Direct Uptake of Nutrition and Caffeine Study (DUNCS): biscuit based comparative study

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ABSTRACT

OBJECTIVES
To identify the time required to achieve optimal palatability of a cup of tea without risk of harm (oral scalding) using the resources available in a standard hospital staff room, and to identify the best accompanying biscuit for nutritional content, crunchiness, and integrity when dunking.

DESIGN
Prospective, non-masked, biscuit based, comparative study.

SETTING
Staff room in the surgery department of a UK hospital.

PARTICIPANTS
Four different varieties of round, non-chocolate biscuit: oat, digestive, rich tea, and shortie. A standardised cup of tea was determined on the basis of the investigators' preference for colour and palatability and pragmatic tea making methods.

MAIN OUTCOME MEASURES
The main outcome was time to achieve a safe temperature for consumption of tea, and the best biscuit to pair with the tea on the basis of nutritional content, absorptive ability, crunchiness, and integrity after dunking. Biscuits were ranked first to last (according to scores 1-4), with penalty points given for adverse events such as scalds and breakability.

RESULTS
Baseline data suggested that after adding 240 mL of freshly boiled water to an unwarmed mug containing a tea bag, the median temperature of a standard cup of tea was 82°C (range 81-84°C). Optimal palatability and agreed universal drinking temperature of 61°C was achieved at 400 (range 360-420) seconds with 30 mL of cow’s milk and 370 (330-450) seconds with 40 mL of milk. The investigators considered tea colour preferable with 40 mL of milk.

CONCLUSION
Healthcare workers can safely consume a cup of tea after less than 10 minutes, especially if enjoyed with a biscuit. Making time for a cup of tea may help healthcare workers avoid their break point.

Introduction
Over recent years the public sector has faced immense challenges, such as the covid-19 pandemic. During difficult times, when morale and motivation have been tested, one quintessential British refreshment has helped the nation to push through. Although the choice of hot drinks now available is extensive, a cup of tea remains the preferred choice. When paired with a biscuit, this combination is rocket fuel for the National Health Service.

Staff wellbeing is important, and optimising staff hydration and nutrition can help to improve mood and performance. We have witnessed how NHS staff avoid breaks because of constraints on their time, often grabbing substandard refreshments in a rush. As scientific evidence is lacking on best snack practice, most healthcare workers are forced to rely on their own experience. Efficient tea making skills and a good quality accompanying biscuit are important for healthcare workers, who deserve to have a brew-tiful day.

Freshly boiled water is an important part of the tea making process, but this raises concerns about the risk of oral scalding if busy healthcare workers are tempted to consume a beverage before it reaches a safe temperature. The choice of accompanying biscuit is also important. If staff prefer dunking, will their biscuit of choice survive immersion and sustain crunchiness?

We identified the time taken to produce a safe, palatable cup of tea. In keeping with the tradition of tea paired with a biscuit, we assessed four biscuit varieties for nutritional content and durability after dunking.

Methods

Biscuit selection
Based on extensive research from years of frequenting staff rooms in NHS hospitals, we identified four biscuits most commonly found in staff biscuit tins—oat, digestive, rich tea, and shortie. We describe and quantify the desirable characteristics (eg, nutritional content and integrity when being dunked) of these biscuits when paired with a safe, palatable cup of tea. To minimise the risk from heterogeneity, we limited our selection to single layer, non-coated, non-filled biscuit varieties.

Preparing a standard cup of tea
We performed a pilot experiment to determine the best volumes of water and cow’s milk (this being to our knowledge the most commonly available for healthcare workers)
workers) required for NHS staff to make a standard cup of tea in a timely manner; this baseline data informed subsequent tests. We reviewed existing literature to identify a standardised methodology; however, the findings were inconsistent or had historical reasoning not in keeping with the contemporary workplace.

One of us (JF) prepared all cups of tea throughout the study, and the other (CJ) monitored relevant times with a stopwatch and recorded data. As the tests involved risks, health and safety was taken into consideration and we refreshed our good cuppa preparation (GCP) training before the study. Equipment was checked thoroughly, syringes were designated for enteral use only, and emergency equipment, including cold water, kitchen roll, a mop, and a food waste bin were readily available.

