

Hodge J E. Dehydrated foods: chemistry of browning reactions in model systems. *J. Agr. Food Chem.* 1:928-43, 1953.

Theories of browning reactions, including carbonyl-amino, caramelization, and oxidative types, are integrated in review. A unified mechanism for browning in sugar-amine systems is presented, wherein sugar-amine condensation, the Amadori rearrangement, sugar dehydration by β -elimination reactions, and reductone formation are shown to be important intermediary reactions leading to the production of brown pigments in cooked and dehydrated foods. [The SC¹® indicates that this paper has been cited over 155 times since 1961.]

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"Writing this Citation Classic has brought forth memories of some of the happiest days of my life. Highly stimulating was the laboratory work at the Northern Regional Research Laboratory, Peoria, that preceded this review.^{1,2} It began with chance discoveries, after which almost every experiment was helpful in forming hypotheses related to the course of sugar-amine browning reactions. These reactions, collectively called the Maillard reaction, produce brown colors, roasted flavors, antioxidants, and modified textures in many cooked foods and feeds. The writing was mostly an endurance test. Evaluation and correlation of some 200 references that were related to my findings was a year-long chore, because the more interesting benchwork took precedence. Were it not for the constant encouragement and helpful criticism given by my supervisor, Mr. Carl E. Rist, this article might not have been published.

"The freedom allowed for me to pursue unexpected results also contributed to this development. Today's tightly organized research seems to leave little room for serendipity. Then, research was planned as it progressed; dollar values were not preassigned. Now, plans of work predominate, while chance discoveries suffocate. How bench scientists thrive upon serendipity is illustrated here.

"My assignment in 1948 was to condense *D*-glucose as an aldehyde with organic compounds containing active hydrogen on carbon. The general idea was to introduce polymerizable functional groups onto the *D*-glucose molecule. I began with acetylene and sodium in liquid ammonia and later tried bisulfite adducts of *D*-glucose with active methylene compounds. Eureka's were few. Without benefit of the later-developed chromatographic separations, I usually obtained ill-defined sirupy mixtures that never crystallized. One fine day I tried glucose-sodium bisulfite and ethyl malonate with piperidine as the catalyst—crystals at last! But alas, *D*-glucose had condensed with the piperidine. Gloom was soon dispelled, however, when I proved that the supposed glucose residue in this compound had isomerized to fructose. Weakly acidic ethyl malonate had acted as the isomerization catalyst! The available literature indicated that such an isomerization, the Amadori rearrangement, was to be obtained only with aromatic amines.

"Productive research then began. Preparation of various types of glycosylamines, with demonstration of spontaneous isomerization in several instances, together with isolation of new amino reductones from tarry reaction mixtures, led to formulation of a reaction scheme that began the central figure of the cited review.

"The review is popular because browning reactions are omnipresent in processed foods and feeds. Because they affect food acceptance both positively and negatively, knowledge of the chemistry involved is basic to the development of better processed foods. Whereas the scheme for Maillard-type browning reactions was presented from organic chemical reactions as found in model systems, subsequent research by others on foods and natural products showed that the test-tube chemistry was generally valid in biomedicine. The review is used in schools of food science for basic instruction, and the reaction scheme has been reproduced in several later reviews and textbooks. It was reproduced totally as a model review article in the book *Scientific Thinking and Scientific Writing*.⁴ My advisor on formulation of this review, Mr. Rist, now retired, maintains that the numerous citations are the result of assembling scattered information from 200 sources into an orderly scheme—one that provided a 'launching pad' for extensive further research."

REFERENCES

1. Hodge J E & Rist C E. *N*-Glycosyl derivatives of secondary amines. *J. Amer. Chem. Soc.* 74:1494-7, 1952.
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3. Hodge J E. The Amadori rearrangement. *Advan. Carbohydr. Chem.* 10:169-205. 1955.
4. Peterson M S. *Scientific thinking and scientific writing*. New York: Reinhold Publishing, 1961. 215 p.