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6TH FORM AGRICULTURE AND HORTICULTURE

PRODUCT PROCESSING AND STORAGE

Introduction:

This unit has been prepared as a teacher's guide for the module Product Processing and Storage, of the Sixth Form Horticulture and Agriculture syllabus.

The aim of the unit is to enable students to gain an understanding of the consequences of deterioration of agricultural and horticultural products, and methods for assessing and controlling deterioration. The emphasis is on student activities based on local products. Teacher background material on several suitable products is included in the Appendices.

Objectives:

On completion of this unit students should have:

1. Acquired a knowledge and understanding of an integrated approach to product care to satisfy market requirements.

2. Acquired a knowledge and understanding of the methods used to control post harvest product deterioration.

3. Acquired a knowledge and understanding of the quality control of a local product.

4. Carried out and evaluated consumer tests of a product.

5. Carried out investigations on product deterioration.

6. Demonstrated that care is needed at all stages of product processing and storage to maintain quality.

TOPICS AND OBJECTIVES	TEACHER NOTES	STUDENT ACTIVITIES
1. THE NEED FOR QUALITY The problem of product variability and deterioration.	Agricultural products result from living things and so are variable in quality and prone to deterioration by natural causes. Standards of quality are dictated by market requirements and health considerations. To be acceptable to a consumer a product may need to conform to certain standards of appearance, smell, taste, or texture.	1. Investigate the market requirements for a particular product, using interviews of retailers and information leaflets on the product. 2. Conduct a consumer survey on a selected product using sensory evaluation. (See Appendix 1).
2. THE PROCESSES OF PRODUCT DETERIORATION. Factors that contribute to deterioration.	Types of deterioration: Internal processes: Many agricultural products continue to live for a time after harvest. This can bring about changes such as: 1. Over-ripening As fruit ripens there are changes in colour accompanied by softening, increased sweetening and a depletion of astringent compounds. Consumers usually desire a particular combination of colour, softness, and taste for a particular type of fruit. If the fruit becomes over-ripe the product will no longer fetch premium prices. Fruit are often picked when they are under-ripe so that they are less likely to be damaged during transport, and will reach the desired ripeness by the time a consumer buys them. Careful timing of harvest is needed to achieve this.	1. Measure changes during fruit ripening such as: Increase of sugar in Kiwifruit, using Brix test; Loss of starch in apples, (using iodine test; Loss of acid in citrus fruit using narrow range litmus paper; colour change in fruit, (e.g., bananas, red apples), using a five point scale; Depletion of astringents (eg. persimmons), using taste; Softening of fruit (eg. tomatoes), using a commercial penetrometer or touch. 6. Investigate the effect of ethylene on the ripening of fruit and on flower senescence. (See Appendices 2 and 3). 7. Investigate the ripening of kiwifruit under different conditions. 8. Investigate starch/iodine scores for Granny Smith apples under different conditions.

TOPICS AND OBJECTIVES	TEACHER NOTES	STUDENT ACTIVITIES
	2. <u>Water loss</u> Most agricultural products have a high water content. Loss of water by evaporation or transpiration may produce undesirable wilting and softening. In some products controlled drying may be desirable (such as grain or hay).	9. Measure water loss by weighing products under different conditions.
	3. <u>Continued growth</u> Some products may continue to grow and develop producing undesirable effects such as distorted shape or colour or taste changes.	10. Investigate the effect of storing asparagus in different positions and conditions.
	<u>Effects of other living things</u>: Agricultural products can provide a food source for organisms and cause damage such as:	
	4. <u>Yeast Fermentation</u> Yeast convert/ sugar into alcohol and carbon dioxide While this fermentation may destroy some stored products such as honey or fruits, it may be actively encouraged in activities such as wine making.	11. Investigate the fermentation of honey.
	5. <u>Bacterial Breakdown</u> Bacteria may invade a product and, by the production of metabolic wastes, change the quality or the nature of that product.	12. Make yoghurt or cheese. (See Appendix 10)
	Bacterial action may be useful in some cases such as in cheese or yoghurt manufacture, but is more often undesirable in its effect.	13. Research on cheese manufacture.

TOPICS AND OBJECTIVES	TEACHER NOTES	STUDENT ACTIVITIES
	Most agricultural products are vulnerable to bacterial breakdown which may result in: Softening or rotting (e.g., fruit) Unpleasant smells (e.g., milk, meat) Increased temperature (e.g. wool)	14. Investigate the antibiotic action of honey. (See Appendix 4). 15. Measure the growth of bacteria in milk using methylene blue. (See Appendix 10).
	6. <u>Fungal Infection</u> Fungi cause damage to stoned products in much the same way as bacteria do. Fungi invade the product with hyphae and produce obvious fruiting structure at the surface. Fungal infections are easily spread via spores. In fruit, parasitic fungi which damage crops in the field may also destroy crops in storage, e.g., <u>Botrytis</u>.	16. Observe diseased fruit, e.g., botrytis in Kiwifruit or Brown spot in stone fruit. 17. Measure fungal growth on bread, with and without fungicide.
	7. <u>Pest attack</u> Pests may cause physical damage to products which make them unsightly and encourage deterioration in that product through contamination. Common pests of stored products are: Rodents which may damage grain; Mites which may damage a wide variety of substances including grains and cheese; Weevils which cause damage to grains and milk products.	18. Observe pest damaged products. 19. Investigate pest-resistant packaging on selected products. (eg. different bag types for wheat in the presence of flour beetles or weevils).

TOPICS AND OBJECTIVES	TEACHER NOTES	STUDENT ACTIVITIES
	Beetles which may damage grains or even woollen products Flies which cause damage to meat and milk products.	
3. <u>CONTROL MEASURES</u> Methods that can be used to reduce product deterioration after harvest.	Product deterioration can be controlled by slowing or stopping the living processes involved, using methods such as:	
	1. <u>Cooling</u> Refrigeration slows growth of bacteria, yeast, or fungi and reduces the rate of ripening, water loss or product growth.	1. Compare the rate of product deterioration at different temperatures.
	2. <u>Heating</u> Heating can kill bacteria but the temperatures required may destroy or change the product.	2. Investigate milk pasteurisation.
	3. <u>Water removal</u> Freezing, drying and salting each have the effect of removing water killing bacteria and slowing living processes.	3. Investigate salt preservation of meat.
	4. <u>Controlled atmosphere</u> Reduced oxygen and increased carbon dioxide concentrations in the atmosphere around a product can reduce the rate of respiration of the product or bacteria or fungi. Increased carbon dioxide concentration also suppresses ethylene production thus prolonging product life.	4. Compare deterioration rates of a product stored in sealed containers with different atmospheres (such as 100% CO_2; air; high oxygen; including $KMnO_4$ crystals to remove ethylene).
	5. <u>Chemical treatment</u> Many products are treated with preservatives to control bacteria or fungi or pesticides to control pests.	5. Investigate seed viability comparing fungicide treated with untreated seeds.

