

## Handout Summary Sheet

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**Title:** Rheological Properties of Agricultural Produce

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### 1. Key Concepts:

- **Force:** Push or pull exerted on produce.
- **Deformation:** Change in shape or size under force.
- **Stress :** Force per unit area.
- **Strain :** Deformation per unit length.

### Formulae:

- $\text{Stress} = \text{Force (F)} / \text{Area (A)}$
  - $\text{Strain} = \text{Length extended (delta L)} / \text{unit Length}$
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### 2. Behavior Types:

- **Elastic Behavior:** Temporary deformation (e.g., pressing apple).
  - **Plastic Behavior:** Permanent deformation (e.g., mango bruising).
  - **Viscous Behavior:** Flow under force (e.g., honey).
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### 3. Newtonian vs Non-Newtonian Liquids:

Type	Behavior	Example
Newtonian	Constant viscosity	Water, fruit juice
Non-Newtonian	Variable viscosity	Tomato puree, honey

### Non-Newtonian Types:

- **Shear-Thinning:** Viscosity decreases (ketchup)
  - **Shear-Thickening:** Viscosity increases (starch paste)
  - **Bingham Plastic:** Needs yield stress to flow (mayonnaise)
  - **Thixotropic:** Viscosity decreases over time (yogurt)
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#### 4. Applications:

- Harvesting (damage prevention)
  - Processing (pulp, juicing)
  - Storage (silo flow)
  - Packaging (filling pastes, sauces)
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#### 5. Design Thinking Framework:

- **Empathize:** Understand user/product needs.
  - **Define:** Identify rheological issues.
  - **Ideate:** Propose solutions.
  - **Prototype/Test:** Experiment and refine.
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#### Student Worksheet Activity

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**Title:** Rheological Properties - Observation Worksheet

**Instructions:** Observe and record the behavior of each material listed below when force is applied.

Material	Type (Solid/Liquid)	Behavior Observed (Elastic/Plastic/Viscous)	Newtonian/Non-Newtonian	Notes
Tomato				
Mango				
Banana				
Water				
Honey				
Cornstarch Solution				

#### Discussion Questions:

1. Which produce showed elastic behavior?
  2. Which samples were Newtonian fluids?
  3. How does rheology impact handling or processing of each produce?
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