

# BMJ Open Cross-sectional survey of the amount of sugar and energy in cakes and biscuits on sale in the UK for the evaluation of the sugar-reduction programme

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## ABSTRACT

**Objectives** To investigate the variation in sugar and energy content of cakes and biscuits available in the UK.

**Design** We carried out a cross-sectional survey in 2016 of 381 cakes and 481 biscuits available in nine main UK supermarkets.

**Methods** The sugar and energy content was collected from product packaging and nutrition labelling of cake and biscuit products.

**Results** The average sugar content in cakes and biscuits was  $36.6 \pm 7.6$  and  $30.0 \pm 9.2$  g/100 g, respectively. The mean energy content was  $406 \pm 37$  for cakes and  $484 \pm 38$  kcal/100 g for biscuits. There was a large variation in sugar and energy content between different cake and biscuit categories and within the same category. 97% of cakes and 74% of biscuits would receive a 'red' (high) label for sugar.

**Conclusions** This research makes available baseline data of the cakes and biscuits market in the UK for future evaluation of the recently launched sugar-reduction programme. The study showed that reductions in sugar and energy content of cakes and biscuits are possible, since there was a large variation in sugar and energy content between different cake and biscuit categories and within the same category. A reduction in sugar and energy content, and overall cake and biscuit consumption, can help reduce overall sugar and energy intake in the UK and thus reduce the risk of obesity and dental caries.

## INTRODUCTION

In July 2015, a new free sugars (sugar) recommendation was announced by the Scientific Advisory Committee on Nutrition due to the link between excess sugar intake and obesity, type 2 diabetes and dental caries risk,<sup>1–7</sup> which are all major public health problems in the UK,<sup>8–14</sup> and contribute to significant health-care costs.<sup>15</sup> Free sugars includes all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups and unsweetened fruit juices and excludes lactose when naturally present in milk and milk products, as well as sugars contained within the

## Strengths and limitations of this study

- This paper for the first time investigates and documents the sugar and energy content of cakes and biscuits sold in the UK.
- The results demonstrate that the amount of sugar and energy can be reduced, since there was a wide variation in sugar and energy content between different categories of cakes and biscuits, as well as within the same category.
- This study was based on the amount of sugar and energy provided on product nutrition labelling in-store; hence, we relied on the accuracy of the data provided on the label.

cellular structure of foods (ie, whole fruits and vegetables).<sup>16</sup>

In 2014, average intakes of sugar exceeded the UK recommendations (less than 5% of energy intake) in all age groups. The average sugar intake in adults is 60 g/day, which is equivalent to 240 kcal and contributes to 12% of energy intake. Some children have a higher sugar intake, 54 and 73 g/day in 4–10 and 11–18-year-olds, respectively.<sup>17</sup> This is likely to be an underestimate of how much sugar they actually consume<sup>18–19</sup> because under-reporting consumption of high-sugar foods and drinks is highly prevalent in surveys that rely on self-reported data.<sup>20–23</sup>

The UK government recently announced in its *Childhood Obesity: A Plan for Action (2016)* a sugar-reduction programme, where it is asking manufacturers to reduce sugar by 20% by 2020 in each of the nine categories of food and drink that contribute most to sugar intake in children's diets. Cakes, morning goods (eg, croissants) and biscuits are main contributors of sugar intake in children (4–10 years), teenagers (11–18 years) and adults (18–64 years), contributing to 9%, 9% and 7% of sugar intake, respectively.<sup>17</sup>



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**Table 1** Description and examples of cake categories

Category	Description and examples
Almond	Products described as almond fingers or almond slices.
Angel	Products described as 'Angel' cake or 'Angel' slices.
Bakewell	Products described as 'Bakewell' slices.
Battenberg	Products described as 'Battenberg'.
Blueberry muffins	Products described as blueberry muffins, including mini size.
Brownies	Products described as brownies, excluding flavoured brownies.
Carrot	Products described as carrot cake, excluding flavoured carrot cake, for example, fudge carrot cake.
Chocolate	Products described as chocolate cake or similar, including chocolate birthday/celebration cakes.
Chocolate cake bar	Products described as chocolate cake bar, including caramel flavoured.
Chocolate muffins	Products described as chocolate muffins, including 'chocolate chip' and 'double chocolate' and sold in regular or mini size.
Chocolate Swiss roll	Products described as 'Chocolate Swiss roll' or chocolate roll or sponge roll and sold in regular or mini size.
Coconut	Products described as coconut cake or similar.
Coffee and walnut	Products described as coffee and walnut cake or similar.
Coffee	Products described as coffee cake, iced or containing buttercream.
Cupcake/fairy cakes	Products described as cupcake and 'Fairy Cake' and do not fit in any other category.
Fruit	Products described as fruit cake or similar, including iced varieties.
Genoa	Products described as 'Genoa'.
Fruit Swiss roll	Products described as 'Swiss roll' and fruit flavoured, for example, Raspberry Swiss Roll, in regular or mini size.
Ginger	Products described as ginger cake or bun.
Lemon	Products described as lemon cake or similar, for example, lemon and poppy seed loaf cake.
Lemon Swiss roll	Products described as 'Lemon Swiss Roll' or similar.
Madeira	Products described as 'Madeira Cake' and plain.
Fruited Madeira	Products described as 'Madeira Cake' with fruit.
Iced Madeira	Products described as 'Madeira Cake', iced and of any flavour.
Red velvet	Products described as 'red velvet', including cupcake varieties.
Victoria	Products described as 'Victoria sponge' or similar.
Walnut	Products described as walnut cake.
White chocolate	Products described as white chocolate cake and filled with strawberry or raspberry jam.
Plain with chocolate	Plain sponge topped with chocolate or containing chocolate chips.

Manufacturers can choose to achieve the 20% reduction in a number of ways: by reformulating their products (without increasing overall calories), reducing portion size or promoting their lower-sugar products. The main aim is to gradually reduce the amount of added sugar until 2020.<sup>24</sup> Sales weighted averages (SWA) address the most popular products on the market and were used to set category-specific sugar-reduction targets per 100 g of a product. SWA for cakes is currently 34.9 g, with the aim of bringing it down to 27.9 g per 100 g by 2020.<sup>24</sup> For biscuits, the SWA is 32.8 g to be reduced to 26.2 g per 100 g.<sup>24</sup> The SWA allows for flexibility in the levels of sugar in different products within a category, for example, a biscuit manufacturer can continue to sell a high-sugar biscuit if the remainder of their portfolio is lower, however if the high-sugar product is a big seller, the amount of sugar will have to be reduced through reformulation, smaller portions, or price promotions will have

to be removed to reduce the overall sale.<sup>24</sup> Calorie caps for single-serve cakes and biscuits are set at a maximum of 325 kcal.<sup>24</sup>

Traditionally, cakes were considered treats for special occasions, such as birthdays, but now only 3 in 10 people buy cakes for this reason.<sup>25</sup> Cakes are consumed more frequently, and the market is changing with the rise in small cakes. The volume sales of small cakes have been growing substantially and has now overtaken large cakes, with a market share of 44% and 37%, respectively.<sup>26</sup> These cakes are likely to be consumed as regular snacks, contributing to the increase in sugar intake.<sup>17</sup>

Biscuits are also widely consumed in the UK; 9 in 10 adults eat sweet biscuits regularly, with 55% of people eating them at least once a week.<sup>27</sup> A Mintel report published in 2015 estimated that values sales in the market would grow by 4% by 2019.<sup>27</sup> Biscuits are not often viewed as a 'treat' like chocolate and desserts. Instead they may

