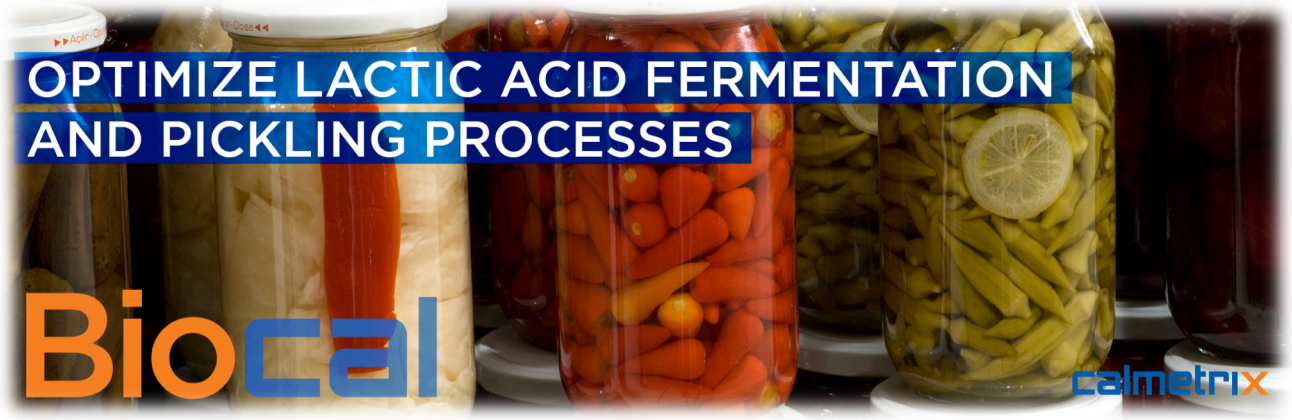


Lactic acid fermentation of vegetables

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

Target use: Research and Quality Control in lactic acid fermentation or pickling of vegetables.

Introduction

Lactic acid fermentation is most commonly known to produce fermented dairy products like yogurt, but it is also used to preserve vegetables [1]. The most common examples of the latter are probably the Korean kimchi (made of different types of vegetables, including cabbage and radish), and the fermented cabbage eaten in Germany, Poland and other Eastern European countries ("sauerkraut"). Carrots can also be preserved that way [2]. To make these products, cut vegetables are mixed with salt and left in containers to which air does not have access. Helped by the saline environment, lactic acid bacteria present on the vegetables will grow and lower the pH to levels that many other microorganisms cannot tolerate. They also consume the oxygen, effectively stopping aerobic organisms such as mold fungi from growing.

Isothermal calorimeters are a convenient and cost effective tool to conveniently assess the efficiency of different lactic acid fermentation / pickling processes, simply by comparing their isothermal calorimetry curves. Using a large sample cell calorimeter such as Biocal, with 125 ml polypropylene or stainless steel ampoules, increases the range of applications by making it possible to study in some instances whole fruits and vegetables, or pieces thereof, in different shapes and sizes.

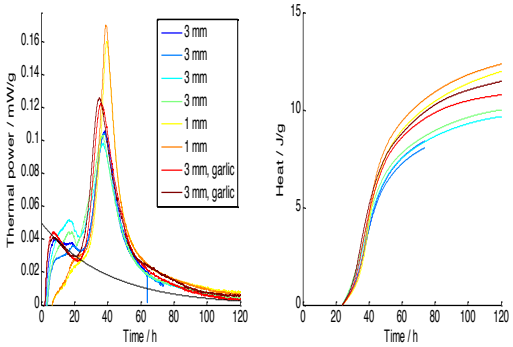
This Application Note shows the thermal activity resulting from lactic acid fermentation of carrots grated in different ways, with and without the addition of garlic.

Test Protocol

Peeled and grated carrots were mixed with 1% sodium chloride, and loaded into a Calmetrix BioCal isothermal calorimeter at 20 °C. The samples of about 100 g were placed in standard polypropylene vials, to which a 15 cm stainless steel tube (inner diameter 0.6 mm) has been attached as an outlet for the produced carbon dioxide. A steel mass in a polyethylene bag was used to keep the carrots down in the liquid. Two grades of grating (3 and 1 mm) and the replacement of 1/3 of the carrots with garlic were tested.

Results and Interpretation

The thermal powers had a typical microbial peak starting after about 40 h, but before this a substantial part of the heat probably came from aerobic and anaerobic processes in the wounded carrot tissue.



When the measurements were stopped the pH was about 3.5 and the products had the typical flavour of non-matured lactic acid fermented vegetables.

The heat produced during the primary fermentation was about 10 J/g. The thermal power decreased to low non-zero values after the main peak. Fine grating gave a sharper peak, but the replacement of a large fraction of the carrots with garlic did not make any difference.

The enthalpy of the conversion of glucose to lactic acid and carbon dioxide is about -100 kJ/mol [3], so about 1/3 of the sugars (carrots typically contain 6% fructose and glucose) were consumed and about 0.01 g of lactic acid was produced per gram carrot.

Conclusion

Isothermal calorimetry is a powerful and simple to use technique to study different types of fermentation processes in the food industry [4], including the fermentation of vegetables, but also other types of food items, e.g. rye bread fermentation [5] or probiotic foods and cheese [6;7;8].

References

[1] Steinkraus, K.H., Lactic acid fermentation in the production of foods from vegetables, cereals and legumes. Antonie van Leeuwenhoek, 49 (1983) 337-348.

[2] Niketic-Aleksic, G.K., M.C. Bourne, and J.R. Stamer, Preservation of carrots by lactic acid fermentation. J. Food Sci., 38 (1973) 84-86.

[3] Forrest, W.W., D.J. Walker, and M.F. Hopgood, Enthalpy changes assiciated with the lactic fermentation of glucose. J. Bacteriol., 82 (1961) 685-690.

[4] Wadsö L, Gómez Galindo F. Isothermal calorimetry for biological applications in food science and technology. Food Control 2009;20(10):956-61.

[5] Mihhalevski A, Sarand I, Viiard E, Salumets A, Paalme T. Growth characterization of individual rye sourdough bacteria by isothermal microcalorimetry. J Appl Microbiol 2010;110:529-40.

[6] Schäffer B, Keller B, Daróczi L, Lorinczy D. Examinatio of growth of probiotic microbes by an isoperibolic calorimetry. J Thermal Anal Calorim 2010;102:9-12.

[7] Schäffer B, Szakály S, Lorinczy D. Examination of the growth of probiotic culture combinations by the isoperibolic batch calorimetry. Thermochim Acta 2004;415:123-6.

[8] Szily B, Óbert G, Schäffer B. Detection of probiotic microbes in probiotic cheese spreads by isothermal microcalorimetry. J Thermal Anal Calorim 2005;82:245-7.