The effect of sugar type on VOC generation in a model baked system

PATRICK SILCOCK, Julien Brecheteau, Loic Toupin and Sam Heenan
Department of Food Science, University of Otago, Dunedin, New Zealand

Abstract

Due to the multiple functions of sugar in foods, in particular the contribution of sugar to the desirable "fresh baked" aroma, efforts to improve the nutritional profile of baked products by reducing sugar is problematic. As such to produce consumer accepted reduced sugar products it is necessary to understand how removing and/or modifying sugar composition influences the final product flavour. Model baked products (muffins) were produced containing variable amounts of sucrose, fructose, glucose and lactose and the volatile organic compound (VOC) composition isolated by solvent assisted flavor extraction (SAFE) and measured by gas chromatography mass spectrometry (GC-MS). Overall changing the sugar composition changed the VOC composition with lactose containing systems producing a VOC composition that was most different from the uncooked and sucrose containing muffins. In comparison to the lactose containing muffins the glucose and fructose containing muffin produced VOC compositions more similar to sucrose containing muffins. Not all compounds increased with increasing levels of sugar.

Introduction

Replacing sugar in baked products is a major challenge. Sugar not only imparts sweetness, but contributes to the fresh flavour quality of baked foods during thermal processing and acts as a tenderiser by retarding and restricting gluten formation [1]. Reducing sugars have a direct influence on the Maillard reaction, which can either promote or reduce Strecker degradation, resulting in the formation of important compounds such as pyrazines that are character impact odorants of freshly baked foods [2]. Sucrose, a non-reducing sugar, can degrade during baking forming the reducing sugars fructose and glucose. Therefore, it is necessary to understand how removing and/or modifying sugar composition influences the final product flavour.

The objective of the study was to investigate the effect of sugar type (sucrose, glucose, fructose and lactose) at two sugar levels (3.7%, 14.7% of batter recipe) on volatile organic compound (VOC) generation in a model baked system (muffins).

Experimental

Model baked systems (muffins) were produced using the generic formulation in Table 1 and sugar composition in Table 2. Dry ingredients (flour, sugar, baking powder, salt, polydextrose and sugar mixture) were mixed with the liquid ingredients (egg white, water and oil) and baked at 200 °C for 18.5 min. Muffin cooked weight was 55 +/- 0.5 g. Muffins were immediately frozen after baking using liquid nitrogen.

Ground frozen muffins (200g) were added to 150mL distilled water and 200mL diethyl ether (*99.7%, Merck KGaA, Germany*). This mixture was shaken for 40min then filtered and 30ppm carvone added.

SAFE (*Glasbläserei, Bahr, Manching, Germany*) distillation was carried out at about 10^{-6} mbar over two hours (including sample addition time of one hour). The 500mL

B. Siegmund & E. Leitner (Eds): Flavour Sci., 2018, Verlag der Technischen Universität Graz
DOI: 10.3217/978-3-85125-593-5-13, CC BY-NC-ND 4.0

sample flask was maintained at 35°C. The 500mL receiver flask was cooled using liquid nitrogen. Circulating Water was held at 42°C. Diethyl ether (25mL) was used to rinse the sample bottle and dropping funnel.

Table 1: Generic formulation of the muffins

Ingredient	*% (weight/weight)*
Flour	31.3
Baking powder	1.8
Salt	0.5
Polydextrose	2.7
Egg white	11.2
Canola oil	11.1
Water	26.7
Sugar mixture	14.7

Table 2: Composition of the sugar mixture used in each muffin variant

Variant number	*Sugar composition*
1	100% sucrose
2	100% fructose
3	100% glucose
4	100% lactose
5	25% sucrose, 75% polydextrose
6	25% fructose, 75% polydextrose
7	25% glucose, 75% polydextrose
8	25% lactose, 75% polydextrose
9	100% sucrose - uncooked
10	100% polydextrose

Distillates were dehydrated with anhydrous sodium sulphate, filtered through celite then concentrated to 1 mL in a Kuderna Danish apparatus under oxygen-free nitrogen. All the extracts were stored in a freezer (-20°C) until GC-MS analysis. Distillates were analysed using an Agilent 6890 GC coupled with Agilent 5973 Quadrapole MS fitted with a BPX5 column (30m x 0.25mm id, 0.25um film thickness).

Data Analysis: Peak alignment and peak area extraction were performed using XCMS [3]. Principal component analysis (PCA) was used to investigate the relationships between samples and peak areas.

Results and discussion

The use of different sugar formulations impacted on the extent of browning upon baking (most browning, 100% fructose; least browning, polydextrose). Differences in the total amount of volatile organic compounds (VOCs) produced, as measured by summed normalised peak areas, were also observed. Summed normalised peak areas were highest for muffins containing 100% lactose followed by 25% lactose, 100% fructose, 100% glucose, 25% glucose, 25% fructose, 100% sucrose, 25% sucrose and polydextrose, respectively.

The effect of sugar type on VOC composition was examined by normalising the peak areas to the sum of the peak areas then assessed by principal component analysis (PCA). The PCA plot explained 78% of the variation on the 1st and 2nd PCs (PC1 60%; PC 2 18%) (Figure 1). Along PC 1 the VOC composition of muffins containing lactose were most different from the uncooked muffin batter.