**Table 2** Description and examples of biscuit categories

Category	Description and examples
Bourbon	Products described as 'Bourbon' or similar.
Custard cream	Products described as 'custard cream' or similar.
Jam filled	Biscuits filled with jam only, for example, Jammie Dodgers and Aldi Belmont Biscuits Jammy Wheels.
Jam and cream	Biscuits with jam and cream filling, for example, Viennese Whirl.
Fruit filled	Biscuits with fruit filling, including yoghurt coated, for example, Go Ahead! Crispy Slices Orange and Garibaldi Biscuits.
Breakfast unfilled	Products described as breakfast biscuits and contain no filling.
Breakfast filled	Products described as breakfast biscuits with filling, for example, Belvita Breakfast Yoghurt.
Chocolate chip	Products described as cookies or biscuit containing dark, milk or white chocolate chips or chunks.
Chocolate-coated ginger	Products described as ginger biscuits and chocolate coated.
Chocolate digestives	Products described as 'digestives' and chocolate coated.
Digestives	Products described as 'digestives' and plain.
Ginger stem	Products described as cookies or biscuits with ginger stem or similar.
Ginger	Products described as ginger-flavoured biscuit and plain, for example, Ginger Nuts.
Iced	Biscuits topped with icing and plain, for example, Fox's Party Rings and McVitie's Iced Gems
Malted milk	Products described as malted milk or similar and plain.
Nice	Products described as 'Nice' or similar and plain.
Oatmeal	Biscuits made of oatmeal or oats and plain, for example, McVitie's Hobnobs.
Rich Tea	Products described as 'Rich Tea' or similar and plain.
Shortbread	Products described as shortbread or similar and plain.
Shortbread with additions or coated	Products described as shortbread with additions, for example, Marks & Spencer Scottish All Butter Choc Chunk Shortbread Rounds and Asda Extra Special Stem Ginger Shortbread Thins.
Flavoured shortbread	Biscuits described as shortbread with flavouring, for example, Asda Extra Special Lemon Shortbread Thins and Waitrose Seriously Delicate All butter Rose Shortbread.
Shortcake	Products described as shortcake or similar and plain.
Wafer	Products described as wafer or similar, for example, Thorntons Double Chocolate Wafer Rolls.

be consumed as a regular staple with a hot drink, and therefore contribute to excess sugar intake.<sup>27</sup>

Supermarket own label products dominate the cake market in the UK, equating to 56% of shares by value.<sup>25</sup> Premier Foods manufactures the two biggest brands on the market, Mr Kipling and Cadbury cakes, with 15% and 6% of shares by value, respectively.<sup>25</sup> In 2014-2015, the biscuit market was dominated by United Biscuits (26%), own label products (23%) and Mondelez International (11%) by value share.<sup>27</sup>

The purpose of this study was to document the levels of sugar and energy in cakes and biscuits in the UK as the data available are generally owned by commercial companies and not in the public domain for comparison and monitoring. This research aims to (a) evaluate the sugar and energy content listed on the labels of cakes and biscuits sold in the UK, (b) report the variability in sugar and energy content, (c) assess the sugar content in relation to the UK's new daily recommendation for sugar intake and by cake and biscuit manufacturers in the UK and (d) compare current serving sizes with the maximum calorie cap of 325 kcal suggested in the sugar-reduction programme.

## METHODS

The data were collected from product packaging and nutrition labelling in 2016. The survey was designed as a comprehensive survey of all cake and biscuit products available in a snapshot in time, using one large outlet per each of the nine main supermarkets.

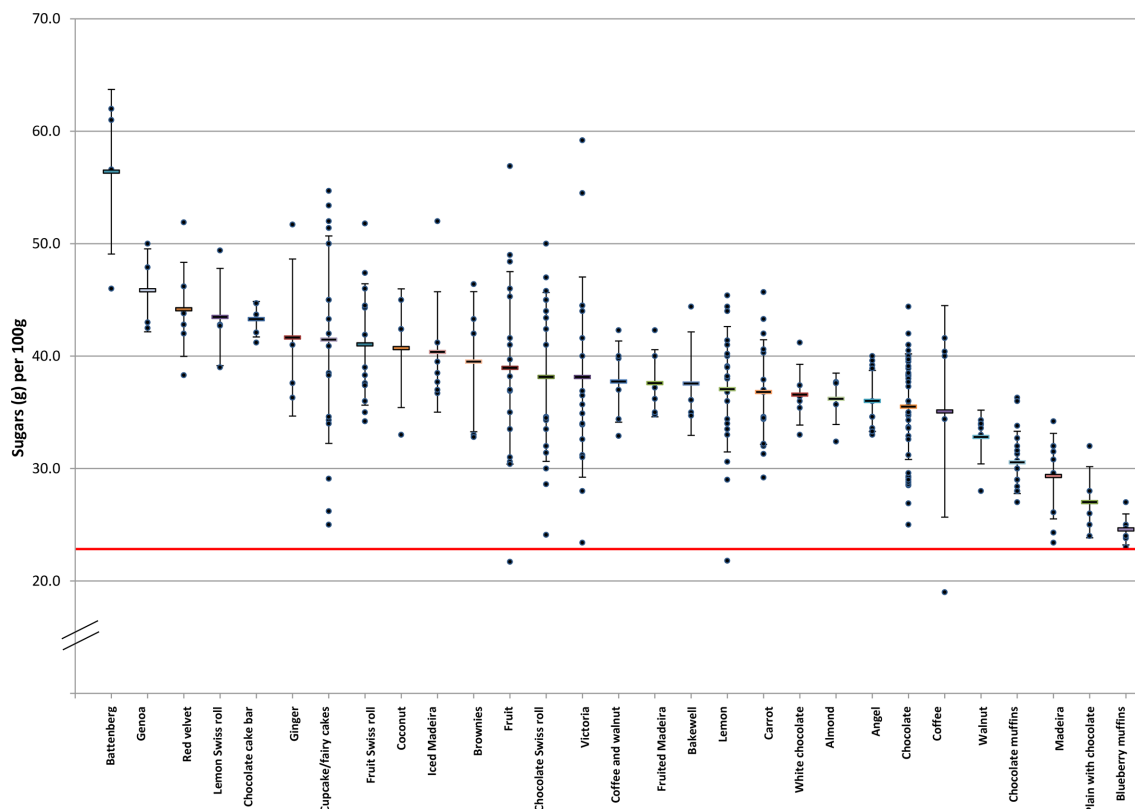
### Data collection

For each cake and biscuit, the data collected included the company name, brand name, product name, pack weight, serving size, total sugars (g) and energy (kcal) content per 100 g as well as per suggested serving size. All data were double-checked after entry, and a further 5% of entries were checked against the original source in a random selection of products.

Data on total energy content was collected since it encompasses the fat, carbohydrate, protein and sugar content of products.

### Stores

Data were collected from each of the major UK supermarkets (Aldi, ASDA, Lidl, Marks and Spencer, Morrisons, Sainsbury's, Tesco, The Co-operative and Waitrose)



**Figure 1** Sugar content in different cake categories (g/100g), red line denotes the red (high) label criteria for sugar (>22.5 g).

as these supermarkets collectively hold over 93.2% of the grocery market share.<sup>28</sup>

### Product categories

Only products with similar formulation/product description were categorised together (tables 1 and 2). Any uncategorised products contributed to the all products data reported. The products were also categorised separately into supermarket own label and branded. Some product categories were excluded from the study (online supplementary file 1).

### Inclusion/exclusion criteria

We included own label and branded cake and biscuit products. We excluded products without nutrition information labelling, such as in-store self-serve bakery items.

### Analysis

**Per 100g:** Some brands sell the same formulation in different serving sizes. The 100g data only included an example of one formulation regardless of the different serving sizes.

**Per serving:** The per-serving data included all the different sugar and energy content available per suggested serving size, or per pack size  $\geq 10$  g or  $<150$  g for cakes and  $\geq 10$  g or  $<90$  g for biscuits.

**High, medium and low criteria for sugar content:** The sugar content was compared with the UK front-of-pack colour-coded labelling for foods: sugars—red/high  $>27$  g/portion or  $>22.5$  g/100 g, amber/medium  $>5.0$  and  $\leq 22.5$  g/100 g, green/low  $\leq 5.0$  g/100 g.<sup>29</sup>

**Maximum sugar intake:** The sugar content was also compared with the maximum daily recommendation for sugar intake (30 g for adults and 19 g for 4-6 year-olds).<sup>16</sup>

**Calorie cap:** The energy content per serving was compared with the maximum calorie cap of 325 kcal suggested in the sugar-reduction programme.<sup>30</sup>

**Manufacturer:** The sugar and energy content was compared between manufacturers, where a manufacturer had five or more products in the sample.

## STATISTICAL ANALYSIS

### Comparison among products

Independent Samples t-test was used to compare the levels of sugar and energy between supermarket own label and branded products.

Data are reported as mean, SD and range as indicated. Significance in all tests carried out was deemed as being  $p < 0.05$ . The data was analysed using SPSS software V.22.

## RESULTS

### Cakes

Nutrition information was collected for 381 products.

