# Particle stabilisation of the air phase in ice cream


Joanne Gould, Steve Johnson and Bettina Wolf

Division of Food Sciences, The University of Nottingham, Loughborough LE12 5RD, UK


EPSRC CENTRE FOR INNOVATIVE MANUFACTURING IN Food

## Introduction

Ice cream has a complex microstructure comprising of, in its frozen state, four phases; ice crystals, air bubbles, partial coalesced and aggregated fat globules, all of which is surrounded by an unfrozen continuous matrix of sugars, proteins, salts, polysaccharides and water. It is because of this complex colloid system that even minor changes to the process or ingredients can have significant effects on the final product quality. With consumer's interest directed at reduced or low fat food, the replacement or removal of fat from the formulation has attracted significant research interest.

Compared with traditional ice cream, typically 10 -20% fat, the texture of low fat ice cream is often described as coarse, icy and crumbly. The texture deterioration is caused by disruption or absence of a fat globule network, as this is responsible for the stabilisation of air cells. In this research we have used cocoa particles as an alternative to fat crystals to stabilise the air cells in ice cream. Commercial cocoa particles act as particulate emulsifiers[1] and in addition are capable of stabilising aqueous foams. We took the approach of removing the fat component and any interfacially active components such as milk solids and emulsifiers from the ingredient list while adding a selection of particles with a range of foaming ability to test our hypothesis that the air phase in ice cream can be solely stabilised by Pickering particles that are not fat globules. Pilot scale ice cream manufacturing trials were carried out and the products analysed for overrun, hardness and microstructure.

## Materials and methods

***Ice cream formulation***

The standard formulation contained 62.85% water, 15% sugar, 11.5% skimmed milk powder, 10% fat (50:50 coconut oil: sunflower oil) and 0.65% stabiliser and emulsifier blend. For trial formulations, the fat, skimmed milk powder and blend were removed and either low fat cocoa, high cocoa or cellulose particles were added to the formulation. Guar gum and locust bean gum were added in the same concentrations present in the blend.

***Ice cream manufacture***

The standard ice cream mix was pasteurised and homogenised, trial formulations were not homogenised due to the absence of fat ingredient. The ice cream was crystallised using a one barrel scraped surface heat exchangers with air incorporation (OMVE, The Netherlands). All formulations were processed at the same process parameters and after manufacture, the ice creams were placed into storage at -18°C.

***Overrun***

Immediately after the product exited the process, the overrun was measured (triplicate analysis) by weighing 70 mL containers filled with the premix and the final product, respectively, and then calculated as:

$$overun = \frac{weight\ of\ premix - weight\ of\ ice\ cream}{weight\ of\ ice\ cream}\ 100\%$$

***Hardness***

The hardness of the ice creams was measured based on a simple penetration test using a texture analyser (TA. XT Plus, Stable Micro Systems). The ice cream samples contained in a 70 mL pot were taken from frozen storage, placed on the base of texture analyser and penetrated 25 mm at 2 mm/s by a small cylindrical probe with the diameter of 4 mm. Hardness was calculated as the maximum force divided by the area of the probe.

