Comparison of Industrial Aerated Structures Using X-Ray Computed Tomography

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Abstract

Aerated foods are an important part of the supermarket shelf, offering novelty and luxury to consumers and new product development opportunities to food manufacturers. Quantifying the structures of aerated foods, and understanding the dynamic processes and formulation/ingredient effects that contribute to these structures, remain challenges to which X-Ray Computed Tomography (XCT) offers valuable insights.

Keywords: food, chocolate, aeration, porosity

Introduction

Numerous foods gain their distinctive appeal from an aerated structure: bread, cakes, whipped cream, ice cream, meringues, aerated chocolate and Yorkshire puddings, to name a few. Other industrial systems similarly exploit bubbles and pores to gain advantages of lightness, strength, high surface area and unusual deformation behaviour. Creating these systems requires an understanding of aeration behaviour at different points during processing. For bread, for example, bubbles are incorporated into dough during mixing, these bubbles are inflated with carbon dioxide gas produced by yeast during proving, and the risen dough piece structure is modified and set by baking. XCT offers the basis to quantify aerated structure and hence understand the creation and control of aerated structures as affected by processing and formulation.

Aerated chocolate was first introduced in the UK in 1935 in the product Aero. To create the aerated structure, either chocolate was expanded under vacuum and allowed to set, or mixed under pressure after which the gases expanded on releasing the pressure to atmospheric. Introduced by Rowntree and now part of Nestle, Aero has evolved down the years and now includes the version comprising a dozen or so small balls of aerated chocolate, simply named Aero Bubbles. Other chocolate manufacturers have introduced their own versions: Cadbury's Dairy Milk Bubbly and Wispa, as well as aerated chocolate bars in which the aerated structure in in the sugar rather than the chocolate component – Cadbury's Crunchie and Mars Maltesers: "The lighter way to enjoy chocolate!"

The current work used x-ray computed tomography and VG studios to analyse, image and quantify the aerated structures of Aero Bubbles, Cadbury's Wispa, Cadbury's Crunchie and Mars Maltesers – two confectionery products in bar form and two in ball form, and two in which the chocolate is aerated, and two in which the sugar (honeycomb) component is aerated. The pore size distribution has been compared showing variation in size between each chocolate to the amount of each of the pore sizes.

Aeration processes

Aeration processes in food systems include mixing, beating and whipping, sparging of gas, and slow or rapid generation and expansion of gas, with steam, air and carbon dioxide the most important gases used to aerate foods [1] , [2]. Important aspects of food aeration are the gas content and how that gas is distributed – the bubble size distribution, if the gas is present as discrete bubbles, or the pore size distribution if the aerated structure is open and porous. The food industry is driven by novelty and the constant creation of new products to tempt consumers, and many food manufacturers are striving to exploit bubbles to deliver distinctiveness and novelty, requiring a greater understanding of the quantification of aerated structures and of bubble dynamics during processing.

Methodology

This study was carried out with a Nikon 225 XCT, due to small specimen size relatively high magnification was possible, resulting in a voxel size of 6 microns. Specimens were fixed by suspension within low density foam, such that it can be digitally removed within the analysis software. Scans were then reconstructed and any noise or beam hardening effects were removed. In each case a region of interest was created around the area of question, defect detection was utilised to provide two dimensional porosity mapping and resulting statistical data was output and compared. The data was further filtered to remove noise, the filter used was related to the voxel size used.

Results

The "porosity detection" study between samples show in Figure 1 presents the bubble network produced during the different aeration process. Both Crunchie and Maltesers bubble structure are produced using a chemical process creates $C0_2$ where as Wispa and Aero Bubbles are produced using vacuum induced $C0_2$. Crunchie and Wispa both show high distribution of pores between 145-190 μm^3 where as Maltesers and Aero have uniform amounts of pores, Shown in Figure 2. The relationship between instrumentally measured properties and consumer perception is an important and often overlooked analysis in the area of bubble-containing foods [1] In food products, quality depends on consumers perception, and in the case of bubble-containing foods, this can either be related to the smooth mouth feel of whipped cream, or to the lightness and crispness of aerated chocolate, It is therefore very important to assess dispersion characteristics, and relate them to consumer perception. [2]. Further analysis will follow in a poster presentation