TOPICS AND OBJECTIVES	TEACHER NOTES	STUDENT ACTIVITIES
	6. Irradiation Gamma radiation is now being tested for its effectiveness and possible undesirable effects. It has not yet been approved for use in New Zealand.	
4. CASE STUDY	Production of a quality product with consumer appeal requires an integrated approach at all stages rather than reliance on post-harvest control measures alone. A local product should be chosen for a detailed study investigating the following aspects which can affect product quality: 1. Harvest: Timing, methods, conditions needed. 2. Grading: Criteria for grading, methods, disposal of inferior material, quality control checking. 3. Packing: Packing materials and their uses, methods, presentation. 4. Storage/Housing: Methods, environmental control, quality checking, use of special methods for control of deterioration, storage life. 5. Processing (if appropriate): Methods, quality checking. 6. Transport: Methods, environmental control. 7. Consumer: Retail methods, shelf life, presentation.	It is suggested that the whole of this unit can be based around a local product. Student activities would involve practical investigations of the sort suggested in Topics 1 to 4 along with book research and visits. Background material on some products is presented in the Appendices: Appendix Number — Topic 4 — Honey 5 — Wheat 6 — Meat 7 — Wool 8 — Commercial Seeds 9 — Kiwifruit 10 — Milk

APPENDIX 1

CONSUMER SURVEYS - SENSORY EVALUATION
(The science of what it tastes like!)

Introduction:

All five senses are used in assessing food quality:

1. Appearance - shape, colour, texture by sight (eg. smooth or lumpy sauces).

2. Smell - perceived through the nose and mouth. The sense of smell tires quickly, and the state of presentation may affect the type and strength of smell detected, eg. whether the substance is solid or in water, whether it is served hot or cold.

3. Taste - different areas of the tongue are sensitive to different tastes because of different concentrations of certain taste buds. The four tastes are sweet, salty (only NaCl, not other salts), sour and bitter. There are interactions between tastes, e.g., increasing acid in a sugar solution gives a decreased perception of sweetness; if salt is added to sugar, the salt decreases the perceived sweetness of the solution. Therefore, laboratory analysis cannot be used to assess the tastes of foods.

4. Texture by touch - includes three stages:

   (a) biting into the food e.g., a crisp apple.
   (b) chewing it e.g., a lumpy sauce.
   (c) swallowing it e.g., smoothness, stickiness etc.

5. Hearing - is now realised to be important in assessing food quality, e.g., the sound of biting into a crisp apple.

Steps in a Consumer Survey:

A consumer test must be carefully prepared if the results are to be a reliable indication of people's preferences.

1. Selecting the assessment team:

The people in the team must be:

(a) interested in the food product.
(b) readily available.
(c) healthy e.g., not colour blind, no sinus problems or colds.
(d) precise and articulate.

Their food likes and dislikes are recorded. Then they are selected on the basis of the power of their senses, (e.g., they are presented with three food samples - two are alike, one is different - they have to select the two similar ones).

Only 20% of the people get through this stage. If selected they are trained to recognise and describe differences using examples.

2. Preparing the test location:

There must be odour control; temperature and humidity control and minimal distraction (partitions between testers to reduce bias). The colour of the surroundings is important (off-white is the best colour) and lighting must be selected, e.g., fluorescent tubes highlight greens and blues, incandescent light biases reds.

3. Presenting the food:

Appearance must be standardised (e.g., no bruised apples), food must be at the temperature at which it is normally eaten, samples must not be too small, there must be a limited number of samples to compare (two to four is best), utensils must be clean (plastics cannot be used because they have a taste), and samples must be presented in random order (the first sample is often rated most highly).

There are two basic types of tests:

1. Difference tests: Food samples are compared for possible differences (e.g., different treatment of the same product. Do different areas of N.Z. produce different flavoured kiwifruits?)

2. Descriptive tests: The samples are described by the test panel.

Investigations:

It is difficult and time-consuming to carry out tests in the highly controlled manner described in the Introduction. However, several interesting aspects could be investigated. Try to adhere to the Introduction guidelines as closely as possible. Some examples include:

1. The effect of food presentation on taste:
Compare samples of the same food with different presentations (e.g., hot/cold; colour with dyes).

2. The effect of appearance on taste:
Compare the sweetness of different coloured apples then repeat with the same apples peeled and see if the rank order of sweetness changes. (It may be possible to check sugar content using the Brix test).

3. The effect of surroundings on taste:
Design investigations to compare the effects of lighting; different coloured containers; different background smells on taste sensation.

4. The effect of taste interactions:
Add increasing amounts of citric acid (or salt) to standard sugar solutions and ask testers to rank the solutions in order of sweetness.

Written Project

Describe how you would introduce a new fruit or a new form of processed fruit, to the public. What consumer tests would you use? How would you present the fruit? What information should be given to the consumer?

APPENDIX 2

INVESTIGATIONS ON FRUIT RIPENING

Introduction:

Ripening involves:

1. softening of the fruit
2. sweetening (a) by sugaring e.g., grapes, bananas
   (b) by loss of acid e.g., citrus fruit
3. colour (a) by loss of chlorophyll e.g., bananas
   (b) by synthesis of anthocyanins (coloured pigments) e.g., red apples
4. depletion of astringent compounds such as tannins, e.g., in persimmons.

There are two distinct forms of ripening, depending on their response to ethylene.

1. Climacteric: Ripening is associated with the release of ethylene gas by the fruit, and an increase in the rate of respiration, e.g., in tomatoes, once there is the first sign of colour in the fruit, ethylene production begins and ripening cannot be stopped. A genetic mutant exists which does not ripen until ethylene is applied to the fruit. It may have a possible use for long-storage material.