### Sugars

Figure 1 and table 3 show the sugar content in different categories of cakes per 100 g. A total of 381 products were included in the per 100g analysis. The

**Table 3** Sugar and energy content in cakes per 100 g

Category	n	Sugars (g), mean±SD (range)	Category	n	Energy (kcal), mean±SD (range)
Own label	290	36.3±7.4 (11.3–61.0)	Own label	290	404±35 (273–502)
Branded	91	37.7±8.4 (19.2–62.0)	Branded	91	414±42 (288–500)
Descending order					
Battenberg	4	56.4±7.3 (46.0–62.0)	Plain with chocolate	5	446±16 (421–457)
Genoa	4	45.9±3.7 (42.5–50.0)	Chocolate cake bar	5	445±41 (376–484)
Red velvet	7	44.2±4.2 (38.3–51.9)	Cupcake/fairy cakes	19	440±41 (380–502)
Lemon Swiss roll	4	43.5±4.3 (39.0–49.4)	Coffee and walnut	6	433±22 (403–460)
Chocolate cake bar	5	43.3±1.6 (41.2–44.7)	Red velvet	7	433±27 (411–489)
Ginger	4	41.7±7.0 (36.3–51.7)	Chocolate	42	430±21 (365–475)
Cupcake/fairy cakes	19	41.5±9.2 (25.0–54.7)	Brownies	5	430±23 (406–454)
Fruit Swiss roll	13	41.0±5.4 (34.2–51.8)	White Chocolate	6	423±12 (402–436)
Coconut	4	40.7±5.3 (33.0–45.0)	Chocolate Swiss roll	18	420±36 (366–500)
Iced Madeira	7	40.4±5.4 (36.7–52.0)	Chocolate muffins	18	416±21 (369–475)
Brownies	5	39.5±6.2 (32.8–46.4)	Coconut	4	416±36 (394–470)
Fruit	17	39.0±8.6 (21.7–56.9)	Walnut	6	405±11 (395–426)
Chocolate Swiss roll	18	38.1±7.5 (24.1–50.0)	Iced Madeira	7	405±20 (391–445)
Victoria	18	38.1±8.9 (23.4–59.2)	Coffee	5	403±19 (391–435)
Coffee and walnut	6	37.7±3.6 (32.9–42.3)	Victoria	18	402±36 (346–456)
Fruited Madeira	6	37.6±3.0 (34.8–42.3)	Battenberg	4	401±22 (375–421)
Bakewell	4	37.6±4.6 (34.7–44.4)	Angel	12	398±16 (378–420)
Lemon	21	37.0±5.6 (21.8–45.4)	Bakewell	4	397±41 (335–422)
Carrot	16	36.8±4.7 (29.2–45.7)	Almond	5	396±16 (379–411)
White chocolate	6	36.6±2.7 (33.0–41.2)	Lemon	21	394±22 (358–439)
Almond	5	36.2±2.3 (32.4–37.7)	Carrot	16	389±20 (323–415)
Angel	12	36.0±2.7 (33.0–40.0)	Madeira	9	387±9 (367–395)
Chocolate	42	35.5±4.7 (25.0–44.4)	Ginger	4	383±20 (362–406)
Coffee	5	35.1±9.4 (19.0–41.6)	Fruited Madeira	6	380±51 (347–484)
Walnut	6	32.8±2.4 (28.0–34.3)	Blueberry muffins	6	378±28 (331–408)
Chocolate muffins	18	30.5±2.8 (27.0–36.3)	Lemon Swiss roll	4	375±34 (349–425)
Madeira	9	29.3±3.8 (23.4–34.2)	Fruit	17	367±39 (273–449)
Plain with chocolate	5	27.0±3.2 (24.0–32.0)	Fruit Swiss roll	13	365±36 (301–422)
Blueberry muffins	6	24.6±1.4 (23.0–27.0)	Genoa	4	356±16 (344–380)
All products	381	36.6±7.6 (11.3–62.0)	All products	381	406±37 (273–502)

average sugar content in cakes was 36.6±7.6 g/100 g. There was a large variation in sugar content between different categories of cakes and within the same category of cake (eg, among all chocolate cake products) ranging from 11.3 to 62.0 g/100 g. On average, Battenberg (56.4±7.3 g/100 g) contained the highest amounts of sugar, ranging from 46 to 62 g, followed by Genoa (45.9±3.7 g/100 g) and red velvet cakes (44.2±4.2 g/100 g), while blueberry muffins (24.6±1.4 g/100 g) contained the lowest amount of sugar. The high amount of sugar in Genoa cakes is partly due to the added dried fruits. Branded cakes had a slightly higher sugar content per 100 g compared

with supermarket own label (37.7 g vs 36.3 g), but the difference was not statistically significant ( $p=0.137$ ). Ninety-seven per cent of cakes would receive a 'red' (high) label for sugar (>22.5 g/100 g) (figure 1).

A total of 370 products provided nutrition information per suggested serving size and were included in the per serving analysis (table 4). The mean sugar content in cakes was 16.9±7.6 g/serving. Red velvet cakes contained the highest sugar content per serving (28.2±9.8 g, almost an adult's entire maximum daily intake for sugar), followed by coffee and walnut cakes (24.9±2.8 g).

On average, a serving of cake contains over half of an adult's (30 g/day) and almost all of a 4–6 year-old

**Table 4** Sugar and energy content in cakes per serving

Category	n	Sugars (g), mean±SD (range)	Category	n	Energy (kcal), mean±SD (range)
Own label	288	17.7±7.7 (4.5–44.6)	Own label	288	196±77 (48–447)
Branded	82	14.1±6.7 (5.3–35.9)	Branded	82	158±74 (46–352)
Descending order					
Red velvet	7	28.2±9.8 (8.3–37.4)	Coffee and walnut	6	287±34 (228–324)
Coffee and walnut	6	24.9±2.8 (21.6–29.2)	Red velvet	7	272±87 (95–357)
Genoa	4	22.1±5.1 (17.9–29.1)	White chocolate	6	248±28 (201–277)
White chocolate	6	21.5±2.6 (16.9–24.5)	Chocolate	40	233±78 (73–407)
Fruit	16	20.2±8.3 (8.8–38.0)	Blueberry muffins	6	220±88 (109–327)
Carrot	16	20.0±6.7 (9.0–34.3)	Carrot	16	215±72 (84–288)
Battenberg	4	19.7±1.1 (18.1–20.7)	Chocolate muffins	18	214±104 (84–355)
Chocolate	40	19.3±7.3 (4.6–35.9)	Victoria	18	200±57 (132–299)
Ginger	4	18.8±6.7 (9.7–26.0)	Coconut	4	187±32 (168–235)
Victoria	18	18.7±6.6 (11.9–34.3)	Cupcake/fairy cakes	15	182±122 (72–361)
Coconut	4	18.2±3.2 (14.9–22.5)	Fruit	16	180±50 (90–264)
Lemon Swiss roll	4	18.0±3.8 (14.1–22.7)	Iced Madeira	7	180±70 (143–338)
Iced Madeira	7	18.0±9.5 (13.2–39.5)	Lemon	21	178±66 (91–284)
Cupcake/fairy cakes	15	16.9±13.2 (4.5–40.1)	Ginger	4	176±71 (93–259)
Lemon	21	16.8±7.4 (8.7–32.5)	Genoa	4	173±44 (133–233)
Chocolate muffins	18	15.7±7.8 (6.1–27.0)	Almond	5	161±27 (122–186)
Fruited Madeira	6	15.2±3.0 (13.2–21.2)	Coffee	5	158±7 (148–164)
Almond	5	14.8±3.5 (10.7–17.5)	Lemon Swiss roll	4	153±26 (115–170)
Blueberry muffins	6	14.7±6.3 (6.2–20.5)	Fruited Madeira	6	153±31 (129–203)
Fruit Swiss roll	13	14.2±4.1 (7.2–20.4)	Walnut	6	153±6 (143–161)
Brownies	5	14.0±5.6 (8.2–21.0)	Brownies	5	146±37 (113–203)
Coffee	5	13.8±4.1 (7.4–17.5)	Battenberg	4	141±18 (129–169)
Walnut	6	12.4±1.5 (9.4–13.6)	Madiera	7	141±12 (121–158)
Chocolate cake bar	5	12.2±1.8 (9.1–13.6)	Plain with chocolate	5	138±48 (107–221)
Chocolate Swiss roll	18	12.0±3.1 (8.1–20.6)	Chocolate Swiss roll	18	135±38 (78–216)
Angel	12	11.9±1.0 (9.7–13.3)	Angel	12	132±9 (117–143)
Bakewell	4	11.5±1.2 (10.1–12.6)	Chocolate cake bar	5	126±26 (81–147)
Madiera	7	11.2±1.2 (9.7–13.0)	Fruit Swiss roll	13	126±33 (78–169)
Plain with chocolate	5	8.6±4.2 (6.1–16.0)	Bakewell	4	124±30 (84–148)
All products	370	16.9±7.6 (4.5–44.6)	All products	370	188±78 (46–447)

child's (19g/day) maximum daily recommended sugar intake.