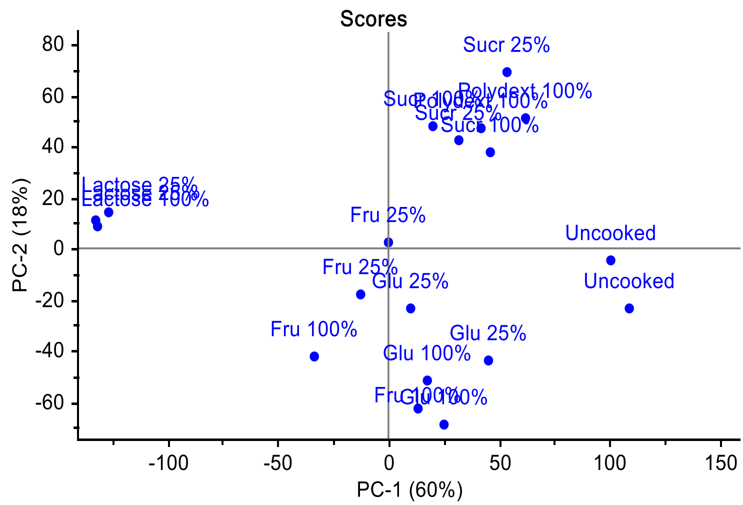

Figure 1: Principal component analysis scores plots of muffins containing different sugar compositions

The separation of the cooked muffins from the uncooked muffin batter on the PCA appeared to be related to a combination of number of compounds detected and higher proportions of common compounds. Separation towards the lactose containing muffins was due the presence of higher proportions of 2-furanmethanol, maltol, γ-butyrolactone, 2(5H)-furanone, and lower proportions of acetic acid, hexanoic acid and three unknown compounds. PC2 separated the muffins containing glucose/fructose from muffins containing sucrose/ polydextrose due to higher proportions of 2,3-dihydro-3,5-dihydroxy-6-methyl-4H-pyran-4-one, 5-(hydroxymethyl)-2-furancarboxaldehyde, 5-methyl 2-furanmethanol, 5-hydroxymethylfurfural, furfural, 2,5-dimethyl-4-hydroxy-3(2H)-furanone, hexanoic acid and 5-hydroxymethylfurfural; and higher proportions of methyl pyrazine, benzeneacetaldehyde, nonanal and two anhydro-glucopyranose compounds, respectively.

Relative peak areas of the main VOC's responsible for the separation of muffins on the PCA plot are shown in Figure 2. Furan methanol and maltol are highest for lactose 100% (Figure 2A and 2B). Acetic acid and 2,3-dihydro-3,5-dihydroxy-6-methyl-4H-pyran-4-one are highest in the fructose and glucose containing muffins (2C and 2F). For these VOC's the muffins containing 25% lactose, 100% sucrose, 100% polydextrose and uncooked muffin all contained similar relative peak areas. Their contribution to the separation on PC 1 was probably due to lower total peak areas for sucrose, polydextrose and uncooked muffins compared to lactose containing muffins. Methyl pyrazine and benzeneacetaldehyde show a similar trend with the sucrose containing muffins containing the highest peak areas (2D and 2E).

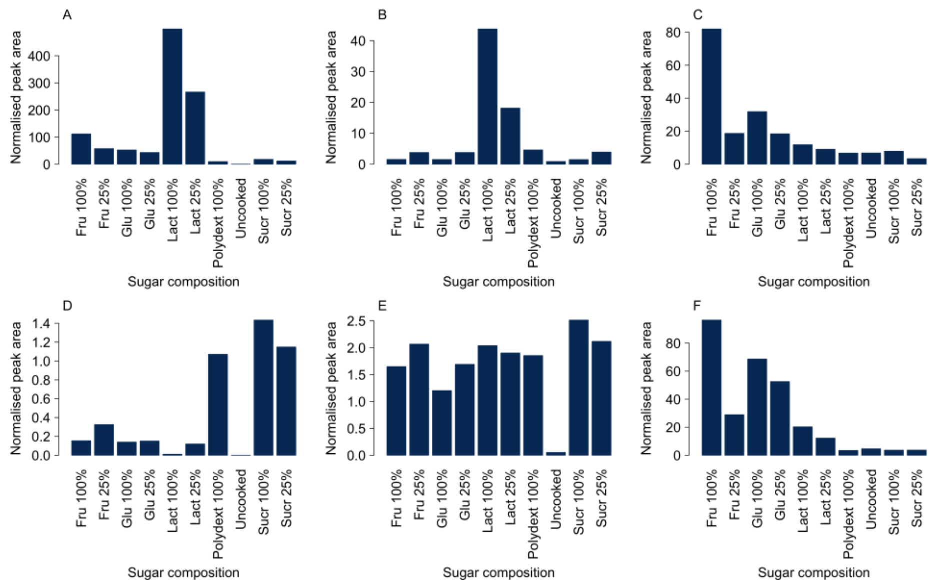

Figure 2: Relative peak areas for compounds responsible for descrimination based on sugar composition (relative peak area of internal standard =30); A. 2-furanmethanol ; B. maltol ; C. acetic acid ; D. methyl pyrazine; E. benzeneacetaldehyde; F. 2,3-dihydro-3,5-dihydroxy-6-methyl-4H-pyran-4-one

Overall changing the sugar composition changed the VOC composition with lactose containing systems producing a VOC composition that was most different from the uncooked and sucrose containing muffins. In comparison to the lactose containing muffins the glucose and fructose containing muffin produced VOC compositions more similar to sucrose containing muffins. In some instances higher relative peak areas were obtained for some compounds (e.g. benzeneacetaldehyde) in the 25% level of muffins containing fructose and glucose compared to the 100% levels. This may reflect some compounds present are intermediates and react to form other compounds.

References

1. Gelinas, P., Roy, G., and Guillet, M. (1999). Journal of Food Science, 64 (5), 937–940.
2. Pozo-Bayon, M. A., Guichard, E., and Cayot, V. (2006). Food Reviews International, 22(4), 335–379.
3. Smith, C.A., Want, E.J., O'Maille, G., Abagyan, R., and Siuzdak G. (2006). Analytical Chemistry, 78, pp. 779–787.