2. Non-climacteric: Ripening is a long steady process not associated with the release of ethylene gas, and is not affected by the application of ethylene e.g., lemons, grapes.

Investigations:

Several experiments can be carried out to investigate the effect of ethylene on the ripening of fruit.

1. Distinguishing between climacteric and nonclimacteric fruit:

Testing involves enclosing well-ripened and unripened fruit together in sealed polythene bags.

Ripe climacteric fruit will actively give off ethylene and promote ripening in unripe climacteric fruit. The ripening rate of nonclimacteric fruit will be unaffected by the presence of ripe fruit. Design an experiment to test if oranges, bananas, grapes, feijoas, or tomatoes are climacteric or not. Make sure you include suitable controls. The time for unripe fruit to ripen can be recorded.

2. The effect of ethylene on the ripening of bananas:

Ethylene produced by ripening fruit can be removed from the atmosphere in a sealed polythene bag, by adding to the bag potassium permanganate wrapped in muslin inside a container with a perforated lid.

Green bananas are used for the test fruit. Suitable controls and several replicates will be needed. Ripening rate can be measured by timing the skin colour change from green to yellow to brown.

State of ripeness can be checked at the end by testing slices of banana for the presence of starch by immersing them in iodine solution. Starch is converted into sugar as bananas ripen.

Design and carry out a suitable experiment.

3. The effect of fruit damage on ethylene production

All plant tissues including fruit give off ethylene if they are damaged by bruising, cutting or even disease. This can be tested by measuring the effect of a damaged fruit on the ripening rate of undamaged fruit using appropriate controls. Apples are bruised when they are dropped during harvesting, grading, packing and transport. It is interesting to know if this affects ripening of undamaged fruit. Design an experiment to test this. There are differences between cultivars - for example Red Delicious are high ethylene producers; Golden Delicious are not, so plan your experiment carefully. Apples can be bruised by dropping onto a hard floor. It may be possible to see if the extent of bruising (drop from say 50 cm and 100 cm) affects the ripening effect. Bruise size can be measured by carefully peeling the fruit and measuring bruise diameter.

Questions: Comment on the saying 'one rotten apple spoils the whole barrel'.

Why is careful handling so important during production, harvest and processing of crops?

APPENDIX 3

INVESTIGATIONS ON FLOWER SENESCENCE

Introduction:

Senescence is the deterioration which leads to the death of plants or plant parts. In the cut flower industry research is being carried out into the factors which control the start and rate of senescence of flower petals. If senescence can be slowed, the storage, transport and shelf-life of flowers can be prolonged. Ethylene gas is known to accelerate flower senescence. It may be produced by the flower as part of its normal development, or as a response to wounding or may come from external sources (such as ripening fruit, or car exhaust fumes).

Investigations:

1. The response of flowers to ethylene:

Different cultivars of flowers can be compared. The flowers should have just broken bud or be just fully opened. Stems are cut under water and the flowers can be placed in deionised water in a large test-tube. The ethylene treatment is applied by enclosing a flower together with a well-ripened piece of apple or banana in a polythene bag. Appropriate controls should be used. The time taken for petals to wilt is a measure of the rate of senescence.

Question: What implications do the results have for the transport and storage of cut flowers?

2. The effects of preservatives on the vase life of carnations:

Two types of chemical have been used to prolong the vase life of carnations (*Dianthus caryophyllus*): silver ions (in the form of freshly made silver thiosulphate and a flower preservative that has fungicide and antibiotic action.

The methods outlined in Investigation 1. can be used to compare the preservative function of these two chemicals on carnation senescence in the presence of ripe fruit using suitable controls. Carnations of one particular colour should be used in each test.

Extensions to such experiments include investigations using the ethylene generator, Ethrel, and comparisons of shelf life of carnations of different colours.

Comments on the chemicals used:

Silver thiosulphate must be freshly made by mixing 1 volume of 1 mM $AgNO_3$ (170 mg per litre) with 1 volume of 4 mM $Na_2S_2O_3 \cdot 5H_2O$ (1.0 g per iltre). It is applied by standing the flower stems in the solution for 1 hour then transferring them to deionised water ('pulse' treatment).

The preservative, 8-Hydroxyquinoline (8.HQC) may be obtainable from a cut flower grower or a horticultural chemical supplier. It is applied in the citrate form in the presence of sucrose as an energy source. (0.5 mM 8-HQC, 20 g sucrose per litre, 20 mM citric acid buffer adjusted to pH4.6).

Ethrel is a compound which decomposes to release ethylene. It is available commercially for accelerated ripening of tomatoes. It should be used at a concentration of 2 mM (290 mg per litre) as an ethylene source in carnation experiments.

APPENDIX 4

HONEY - BACKGROUND NOTES

Introduction:

Nectar is collected by bees and brough back, a pinhead at a time, in the honey stomach where the sucrose is converted to simpler sugars. Each dewdrop of collected honey is stored within the hive in open cells where is is allowed to 'ripen' into honey proper by evaporating away 80% of its water content. Once ripened into a syrup each honey cell gets its quality control seal of approval and is capped with a lid of wax by the worker bees.

Chemical constituents of honey are typically:

Water	17.5%
Ash	0.18%
Dextrose	36.2%
Levulose	40.0%
Sucrose	2.8%
Dextrins etc	3.32%

Harvest:

Honey is removed from the hive in February. Each capped frame contains about 2 kg of honey and each hive may be expected to yield upwards of 50 or more kg in total.

The two basic sorts of honey produced are comb honey and extracted honey. Cut-comb honey is simply the slicing up of the honey frame or wax comb into appropriately sized squares and packaging them directly for sale. Section honey is a similar consumer product but it involves producing the capped honey in the hive as miniature 'frames' which may be square or circular in shape. Careful hive management is necessary to produce section honey. In both cases extra thin wax foundation is used to make the product easier to eat.

Extracted honey is removed from the combs by centrifugaiton. The wax cappings are removed with a hot spatula and in commercial extraction, 45 frames at a time are spun out in a honey extractor. To make the honey flow a little easier frames may be kept at 37^{o}C for 3 or 4 hours beforehand.

After extraction, the honey is filtered through honey strainers, being careful not to introduce air bubbles into the honey as contamination may enter the honey in this way.

