

Physical Chemistry of Roasted and Ground Coffee: Shelf Life Improvement for Flexible Packaging

T. P. LABUZA¹, C. CARDELLI^{1,3}, B. ANDERSON^{1,4}, E. SHIMONI^{1,2}

¹Department of Food Science and Nutrition, University of Minnesota, St. Paul, MN, USA

²Department of Food Engineering and Biotechnology, Technion –
Israel Institute of Technology, Haifa, Israel

³Con Agra, San Diego CA, USA

⁴Department of Food Science, UC Davis, Davis, CA, USA

SUMMARY

Traditionally coffee has been roasted, ground and then vacuum packaged in metal containers for the consumer. In the last ten years or so due to the rising cost of the whole bean and improved packaging materials, manufacturers of FRG coffee have been moving out of the can into plastic containers. This has led to a need for a better understanding of certain process steps as well as the interaction of the coffee with the environment inside a plastic container. Two key areas have been the focus of our research at the University of Minnesota.

The first has been related to the unusual nature of coffee roasting. In this process, due to both pyrolysis of cell materials and the rapid rate of one branch of the Maillard reaction, namely Strecker degradation, significant CO₂ is produced and trapped in the roasted bean. At the end of roasting and after quenching and cooling there can be up to 10 mL of CO₂ per gram in the bean. About 50% of this are lost upon grinding however the remaining CO₂ presents a problem in that with a flexible film package, the release of the gas after packaging can cause bursting of the package. Tempering the coffee for 24 to 48 hours helps to reduce CO₂ but about 10% of the shelf life are lost for each day of tempering. Our laboratory has focused on the physics of the release rate during tempering as well as after packaging. It is clear that the CO₂ is in two domains, one that represents CO₂ trapped in collapsed pockets and the other as sorbed CO₂ in equilibrium with specific sites as described by a Langmuir sorption isotherm. This work should lead to an alternative to the current practices of either vacuum packaging, use of a pressure relief valve or high CO₂ permeable films. Indeed, by flushing with the equilibrium CO₂ partial pressure and using a highly impermeable film, one can stabilize the package and prevent bursting much more economically.

Our second area of research focused on the analysis of the influence of moisture content, oxygen level and temperature on the shelf life of FRG coffee. The rate of oxidation as a function of oxygen pressure follows the typical hyperbolic function found for lipid oxidation. This correlated very well with sensory determination of end of shelf life using a new technique called Weibull Hazard Analysis. This sensory method describes the % of consumers who will be displeased as a function of storage time at given conditions. Our work showed that reducing the oxygen level to 0.5% increased shelf life by 20 fold. Water content as described by the corresponding water activity (a_w) also had a major effect, with about a 60% increase in reaction rate for ca. 1.5% increase in moisture content above the BET monolayer moisture content (about a 0.1 a_w increase). Surprisingly, temperature had the least influence, only about a 20% increase in rate for a 10°C rise in temperature. Thus coffee at room temperature with an a_w of 0.11 has 20 weeks high quality life at 4% oxygen, while at 0.4 a_w one needs to reduce the oxygen level to <0.5% to achieve the same shelf life. In air at

0.1 a_w , the shelf life is 7 weeks while at 0.4 a_w the shelf life is 10 days, thus moisture control by quenching and choosing a low WVTR film is critical to shelf life. An Excel spreadsheet has been developed that predicts shelf life in distribution account for temperature fluctuations as well as oxygen and moisture transfer through the flexible film used for packaging.