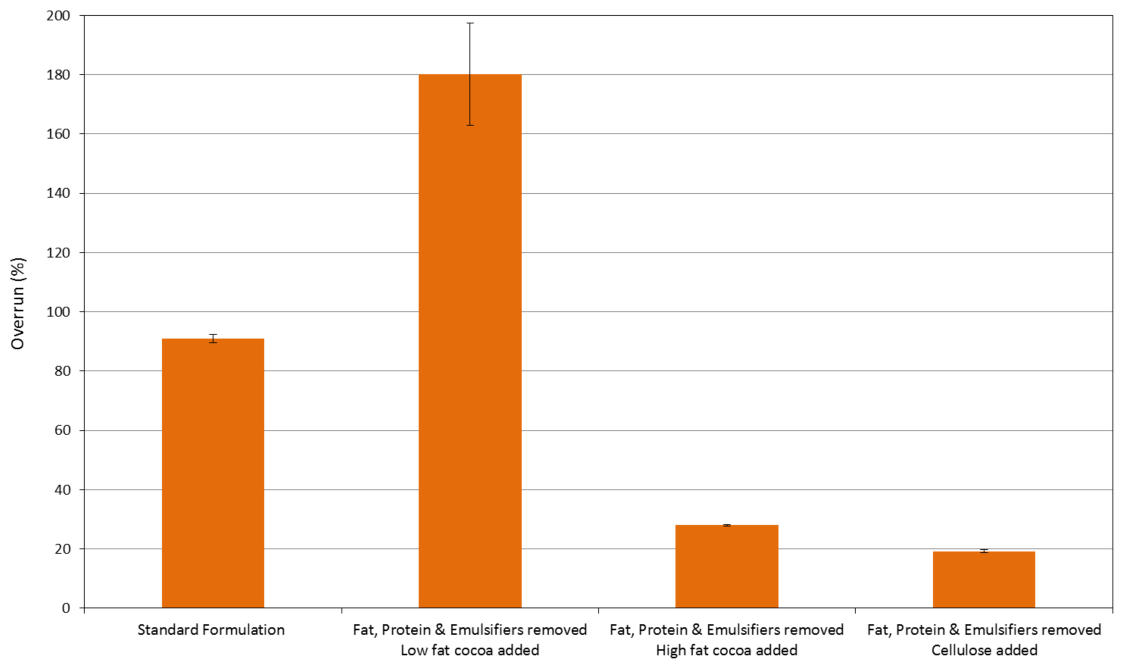
***Cryo-SEM***

Cryo-scanning electron microscopy (SEM) was used to evaluate the frozen microstructure. The system used comprises a cryo-preparation and transfer system (Oxford CT 1500, Oxford Instruments, Oxford, UK) which is used in conjunction with an SEM (JSM 6060LV, JEOL, Tokyo, Japan).

## Ice cream Properties

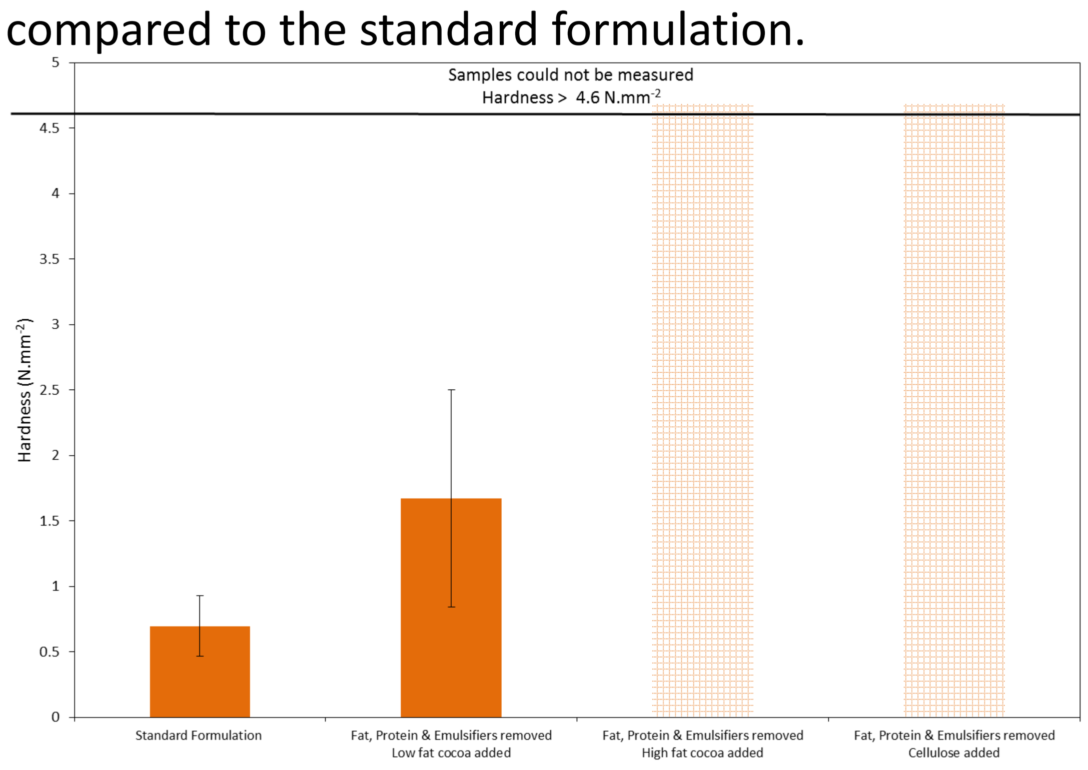
***Air cell stabilisation***

The overrun of ice cream is a measure of the air incorporation and impacts on serving as well as eating properties. The standard formulation had an overrun of around 95% whereby the overrun was double that for the ice cream solely comprised of low fat cocoa particles, guar gum, locust bean gum, water, sugar and air. The overrun of formulations containing instead high fat cocoa particles or cellulose have a much reduced overrun compared to the standard formulation. We know from whipping these three types of particles in water, that only low fat cocoa particles allows to generate a foam and here we see that application in ice cream ties in with this observation.