Granulation:

The very nature of the product means that there is a tendency for it to 'granulate' or crystalise. A fine, even granulation produces a creamy, opaque honey which is by far the most commonly sold variety. Liquid honey (very common in the U.S.A.) is made by heating extracted honey to 71°C. This retards the granulation process - almost indefinitely if product is then kept in a moderately warm environment. Overheating will alter flavour, colour and may even caramelise the sugar.

A good quality product is achieved by making sure that granulation is swift and even. To assist granulation, a 'starter' of smooth-grained honey is mixed into newly extracted honey. The honey is packed immediately and granulation may be hastened by storing in a cool store at 18°C. Under normal N.Z. conditions, however, cool night temperatures of early autumn are sufficient.

A coarse grained sugary honey is considered poor quality but this may be improved by the Dyce method of heating the honey to 24°C and mixing a fine grained starter, allowing it then to recrystalise into finer granules.

Quality Control:

Essentially honey is a product quality controlled by the bees themselves. Variations do occur however due to differing floral nectars which account for different flavours and granulation properties.

e.g., Clover honey is a light fine grained honey, mild flavoured.
Pohutakawa is a light medium grained honey with a rich flavour.
Manuka honey is highly viscous, difficult to extract, dark, coarse grained and highly flavoured.

Honey houses achieve overall quality by dividing honeys up into light, dark and manuka as a class of its own. Some growers specialise in producing honey of a particular floral type e.g., tawa or pohutakawa. This is achived by locating hives in appropriately forested areas and removing honey frames as flowering of that particular plant species ends.

Product Deterioration:

Honey, properly cared for during extraction, should last indefinitely. It is, after all, a food storage product for bees.

Inhibition of Bacteria:

Honey has a naturally "antibiotic" effect: indeed during the Crimean war it was used as an antiseptic. Its antibacterial properties are thought to be due to three things:

(i) Osmotic inhibition. The high concentration of sugars in honey removes water from bacterial cells through osmotic inbalance.

(ii) Inhibine. A substance, now thought to be H_2O_2, acts to inhibit bacterial growth.

(iii) Acidity. Honey, surprisingly, is about one eighth the acidity of vinegar ie. fairly acidic. This too inhibits bacterial growth.

Yeasts:

Yeasts, unlike bacteria, are aerobic organisms and will ferment honey in the presence of oxygen if the water content is high.

Producers go to pains to ensure that no air bubbles are mixed into the liquid honey and that water content is kept at minimum.

A Twaddle hydrometer is used to measure honey density and therefore how 'ripe' the honey is. In addition, care is taken to extract only in dry conditions, not to use wet instruments etc.

Suggested Student Activities:

1. **Antibacterial action**

   Impregnate a small piece of filter paper with honey and place it on the surface of an agar plate streaked with bacterial culture. Incubate 48 hours. Any antibacterial activity will be evident by a distinct clear area around the paper, bacterial plaques growing abundantly elsewhere.

   A control of golden syrup or sugar solution may be used.

2. **Fermentation action of yeasts**

   In a series of 250 ml flasks add pure honey, honey + 1% water, honey + 5% water, 10% water and leave over a few weeks or incubate. Yeast is thought to be present naturally in honey so inocculation will be unnecessary. Degree of fermentation can be readily measured by measuring the evolution of gas by a manometer.

3. Effect of temperature on the rate of granulation

Take some freshly extracted honey (or granulated honey gently warmed at 24 or 25°C beforehand) and place in different environments to granulate over some weeks (fridge, incubator, room etc). Also, include a honey sample previously heated to 70°C. Measure the time taken for granulation to occur.

4. Heat effects on quality

Heat honey to different temperatures (40°C, 60°C, 70°C, 90°C). Allow to cool over a day or so and taste for quality and colour differences compared with an unheated 'control'.

APPENDIX 5

WHEAT - BACKGROUND NOTES

1. Harvest

- The harvesting machine collects the ripe grain, threshes it to remove the husks, and winnows to separate the grain from the trash.

- Careful harvesting produces high quality grain and seed for storage.

- Chipped and broken grains are more easily infested by pests.

- Green seeds give off unwanted moisture.

2. Storage

- Silos must be kept clean and pest free by removal of residues and dust, and spraying with insecticide.

- Grain must be kept dry, 95% of all insect and mite infestations occur in wheat above 13.5% moisture content.

- Grain must be kept cool. Temperatures above 21°C favour insect development.

- Stored grain should be checked regularly.

3. Packaging

- Sacking is easily penetrated by storage insects. Some insects can penetrate 5-ply paper bags.

- Polycarbonate film appears to be best.

- Bags should be stored off the floor and away from walls.

4. Processing

- Wheat is used in breakfast cereals, bread, and other flour products, starch products and stock feed.

5. Quality Control and Grading

- Quality requirements for wheat that will be used in flour milling are stringent. A limited number of insecticides and fumigants are allowed.

- The quality of grain (protein content) determines its use. Highest protein (13-15%) is used in high quality bread; 11-13% protein in bread; 9-11% in some bread, biscuits and cakes; < 9% protein in biscuits and cakes.

- Damaged grain is unsuitable for milling.

6. Transport

- Trucks transport grain from farm to silo then to mill.

References:

1. Ag Links: FPP 368, FPP 200, FPP 367, FPP 369.
2. Agricultural Science Materials Project, 'Wheat' Unit 0804.
3. Wheat Research Institute, Christchurch.

APPENDIX 6

MEAT QUALITY CONTROL - BACKGROUND NOTES

Each meat type has rules and regulations that differ slightly from one another but essentially the same basic processes apply to pork, sheepmeat and beef.

(i) Antemortal Inspection

The day prior to slaughter, animals are inspected by a meat inspector and a vet. Reject animals are those that:

(a) need dagging (to prevent faecal contamination of meat)
(b) need washing
(c) appear "abnormal" in some way.

Abnormal animals will be separated for further inspection and either passed through the killing chain or slaughtered for animal byproduct production (blood and bone, bonemeal etc).

(ii) Killing Chain

On the day of slaughter animals are again inspected and certificated for killing. From the point of slaughter onwards, each animal must be physically separated from the next.

After bleeding, the animal is eviscerated and the viscera placed on the viscera belt. The viscera belt and the carcass kept abreast of each other down the chain so that defective viscera can be identified as coming from a particular carcass.

Each organ is inspected for abnormality on the viscera belt and any suspect removed for further tests while the corresponding carcass is also removed.