Throughout the study, tea was prepared in standardised, newly purchased, unchipped porcelain mugs, each with a liquid holding capacity of 310 mL. Taking into account the non-filled void for safe carriage and a comfortable slurp rim, we determined that the total fluid volume (water plus milk) could not exceed 280 mL. We then agreed that 240 mL of water would be the standard and would allow the addition of 30-40 mL of milk.

The mutually agreed tea making process involved pouring 240 mL of freshly boiled water over a single tea bag in an unwarmed mug. JF stirred the tea bag gently with a metal spoon for 60 seconds (checked by CJ), before giving it a gentle squeeze and extracting it from the cup. The milk was taken straight from the fridge (temperature set to 4°C) and as soon as it was added to the tea, the stopwatch was started (time zero). The temperature of the tea was measured at 30 second intervals using a thermometer (fig 1). We both slurped the tea to assess palatability and the potential for oral scalding. Testing for palatability was repeated every 30 seconds. Data were collected on the rate the tea temperature dropped and the overall time required for a comfortable, and therefore potentially safe, drinking temperature to be achieved. Two volumes of milk (30 mL and 40 mL) were initially investigated, and we both reviewed the tea’s colour, palatability, and cooling time—or time to drinkable tea (TTDT). Based on our pilot experiment findings, we used 40 mL of semi-skimmed cow’s milk to prepare standard cups of tea for all six tests.

Biscuit tests

**Time to drinkable tea (TTDT)**

2 biscuits, selected at random from the packet, were dunked into the tea, one at the 30 second interval, one at 60 seconds. Making tea more palatable quicker is preferable and the biscuit reducing the TTDT the most was seen as the winner.

**Nutritional content**

3 biscuits from each packet were chosen at random for weighing, and energy content (raw/added) recorded from the packets. The biscuit with the highest calorie per biscuit value was deemed the best in test.

**Saturation volume**

Tea was syringed onto the centre of each biscuit in 1 mL increments. The winner was the biscuit that absorbed the highest volume before permeation onto a doily below.

**Crunch reduction**

Crunch scores were recorded using a metal ruler and scored for each biscuit. The winner was the biscuit with the smallest reduction in crunch volume.

**Dunk break point**

Biscuits were dunked for 2 seconds into a fresh standard brew, then held away from the cup. The time for the biscuit to break was recorded, the winner having the longest post-dunk integrity.

**Pragmatic dunk break point**

Biscuits were dunked for 2 seconds into a fresh standard brew, then held away from the cup. The time for the biscuit to break was recorded, the winner having the longest post-dunk integrity.

**Overall score** (lower scores are better)

1. Oat
2. Digestive
3. Shortie
4. Rich tea

**Overall rank**

1. 2. 3. 4.

Biscuit tins. Each of these biscuits was subjected to rigorous experiments, designed to qualify and quantify desirable biscuit characteristics.

Experiments were repeated 3 times per biscuit.

The DUNC Study

Direct Uptake of Nutrition and Caffeine

Preparing a “standard brew”

Preparing a “standard brew” involves boiling 240 mL of freshly brewed tea over a single tea bag placed inside an unwarmed mug. It was stirred gently for 60 seconds before a gentle squeeze and extraction. 40 mL semi-skimmed cow’s milk, taken straight from the fridge (4°C), was added. Milk addition was time zero for the experiments.

Nutritional content

To assess the nutritional content of each biscuit and to corroborate the findings with the information provided by the manufacturers, we weighed three randomly chosen biscuits from each of the four packets. We then compared the recorded weights with those shown on the relevant packet and reviewed the energy content (kcal). The biscuit with the highest energy content was ranked first (score 1) and the biscuit with the longest TTDT was ranked last (score 4).

Satisfaction volume

For the saturation volume test we hypothesised that those biscuits that absorbed the most tea in each dunk would help towards TTDT. Bespoke doilies, made from kitchen roll, were placed on saucers, and one randomly chosen biscuit from each packet was then placed on a doily. Using a syringe, we dripped freshly brewed tea
onto the centre of each biscuit in 1 mL increments. We then inspected the doilies for signs of tea (fig 2) and recorded the volume of tea required before permeation to the doily. The biscuit that absorbed the largest volume of tea before signs of permeation was ranked first (score 1).

