

## Technical Briefing Functionality of Sugar in Cakes



starches



flours



fibres



proteins

## Functionality of Sugar in Cakes

In July 2015 the Scientific Advisory Committee on Nutrition, SACN, recommended reducing the amount of free sugars consumed to less than 5% of our total energy intake. The guideline daily amount for sugars in the UK has now dropped from 90 grams to just 30g. This is less sugar than you'd find in a 335ml can of coke!

Recent research has outlined the negative health effects associated with consuming too much sugar; these include obesity, diabetes, tooth decay and cardiovascular disease.

Over consumption of sugar is something most of us are guilty of doing, sometimes without even realising. Many of us think we are making healthy food choices by consuming low fat, gluten free, vitamin waters etc without realising the sugar content has been increased to produce a comparative product to the original "unhealthy" version.

This push in reducing consumption of free sugars in turn will impact the food industry as demand for lower levels of sugar in products increases.

The sweet bakery industry is an obvious sector which is going to be impacted by these new regulations. Unlike some other applications, such as beverages, sugar plays an important role giving more than just sweetness to the product.

Sugar is a highly functional ingredient. Depending on the application it is in, it will contribute different functions and potentially multiple functions. It is this varied and vast functionality which makes sugar such a complex and interesting ingredient to replace. Here you will find out how these functions affect muffins and cakes.

There are three basic phases of cake baking; expansion, setting and browning and sugar is vital in all three of these stages.

### So, how does sugar impact the different stages of the cake baking process?

#### Volume

Even though it's missed from every ingredient list, air is a key ingredient for good cakes!

Creaming the fats and sugar aerates the batter increasing volume even while in the bowl prior to the addition of baking powder.

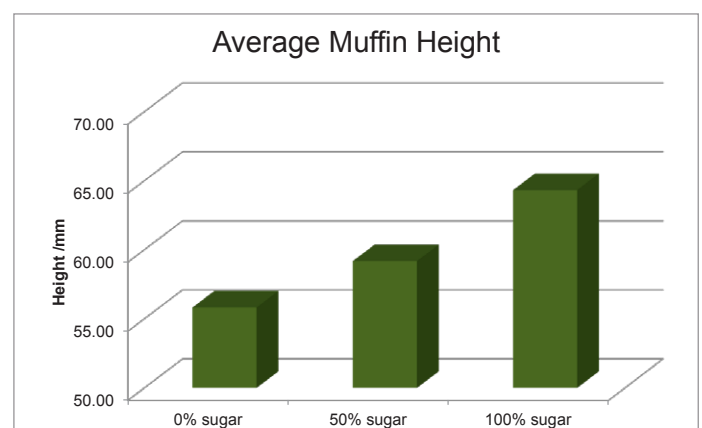
The creaming process is vital as the number of bubbles in the batter ends up being the number of bubbles in our final cake. Due to the high surface tension of the batter the carbon dioxide released by the baking powder is only able to increase the size of existing bubbles, not produce additional ones.

These bubbles also increase by two other mechanisms; thermal expansion, because air expands when it's hot and also from the water vapour which is starting to be produced.

If there is too much sugar present then the cake will collapse, (think of a brownie). This is due to the sugar crystallising in the cake and preventing the gluten from forming, this in turn causes the cake to fall. This sugar crystallisation also creates a heavy top which makes the cake unable to rise.

However, if there is not enough sugar present in the cake or muffin this affects the protein formation but this time results in a firmer cake due to a higher level of gluten being present. It's a fine balance!

Figure 1:



*Effect of sugar reduction on muffin height*

#### Structure

The combination of protein coagulation and starch gelatinization is what forms the final structure of the cake sponge; the rate that this occurs is directly correlated to the levels of sugar present in the cake.

More sugar increases the starch gelatinization temperature which in turn allows more time for the batter to expand. This additional time for batter expansion results in an increase in the final cake or muffin's volume.

Sugar also slows down the coagulation of egg whites and milk proteins, this again then allows more time for the batter to expand before the structure is set.

### Colour, flavour and aroma formation

Sugar is of course well known for the sweetness it gives to products but this isn't the only way sugar affects the taste and aroma of the cake.

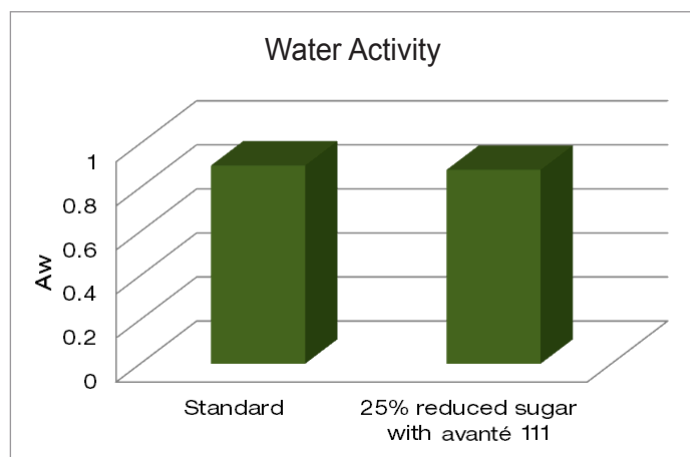
There are two reactions which result in non-enzymatic browning.

