Food processing is seasonal in nature, both in terms of demand for products and availability of raw materials. Most crops have well established harvest times – for example the sugar beet season lasts for only a few months of the year in the UK, so beet sugar production is confined to the autumn and winter, yet demand for sugar is continuous throughout the year. Even in the case of raw materials which are available throughout the year, such as milk, there are established peaks and troughs in volume of production, as well as variation in chemical composition.

Availability may also be determined by less predictable factors, such as weather conditions, which may affect yields, or limit harvesting.

In other cases demand is seasonal, for example ice cream or salads are in greater demand in the summer, whereas other foods are traditionally eaten in the winter months, or even at more specific times, such as Christmas or Easter.

In an ideal world, food processors would like a continuous supply of raw materials, whose composition and quality are constant, and whose prices are predictable. Of course this is usually impossible to achieve.

In practice, processors contract ahead with growers to synchronise their needs with raw material production.

The basic physical characteristics of foods and food products

Since the physical characteristics of plant and animal food materials affect how they are to be processed, handled, stored, and consumed, knowledge of these characteristics are important to engineers, processors and food scientists, plant and animal breeders, and other scientists.

The following provides a list of various properties-

Physical Characteristics

1. Shape
2. Size
3. Weight
4. Volume
5. Surface area
6. Density
7. Porosity
8. Color
9. Appearance
10. Drag coefficient
11. Center of gravity

**Mechanical Properties**

1. Hardness
2. Compressive strength
3. Tensile strength
4. Impact resistance
5. Shear resistance
6. Compressibility
7. Sliding coefficient of friction
8. Static coefficient of friction
9. Coefficient of expansion
   a. moisture
   b. thermal
10. Elasticity
11. Plasticity
Properties of Raw Food Materials

- The selection of raw materials is a vital consideration to the quality of processed products.
- The quality of raw materials can rarely be improved during processing and, while sorting and grading operations can aid by removing oversize, undersize or poor quality units,
- It is vital to procure materials whose properties most closely match the requirements of the process.
- Quality is a wide-ranging concept and is determined by many factors.
- It is a composite of those physical and chemical properties of the material which govern its acceptability to the ‘user’ (the final consumer, or the food processor).
- Geometric properties, colour, flavour, texture, nutritive value and freedom from defects are the major properties likely to determine quality.
- An initial consideration is selection of the most suitable cultivars in the case of plant foods (or breeds in the case of animal products).
- Other preharvest factors (such as soil methods and postharvest conditions, maturity, storage and postharvest handling also determine quality.
- The timing and method of harvesting are determinants of product quality. Manual labour is expensive, therefore mechanised harvesting is introduced where possible. Cultivars most suitable for mechanised harvesting should mature evenly producing units of nearly equal size that are resistant to mechanical damage.
- Uniform maturity is desirable as the presence of over-mature units is associated with high waste, product damage, and high microbial loads, while under-maturity is associated with poor yield, hard texture and a lack of flavour and colour.
- For economic reasons, harvesting is almost always a ‘once over’ exercise, hence it is important that all units reach maturity at the same time.
• The prediction of maturity is necessary to coordinate harvesting with processors’ needs as well as to extend the harvest season.
• It can be achieved primarily from knowledge of the growth properties of the crop combined with records and experience of local climatic conditions.
• For more severe processing, including heat preservation, drying or freezing, the quality characteristics may change markedly during processing. Hence, those raw materials which are preferred for fresh consumption may not be most appropriate for processing.

For example,
  ➢ succulent peaches with delicate flavour may be less suitable for canning than harder, less flavoursome cultivars, which can withstand rigorous processing conditions.
  ➢ Similarly, ripe, healthy, well coloured fruit may be perfect for fresh sale, but may not be suitable for freezing due to excessive drip loss while thawing.

**Raw Material Properties**

The main raw material properties of importance to the processor are
  ➢ Geometry,
  ➢ Colour,
  ➢ Texture,
  ➢ Flavour,
  ➢ Functional properties.

**Geometric Properties**

• Food units of regular geometry are much easier to handle and are better suited to high speed mechanised operations. In addition, the more uniform the geometry of raw materials, the less rejection and waste will be produced during preparation operations such as peeling, trimming and slicing.