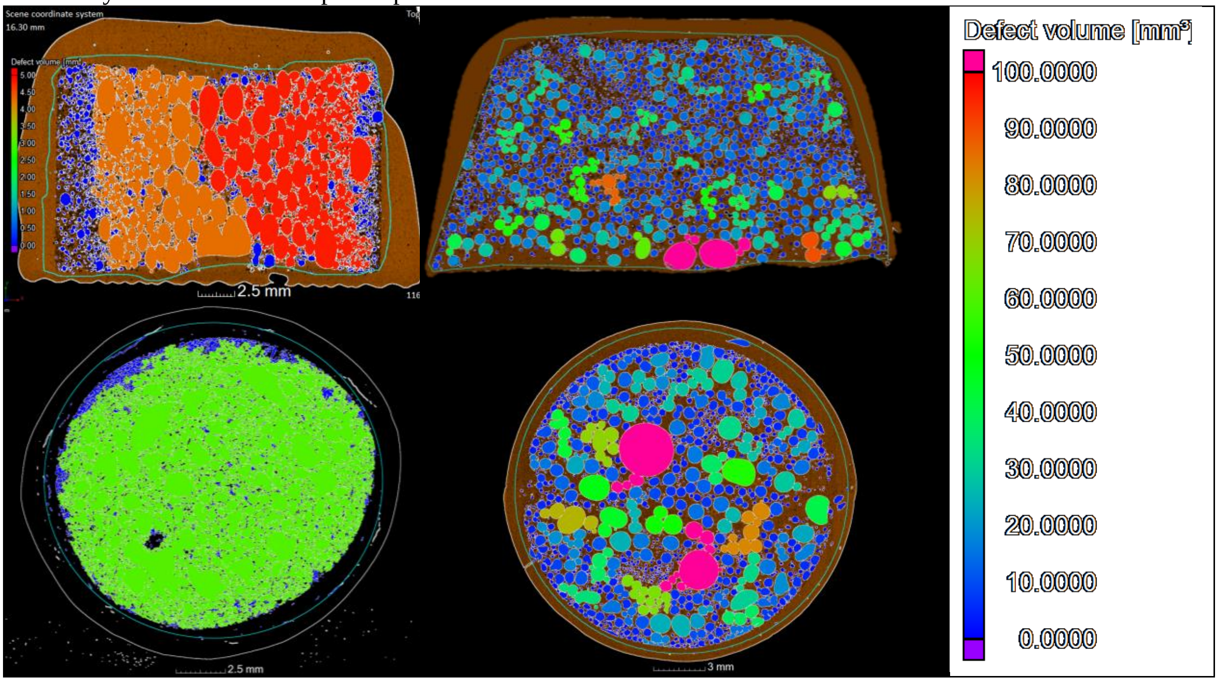

Figure 1: Chocolate 2D porosity comparison Cadbury's Wispa (Top Right), Cadbury's Crunchie (Top left), Aero Bubbles (Bottom Right), and Mars Maltesers (Bottom Left)

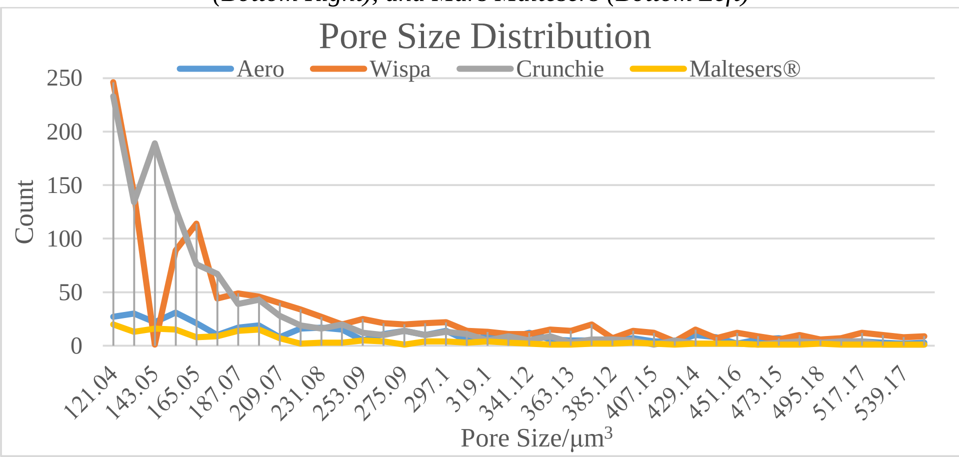

Figure 2: 2D Distribution of Pore Size

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