The chemical reaction between reducing sugars and amino acids, from proteins, is known as Maillard reaction and it is this which gives colour and flavour to the cake. This process also releases aromas characteristic of the roasting process. The Maillard reaction only occurs on the surface of the batter as this is the only part of the cake which reaches a high enough temperature and dehydrates enough to allow the Maillard reaction to occur.

The second reaction which aids colour and flavor formation is caramelisation. This is the breakdown of complex sugars into simple sugars prior to polymerization. Unlike Maillard's reaction, the caramelisation process doesn't require the presence of proteins or amino acids, it's purely the breakdown of sugars. Also dissimilarly to Maillard's reaction, caramelisation is temperature dependant. Lower than 180°C will see less caramelisation than if the temperature was set higher which aids the caramelisation of sucrose.

Maillard's reaction and caramelisation both produce bitter tasting compounds and many volatile aromatic molecules, hence the lovely smells produced from baking.

Figure 2:



*Water activity is maintained even when sugar is reduced by 25% when using the sugar replacer*

### Preservation

Due to sugar binding water, the shelf life of the cake is extended. Sugar increases the osmotic pressure in the cake hence lowering the water activity. The osmotic pressure refers to the pressure required to prevent the water flowing from a high water activity area to a low water activity area. If the level of sugar increases then the osmotic pressure is increased, this is because the sugar is binding the water. This results in the microorganisms being unable to absorb the water they require through their cell wall for growth. As the water activity in the environment decreases the number of microorganisms capable of survival also decreases. This is because there is no free water for the bacteria to grow hence inhibiting microbial growth.

Sugar also extends the shelf life in terms of softness of the cake over life.

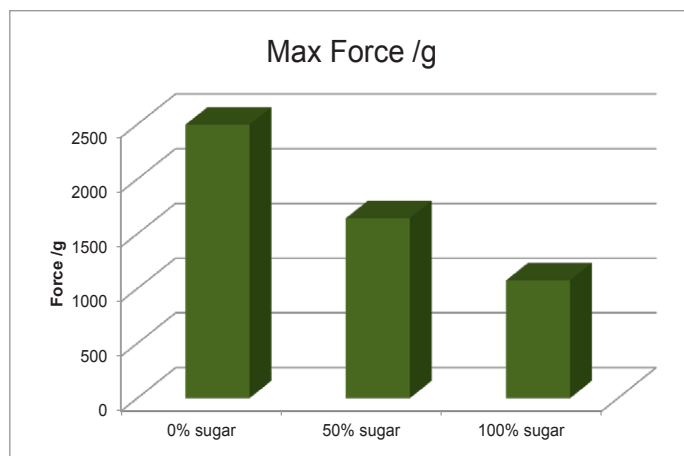
### Texture

Sugar acts as a tenderising agent as it absorbs water delaying protein coagulation and starch gelatinization. Too little sugar affects protein formation and results in gluten forming which makes the cakes firmer.

The more available water there is present in a dough or batter the easier it is for the glutenin and gliadin to bind. Sugar competes with gluten for the water. By absorbing water from the batter this slows down the rate that the glutenin and gliadin will bind.

As well as the sugar and gluten competing for the water in the batter, starches are also competing. The sugar increases the starches gelatinisation temperature by lowering the available water content, and therefore the water activity, of the batter. This also means that at higher levels of sugar the starches are unable to bind as much water and the batter is less viscous.

Figure 3:



*Effect of sugar reduction on muffin firmness*

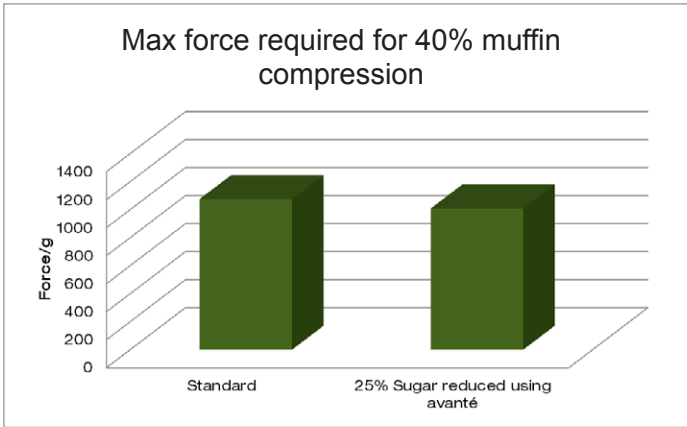
As you can see from the following images, as the sugar is reduced not only does the volume decrease but the surface

of the cake becomes very rough and the crumb structure becomes much denser.