For example,
Potatoes of smooth shape with few and shallow eyes are much easier to peel and wash mechanically than irregular units. Smooth-skinned fruits and vegetables are much easier to clean and are less likely to harbour insects or fungi than ribbed or irregular units.

- Agricultural products do not come in regular shapes and exact sizes. Size and shape are inseparable, but are very difficult to define mathematically in solid food materials. Geometry is, however, vital to packaging and controlling fill-in weights.

For example

- It may be important to determine how much mass or how many units may be filled into a square box or cylindrical can.
- Size and shape are also important to heat processing and freezing, as they will determine the rate and extent of heat transfer within food units.
- Uniformity of size and shape is also important to most operations and processes. Process control to give accurately and uniformly treated products is always simpler with more uniform materials.

- It is essential that wheat kernel size is uniform for flour milling.
- The presence of geometric defects, such as projections and depressions, complicate any attempt to quantify the geometry of raw materials, as well as presenting processors with cleaning and handling problems and yield loss. Selection of cultivars with the minimum defect level is advisable.
- There are two approaches to securing the optimum geometric characteristics: firstly the selection of appropriate varieties, and secondly sorting and grading operations.

**Colour**

- Colour and colour uniformity are vital components of visual quality of fresh foods and play a major role in consumer choice. However, it may be less important in raw materials for processing.
• For low temperature processes such as chilling, freezing or freeze-drying, the colour changes little during processing, and thus the colour of the raw material is a good guide to suitability for processing.

• For more severe processing, the colour may change markedly during the process. Green vegetables, such as peas, spinach or green beans, on heating change colour from bright green to a dull olive green. This is due to the conversion of chlorophyll to pheophytin.

• There are two approaches: i.e. procuring raw materials of the appropriate variety and stage of maturity, and sorting by colour to remove unwanted units.

Texture

• The texture of raw materials is frequently changed during processing. Textural changes are caused by a wide variety of effects, including water loss, protein denaturation which may result in loss of water-holding capacity or coagulation, hydrolysis and solubilisation of proteins.

• Raw materials must be chosen so that the texture of the processed product is correct, such as canned fruits and vegetables in which raw materials must be able to withstand heat processing without being too hard or coarse for consumption.

• Texture is dependent on the variety as well as the maturity of the raw material and may be assessed by sensory panels or commercial instruments. One widely recognised instrument is the tenderometer used to assess the firmness of peas

Flavour

• Flavour is a rather subjective property which is difficult to quantify. Again, flavours are altered during processing and, following severe processing, the main flavours may be derived from additives.

• Hence, the lack of strong flavours may be the most important requirement. In fact, raw material flavour is often not a major determinant as long as the material imparts only those flavours which are characteristic of the food.
Flavour is normally assessed by human tasters, although sometimes flavour can be linked to some analytical test, such as sugar/acid levels in fruits.

**Functional Properties**

- The functionality of a raw material is the combination of properties which determine product quality and process effectiveness. These properties differ greatly for different raw materials and processes, and may be measured by chemical analysis or process testing.

For example,

- a number of possible parameters may be monitored in wheat. Wheat for different purposes may be selected according to protein content. Hard wheat with 11.5–14.0% protein is desirable for white bread and some wholewheat breads require even higher protein levels, 14–16%.
- Similar considerations apply to other raw materials. Chemical analysis of fat and protein in milk may be carried out to determine its suitability for manufacturing cheese, yoghurt or cream.

**Deterioration of Raw Materials**

- All raw materials deteriorate following harvest, by some of the following mechanisms:
  - Endogenous enzymes: e.g. post-harvest senescence and spoilage of fruit and vegetables occurs through a number of enzymic mechanisms, including oxidation of phenolic substances in plant tissues by phenolase (leading to browning), sugar-starch conversion by amylases, postharvest demethylation of pectic substances in fruits and vegetables leading to softening tissues during ripening and firming of plant tissues during processing.
  - Chemical changes: deterioration in sensory quality by lipid oxidation, nonenzymic browning, breakdown of pigments such as chlorophyll, anthocyanins, carotenoids.
  - Nutritional changes: especially ascorbic acid breakdown.
  - Physical changes: dehydration, moisture absorption.
  - Biological changes: germination of seeds, sprouting.
Microbiological contamination: both the organisms themselves and toxic products lead to deterioration of quality, as well as posing safety problems.