(iii) Chillers

The clean carcasses are stored in chillers ($10^{o}C$ maximum). A hand's width must separate each carcass to allow for air circulation. All chillers undergo a 'pre-operative hygiene check' prior to use for carcass storage.

In short, high quality is maintained by keeping a close eye on disease and keeping healthy carcasses cool and clean.

Transport

Meat is transported in chilled trucks which are kept to a high standard of hygiene. All meat must hang on rails and there are strict standards of cleanliness for meat handlers who transport the product. All overalls must be white and fitted with hoods.

Chemical Residues

Farmers using the organophosphate insecticide 'Lindane' are registered and fat samples from their stock are analysed for organophosphate residues. In addition there may be random sampling of meat for antibiotic residues. This is checked in a bioassay technique similar to that of milk sampling.

Monitoring for chemical residues is particularly important in exported meat as some overseas markets demand extremely high quality in this regard.

Grading:

The finer points of meat grading can become quite complex and are different for different meats. Generally speaking however, meat is graded on:

(i) Age of the animal at slaughter.
(ii) Weight of the carcass.
(iii) Fat content
(iv) General appearance and condition eg. fat colour.

Fat is measured by electronic probe (G.R. measurement) and will give a readout in mm of average fat cover. eg. Grades for lamb export carcasses.

	Fat Cover					
Weight Range	Absent (A)	Light Y	Medium P	Heavy T	Excessive F	Mixed C M
Under 9-0 kg	A					
9-0 - 12.5 (LIGHT) (L)		YL	PL	TL	FL	CL M
13-0 - 16-0 (MEDIUM) (M)		YM	PM	TM	FM	CM M
16-5 - 20-0 (HEAVY) (H)		PX	PX	TH	FH	CH M
20-5 - 25-5 (HEAVY) (H)		PH	PH	TH	FH	CH M

* C = Damaged carcasses
* M = Lean, yellow fatted, badly damaged

Yellow Fat

Excessively yellow fat on a carcass may be an indication of liver damage and are therefore checked. Yellow fat can, however, be a result of diet, in which case the meat will be unaffected but it may result in downgrading of the carcass.

Student Activities:

Meat may not be a very pleasant substance to work with if you're investigating its keeping qualities!

1. You could try leaving meat samples under various conditions of temperature, humidity etc. for set periods of time and decide by smell which conditions appear best for storage.

2. Brine curing. It should be possible to brine-cure a small slab of meat in the classroom and compare this with fresh meat (or cooked meat) for keeping quality.

   Method:

   360 g salt
   90 g sugar
   5 g sodium nitrate (salt petre)
   250 ml water (boiled, then cooled)

   (Traditionally, the mixture should be concentrated enough to make a potato float!).

   Soak the meat completely submerged for three days or so, remove, was and dry in a cool dry environment. Smoke-cured meat (using a fish smoker) could also be compared for keeping qualities.

APPENDIX 7

WOOL QUALITY - BACKGROUND NOTES

Wool is a product which is highly variable in its characteristics and quality. The wide range of woollen manufactured goods ranging from carpets to fine clothing fabric each demand a fibre of specific character. Sheep have been specifically bred to produce wool of the coarse or fine quality demanded by the product's many uses, but within each breed there is still a wide variation in the quality and type of wool produced. Even a single fleece may vary markedly.

Before Shearing:

To maintain a high quality fleece a farmer should:

(i) Keep dust contamination to a minimum during mustering and yarding.

(ii) Clean up daggy sheep as dung stain affects dyeing properties.

(iii) Sort sheep into mobs according to breed and length of wool. Mobs are shorn separately.

(iv) Do not shear wet sheep as wool pressed damp discolours.

The Woolshed:

Woolsorters spread a newly shorn fleece on the wool table and carry out the task of sorting the wool according to length, degree of discoloration and various other flaws.

(i) Skirting is the removal of very greasy or discoloured bits from around the edge of the fleece.

(ii) Discoloured wool is removed and kept separate.

(iii) Wool which is markedly shorter than the rest is removed e.g., around the neck.

(iv) Wool contaminated with weeds, twigs and bidibids is separated out.

Classing

Wool may be classed into fine, medium and strong lines according to the fibre diameter of the wool (measured with a micrometer). Classing can be done by the farmer or by a registered classer.

The various grades of wool are packed into separate bales in a woolpress. The minimum bale weight is 100 kg while the maximum is 204 kg.

Wool Assessment:

Since the 1930's increased competition for synthetic fibres and certain import regulations by some countries demanded that some quantitative assessment be made of wool quality. The following features are now routinely measured in random samples taken from deep within a wool bale (grab samples).

(i) Yield

Freshly shorn wool carries various quantities of 'contaminants'. Typical constituents are shown below:

	Merino	Corriedale
Clean dry wool	55%	60%
Wax and grease	32%	26%
Dirt	4%	4%
Moisture	9%	10%

As only clean wool is used in manufacture this is the important part of the 'crop' and the % of clean wool obtained from the sample is the YIELD.

(ii) Vegetable Matter

Inevitably some seeds, twigs and other particles of vegetable matter become entangled in a sheep's fleece. This is not a serious form of contamination (approx. 0.4% of the wool clip may be affected). The quantity of vegetable matter is determined by dissolving a sample in strong alkaline solution and weighing the undissolved vegetable matter remaining.

Fibre Diameter

Electronic instruments have been developed to measure mean fibre diameter of a wool sample (measured in microns). Fibre diameter is important in determining the fineness or coarseness of wool. Fine wool may be as low as 17 microns and coarse wool being up to 42 microns in diameter.

Fibre Length

This is important in determining the spinning qualities of the fibre. Probably more important than fibre length in this regard is STAPLE length which is simply how long a sample of clean wool will "tuft out" before breaking. This may be measured on a staplemeter or simply with a ruler.

Fibre Strength

May be measured individually or in groups of fibres. Hand assessed 'staple strength' is still the most widely accepted in the wool trade however.

Bulk

Bulk is a measure of wool's "filling power" and is measured as the volume of a weighed sample under a light load. This is calculated into a bulk index measured as cm^3/g.

Bulk is of importance in the carpet industry as this affects the spongy feel of the carpet pile.

Colour

Clean scoured wool is tested for colour using a colourimeter which measures brightness and yellowness. This information is of special importance in specific dyeing qualities.

Storage Properties:

Wool has excellent storage properties and wool stores employ no special monitoring or environmental controls on the stored product.

