NPL

Measurement at Home

Report on Break a Flake

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1. Quick Overview. **90 results from 72 teams testing at least 12 flake types suggests that Special K and Cornflakes are stronger than Honey Flakes, with Bran Flakes and Frosted Flakes between. Flake size does not seem to affect break point. Cornflakes seem are more uniform in size than other flake types.**

2. Results submitted in first three days. 72 teams took part in the first 3 days. 90 results were submitted, with some additional results unfortunately being lost due to a data collection issue.

Many thanks to: Lucas, Humiya, Lucas, Andrew, Erik, Edward, James, Alfie, Jonathan, Beth, Lukas, John and George, Will, Owain, Abdul, Elsa, Gordon, Claudia, Amber, Aleric, Alvar, Freddie, Melissa, Martha, Ayanna, Tom H, Rowan, Oliver, Hugh, Jess, Kayden, Seb, Kata, Caoimhe, Conrad, Lauren, Chris, Liam, Waranya, William, William, Kornelia, Luke, Caitlin, Jacob, Max, Jack, Jack, Michaela, Lara, Alex and Anastasia, Finn, Sam, Evan, Sophie, Manny, Oliver, Peter, Celia, Molly, Shane and others who remained anonymous.

Flake sample types: as well as the flake types we suggested, people named 10 others – special mention to Erik from Yorkshire who tested crinkle cut potato crisps!

3. Which flakes are strongest? Here is a league table of strength.

Flake type	Mean break force /N	Number of tests	Flake type	Mean break force /N	Number of tests
Weeto	12.9	1	**Bran**	**6.2**	**19**
Shreddies	12.4	2	**Frosted**	**5.3**	**7**
Mighty Malties	11.5	1	Tesco Low Fat Special Flakes Rice & Wholewheat	5.0	1
Special K	**9.8**	**11**	**Honey Flakes**	**2.6**	**12**
Corn	**9.4**	**22**	Sainsbury's Honey Nut	2.0	1
Other	7.4	10	Almond flake	1.4	1
Crinkle cut potato crisp	7.2	1	Crunchy nut	1.2	1

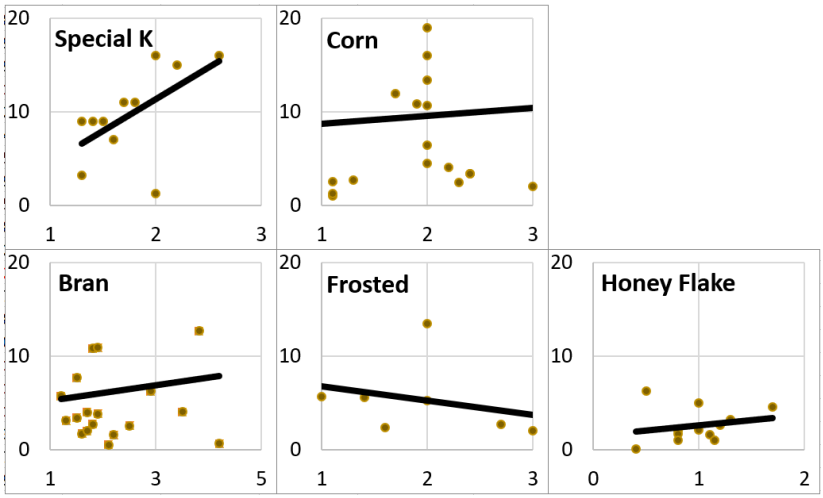
Comments

Many variables! Experiments have an **independent variable**, (the factor you change), **dependant variables** (which depend on the independent variable), and **control variables** (factors that should remain constant). 72 people with different apparatus meant different distances between pencils, flatness of scales and finger shapes which all affected results. Well done Gordon from Hertfordshire for converting results from a pan balance with imperial weights to metric values and force in newtons.

Sample number. More measurements give greater confidence in results. This was the situation for five flake types (marked in bold in the table above) suggesting that **Special K and Cornflakes are joint winners**, with **Bran Flakes** and **Frosted Flakes** mid table, with **Honey Flakes** the weakest. The winners were three times stronger than Honey Flakes, with the others halfway between.

4. Does width of flake affect break force?

In most cases, plotting breaking force as a function of flake width (see graphs below) gives an almost flat line, indicating **we did not see any effect at all**. The only exception was Special K, where most results came from one person using one set of apparatus. This probably indicates a bigger problem with variations in results due to different apparatus and experimenters hiding than the effect we are looking for. (This relates to earlier comments about *control variables*.)



In plots here, the x-axis is flake width in cm, and the y-axis is the breaking force in newtons. The black lines are simple straight-line fits which sometimes include a few extra points out of plot area.

5. Observation on flake size.

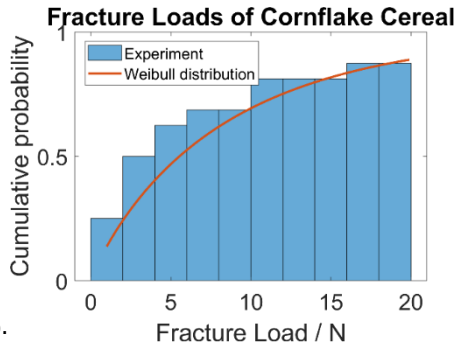
It was remarkable how many cornflakes were 2 cm wide. Measurements were made all over the UK, and in all graphs hardly any points occupied the same position, so this is a genuine effect being measured. This is typical in science – **you try to find one answer and discover something completely different.** We noticed that there was a big range in break point for these 2 cm flakes likely partly due to the different apparatus/approaches, but also this leads us onto the final section of this report.

6. Discussion: why don't similar sized flakes break at the same force?

If the cornflake's strength doesn't depend on size, what does it depend on?

In some materials, such as metals or plastics, we expect the breaking force to be very predictable – two similar metal paperclips should break at the same force.

This isn't the case for brittle materials such as glass and cereal flakes. Instead, these flakes are full of little crevices and cracks that grow wider when you push on the flake. The breaking force of a flake depends of its weakest link – the biggest crack in the flake. When the first crack gets big enough, the whole thing shatters.



The maths used describe this 'weakest link survival' theory is called the Weibull Distribution. This model describes our cornflake strengths quite well! In the figure below, the horizontal axis is the cornflake breaking force in newtons, and the vertical axis is the probability that cornflake has broken. At a force of 5 N, the chance that the cornflake has broken is 50 %. At 20 N, 90 % of cornflakes should have broken.

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