The images above show muffins containing (left to right) 0%, 50% and 100% sugar, demonstrating the effect of sugar on volume.

Figure 4:



Ulrick & Short's sugar replacer maintains softness even when 25% of the sugar is removed

So in summary...

In addition to sweetness, sugar...

- increases the starch gelatinization temperature
- slows down protein coagulation
- increases batter volume
- provides crust colour
- extends shelf life
- gives texture and softness

Due to sugar's high functionality it is challenging to mimic for successful replacement. Here at Ulrick & Short we have had great results replacing up to a third of the sugar in cakes and muffins without losing the functionality but whilst being

able to improve the nutritional of the product; lowering both sugar and therefore overall calories. This improved nutritional profile will in turn help consumers stay within their GDA limit of 30g.

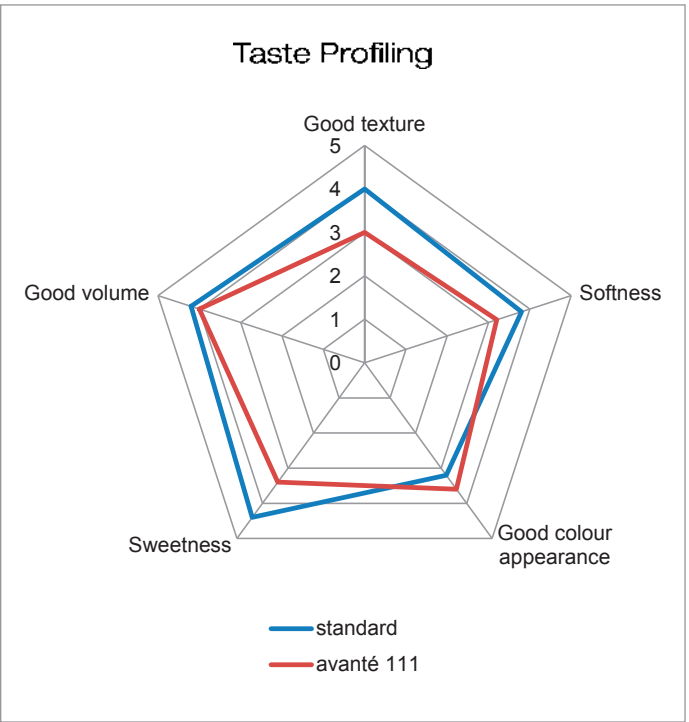
We have been successful replacing sugar with our avanté range in the following applications:

- cakes
- flapjacks
- granola / cereal
- cereal bars
- biscuits
- muffins



Above you'll see one muffin containing sugar and another with avanté – can you tell the difference? We can't!

Minimal differences noticed when tasting the sugar reduced muffins compared to the standard full sugar version. Appearance, volume and softness all maintained.





## Starches and Flours

Produced from a range of crops including Tapioca, Wheat, Rice, Sweet Potato, Pea and Waxy Maize.

- Available in 'cook up', 'pre-gelatinised' and 'cold water swelling' formats.
- Heat, pH, freeze/thaw stable versions available with a range of viscosity profiles and a whole palette of textures.
- Thickening, stabilising, fat replacement, sugar reduction, phosphate removal and glazing are only a few of the functions possible.
- Simple, clean and consumer friendly declarations in the following key application areas:
  - Bakery
  - Processed meats
  - Sauces
  - Ready meals
  - Desserts
  - Snacks



## Fibres

Produced from a range of crops including Wheat, Oat, Bamboo, Flax and Pea.

- Insoluble fibres with high water binding capacity in a range of fibre lengths, giving full control over the desired texture.
- 'Source of' and 'high in' claims for fibre and omega 3 achievable.
- Shear, acid, heat and freeze/thaw stable.
- Key application areas:
  - Bakery
  - Processed meats
  - Sauces
  - Performance foods
  - Sports nutrition
  - Snacks
  - Breakfast cereals



## Proteins

Produced from a range of crops including Wheat, Pea and Rice.

- A range and variety of protein content.
- Can be used as effective binders and emulsifiers.
- Nutritionally enhance foods and boost amino acids.
- Easy to apply and use in the following key application areas:
  - Processed meats
  - Bakery
  - Sports nutrition
  - Infant formulas
  - Functional foods



## Clean & Clear Label

Starches | Flours | Fibres | Proteins

- ✓ Non-GM
- ✓ Additive free
- ✓ Wide range of crops and functionalities
- ✓ Allergen free options
- ✓ Simple consumer friendly declarations
- ✓ Enhanced nutritional profiles
- ✓ Quality assured from field to fork
- ✓ Fully accredited including BRC, Kosher and Halal approved

All backed up by onsite technical support.





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