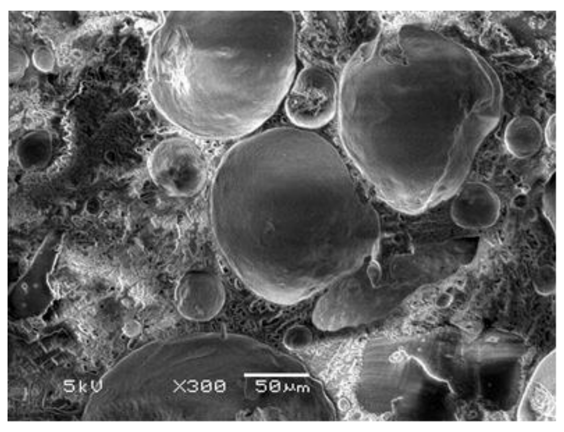

***Product Hardness***

Product hardness is an important in-use parameter last but not least for being able to spoon the product out of its tub. The non-foaming particles generated a rock solid product which could not be assessed with this hardness test. The low fat cocoa particle based formulation was also harder although other trials have shown that the addition of skimmed milk powder into this formulation reduced the hardness to a similar level as the standard formulation. On another note, this trial ice cream appears to be quite inhomogeneous as the error bar indicating ± standard deviation based on 10 replicates is huge compared to the standard formulation.

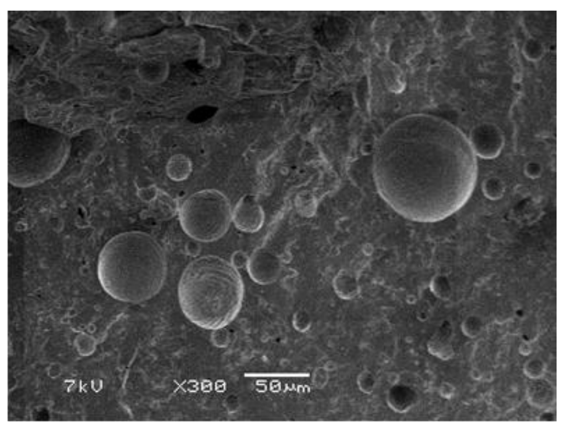



***Ice Cream Microstructure***

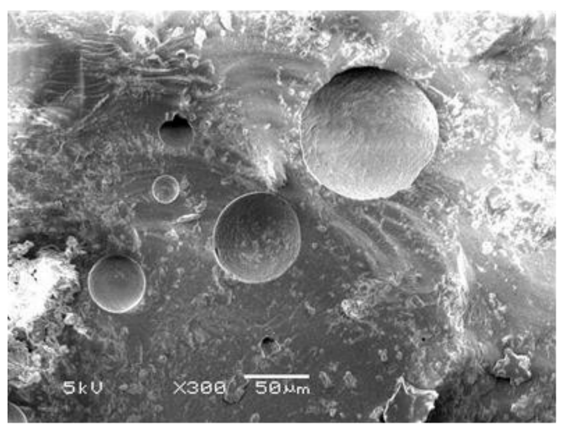
The use of cryo-SEM enabled us to image the air cells present in the ice creams. In the standard formulation the presence of large smooth air cells can be seen, for formulations with cocoa particles a rough air cell interface is evident due to their absorption to the air interface. Although the stabilisation of air cells with the addition of high fat cocoa and cellulose particles was evident, the overrun and texture analysis data confirmed this was to a lesser extent than the in the presence of the foaming stabilising low fat cocoa particles.



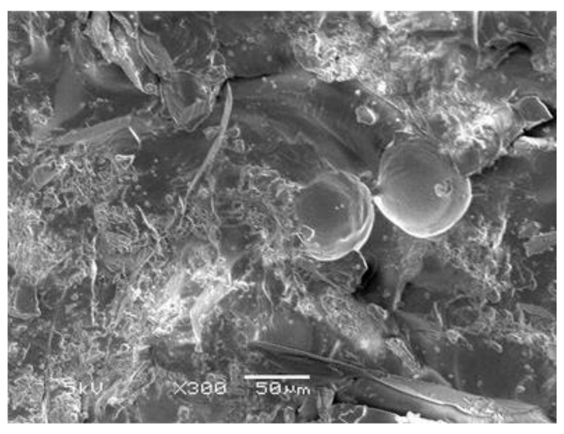
Standard Formulation



Fat, Protein & Emulsifiers Removed
Low fat cocoa added



Fat, Protein & Emulsifiers Removed
High fat cocoa added



Fat, Protein & Emulsifiers Removed
Cellulose added

## Conclusions and Outlook

The results of our preliminary investigations into the use of low fat cocoa particles as a particulate foam stabiliser in ice cream are promising, with trial formulations having a high overrun. There are many aspects we would like to study including the effect of particle size reduction and the interplay between the added particles and other ice cream ingredients on the ice cream product properties. The removal of fat will make delivery of lipophilic flavours challenging requiring further formulation innovation. We also hypothesise that our concurrent research into lignin-rich food waste particles for interfacial stabilisation may provide us with further particles for air phase stabilisation in ice cream provided they are low in fat. We are looking for an opportunity to take this work further.


**References:** [1] Gould, J., Vieira, J., & Wolf, B. (2013). *Food & Function*, *4*(9), 1369-1375.


The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Loughborough University

UNIVERSITY OF BIRMINGHAM