5. SUSTAINABLE FUEL:
INCREASING SURFACE AREA

1 - 1.5 HOURS

In this activity, children investigate the properties of different grinding materials to find out which are better at grinding sugar cubes into more finely milled granules or powder.

TYPE OF ENQUIRY

Comparative tests

Problem solving

OBJECTIVES

Compare and group together everyday materials based on their properties. (Y5 materials)

Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary. (UKS2 Working Scientifically)

Taking measurements, using a range of scientific equipment, with increasing accuracy and precision. (UKS2 Working Scientifically)

Reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results. (UKS2 Working Scientifically)

SCIENCE VOCABULARY

material, property, hard, soft, brittle, mass, volume

RESOURCES

- **Activity Sheets 5 and 6**
- 3 small tough plastic/cardboard containers with lids e.g. 500ml food storage tubs or 40g Pringles containers
- Cup of sugar cubes
- Range of spherical grinding materials, hard and soft, and of different sizes e.g. 1 or 2 materials from each of the following:
- hard - marbles, ball bearings, large beads
- soft - polystyrene balls, Smarties, cheese ball crisps
- 3 foil cases (e.g. mince pie case)
- Funnel (optional)
- 10-25ml measuring cylinder (optional)
- Ice-cube tray (optional)

For the class

- Digital scales (which can measure accurately to the gram)
- **Activity Sheet 4**

TOP TIPS

Use containers with enough space for the grinding materials and sugar cubes to move around.

Ensure containers are durable, as heavier grinding materials will break flimsier containers.

This activity can be very noisy so you may prefer to carry out the shaking outside, in a space away from other classrooms, or even plan for one group out at a time to carry the activity. Ensure anyone with noise sensitivities has ear defenders available to use.

SAFETY GUIDANCE

Ensure lids are tightly sealed before shaking, and that one hand is on the lid during shaking. Extra care should be with any materials which are particularly heavy such as ball bearings and marbles.

Spherical items pose a slipping hazard if dropped, so clear away dropped items immediately.

PRIOR KNOWLEDGE/EXPERIENCE

Children will have set up simple practical enquiries and comparative tests. They will have had experience of measuring mass and volume accurately to the nearest 1g or 1ml. They will have created tables of results and used these to create bar charts.

ACTIVITY NOTES

Please note, this is a follow-on activity from the Lumpy challenge so please complete the activities in sequence to support children's understanding.

Use the letter (**Activity Sheet 4**) to explain to children that scientists would like them to carry out a shake test using sugar cubes and a range of spherical grinding materials. This might include marbles, wooden beads, ball bearings, polystyrene balls, Smarties, and cheese ball crisps. The aim is to break down the lumpy sugar cubes into small pieces, increasing their surface area. The scientists will use this information to decide how best to grind their ingredients.

Give groups time to examine the samples and to discuss the properties of the materials. Ask each group to choose three grinding materials and explain the reasons for their choice of type, quantity, and size of materials. They should aim to select three materials which vary in hardness.

Children plan how they will control as many variables as possible in this comparative test. They can use the Post-It Planning Template (**Activity Sheet 5**) for support in the planning phase by generating a list of variables that they could change and observe/measure. In the case of this investigation, they may think of considering how to control variables such as amount of grinding material used, number of shakes and the duration or method of shaking.

They must also decide how they will measure the amount of ground ingredient produced. One idea to do this is to separate the grinding material from the ingredient, remove any unground ingredient (cubes), collect the ground ingredient, and measure and record its mass (g) or volume (ml).

To measure mass, the ground ingredient can be poured from the container into foil case and placed on a digital scale which will measure accurately to the nearest gram.

To measure volume, children pour the ground ingredient through a funnel into a measuring cylinder. Results may be recorded in a table, bar chart, or other appropriate format. An example recording sheet is provided in Activity Sheet 6.