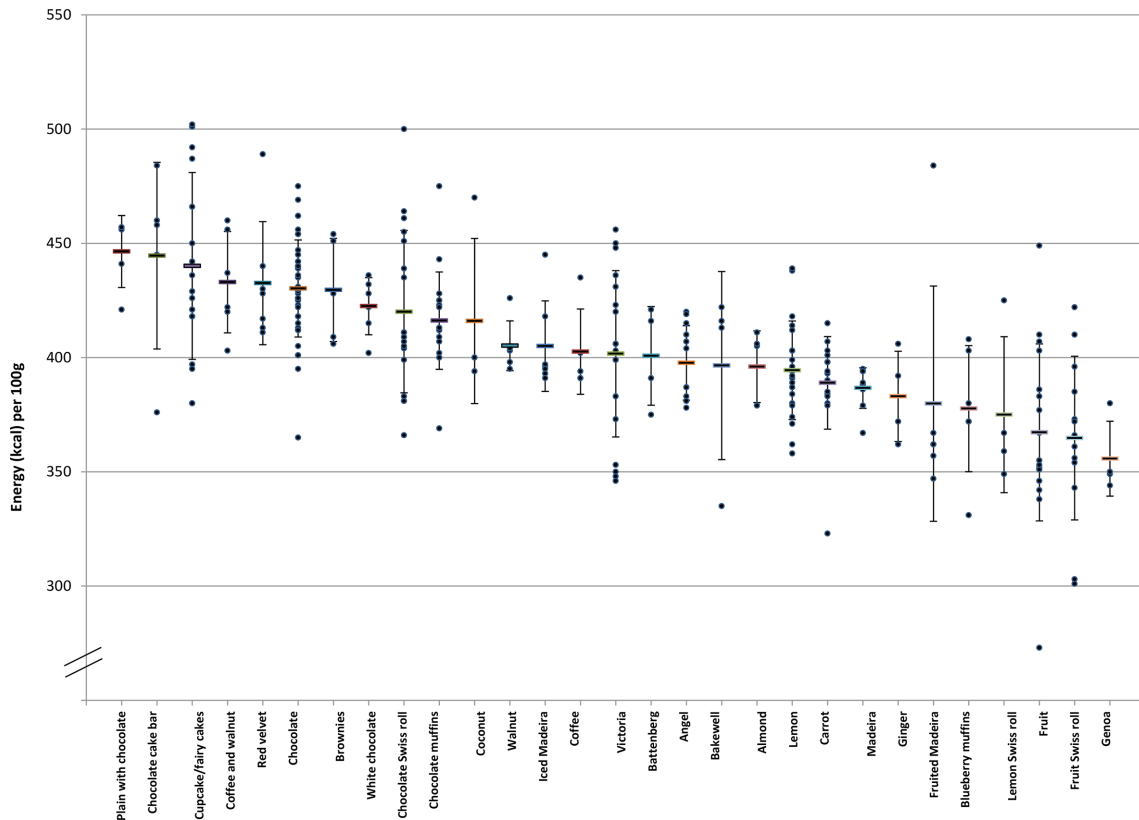
### Energy

Figure 2 and table 3 show the energy content in different categories of cakes per 100g. The average energy content in cakes was 406±37 kcal/100g. There was a large variation in energy content between different categories of cakes and within the same category of cakes ranging from 273 to 502 kcal/100g. On average, plain sponge with chocolate (446±16 kcal/100g) contained the highest amount of

energy, ranging from 421 to 457 kcal, while Genoa cakes (356±16 kcal/100g) contained the lowest amount of energy.

The mean energy content in cakes was 188±78 kcal/serving. Coffee and walnut cakes contained the highest amount of energy per serving (287±34 kcal/serving) and Bakewell (124±30 kcal/serving) contained the lowest (table 4). A total of 19 products exceeded the maximum calorie cap of 325 kcal per serving.

Among the manufacturers with five or more cakes, the McVitie's product range contained the highest average sugar (43.1±7.3g) and Premier Foods



**Figure 2** Energy content in different cake categories (kcal/100g).

contained the highest energy ( $424 \pm 26$  kcal) per 100 g (table 5).

### Biscuits

Nutrition information was collected for a total of 481 biscuit products.

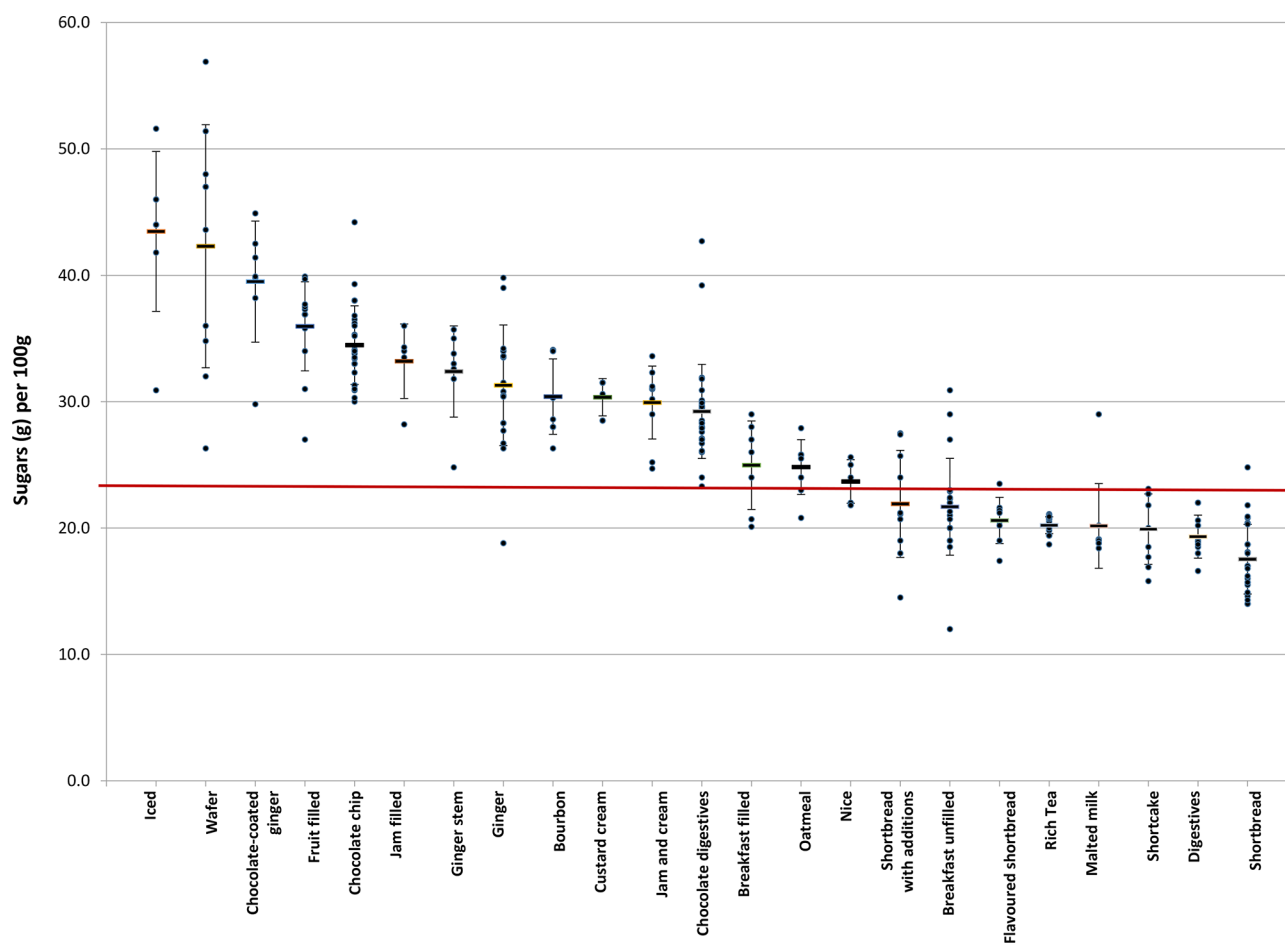
### Sugars

Figure 3 and table 6 show the sugar content in different categories of biscuits per 100g. A total of 481 products were

included in the per 100g analysis. The average sugar content in biscuits was  $30.0 \pm 9.2$  g/100g. There was a large variation in sugar content between different categories of biscuits and within the same category of biscuits, ranging from 12.0 to 74.0 g/100g. On average, iced biscuits ( $43.5 \pm 6.3$  g/100g) contained the highest amounts of sugar and shortbread biscuits ( $17.5 \pm 2.8$  g/100g) contained the lowest. Branded biscuits had a significantly higher sugar content compared