Crunch reduction
To test for crunchiness after a biscuit had been dunked, JF first selected three biscuits at random from each packet and then determined the baseline crunch score of each biscuit variety by breaking the biscuits in half next to a decibel meter (app on smartphone). Three more biscuits were then selected from each packet. Using another syringe, 2 mL of freshly brewed tea was then dripped onto the centre of each biscuit. Each treated biscuit was immediately broken in half next to the decibel meter and the crunch score recorded. For comparative purposes, both dry and wet crunch volumes were recorded (three sets of data for each biscuit variety) and the percentage reduction in crunch volumes were calculated. The biscuit with the smallest reduction in crunch volume was ranked first (score 1).

Dunk break point
The dunk break point test was used to identify the biscuit that would be best for dunking. One of each biscuit variety was held firmly between thumb and index finger (the universal dunking grip) before being dunked into a standard cup of tea as far as the fingertips. The biscuit was gently moved back and forth until the dunked portion broke away and sank (the dunk break point). JF dunked the biscuits while CJ recorded the dunk break point. The biscuit that took the longest to reach the dunk break point was ranked first (score 1).

Pragmatic dunk break point
The test for pragmatic dunk break point imitates the real world of tea and biscuit pairing more closely. JF selected a biscuit from each packet in turn and dunked it (using the universal dunking grip) for two seconds into a cup of freshly brewed tea. The biscuit was then held away from the cup and the time recorded until the biscuit fell apart. The biscuit that maintained its integrity for the longest after being dunked was ranked first (score 1). Biscuits were given penalty points if they broke apart before being moved away from the cup (the floater effect).

Statistical analysis
For all six tests, each biscuit variety was ranked based on median and mean scores, with a score of 1 (ranked first) assigned to the biscuit with the best result and a score of 4 (ranked last) assigned to the biscuit with the worst result. We added the scores for each test together, with each test given equal weighting in the scoring process. The biscuit with the lowest overall score was thus considered the best biscuit.

Patient and public involvement
Members of the public were not involved in the design of the study. The manuscript, however, has been received with interest.

Results
Preparing a standard cup of tea
Baseline data suggested that the initial median temperature of a standard brewed cup of tea was 82°C (range 81-84°C) after adding 240 mL of freshly boiled water to a single teabag in an unwarmed mug. After gently stirring for 60 seconds, removing the tea bag, and adding the milk we observed temperature drops of 10°C (range 9-10°C) with the addition of 30 mL milk and 11°C with the addition of 40 mL milk. The tea further cooled by 1°C every 30 seconds. Optimal palatability and agreed universal drinking temperature was 61°C, which was achieved at 400 (360-420) seconds with 30 mL of milk and 370 (330-450) seconds with 40 mL of milk. We preferred the colour of tea with 40 mL of milk.
Table 1 | Baseline time to drinkable tea (TTDT) and dunking by biscuit variety in a freshly brewed standard cup of tea

<table>
<thead>
<tr>
<th>Milk volume (mL)</th>
<th>Median (range) TTDT (sec)</th>
<th>TTDT reduction (sec)</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>400 (360-420)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>40</td>
<td>370 (330-450)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Biscuit dunked**

<table>
<thead>
<tr>
<th>Oat</th>
<th>270 (270-300)</th>
<th>100 (70-100)</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestive</td>
<td>240 (210-240)</td>
<td>130 (130-160)</td>
<td>1</td>
</tr>
<tr>
<td>Rich tea</td>
<td>300 (300-330)</td>
<td>70 (40-70)</td>
<td>4</td>
</tr>
<tr>
<td>Shortie</td>
<td>300 (270-300)</td>
<td>70 (70-100)</td>
<td>3</td>
</tr>
</tbody>
</table>

**Time to drinkable tea: impact of dunking**

The TTDT for all four biscuits decreased during dunking at 30 and 60 second intervals (table 1). The digestive showed the most significant reduction (median TTDT 240 (range 210-240) seconds) and was ranked first (1 point), with the rich tea showing the least reduction (median 300 (300-330) seconds) and ranked fourth (4 points).

