calmetrix

Application Note AN-F04

Respiration of Fruits and Vegetables and their Perishability

Instruments to which this note applies: Biocal 2000, Biocal 4000

Target use: Research and Quality Control of processing and preservation methods used for fresh cut fruits and vegetables.

Introduction

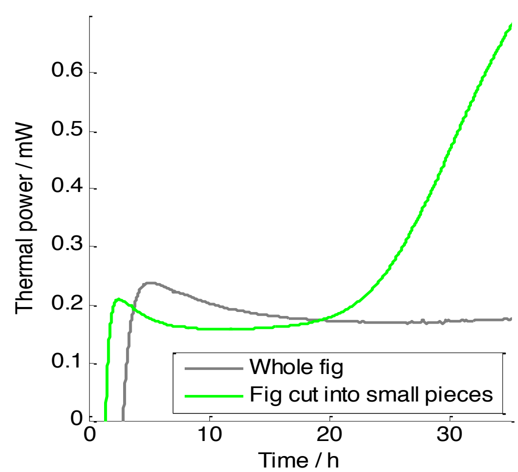
Fresh fruits and vegetables are particularly prone to spoilage because many are offered to consumers as fresh-cut products with minimal preservatives. Processes like cutting, shredding or peeling can cause alterations that are undesirable to the consumer, including discoloration, browning and changes in texture or taste. The wounding induced by mechanical transformation also translate into a higher respiration rate, which is known to correlate to perishability [1]. This respiration rate can easily be seen in an isothermal calorimetry curve. In an isothermal calorimeter such as the Calmetrix Biocal, one can study not only the effect of different types of wounding (e.g. different ways to cut, peel or shred), but also certain storage conditions, temperature and other possible conservation methods on respiration rate to minimize decay attributable to processing methods.
Results are measured continuously without the external intervention of a technician and can be retrieved and analyzed easily at the end of the experiment. This makes isothermal calorimetry a convenient and cost effective tool to quickly assess how spoilage develops in different food items, and which processing and preserving methods work best, simply by comparing their isothermal calorimetry curves. Using a large sample cell calorimeter such as Biocal, with 125 ml plastic or stainless steel ampoules, increases the range of applications by making it possible to study food, and in some instances whole fruits and vegetables, or cut pieces thereof, in different shapes and sizes.
This Application Note shows the thermal activity resulting from respiration in a fig, both as a whole fruit and cut in pieces.

Test Protocol

In a Biocal 2000 calorimeter at 23 °C, one sample channel contained a whole fresh fig (37.5 g), while the other channel contained a similar fresh fig (34.5 g) cut in 10 mm pieces.

Results and Interpretation

Both samples show similar respiration at about 0.2 mW for about 15 h. After this, the heat production from the cut fruit starts to increase in an “exponential” way. When the vials were opened after the experiment, the cut fig was heavily molded.



The rate of respiration of 0.2 mW for a fruit with a mass of about 35 g, corresponds to about 6 μW/g fresh mass.
The microbiological activity shows – as it commonly does – an accelerating phase. This is usually termed the "exponential" phase, but perfectly exponential behavior is mainly seen in liquid cultures. In the present case we have surface growth of molds (and possibly also other organisms, e.g., bacteria), and the rate of such a process is not only influenced by how fast the organism can grow, but also by such factors as nutrient availability and crowding on the surface.
Both figs and molds are aerobic organisms: in contrast to yeast and many bacteria, they need oxygen for their metabolism. If we assume that all the measured heat comes from aerobic metabolism (respiration) we can calculate how much oxygen is consumed during the experiment, as the heat or respiration is known to be about -455 kJ/mol (O_2) [2]. The whole fig produces about 20 J during the measurement; this corresponds to 44 μmol of consumed oxygen. For the cut fig the total heat is about 35 J, corresponding to about 77 μmol oxygen. Both these amounts of oxygen are quite low; the air in a 125 mL ampoule with a fig can support respiration producing about 400 J of heat. It is important to not run out of oxygen in respiration experiments, but in this case the respiration is very low, so that the oxygen level only dropped from 21% to about 20% during the measurement.

Conclusion

Isothermal calorimeters such as Biocal 2000 and Biocal 4000 are an effective and easy-to-use tool to measure respiration rate due to wounding of fresh fruits and vegetables. The method described in this Application Note can be used for example for small whole fruit, as well as fresh-cut produce in general and to study the metabolic response to various cutting or peeling methods. .

References

[1] Bolin, H.R. and Huxsoll, Effect of preparation and storage parameters on quality retention of salad-cut lettuce. Journal of Food and Science 5691(1991) 60-67.

[2] Hansen, L. D., C. MacFarlane, et al. (2004). "Use of calorespirometric ratios, heat per CO2 and heat per O2, to quantify metabolic paths and energetics of growing cells." Thermochim Acta 422: 55-61.

[3] Wadsö, L. and F. Gómez Galindo (2009). "Isothermal calorimetry for biological applications in food science and technology." Food Control 20(10): 956-961.