**Table 5** Sugar and energy content in cakes by manufacturer per 100g

Manufacturer	n	Sugars (g), mean±SD (range)	Manufacturer	n	Energy (kcal), mean±SD (range)
McVitie's	7	43.1±7.3 (36.8–52.5)	Premier Foods (Cadbury Cakes and Mr Kipling)	33	424±26 (383–492)
Premier Foods (Cadbury Cakes and Mr Kipling)	33	39.7±6.7 (27.6–62.0)	Waitrose	24	416±32 (342–474)
Morrisons	35	39.0±4.9 (31.5–56.9)	Lidl	21	413±31 (346–500)
Waitrose	24	38.6±7.0 (27.0–57.0)	Tesco	51	410±40 (303–501)
Tesco	51	38.4±8.1 (21.8–54.7)	Morrisons	35	407±36 (346–478)
Aldi	20	36.7±7.8 (26.0–61.0)	Aldi	20	403±45 (273–475)
Sainsbury's	45	35.9±7.2 (23.4–52.0)	Sainsbury's	45	400±33 (301–502)
Co-operative	12	35.2±5.6 (25.0–46.0)	Co-operative	12	400±34 (361–475)
Marks & Spencer	31	34.4±9.3 (11.3–49.4)	Asda	51	399±29 (338–475)
Asda	51	33.9±6.5 (19.0–49.0)	Marks & Spencer	31	388±34 (310–456)
Lidl	21	33.7±6.1 (23.0–47.0)	McVitie's	7	369±14 (355–395)



**Figure 3** Sugar content in different biscuit categories (g/100g), red line denotes red (high) label criteria for sugar (>22.5 g).

with supermarket own label (32.8g vs 28.3g,  $P < 0.001$ ). Seventy-four per cent of biscuits would receive a 'red' (high) label for sugar (>22.5g/100g) (figure 3).

A total of 408 products provided nutrition information per suggested serving size, where the serving size was  $\geq 10$ g (table 7). The mean sugar content in biscuits was  $6.2 \pm 3.7$ g/serving. Breakfast biscuits with filling had the largest serving size, therefore the highest sugar content ( $12.0 \pm 2.4$ g/serving), followed by breakfast biscuits without filling ( $10.2 \pm 2.1$ g).

On average, a biscuit serving (as set by the manufacturers) contains 21% of an adult's (30g/day) and 33% of a 4–6years old child's (19g/day) maximum recommended sugar intake.

Among the 29 breakfast biscuits (filled and unfilled), 59% contained more than a third of an adult's ( $\geq 10$ g) maximum daily recommendation of sugar per serving; this is partly because one serving is 2–4 biscuits.

### Energy

Figure 4 and table 6 show the energy content in different categories of biscuits per 100g. The average energy content in biscuits was  $484 \pm 38$  kcal/100g. There was a large variation in energy content between different categories of biscuits and within the same category of biscuit ranging from 331 to 585 kcal/100g. On average,

shortbread biscuits with additions ( $528 \pm 18$  kcal/100g) contained the highest amount of energy and fruit-filled biscuits ( $391 \pm 11$  kcal/100g) contained the lowest amount of energy.

The average energy content in biscuits per serving was  $97 \pm 46$  kcal (table 7). Only one product exceeded the maximum calorie cap of 325 kcal per serving.

Among the manufacturers with five or more products, the Fox's product range contained the highest average sugar content,  $35.8 \pm 8.5$ g/100g, and Dr. Schar product range contained the highest average energy content,  $512 \pm 10$  kcal/100g (table 8).

### DISCUSSION

This research makes available important baseline data on the sugar and energy content of cakes and biscuits in the UK, for future evaluation of the recently launched sugar-reduction programme. This study also showed that the levels of sugar and energy in products can be reduced, since there was a large variation in sugar and energy content within the same category of cakes and biscuits. For instance, some manufacturers can produce chocolate cake bars with 22% fewer calories per 100g. Biscuits contain less sugar compared with cakes, but



**Table 6** Sugar and energy content in biscuits per 100 g

Category	n	Sugars (g), mean SD (range)	Category	n	Energy (kcal), mean±SD (range)
Own label	296	28.3±8.4 (12.0–70.0)	Own label	296	490±35 (375–558)
Branded	185	32.8±9.6 (15.7–74.0)	Branded	185	474±41 (331–585)
Descending order					
Iced	7	43.5±6.3 (30.9–51.6)	Shortbread with additions	10	528±18 (496–554)
Wafer	10	42.3±9.6 (26.3–56.9)	Shortbread	28	519±11 (497–553)
Chocolate-coated ginger	7	39.5±4.8 (29.8–44.9)	Flavoured shortbread	8	519±9 (505–532)
Fruit filled	13	36.0±3.5 (27.0–39.9)	Chocolate-coated ginger	7	505±23 (466–534)
Chocolate chip	29	34.5±3.1 (30.0–44.2)	Jam and cream	10	505±39 (425–558)
Jam filled	5	33.2±2.9 (28.2–36.0)	Wafer	10	498±89 (331–585)
Ginger stem	7	32.4±3.6 (24.8–35.7)	Chocolate chip	29	498±10 (485–522)
Ginger	19	31.3±4.8 (18.8–39.8)	Nice	5	497±7 (487–505)
Bourbon	9	30.4±3.0 (26.3–34.1)	Chocolate digestives	31	495±13 (456–512)
Custard cream	6	30.4±1.5 (28.5–31.5)	Custard cream	6	492±3 (487–494)
Jam and cream	10	29.9±2.9 (24.7–33.6)	Shortcake	9	490±13 (458–502)
Chocolate digestives	31	29.2±3.7 (23.3–42.7)	Malted milk	9	489±7 (476–500)
Breakfast filled	7	25.0±3.5 (20.1–29.0)	Digestives	11	481±14 (447–498)
Oatmeal	8	24.8±2.2 (20.8–27.9)	Bourbon	9	480±9 (460–487)
Nice	5	23.7±1.7 (21.8–25.6)	Oatmeal	8	478±11 (454–491)
Shortbread with additions	10	21.9±4.2 (14.5–27.5)	Ginger stem	7	466±28 (430–502)
Breakfast unfilled	22	21.7±3.8 (12.0–30.9)	Ginger	19	456±17 (421–489)
Flavoured shortbread	8	20.6±1.8 (17.4–23.5)	Breakfast filled	7	455±22 (433–497)
Rich Tea	16	20.2±0.7 (18.7–21.1)	Rich Tea	16	454±7 (436–467)
Malted milk	9	20.2±3.3 (18.4–29.0)	Iced	7	451±38 (399–515)
Shortcake	9	19.9±2.8 (15.8–23.1)	Breakfast unfilled	22	432±19 (395–461)
Digestives	11	19.3±1.7 (16.6–22.0)	Jam filled	5	426±18 (396–445)
Shortbread	28	17.5±2.8 (14.0–24.8)	Fruit filled	13	391±11 (375–410)
All products	481	30.0±9.2 (12.0–74.0)	All products	481	484±38 (331–585)

people often consume more than one serving (ie, more than one biscuit).

