Dense Phase Carbon Dioxide Processing of Liquid Foods: a Review

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INTRODUCTION

Dense Phase Carbon Dioxide (DPCD) is a non-thermal process that pasteurizes mostly liquid foods. It inactivates vegetative bacterial cells, some spores, yeasts and molds, some viruses, and some enzymes. The traditional approach to develop a DPCD process for a new product involves a complex experimental plan to investigate microbial and safety effects. Recent studies show the importance of the solubility of CO\textsubscript{2} in the aqueous portion of the food, and its influence on microbial inactivation. The accurate prediction of solubility based on a thermodynamic approach and especially its correlation with microbial inactivation promises to simplify and facilitate these efforts. The objectives of this study are to present the work done to correlate CO\textsubscript{2} solubility values (experimentally determined, or thermodynamically predicted) with microbial inactivation kinetics, and to review some studies regarding the product quality and nutrient retention aspect of the DPCD technology.

MATERIALS & METHODS

The CO\textsubscript{2} solubility in water/aqueous media depends on pressure, temperature, and media composition. Experimental methods to measure solubility in liquid foods (grapefruit juice, apple juice, guava puree, hibiscus beverage) at different temperatures and pressures have been developed. Aspen Plus\textsuperscript{®} software version 2006.5 (Aspen Technology, Inc., Burlington, MA) was used to simulate the equilibrium formed in the liquids. The Peng–Robinson–Wong–Sandler (PRWS) thermodynamic model was applied for the simulations to predict CO\textsubscript{2} solubility in these liquids.

Microbial inactivation kinetics of total aerobic count were obtained for the grapefruit juice treated with a continuous DPCD treatment at different pressures (13.8, 24.1, 34.5 MPa), treatment times (5, 7, 9, 11, 13, 15 minutes) and fixed temperature (40°C). The microbial inactivation kinetics obtained was fitted with the Peleg model. The ‘b’ (rate) and ‘n’ (shape) parameters of the Peleg model were expressed as functions of the CO\textsubscript{2} solubility previously obtained with the PRWS thermodynamic model. This approach has been adopted to include CO\textsubscript{2} solubility into the Peleg equation [1, 2, 3]. The resulting microbial inactivation predictions have been successfully compared with the experimental values obtained for the grapefruit juice.

For commercial acceptance, the quality and retention of nutritive value are as important as safety aspects. The effects of DPCD treatment on phytochemicals, antioxidant activity, sensory attributes and other quality aspects for juices and beverages have also been studied. Examples include orange juice, muscadine grape juice, beer, grapefruit juice, hibiscus beverage, and guava puree.
RESULTS & DISCUSSION

Figure 1 presents the comparison of observed and predicted (PRWS – Peleg) microbial inactivation of total aerobic count in grapefruit juice. The points are observed (X axis) and predicted (Y axis) microbial inactivation values at different pressures. It should be noted that the prediction worked well for different pressures. Quality analyses of the samples after the DPCD process demonstrated that the treated samples scored better in sensory tests compared with traditional thermal pasteurization. Vitamins remained similar to untreated juice levels. For instance, in muscadine grape juice, anthocyanins decreased by 16%, total phenolics by 26% and antioxidant activity by 10% by thermal pasteurization, while no significant changes occurred in DPCD treated samples. Sensory scores for DPCD treated beer were better than thermally pasteurized samples.

![Figure 1. Experimental and predicted (combined thermodynamics and Peleg model) microbial inactivation during DPCD treatment.](image)

CONCLUSION

DPCD treatment of liquid foods results in better sensory quality and nutrient retention, and less quality changes compared to thermal pasteurization. The combination of thermodynamic solubility prediction and the Peleg microbial inactivation model allows for simpler prediction of microbial inactivation and therefore a more rapid process development for liquid foods.

REFERENCES