Water is only a problem if wool bales are thoroughly soaked over a period of time. Micro-organisms acting mainly on the lanolin, may raise the temperature of a bale markedly - to combustion in fact! Thorough drenching may also affect colour but this can be corrected at scouring.

Wool is potentially at risk from carpet beetles that devour it, but this is not considered a problem in stored wool.

Student Activities:

Raw or clean scoured wool can be used for:

(i) Crude yield measure:

Weigh a dry sample of shorn wool. Soak in a warm solution of strong detergent or washing powder (with hungry enzymes!) for several hours. Thoroughly wash it, rinse it, dry it and re-weigh. Calculate % weight change to give approx. yield. Lanolin is a significant weight in raw wool so scouring it out should give a significant result.

(ii) Water holding property:

Compare weighed samples of clean dry wool and cotton wool. Thoroughly soak both and allow to drain past the dripping stage. Reweigh and calculate water-holding capacity.

or

Thoroughly dry weighed samples of cotton wool and clean scoured wool. Leave in a humid atmosphere over a number of days and re-weigh. Calcualte % weight gain to show hygroscopic quality of wool.

(iii) Bulk measurement:

Weight out a suitable quantity of wool. Cut the top off a discarded tin can. Keep the lid! Pack the wool into the tin so that it fills about 2/3 the volume of the tin. Place the lid on top and add a weight - say 200 g. Measure how far down the lid is depressed.

Remove the weight and measure recovery (resilience). Compare with cotton wool.

APPENDIX 8

COMMERCIAL SEED PRODUCTION - BACKGROUND NOTES

Commercial seed production is closely linked to research programmes involved with developing new or improved cultivars - in itself an exciting and complex part of the horticultural industry. Once cultivars with the desired characteristics have been developed through breeding programmes and researchers have completed the often lengthy field trials, a new line may be ready for commercial production.

Seed Production:

Crops grown for seed production are normally grown under contract to the marketing company.

Variability in the crop is a major concern. A certain amount of variability is inevitable but strict controls are required to ensure that variability is not so great that the identity of the cultivar is lost. Preventing chance pollination from outside sources is therefore of major importance. This can be achieved by (i) enclosing the crop,
(ii) distancing crops from sources of possible rogue pollen, distances naturally being further for cross pollinators than self pollinators.

In addition a constant eye is kept on the growing crop and any oddities or individuals that do not come up to standard are removed prior to harvesting.

Harvesting takes place when seeds are 'ripe' and moisture content correct for that particular species.

After harvesting, seed is cleaned and stored in a 'seed vault' where temperature and humidity are controlled at 20°C and 20% respectively. Seed respiration is at a minimum under these conditions.

Packaging:

(i) Foil packs. Seeds may be sealed in airtight/moisture proof laminated foil packs directly from the seed vault (20% humidity).

(ii) Paper packs. Some seeds are not suited to foil packaging because of naturally higher moisture content (eg. beans, peas). These seeds can be dusted with fungicide and packed in paper packets.

Quality Control:

(i) Purity. Random weighed samples are examined visually for the presence of weed seeds, other crop seeds and foreign material.

(ii) Germination. Batches of seeds are tested for % germination under ideal conditions. Seed samples may be laid out in dishes or in paper rolls.

(iii) Tetrazolium test. Tetrazolium is a chemical that distinguishes between living and dead tissues. Living tissue is stained red and this can be used to determine a weakness in a seed line.

(iv) Controlled deterioration test. Seeds are "aged" by increasing temperature and humidity in a controlled fashion. Subsequent germination tests can then determine seeds with short storage life.

(v) Conductivity test. Some seeds (eg. peas) may perform well in laboratory germination tests but fail in field conditions, (pre-emergence failure). Some seeds release salts into the soil that increase the activity of soil borne fungi which in turn interferes with germination. The possibility of pre-emergence failure can be detected by soaking seeds to leach out the salts and using electrical conductivity of the water to determine the quantity of salts leached.

(vi) Ultra Violet test for ryegrass. Fluoresence of certain genes under specific conditions can indicate their presence or absence, hence the perenniality of ryegrass can be determined as these genes control this characteristic in the species.

(vii) Ongoing quality control. Packed seeds are given a shelf life of four years, after which they are destroyed. During that time, samples of particular batches held in store are tested for vigour and if below standard are withdrawn from supply.

(Information courtesy of Arthur Yates Ltd)

SUGGESTED STUDENT ACTIVITIES

(i) Collecting Seeds

Allow some garden plants to 'go to seed' and collect these when they are 'ripe'. Some seeds are easily collected in situ (eg. Antirrhinums (snapdragons)). For others it is best to remove the plant, place a bag over the seedhead and hang upside down to dry in the garden shed (eg. lettuce, silverbeet).

Juniors derive a great deal of pleasure from designing their own seed packets, complete with instructions and storing these for planting out in spring.

Collecting seeds from native plants is an enjoyable autumn activity. Most native seeds do best if sown FRESH.

(ii) Seed Viability

Compare commercial seeds with collected seeds for germination. (Paper roll test for example).

Compare foil packed seeds opened as against freshly bought (lettuce is good for this but you've got to have an opened foil pack lying around your shed sometime from last year!).

Compare germination in packs with different expiry dates. Field test your own harvested broad beans against fungal treated bought ones for germination rate and vigour.

In autumn collect seeds and store some in refrigerator (low temp/low humidity) for a while and pack into airtight vials. Compare with the same collected seeds stored in paper envelopes (germination test).

(iii) Crop Quality

Compare a mature crop grown from your own seeds against commercial seed grown for vigour, growth, quality, yield etc.

* Do not store collected seeds in plastic bags as moisture content will encourage viability failure.

APPENDIX 9

KIWIFRUIT - BACKGROUND NOTES

Harvest

Kiwifruit is generally harvested in early May just as the sugar content of the fruit is beginning to rise. Sugar content is determined by measuring the refractive index of the fruit juices using a hand held instrument. Field officers of the M.A.F. or Kiwifruit Marketing Authority check an orchard for diseased vines and measure sugar content before giving the go ahead to harvest.

Harvesting is done by hand and the vines completely cleared of all fruit at once. Pickers wear gloves to avoid nicking the fruit with fingernails as this leads to rapid fruit deterioration. Newly picked fruit is hard and quite impossible to eat - very disappointing if you're a picker! No wet fruit may be harvested as this could encourage fungal growth in storage.