There is extensive evidence that consuming too much sugar and energy is a major contributor to obesity and dental caries.<sup>1–16</sup> Hence, there is an urgent need to reduce the amount of sugar and energy consumed. The sugar and energy content in cakes and biscuits can be reduced through reformulation, that is, by gradually reducing the amount of sugar and total energy.<sup>30</sup> Indeed, evidence from modelling studies suggests that sugar reformulation programmes can potentially reduce sugar intake and improve health outcomes.<sup>31–35</sup>

Studies show that biscuits can be reformulated to reduce sugar and energy content, for example, by using prebiotic fibre (fructo-oligosaccharide),<sup>36–37</sup> acesulfame-K, polyols,<sup>38–39</sup> stevia, coffee silverskin<sup>40</sup> and protein.<sup>37</sup> The reformulated biscuits were acceptable in terms of eating quality, flavour, colour and improved nutritional value.<sup>36–38,40</sup> Similar studies have been carried out to produce reduced sugar and reduced energy

cakes and muffins.<sup>41–45</sup> Indeed, many consumers are increasingly interested in buying cakes made with alternatives to sugar (eg, xylitol).<sup>46</sup>

Despite this, manufacturers have made little progress in reducing sugar in cakes and biscuits since 97% of cakes and 74% of biscuits would receive a ‘red’ (high) label for sugars per 100g and only one in four cake launches featured low/no/reduced fat claims in 2013 and less than 1% claimed to be low/no/reduced sugar.<sup>26</sup>

The industry should be encouraged to shift sales to new ‘healthier’ alternatives with significantly lower sugar and energy levels, since this will also help to achieve the necessary change in the SWA. However, for the full benefits of reformulation to be seen, it needs to permeate the entire cake and biscuit supply chain; and therefore argues against making new products with claims, for example, ‘x% less fat/sugar’. Owing to the huge volume of standard popular cakes and biscuits consumed, even small reductions could

**Table 7** Sugar and energy content in biscuits per serving

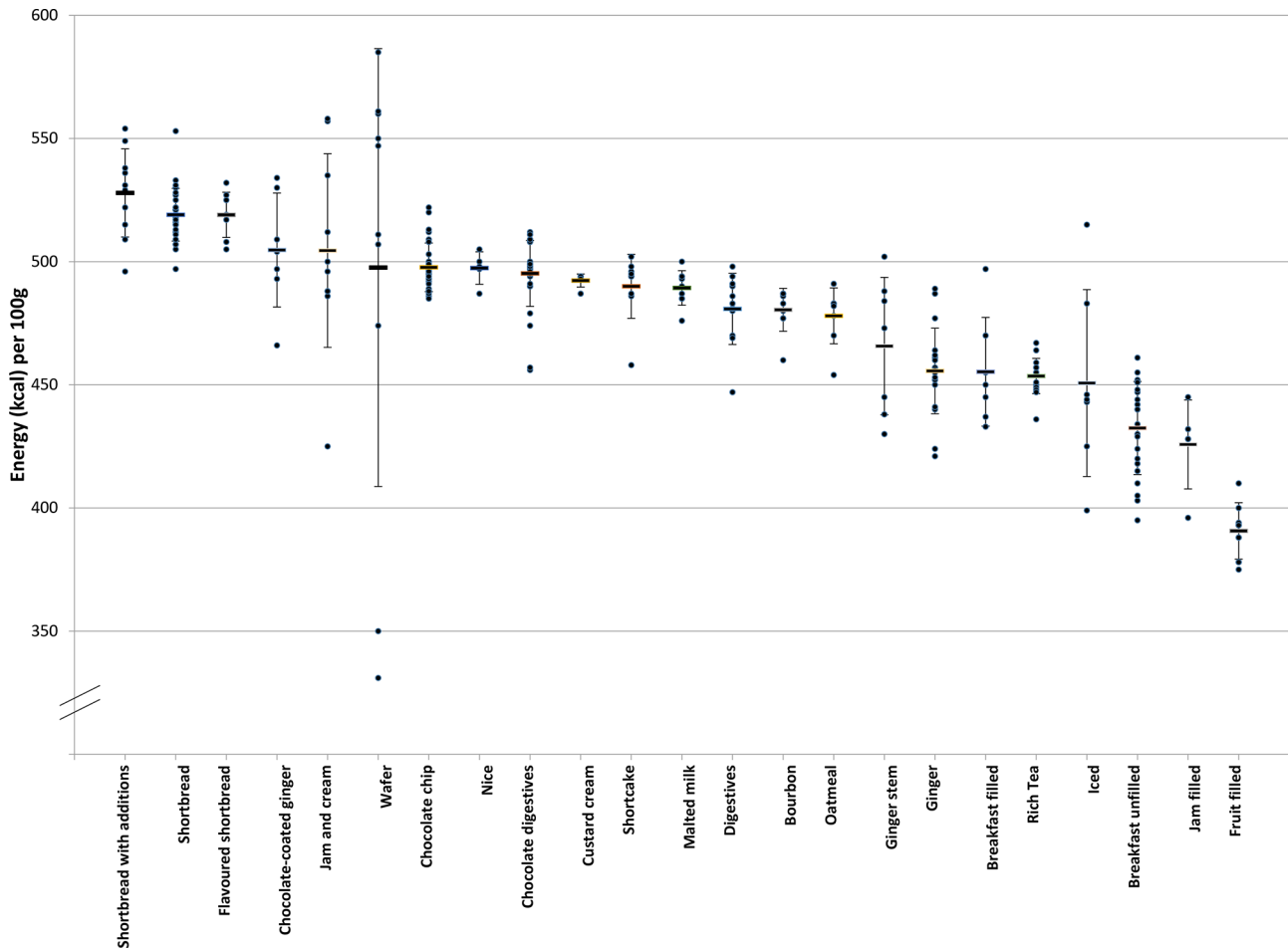
Category	n	Sugars (g), mean±SD (range)	Category	n	Energy (kcal) mean±SD (range)
Own label	247	5.6±3.7 (1.9–35.9)	Own label	247	93±45 (38–385)
Branded	161	7.1±3.5 (1.7–24.4)	Branded	161	104±47 (44–230)
Descending order					
Breakfast filled	7	12.0±2.4 (9.3–14.7)	Breakfast filled	7	218±22 (188–251)
Breakfast unfilled	22	10.2±2.1 (4.5–14.5)	Breakfast unfilled	22	202±21 (161–228)
Iced	4	9.4±3.7 (4.2–12.9)	Malted milk	1	119±0
Wafer	6	8.7±0.8 (7.2–9.4)	Ginger stem	7	105±15 (83–122)
Chocolate-coated ginger	7	7.4±1.9 (4.8–10.0)	Shortbread	24	97±24 (54–182)
Ginger stem	7	7.4±1.5 (4.7–9.1)	Shortbread with additions	10	95±18 (62–110)
Jam filled	5	6.1±0.4 (5.6–6.8)	Chocolate-coated ginger	7	94±21 (67–123)
Chocolate chip	27	6.1±2.4 (3.3–9.8)	Wafer	6	93±35 (49–137)
Jam and cream	10	5.2±1.5 (3.9–9.0)	Iced	4	89±26 (52–112)
Fruit filled	13	5.1±1.5 (3.4–7.8)	Chocolate chip	27	88±33 (50–131)
Malted milk	1	5.1±0.0	Jam and cream	10	88±28 (73–166)
Chocolate digestives	31	4.9±1.0 (3.3–8.1)	Chocolate digestives	31	83±11 (52–124)
Shortbread with additions	10	3.9±1.0 (2.5–5.3)	Jam filled	5	79±6 (74–89)
Bourbon	9	3.9±0.4 (2.9–4.2)	Digestives	11	72±7 (62–85)
Custard cream	6	3.9±0.2 (3.6–4.1)	Oatmeal	6	71±2 (69–74)
Ginger	15	3.7±1.2 (2.6–7.6)	Flavoured shortbread	8	69±17 (53–103)
Oatmeal	6	3.6±0.3 (3.2–3.9)	Custard cream	6	64±3 (62–69)
Shortbread	24	3.3±0.9 (2.2–6.5)	Bourbon	9	63±7 (51–68)
Digestives	11	2.9±0.2 (2.5–3.2)	Shortcake	9	62±21 (49–115)
Flavoured shortbread	8	2.7±0.6 (2.1–3.5)	Fruit filled	13	55±17 (38–95)
Shortcake	9	2.5±1.0 (1.8–5.0)	Ginger	15	52±18 (45–116)
Rich Tea	1	2.0±0.0	Rich Tea	1	47±0
All products	408	6.2±3.7 (1.7–35.9)	All products	408	97±46 (38–385)

have a significant impact on sugar and energy intake of the entire population. Reformulating in ways such as reducing sugar, replacing icing and buttercream with low-fat yoghurt in frosting and fillings, making cakes with fruit and vegetables (eg, carrot, beetroot) and biscuits with dried fruits. Alternatives with claims, even after several years on the market, generally only account for a small proportion of sales, and are unlikely to change sugar and energy intake of the entire population significantly.<sup>24</sup>

Some portion sizes are getting bigger and pose a greater challenge.<sup>47</sup> Research shows that larger portion sizes result in more calories being consumed and it is estimated that if larger-sized portions were removed from the diet completely, this could reduce energy intake by up to 16%.<sup>48</sup> Therefore, the cakes and biscuits sector need to reduce portion size of the large portions available. Furthermore, many sweet biscuits are often

packaged in formats that encourage greater consumption. Some consumers limit how often they eat biscuits because it is easy to eat too many biscuits once the pack is opened.<sup>49</sup> As such, packaging formats offering portion control would help.<sup>27</sup> However, there is a lack of research on the threshold size for smaller portions, eg, the cut-off point where consumers will consume two portions instead of one. Public Health England has defined single-serve cakes as all cakes above 10 g or ≤150 g and biscuits as all products above 10 g or ≤80 g.<sup>24</sup> The survey showed that not many products exceeded the maximum calorie cap of 325 kcal. This may suggest the calorie cap is more applicable to cakes and biscuits served in the out-of-home than the retail sector, or that the cap is not challenging enough.

