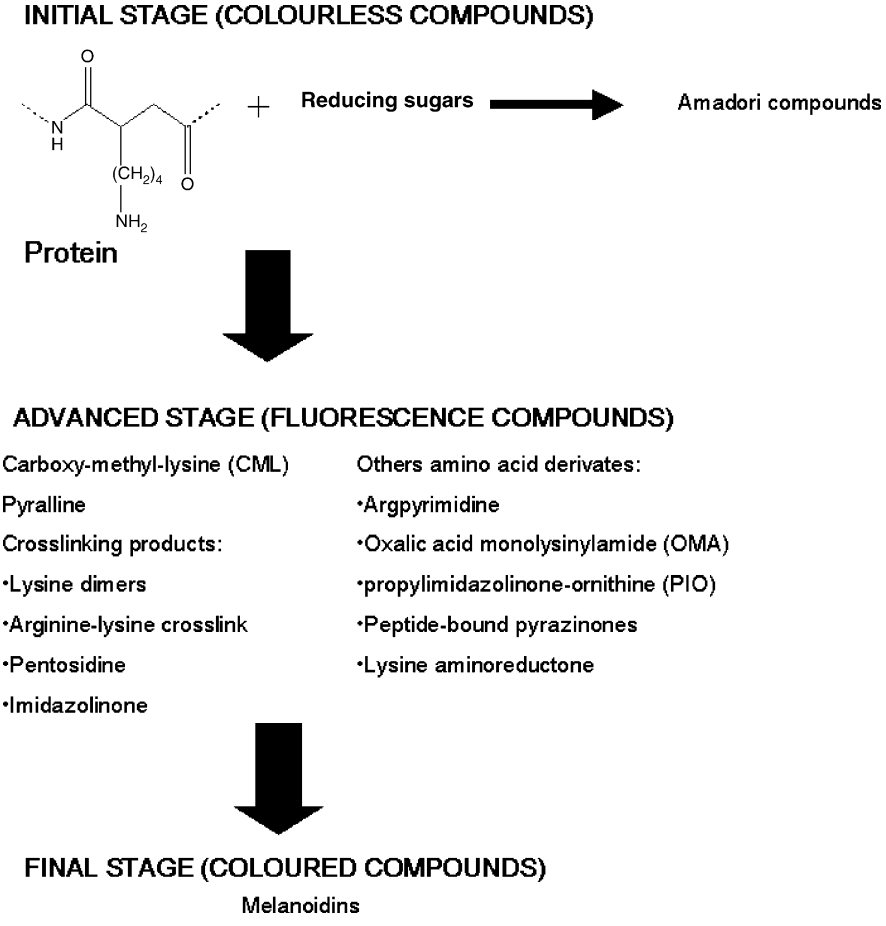


Fig. 1. General scheme of the MRPs formed during the Maillard reaction.