Grading

The export market is becoming increasingly particular about the quality of fruit. What was accepted five years ago as an export fruit may now not even make the local market. A summary of grading standards is attached. Unacceptable fruit is removed before passing through the grading machine. The grading machine sorts the fruit out into size categories.

Packaging

Kiwifruit are packed into cardboard trays lined with a plastic insert recessed to take a certain number of fruit. Each exported tray has the same weight, (approx. 3.5 kg) so that a tray carrying large fruit will have correspondingly fewer fruit than a tray carrying small fruit. Consequently there are six types of tray referred to as 25's, 28's, 33's, 36's, 39's and 42's, corresponding to how many fruit that particular tray will carry. Up until 1985 there was a smaller grade of 46's but these have now been relegated to the ranks of 'local market'.

Trays are all packed by hand and full trays wrapped in polythene film prior to being finally closed with a lid and set on pallets.

Fruit rejected for export is sold loose either to the local market or to processing companies for pulping depending on the reason for rejection. Packhouses are required to do their own spot checks on fruit quality, tray weights etc. and these are checked by M.A.F. or N.Z.K.A. officers.

Storage

Left to themselves kiwifruit will gradually ripen over a number of weeks, hastened if there is a source of ethylene (other fruit etc). In cool storage however, kiwifruit will maintain high quality over 12 months.

Kiwifruit is stored in large coolstores at 1°C a temperature low enough to arrest the ripening process but above freezing point. Should the coolstore temperature accidentally fall below freezing, the fruit would of course be ruined. Polythene film liners in each tray prevent the fruit from dehydrating. Care is taken that no other fruit is stored nearby as ethylene production could accelerate the ripening process. All forkhoists must be electrically operated as diesel fumes contain trace quantities of ethylene.

Product deterioration in storage

Spot checks are made throughout the storage period on the keeping quality of the fruit. Problems can occur even at this stage.

(i) Diseases such as Botrytis will result in rotting fruit and, of course, an export ban on that grower until the appropriate checks have been made.

(ii) Pests eg. greedy scale or leafroller found on fruit.

(iii) Fruit deterioration eg. cutfruit may produce ethylene and accelerate the ripening process.

APPENDIX 10

MILK QUALITY - BACKGROUND NOTES

By its very nature, milk is a product that may be variable in the proportion of its constituent parts: fat, protein, lactose, and water. This is dependent on:

(i) Breed of cattle
(ii) Age of cattle
(iii) Time since onset of lactation
(iv) Cattle nutrition/health

A low fibre diet results in diminished butterfat content.

Typical milk composition:

	Milk Fat%	Protein %	Lactose %
Fresian	3.8	3.2	4.8
Jersey	5.3	3.9	4.8

Milk constituent proportions are monitored by dairy companies and quality control demands that they fall within certain tolerances.

Grading Tests:

To maintain a product of highest possible standard for both the dairy food industry and town supply the following tests are carried out by all dairy companies:

(i) Senses Test

A tasting panel of people smell and taste samples to determine the milk's overall acceptability. Colour variations and taints due to agricultural chemicals, feeds, blood, colostrum and grass bacterial contamination may be picked up in this way.

(ii) Standard Plate Count (SPC)

A small sample of milk is mixed with agar on a sterile plate. The agar prevents the bacteria moving. The plate is incubated for three days and scanned for excessive colony growth. Gross bacterial contamination is evident within 24 hours.

(iii) Inhibitory Substances

This tests the presence of trace amounts of antibiotics as a milk contaminant. The test involves mixing the milk sample with an antibiotic-sensitive bacteria culture (Baccillus stearo-thermophilus) and a pH indicator bromocresol purple (BCP). If

there is no contamination, the organism grows rapidly under incubation to produce acid waste products and a pH colour change to yellow. With an antibiotic contamination, there will be no bacterial growth and therefore no colour change. Not only will antibiotic-contaminated milk inhibit 'starter cultures' in dairy food manufacture (yoghurt, cheese) but it also has serious health implications for human consumption at large.

(iv) Sediment Test

Ultra fine filters filter out any tiny particles of solid contaminants and these are compared to standard charts to ascertain acceptable limits.

(v) Thermoduric Plate Count

Thermoduric bacteria are bacteria which can survive high temperature treatment (pasteurisation). Plate counts (similar to SPC) are made after a three day incubation.

(vi) Coliform Count

Coliform bacteria are associated with faecal contamination and are carried out following a high SPC test to ascertain the cause of contamination. A specific agar preparation is used (violet red bile agar) for what is otherwise a standard plate test.

(vii) Somatic cell counts

White blood cells (somatic cells) are naturally present in small quantities as part of the cow's natural defense against infection. Cell counts are either done directly by "electronic eye" which measures light absorption in a sample or indirectly by milk viscosity. A cell count of under 200,000 per ml is considered normal. Higher numbers could mean a mastitis problem in the herd.

A high standard is maintained by using standard test results to immediately feedback to producers and, if necessary, impose penalties on those producing substandard milk.

To keep contamination to an absolute minimum, a high standard of hygiene is required in all milking operations and milk storage. It is mandatory that milk be cooled at 7°C within three hours of milking and the product is kept refrigerated throughout.

Pasteurisation

All but the thermoduric bacteria are killed in the process of pasteurisation where milk is heated to 72°C for 15 seconds and then cooled rapidly to 3°C.

UHT treated milk is now marketed as a product with a shelf life at room temperature of 6 months. The milk is heated under pressure to 200°C, cooled and packaged under completely sterile

conditions. Cardboard packaging is treated with a peroxide compound and completely sealed so that the product is guaranteed sterile.

Suggested Student Activities:

1. Milk keeping properties - smell test.

1 = non sterile milk
2-5 = Sterilised by heating to 105° for 15 minutes.

unplugged after sterilising for 20 minutes then plugged.

Leave about 1-2 weeks and smell!

2. What does milk contain?

You will need:

* 50 ml whole milk (not homogenised, if the milk is homogenised the experiment will not work!)
* distilled water
* 15 ml concentrated H_2SO_4 solution
* 10 ml 2M HCl
* 15 ml Fehlings solution
* 2 g sucrose
* 4 x 25 mm test tubes and a rack
* boiling water in a large beaker
* 50 ml volumetric flask.