Aside from reformulation and portion size restrictions, evidence shows that consumption of cakes and biscuits is influenced by in-store promotions. One in



**Figure 4** Energy content in different biscuit categories (kcal/100g).

three people stock up on cakes when on promotion.<sup>25</sup> Therefore, reducing the level of promotion on cakes and biscuits is also necessary to reduce intake.<sup>30</sup>

### LIMITATIONS

Our study was based on sugar and energy content data provided on cake and biscuit product packaging labels in store; hence, we relied on the accuracy of the data provided on the label. It is assumed that the manufacturers provide accurate and up to date information in line with regulations. However, further studies should include sugar and energy content determined through laboratory analysis to ensure greater accuracy and to achieve a better understanding of the types of sugars used. This is because we were unable to distinguish if sugars labelled on the packaging are all free sugars or if some are from milk, fruits and vegetables.

This study did not include Christmas cakes and biscuits which are typically more indulgent; therefore, depending on the time of year, results may be slightly different. Also, this survey did not include in-store bakery items as the nutrition labelling was not available on pack for these products, which may have affected the results.

Furthermore, this study did not analyse the fat and saturated fat contents of the cakes and biscuits, however total

energy content was included, which would encompass the amount of energy coming from fat and therefore any potential future reductions in the amount of total energy can be achieved from reductions in fat and/or sugar.

Our data do not include sugar and energy content of cakes and biscuits in the out-of-home sector; this is due to the lack of publicly available data. Future studies should endeavour to include this type of data too, especially as purchases of these products have increased in recent years, and food eaten out of the home now accounts for a growing proportion of the total amount of food eaten. More than 25% of adults and one-fifth of children buy and consume food out of home/on the go at least once a week.<sup>50</sup>

Nevertheless, the results of this study document the sugar and energy content of cakes and biscuits sold in the UK, providing baseline data to evaluate public health interventions such as the sugar-reduction programme and potentially incentivise the cakes and biscuits industry to reformulate their products.

### CONCLUSION

This research provides baseline data of the cakes and biscuits market in the UK for evaluation of the recently launched sugar-reduction programme. The study also

**Table 8** Sugar and energy content in biscuits by manufacturer per 100 g

Manufacturer	n	Sugars (g), mean±SD (range)	Manufacturer	n	Energy (kcal), mean±SD (range)
Fox's	27	35.8±8.5 (19.1–49.0)	Dr. Schar	5	512±10 (500–523)
Bahlsen	11	35.4±6.0 (23.0–43.0)	Bahlsen	11	511±31 (445–561)
Burton's Biscuit Co.	12	34.3±3.6 (28.2–41.3)	Waitrose	23	507±33 (378–534)
Mondelez International	33	32.3±8.8 (19.0–49.9)	Marks & Spencer	68	504±29 (430–558)
McVitie's	42	32.1±8.4 (16.6–51.6)	Asda	36	492±32 (375–548)
Dr. Schar	5	31.6±1.7 (29.0–33.0)	Fox's	27	488±28 (441–527)
Aldi	28	30.3±7.9 (12.0–42.0)	Lidl	19	487±31 (418–535)
Morrisons	27	30.1±11.1 (15.5–61.6)	Morrisons	27	487±36 (379–531)
Tesco	31	30.0±10.8 (14.6–70.0)	Sainsbury's	51	486±36 (378–553)
Border Biscuits Ltd	7	29.6±8.6 (16.4–44.9)	Tesco	31	482±33 (388–539)
Lidl	19	29.5±6.6 (16.0–39.0)	Mondelez International	33	475±37 (395–539)
Marks & Spencer	68	28.7±8.9 (14.3–48.9)	Aldi	28	474±34 (382–514)
Waitrose	23	27.9±7.6 (17.9–46.2)	Co-operative	13	472±41 (380–525)
Asda	36	27.6±7.3 (14.0–45.0)	Burton's Biscuit Co.	12	469±35 (425–512)
Kellogg's	6	26.0±5.8 (19.0–32.0)	McVitie's	42	462±39 (393–516)
Sainsbury's	51	25.7±6.5 (14.0–47.0)	Weight Watchers	5	461±18 (438–483)
Weight Watchers	5	25.2±4.9 (17.1–30.0)	Border Biscuits Ltd	7	460±34 (400–505)
Co-operative	13	24.5±6.4 (14.9–34.0)	Nairn's	8	457±12 (438–470)
Nairn's	8	18.7±2.6 (15.7–22.7)	Kellogg's	6	429±31 (379–470)

showed that reduction in the sugar and energy content of cakes and biscuits is possible because there was a large variation in sugar and energy content not only between different categories of cakes and biscuits but also within the same category. A reduction in sugar and energy content and overall cake and biscuit consumption can help reduce overall sugar and energy intake in the UK and thus help to reduce the risk of obesity and dental caries.

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**Data sharing statement** The sugar and calorie information of each product included will be available on emailing the corresponding author.

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## REFERENCES

1. SACN. Carbohydrates and health. 2015. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/445503/SACN\\_Carbohydrates\\_and\\_Health.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/445503/SACN_Carbohydrates_and_Health.pdf)
2. Romaguera D, Norat T, Wark PA, *et al.* Consumption of sweet beverages and type 2 diabetes incidence in European adults: results from EPIC-InterAct. *Diabetologia* 2013;56:1520–30.
3. de Koning L, Malik VS, Rimm EB, *et al.* Sugar-sweetened and artificially sweetened beverage consumption and risk of type 2 diabetes in men. *Am J Clin Nutr* 2011;93:1321–7.
4. Maki KC, Phillips AK. Dietary substitutions for refined carbohydrate that show promise for reducing risk of type 2 diabetes in men and women. *J Nutr* 2015;145:159S–63.
5. Te Morenga L, Mallard S, Mann J. Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ* 2012;346:e7492.
6. Johnson RK, Appel LJ, Brands M, *et al.* Dietary sugars intake and cardiovascular health: a scientific statement from the American Heart Association. *Circulation* 2009;120:1011–20.
7. Moynihan PJ, Kelly SA. Effect on caries of restricting sugars intake: systematic review to inform WHO guidelines. *J Dent Res* 2014;93:8–18.
8. Public Health England. UK and Ireland prevalence and trends. 2013. [https://www.noo.org.uk/NOO\\_about\\_obesity/adult\\_obesity/UK\\_prevalence\\_and\\_trends](https://www.noo.org.uk/NOO_about_obesity/adult_obesity/UK_prevalence_and_trends) (accessed 2 Jul 2015).
9. HSCIC. Statistics on obesity, physical activity and diet: England 2014. 2014. <http://www.hscic.gov.uk/catalogue/PUB13648/Obesity-acti-diet-eng-2014-rep.pdf> (accessed 2 Jul 2015).
10. Public Health England. Adult obesity and type 2 diabetes. 2014. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/338934/Adult\\_obesity\\_and\\_type\\_2\\_diabetes.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/338934/Adult_obesity_and_type_2_diabetes.pdf) (accessed 2 Jul 2015).
11. HSCIC. National diabetes audit. 2008. <http://www.hscic.gov.uk/catalogue/PUB02580/nati-diab-audi-07-08-exec-sum.pdf> (accessed Jul 2015).

