Assessing the Extent of Degradation in the UV Radiation and Heat-Catalyzed Oxidized Whole Milk Powder: The UV Photoacoustic and Diffuse Reflectance Spectroscopies Versus the Peroxide Value

OTTÓ DÓKA,* ZSOLT AJTONY, DANE BICANIC, and ROB KOEHORST

Department of Physics, The University of West Hungary, P.O.B. 90, 9201 Mosonmagyaróvár, Hungary (O.D.); Institute of Food Science, The University of West Hungary, P.O.B. 90, 9201 Mosonmagyaróvár, Hungary (Zs.A.); Department of Agrotechnology and Food Science, Wageningen University and Research Centre, Bomenweg 4, 6703 HD Wageningen, The Netherlands (D.B.); and Department of Molecular Physics, Wageningen University and Research Centre, Dreijenlaan 3, 6703 HA Wageningen, The Netherlands (R.K.)

The extent of quality loss caused by enzymatic and nonenzymatic browning reactions in milk powders is usually assessed by the chemical methods, among which the determination of peroxide value (PV) is a widely used approach. In this paper, peroxide values obtained from deliberately oxidized (UV irradiation combined with the thermal stress) whole milk powders are compared to the results of photoacoustic spectroscopy (PAS) and diffuse reflectance spectrometry (DRS) in the ultraviolet and visible region. The same samples were also investigated by various methods in the near-infrared (NIR) region. The experimental data suggest a good degree of correlation between the PV and the PAS and DRS data collected at 335 nm.

Index Headings: **Oxidation; Peroxide value; Whole milk powder; Photoacoustic spectroscopy; Diffuse reflectance spectroscopy.**

INTRODUCTION

Lipid oxidation in milk powders, a process responsible for the quality loss, can be promoted or inhibited by a number of factors.[1,2] For example, water activity was found to affect the rate of the auto-oxidative process in milk powder; the low (below 0.1) water activity apparently enhances the peroxide value (PV).[3] On the other hand, Stapelfeld et al.[4] found that at 25 °C the quality of whole milk powder remains insensitive to water activity [illegible] 0.11 to 0.23. At larger water activity (0.31) and higher temperature (45 °C), quality is markedly influenced. The extent of nonenzymatic browning (i.e., the Maillard reaction), due to the effect of light and heat on lactose and protein in the milk powder, was found[5] to be related to the amount of hydroxymethyl furfural (HMF); the latter is usually determined by means of chemical methods.[6]

Since the oxidative process (which affects the lipids) is associated with the changes of peroxide and iodine values, measurements of these parameters provide information about the extent of degradation in a milk powder. Currently used chemical methods for measurements of PV and iodine values are not only time consuming; in addition they involve the use of toxic and environmentally unfriendly chemicals.[6–8]

It is worth remembering that the process of browning is a direct consequence of the oxidation. However, whether or not the oxidation will indeed result in a change of color depends on the experimental circumstances. When the oxidation is accompanied by alteration of the powder's color, the spectrophotometric approach to the assessment of the extent of oxidation might be considered. This paper is concerned with an experimental investigation the main objective of which was to evaluate the potential of photoacoustic spectroscopy (PAS) at UV and visible wavelengths for investigating the changes (caused by oxidation due a combined effect of UV radiation and heat) deliberately induced in whole milk powder.

EXPERIMENTAL

The whole milk powder (manufactured from a bulk milk; composition 27% fat, 26% protein, 5% water, 36% lactose, and 6% ash) used in this study was a product of the Hungarian Dairy Research Institute, Mosonmagyaróvár, Hungary. The manufacturing process includes solely physical processes such as ultra- and diafiltrations, followed by vacuum evaporation and spray drying, and finally spontaneous air cooling down to room temperature. This very fine powder (the size of the particles varying between 10 and 40 μm) is used as an ingredient, a binder, and a texture modifier.

Fresh whole milk powder was oxidized by exposing it to UV radiation and heat in the presence of air. The powder was initially exposed to a low-pressure 40 W mercury source, ST913/41 UV (approximately 75% of the emitted power is at 254 nm), manufactured by Labor MIM, Hun-

Received 14 February 2000; accepted 8 May 2000.
* Author to whom correspondence should be sent.

0003-7028/00/5409-1405$2.00/0