(a) Milk Fat:

Presence of milk fat can be shown by denaturing the milk protein which makes milk white and makes the fat hard to see. The same process breaks open the tiny fat globules and causes the milk fat to rise as a continuous oily layer.

What to do:

1. Measure 15 ml of whole milk into the 50 ml volumetric flask (or a large test tube).

2. Add 15 ml concentrated H_2SO_4.

3. Allow to stand until reaction is complete (about 5 minutes). Describe what happens during the reaction.

4. Add hot water using a pipette to bring the liquid level up into the neck of the volumentric flask. The milk fat will be seen to rise and float on top.

This gives a qualitative indication of milk fat. If you want to measure milk fat percentage accurately, find out about the BABCOCK BUTTERFAT TEST. You may be able to borrow the necessary equipment from a local dairy factory.

(b) Milk Protein:

The milk protein casein can be coagulated in a milk sample by adding dilute acid or RENNET.

What to do:

1. Measure 25 ml of whole milk into a test-tube.

2. Add 10 ml 2M HCl.

3. Describe what happens to the milk.

4. The white curd is casein protein.

5. Retain the liquid whey.

(c) Milk Sugar:

Milk sugar (lactose) is a disaccharide very similar to sucrose (or table sugar). The presence of lactose and sucrose can be demonstrated using Fehlings solution. If sugar is present a yellow to brown precipitate will be produced after adding Fehlings solution.

What to do:

1. Set up three test tubes as follows:

   To test tube 1 add 10 ml distilled water.
   To test tube 2 add 10 ml whey retained from the previous experiment. If 10 ml are not available repeat milk protein test until 10 ml are obtained.
   To test tube 3 add 2 g sucrose and 10 ml distilled water.

2. Add 5 ml Fehlings solution to each tube.

3. Stand the test tubes in boiling water for 5 minutes. Note any colour change.

4. Use a biochemistry text book to find out the structural formula of sucrose and lactose.

3. How is Butter Made?

You will need:

* 250 ml cream
* 5 g Table salt - sodium chloride
* An egg beater or other suitable appliance
* A plastic bowl or 800 ml beaker
* Clean plastic sheet
* Two stainless steel spatulas

What to do:

Best results are obtained with an egg beater and a plastic bowl but butter can be made using a fork or whisk (a much slower method).

1. Pour the cream into the bowl.

2. Whisk with the egg beater until yellow globules of butter appear.

3. Remove as much butter from the beaters as possible using spatulas.

4. Continue to work the butter with the spatulas. Pour off butter milk as it is separated.

5. Spread the butter thinly onto the plastic and sprinkle with salt.

6. Continue to work the butter until all the butter milk is removed.

7. Retain this butter for the next experiment.

Questions

1. What weight of butter was produced from 250 ml of cream? Express this as a percentage.

2. Why is salt added to the butter?

3. In what form is butterfat in cream and milk - why does it not appear as a yellow paste?

4. What are the main fats in butterfat?

5. Buttermilk is highly nutritious. What nutrients does it contain?

4. How is Cheese Made?

Cheese is made by microbial fermentation of coagulated milk protein. Best results are obtained by using special cheese cultures to add to the curd but milk contains natural microbes which will turn the curd to cheese.

You will need:

* 1 litre of milk, old but not sour. Best results are obtained by using unpasteurised milk. If this is unavailable see step five of method.
* 1/2 junket tablet (or teaspoon of Rennet).
* 1 litre beaker.
* bunsen burner, tripod and gauze.
* cheese cloth or old stocking.
* 2 litre ice cream container with 50 small holes cut in the bottom (2 mm dia.).
* stainless steel spatula
* thermometer 0-110^{o}C.

What to do:

1. Crush the junket tablet in warm water and mix it thoroughly with the milk in the beaker.

2. Warm to 28-30^{o}C till curd forms. Remove heat.

3. Allow the curd to form while it cools.

4. Cut the curd in many directions using the spatula. Pour off whey if possible but take care not to lose any curd.

5. If milk was pasteurised and if cheese culture is available add it to the curd.

6. Continue cutting the curd and pouring the whey until the curd becomes crumbly. Best results are obtained if this step takes 30-40 minutes.

7. Pour the crumbly curd into cheese cloth and place it in the ice cream container.

8. Knead the curd to squeeze out whey.

9. Push the curd into the desired shape and allow to stand in a cool dry place for one week.

Because of the risk of contamination cheese made by this method should not be eaten.

Questions

1. What weight of cheese was made from 1 litre (1000 g milk)?

2. Why are specially prepared cultures used to make cheese instead of allow naturally occurring organisms to do the job?

3. What type of organism is principally responsible for making cheese?

5. Growth of Bacteria in Milk

Introduction:

Milk quality is affected by chemicals and by bacteria.

When there is a lot of oxygen present in milk the dye methylene blue stays blue. When there is no oxygen it goes colourless. Like ourselves many bacteria use oxygen to live. The more bacteria present the more oxygen is used. As oxygen is removed methylene blue will change from blue to colourless. In this experiment you are going to use methylene blue to find out how many bacteria are present in milk that has been stored in different ways.

Problem:

To compare the growth of bacteria in milk stored in or out of the refrigerator.

Prediction (Hypothesis):

Predict which type of milk will have the greatest number of bacteria.

Equipment:

About 20 ml of fresh milk, about 20 ml of milk a few days old (unrefrigerated), methylene blue solution (approx. 1%), 2 sterile test tubes, 2 sterile corks to fit test tubes, clock or watch displaying seconds.

Method:

1. Lable test tubes A and B.

2. Into test tube A place 20 ml of fresh milk.

3. Into test tube B place 20 ml of old milk.

4. Add 0.5 ml of methylene blue to both test tubes.

5. Stopper tubes and leave to stand at the same temperature condition. (An incubator speeds the reaction).

6. Record the change of colour in each and the time it takes.

What to write in your books:

1. Copy title and problem.

2. Write down your prediction.

3. Record your method.

4. Under the heading "Results" complete the following.

	TUBE A	TUBE B
Time taken to change colour		

Questions:

1. Which sample of milk did you predict to change colour first? Why?

2. Which test tube was the control?

3. The change from blue to clear gives an indication of the number of bacteria present. Which tube contained the larger number of bacteria?

4. Under what conditions should milk be kept once its taken from the cow? Why?

Extensions:

What is long life milk?

APPENDIX 11

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