**Nutritional content**

No discrepancies were found between the recorded weights of biscuits and the weights given on the packets for all four biscuit varieties (table 2). The oat biscuit had the highest energy content (70 kcal/biscuit; 1 kcal=4.18 kJ) and was ranked first (1 point), and the rich tea had the lowest energy content (43 kcal/biscuit) and was ranked fourth (4 points).

**Saturation volume**

The rich tea was ranked first (1 point) in the saturation volume test (table 2), absorbing a median of 9 (range 8-9) mL of tea before permeating to the doily. The results for the oat biscuit and digestive were comparable. The shortie was ranked fourth (4 points), absorbing a median of 4 (3-4) mL of tea during the three tests.

**Crunch reduction**

The digestive was ranked first (1 point) for crunch reduction (table 2), with a 15% reduction in crunch volume. The results for the oat biscuit and rich tea were comparable, and the shortie was ranked fourth (4 points), with a 32% reduction in crunch volume.

**Dunk break point**

The oat biscuit ranked first in the dunk break point test, with a mean dunk time of 34.3 seconds to dunk break point (table 3). The shortie was ranked second, with a mean 31.7 seconds to dunk break point, followed by the digestive (ranked third) and rich tea (ranked fourth), with 28.3 seconds and 21.3 seconds, respectively.

**Pragmatic dunk break point**

The oat biscuit ranked first in the mean pragmatic dunk break point test, with 29 seconds compared with 17.5 seconds for the shortie (ranked second) and 8.5 seconds for the digestive (ranked third). The rich tea was ranked fourth; it was also given three additional penalty points for having the lowest dunk break point in all three repeat tests.

**Overall biscuit scores and best performing biscuit**

The oat biscuit ranked first after all six tests (table 4). The digestive ranked second—it crumbled in three tests of absorptive capability and structural integrity (saturation volume, dunk break point, and pragmatic dunk break point). The shortie was ranked third, whereas the rich tea (the only biscuit given penalty points) was ranked fourth; the penalty points did not directly influence the rich tea's ranking.

**Discussion**

Good hydration and nutrition are fundamental, whether in the context of protocols for enhanced recovery after surgery, trace element replacement on the intensive care unit, or simply avoiding “hangriness.” Optimising fluid and energy intake is essential for peak performance. As with elite athletes who require expert diet management to optimise performance, healthcare workers also need to perform at their best. Tea and biscuits are part of British culture, and it would be beneficial to harness the rejuvenation provided by the pairing of these two and to deliver them to healthcare workers directly.

Although the study results varied, important findings were that it takes around 400 seconds for a cup of tea to reach optimal palatability (61ºC) with 30 mL of milk, and just 370 seconds with 40 mL of milk. A healthcare worker can expect to enjoy a cup of tea and it would be beneficial to harness the rejuvenation provided by the pairing of these two and to deliver them to healthcare workers directly.

Table 2 | Nutritional content, saturation volume, crunch reduction, and dunk break point by biscuit variety

<table>
<thead>
<tr>
<th>Nutritional content</th>
<th>Oat (g)</th>
<th>Digestive (g)</th>
<th>Rich tea (g)</th>
<th>Shortie (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g)</td>
<td>15</td>
<td>15</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Energy content</td>
<td>70</td>
<td>67</td>
<td>43</td>
<td>65</td>
</tr>
<tr>
<td>Score</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

**Saturation volume (mL)**

<table>
<thead>
<tr>
<th>Median (mL)</th>
<th>Oat</th>
<th>Digestive</th>
<th>Rich tea</th>
<th>Shortie</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>5</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>5</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

**Crunch volume (decibels)**

<table>
<thead>
<tr>
<th>Dry test No:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% wet test</td>
<td>75</td>
<td>62</td>
<td>78</td>
<td>62</td>
</tr>
<tr>
<td>50% dry test</td>
<td>70</td>
<td>67</td>
<td>81</td>
<td>64</td>
</tr>
<tr>
<td>25% wet test</td>
<td>77</td>
<td>61</td>
<td>80</td>
<td>55</td>
</tr>
</tbody>
</table>