Damage to Raw Materials:

- Damage may occur at any point from growing through to the final point of sale.

It may arise through external or internal forces.

- External forces result in mechanical injury to fruits and vegetables, cereal grains, eggs and even bones in poultry. They occur due to severe handling as a result of careless manipulation, poor equipment design, incorrect containerisation and unsuitable mechanical handling equipment. The damage typically results from impact and abrasion between food units, or between food units and machinery surfaces and projections, excessive vibration or pressure from overlying material. Increased mechanisation in food handling must be carefully designed to minimise this.

- Internal forces arise from physical changes, such as variation in temperature and moisture content, and may result in skin cracks in fruits and vegetables, or stress cracks in cereals.

- Either form of damage leaves the material open to further biological or chemical damage, including enzymic browning of bruised tissue, or infestation of punctured surfaces by moulds and rots.

Improving Processing Characteristics

- Selective breeding for yield and quality has been carried out for centuries in both plant and animal products. Until the 20th century, improvements were made on the basis of selecting the most desirable looking individuals, while increasingly systematic techniques have been developed more recently, based on a greater understanding of genetics.

- The targets have been to increase yield as well as aiding factors of crop or animal husbandry such as resistance to pests and diseases, suitability for harvesting, or development of climate-tolerant varieties (e.g. cold-tolerant maize, or drought-resistant plants).
• Raw material quality, especially in relation to processing, has become increasingly important.

Selective Plant Breeding

• There are many examples of successful improvements in processing quality of raw materials through selective plant breeding, including:
  ➢ Improved oil percentage and fatty acid composition in oilseed rape;
  ➢ Improved milling and malting quality of cereals;
  ➢ High sugar content and juice quality in sugar beets;
  ➢ Development of specific varieties of potatoes for the processing industry, based on levels of enzymes and sugars, producing appropriate flavour, texture and colour in products, or storage characteristics;
  ➢ Brussels sprouts which can be successfully frozen.

• Similarly traditional breeding methods have been used to improve yields of animal products such as milk and eggs, as well as improving quality, e.g. fat/lean content of meat. Again the quality of raw materials in relation to processing may be improved by selective breeding. This is particularly applicable to milk, where breeding programmes have been used at different times to maximise butterfat and protein content, and would thus be related to the yield and quality of fat- or protein-based dairy products. Furthermore, particular protein genetic variants in milk have been shown to be linked with processing characteristics, such as curd strength during manufacture of cheese. Hence, selective breeding could be used to tailor milk supplies to the manufacture of specific dairy products.

Genetic engineering

☐ Traditional breeding programmes will undoubtedly continue to produce improvements in raw materials for processing, but the potential is limited by the gene pool available to any species.

☐ Genetic engineering extends this potential by allowing the introduction of foreign genes into an organism, with huge potential benefits. Again many of the developments have been aimed at agricultural improvements, such as increased yield, or introducing
herbicide, pest or drought resistance, but there is enormous potential in genetically engineered raw materials for processing.

The following are some examples which have been demonstrated:

- tomatoes which do not produce pectinase and hence remain firm while colour and flavour develop, producing improved soup, paste or ketchup;
- potatoes with higher starch content, which take up less oil and require less energy during frying;
- canola (rape seed) oil tailored to contain:
  
  (a) high levels of lauric acid to improve emulsification properties for use in confectionery, coatings or low fat dairy products,
  
  (b) high levels of stearate as an alternative to hydrogenation in manufacture of margarine,
  
  (c) high levels of polyunsaturated fatty acids for health benefits;

- wheat with increased levels of high molecular weight glutenins for improved bread making performance;
- fruits and vegetables containing peptide sweeteners such as thaumatin or monellin;
- ‘naturally decaffeinated’ coffee.
References