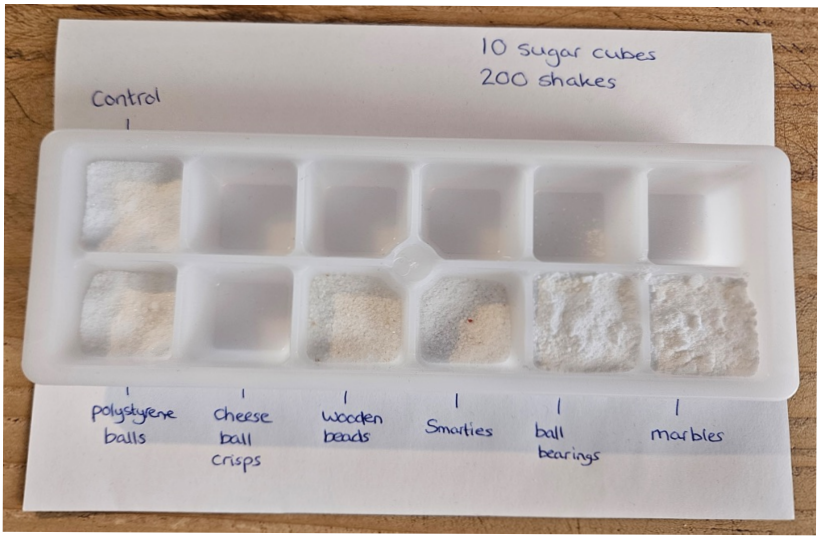
Groups can repeat the process to test further grinding materials to discover how well each one performs, including observations of the fineness of the ground material. Remind children of their findings from Activity 4 where they investigated different kinds of sugar.

Example data set using 10 sugar cubes and 200 shakes per grinding material:

Grinding material	Mass (g)	Volume (ml)	Ground ingredient coarse or fine?	Observations
none (control)	6	7.5	coarse	Clean sample. Ground sugar is powdery with some lumps.
polystyrene balls	3	3.5	medium	Clean sample. Ground sugar is mostly powdery with a couple of lumps.
cheese ball crisps	-	-	-	Sample heavily contaminated. No visible ground sugar to separate from the fragments of cheese ball crisps.
wooden beads	4	4	coarse	Sample is contaminated with fragments of wood which have chipped off. Ground sugar is powdery with some lumps.
smarties	5	6	fine	Sample contaminated with fragments of smarties and difficult to separate sample from grinding material. Ground sugar is powdery
ball bearings	7	10	extremely fine	Clean sample. Ground sugar has the appearance of flour.
marbles	13	15	extremely fine	Clean sample. Ground sugar is powdery.

TOP TIPS

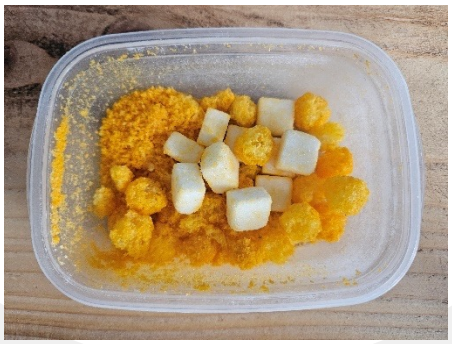
Groups will have tested a variety of grinding materials between them. An ice cube tray or divided paint tray is a good way to 'pool' all the class samples for easy visual comparison.



Polystyrene balls and marbles give the largest measurable difference between the amount of ground material produces and how visually coarse/fine the material is.

Smarties and cheese ball crisps are good materials to use to demonstrate brittleness of certain solids. Grinding materials need to be durable and not break apart during the process. Both the Smarties and the cheese balls start to disintegrate. This contaminates the ground sugar making it unusable.

The cheese balls cushion the impact of the cubes against the side of the container often resulting in no ground material at all to measure.



QUESTIONS FOR THINKING

- Why did some grinding materials work better than others?
- What are the properties needed for a grinding material to be more effective?
- What ingredients do you have at home which may have been ground?
- What other materials might be good at grinding ingredients?
- Are there any ingredients you have at home that you would not want to be ground?
- How are ingredients packaged to stop them being ground?

INDUSTRY LINKS AND AMBASSADORS

Ambassadors could explain to the children the methods used in industry to grind materials. Bringing photographs of equipment, pre and post grinding samples of the ground materials and the ceramic beads used for grinding in the plant and laboratory would make the lesson more engaging and memorable.

The ambassadors could respond to questions from the children or give feedback on the quality of the class investigation methods and results.

Emily is a membrane scientist at Johnson Matthey and works in a lab, where she tests catalyst recipes together with new membranes to find out how well they work together in real life.

Emily tries a couple of new catalyst-membrane combinations every month. If Emily is lucky, she finds one combination from about every ten she tries

You can learn more about Emily and STEM careers linked to sustainable fuel in **Activity 6.**