**Crunch volume:**

<table>
<thead>
<tr>
<th>Decibels</th>
<th>16.3</th>
<th>9.6</th>
<th>18</th>
<th>19.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage reduction</td>
<td>22%</td>
<td>15%</td>
<td>23%</td>
<td>12%</td>
</tr>
<tr>
<td>Score</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

1 kcal=4.18 kJ=0.00418 MJ.
## Strengths and limitations of this study

Leafing through the literature and steeping ourselves in the evidence, we were unable to identify a pragmatic recipe for brewing a standard cup of tea. Although we appreciate that opinions differ widely on how to brew a palatable cup of tea, waiting 3-4 minutes for tea to brew is unrealistic for all but the most senior of NHS managers. We are confident that our study methods reflect a real world approach to tea making in NHS staff rooms. Each biscuit was assessed and scrutinised in an open and unbiased manner, although both of us acknowledge a personal preference for the shortie.

Our study addressed the multifactorial nature of tea making and biscuit choice to better inform NHS staff when having a tea break. We used the time needed to brew and consume a standard cup of tea as a proxy for the time needed to have a restorative tea break, and we identified the cooling effect of a dunked biscuit that might help in the consumption of this beverage. Although we performed six tests, the joy of dunking a biscuit never waned and, at times, actually provided hilarity. This joyfulness enhanced the tea break experience and this could have an important place in teambuilding and connectedness between different hierarchies and disciplines; a powerful influence to be considered.

We limited our biscuit choice, excluding chocolate and cream variants with their potential for high desirability as we believed it important to limit the distraction and potential finger licking that usually occurs when eating biscuits with cream or chocolate fillings. The sticky and licked finger scenario is not compatible with a healthcare environment and should be reserved for non-work time. Future research will include an observation of sandwich style biscuits, such as the classic custard and bourbon creams; perhaps studies on the biscuit filled with jam could be enlightening.

## Comparison with other studies

Previous research into biscuit dunking has predominantly focused on how quickly biscuits break as a popular science experiment for schoolchildren aged 5-7 years. A previous study applied the Washburn equation—a more mathematical approach to the optimum dunk as it describes capillary flow in porous materials.

## Conclusion

NHS staff can easily enjoy the pairing of a cup of tea with a biscuit in less than 10 minutes. Biscuit dunking has a beneficial effect on tea cooling and should be encouraged, and the oat biscuit was the best at achieving this when compared with the digestive, rich tea, and shortie. Making time for a cup of tea is an important daily ritual, and it should be encouraged to help improve the mood and performance of healthcare workers.

## Data sharing

Dataset is available from corresponding author (cari.jones4@wales.nhs.uk)

The manuscript's guarantors (both authors) affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Dissemination to participants and related patient and public communities: We have not disseminated the information at present but continue to share the information within our regional multidisciplinary team meetings.

Provenance and peer review: Not commissioned; externally peer reviewed.

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### Table 3 | Dunk break point by biscuit variety

<table>
<thead>
<tr>
<th>Dunk break point (sec)</th>
<th>Oat</th>
<th>Digestive</th>
<th>Rich tea</th>
<th>Shortie</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35</td>
<td>29</td>
<td>21</td>
<td>33</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>30</td>
<td>21</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>37</td>
<td>26</td>
<td>22</td>
<td>34</td>
</tr>
<tr>
<td>Mean (sec)</td>
<td>34.3</td>
<td>28.3</td>
<td>21.3</td>
<td>31.7</td>
</tr>
<tr>
<td>Score</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

*Includes penalty points.

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### Table 4 | Overall test scores by test and biscuit variety

<table>
<thead>
<tr>
<th>Test</th>
<th>Biscuit variety</th>
<th>Oat</th>
<th>Digestive</th>
<th>Shortie</th>
<th>Rich tea</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMDT</td>
<td></td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Nutritional content</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Saturation volume</td>
<td></td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Crunch reduction</td>
<td></td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Dunk break point</td>
<td></td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Pragmatic dunk break point</td>
<td></td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4+3*</td>
</tr>
<tr>
<td>Overall score</td>
<td></td>
<td>9</td>
<td>13</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>Overall rank</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

*Includes penalty points.

TDT=time to drinkable tea.