12. Public Health England. National Dental Epidemiology Programme for England: oral health survey of five-year-old children 2012. A report on the prevalence and severity of dental decay. 2012. <http://www.nwph.net/dentalhealth/Oral%20Health%205yr%20old%20children%202012%20final%20report%20gateway%20approved.pdf> (accessed 2 Dec 2015).
13. Public Health England. Dental public health epidemiology programme. Oral health survey of three-year-old children 2013. A report on the prevalence and severity of dental decay. 2014 <http://www.nwph.net/dentalhealth/reports/DPHEP%20for%20England%20OH%20Survey%203yr%202013%20Report.pdf> (accessed 2 Dec 2015).
14. NHS. Executive summary: adult dental health survey. 2009. <http://www.hscic.gov.uk/catalogue/PUB01086/adul-dent-heal-surv-summ-them-exec-2009-rep2.pdf> (accessed 2 Dec 2015).
15. Public Health England. Sugar reduction responding to the challenge. 2014. 1 Jun 2014. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/324043/Sugar\\_Reduction\\_Responding\\_to\\_the\\_Challenge\\_26\\_June.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/324043/Sugar_Reduction_Responding_to_the_Challenge_26_June.pdf)
16. Public Health England. Why 5%?. 2015. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/446010/Why\\_5\\_-\\_The\\_Science\\_Behind\\_SACN.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/446010/Why_5_-_The_Science_Behind_SACN.pdf)
17. Public Health England. NDNS: results from years 5 and 6 (combined). 2016. 2 Jun 2016. <https://www.gov.uk/government/statistics/ndns-results-from-years-5-and-6-combined>
18. Rennie KL, Jebb SA, Wright A, *et al*. Secular trends in under-reporting in young people. *Br J Nutr* 2005;93:241–7.
19. Campbell R, Tasevska N, Jackson KG, *et al*. Association between urinary biomarkers of total sugars intake and measures of obesity in a cross-sectional study. *PLoS One* 2017;12:e0179508.
20. Hebert JR, Ebbeling CB, Matthews CE, *et al*. Systematic errors in middle-aged women's estimates of energy intake: comparing three self-report measures to total energy expenditure from doubly labeled water. *Ann Epidemiol* 2002;12:577–86.
21. Lara JJ, Scott JA, Lean ME. Intentional mis-reporting of food consumption and its relationship with body mass index and psychological scores in women. *J Hum Nutr Diet* 2004;17:209–18.
22. Rennie KL, Coward A, Jebb SA. Estimating under-reporting of energy intake in dietary surveys using an individualised method. *Br J Nutr* 2007;97:1169–76.
23. Archer E, Hand GA, Blair SN. Validity of U.S. nutritional surveillance: National Health and Nutrition Examination Survey caloric energy intake data, 1971–2010. *PLoS One* 2013;8:e76632.
24. Public Health England. Sugar reduction: achieving the 20%. 2017. <https://www.gov.uk/government/publications/sugar-reduction-achieving-the-20>
25. Mintel. Cakes and cake bars UK. 2014. (June 2014).
26. Mintel. Cakes market trends: small cakes overtake large cakes. 2013. 2 Jun 2016. <http://www.mintel.com/press-centre/food-and-drink/uk-cakes-market-trend>
27. Mintel. Biscuits, cookies and crackers - UK - April 2015. 2015 [http://academic.mintel.com/display/715858/?\\_\\_cc=1](http://academic.mintel.com/display/715858/?__cc=1)
28. Kantar-Worldpanel. Grocery market share - Kantar Worldpanel. 2016 <http://www.kantarworldpanel.com/en/grocery-market-share/great-britain> (accessed 30 Apr 2016).
29. Department-of-Health. Guide to creating a Front of Pack (FoP) nutrition label for pre-packed products sold through retail outlets. 2016 <https://www.food.gov.uk/sites/default/files/multimedia/pdfs/pdf-ni/fop-guidance.pdf> (accessed 1 July 2017).
30. Public Health England. Sugar reduction the evidence for action. 2015 [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/470179/Sugar\\_reduction\\_The\\_evidence\\_for\\_action.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470179/Sugar_reduction_The_evidence_for_action.pdf) (accessed 2 October 2015).
31. Tedstone A, Targett V, Allen R. Sugar Reduction: The evidence for action Annexe 5: Food supply. 2015 [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/470176/Annexe\\_5\\_-\\_Food\\_Supply.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470176/Annexe_5_-_Food_Supply.pdf) (accessed 2 Jan 2017).
32. Combris P, Goglia R, Henini M, *et al*. Improvement of the nutritional quality of foods as a public health tool. *Public Health* 2011;125:717–24.
33. Leroy P, Réquillart V, Soler LG, *et al*. An assessment of the potential health impacts of food reformulation. *Eur J Clin Nutr* 2016;70:694–9.
34. Roodenburg AJ, Schlatmann A, Dötsch-Klerk M, *et al*. Potential effects of nutrient profiles on nutrient intakes in the Netherlands, Greece, Spain, USA, Israel, China and South-Africa. *PLoS One* 2011;6:e14721.
35. Roodenburg AJ, van Ballegooijen AJ, Dötsch-Klerk M, *et al*. Modelling of usual nutrient intakes: potential impact of the choices programme on nutrient intakes in young dutch adults. *PLoS One* 2013;8:e72378.
36. Boobier WJ, Baker JS, Davies B. Development of a healthy biscuit: an alternative approach to biscuit manufacture. *Nutr J* 2006;5:7.
37. Gallagher E, O'Brien CM, Scannell AGM, *et al*. Use of response surface methodology to produce functional short dough biscuits. *J Food Eng* 2003;56:269–71.
38. Zoulias EI, Piknis S, Oreopoulou V. Effect of sugar replacement by polyols and acesulfame-K on properties of low-fat cookies. *J Sci Food Agric* 2000;80:2049–56.
39. Laguna L, Vallons KJR, Jurgens A, *et al*. Understanding the Effect of Sugar and Sugar Replacement in Short Dough Biscuits. *Food Bioproc Tech* 2013;6:3143–54.
40. Garcia-Serna E, Martinez-Saez N, Mesias M, *et al*. Use of Coffee Silverskin and Stevia to Improve the Formulation of Biscuits. *Pol J Food Nutr Sci* 2014;64.
41. Psimouli V, Oreopoulou V. The effect of alternative sweeteners on batter rheology and cake properties. *J Sci Food Agric* 2012;92:99–105.
42. Struck S, Gundel L, Zahn S, *et al*. Fiber enriched reduced sugar muffins made from iso-viscous batters. *LWT - Food Science and Technology* 2016;65:32–8.
43. Martinez-Cervera S, Sanz T, Salvador A, *et al*. Rheological, textural and sensorial properties of low-sucrose muffins reformulated with sucralose/polydextrose. *LWT - Food Science and Technology* 2012;45:213–20.
44. Masooi FA, Sharma B, Chauhan GS. Use of apple pomace as a source of dietary fiber in cakes. *Plant Foods Hum Nutr* 2002;57:121–8.
45. Martinez-Cervera S, Salvador A, Sanz T. Comparison of different polyols as total sucrose replacers in muffins: Thermal, rheological, texture and acceptability properties. *Food Hydrocoll* 2014;35:1–8.
46. Mintel. National afternoon tea week: Young brits shun the traditional cuppa, but cake sales are yet to crumble. 2016 <http://www.mintel.com/press-centre/food-and-drink/national-afternoon-tea-week-young-brits-shun-the-traditional-cuppa-but-cake-sales-are-yet-to-crumble>
47. Food Standards Agency. The role of portion sizes in our diet. 2008 <http://webarchive.nationalarchives.gov.uk/20120206100416/http://food.gov.uk/news/newsarchive/2008/jun/portionsize>
48. Hollands GJ, Shemilt I, Marteau TM, *et al*. Portion, package or tableware size for changing selection and consumption of food, alcohol and tobacco. *Cochrane Database Syst Rev* 2015:CD011045.
49. Mintel. Biscuits, cookies and crackers - UK - consumer market research report - company profiles - market trends - 2015. 2 Jun 2016. 2016. <http://store.mintel.com/biscuits-cookies-and-crackers-uk-april-2015>
50. Public Health England. Health matters: obesity and the food environment. <https://www.gov.uk/government/publications/health-matters-obesity-and-the-food-environment/health-matters-obesity-and-the-food-environment-2>