SENIOR FOUR AGRICULTURE

THEME: ANIMAL PRODUCTION

TOPIC 4.1: PROCESSING DOMESTIC MILK PRODUCTS

Competency: The learner should be able to demonstrate hygienic milk handling, processing and milk safety

LEARNING OUTCOMES

The learner should be able to:

a) understand and be able to carry out the following processes:
b) pasteurization of milk
c) homogenization of milk
d) demonstrate skills in processing fermented and other milk products
e) process flavored milk and sweetened condensed milk
f) handle, collect, test and quality control milk

Milk is a nutrient-rich, white liquid food produced by the mammary glands of mammals. It is the primary source of nutrition for infantmammals (including humans who are breastfed) before they are able to digest other types of food. Early-lactation milk contains colostrum, which carries the mother's antibodies to its young and can reduce the risk of many diseases. It contains many other nutrients including protein and lactose. Interspecies consumption of milk is not uncommon, particularly among humans, many of whom consume the milk of other mammals.



Figure: ***A glass of pasteurized cow's milk***

Milk is processed into a variety of products such as cream, butter, yogurt, kefir, ice cream, and cheese. Modern industrial processes use milk to produce casein, whey protein, lactose, condensed milk, powdered milk, and many other food-additives and industrial products.

Whole milk, butter and cream have high levels of saturated fat.

The sugar lactose is found only in milk, forsythia flowers, and a few tropical shrubs. The enzyme needed to digest lactose, lactase, reaches its highest levels in the human small intestine after birth and then begins a slow decline unless milk is consumed regularly

Nutritive value of cow's milk

Milk is a highly nutritious liquid formed in the mammary glands of mammals to sustain their newborns during their first months of life.

A huge variety of food products are made from cow's milk, such as cheese, cream, butter, and yogurt.

These foods are referred to as dairy or milk products and are a major part of the modern diet.

The nutritional composition of milk is highly complex, and it contains almost every single nutrient that your body needs.

One cup (240 ml) of whole cow's milk with 3.25% fat provides

Calories: 149

Water: 88%

Protein: 7.7 grams

Carbs: 11.7 grams

Sugar: 12.3 grams

Fiber: 0 grams

Fat: 8 grams

Milk proteins

Milk is a rich source of protein — providing approximately 1 gram of this nutrient in each fluid ounce (30 ml), or 7.7 grams in each cup (240 ml).

Proteins in milk can be divided into two groups based on their solubility in water.

Insoluble milk proteins are called casein, whereas soluble proteins are known as whey proteins.

Both of these groups of milk proteins are considered to be of excellent quality, with a high proportion of essential amino acids and good digestibility.

Casein

Casein forms the majority — or 80% — of proteins in milk.

It's really a family of different proteins, with alpha-casein being the most abundant.

One important property of casein is its ability to increase the absorption of minerals, such as calcium and phosphorus.

It may also promote lower blood pressure.

Health benefits of milk

Milk is one of the most nutritious foods you can find.

In particularly, cow's milk may positively affect your bones and blood pressure.

Bone health and osteoporosis

Osteoporosis — a condition characterized by a decrease in bone density — is the main risk factor for bone fractures among older adults.

One of the functions of cow's milk is to promote bone growth and development in the young calf.

Cow's milk seems to have similar effects in people and has been associated with a higher bone density.

The high calcium and protein content of milk are the two main factors believed responsible for

this effect.

Blood pressure

Abnormally high blood pressure is a major risk factor for heart disease.

Dairy products have been linked to a reduced risk of high blood pressure

It's thought that the unique combination of calcium, potassium, and magnesium in milk are responsible for this effect.

Other factors may also play a part, such as peptides formed during the digestion of casein.

Being a rich source of calcium, milk may promote increased bone mineral density, cutting your risk of osteoporosis. Milk and its products have also been linked to reduced blood pressure.

Role of milk and milk products in cookery

It contributes to the nutritive value of the diet, e.g., milk shakes, plain milk, flavoured milk, cheese toast.

Milk adds taste and flavour to the product, e.g., payasam, tea, coffee.

It acts as a thickening agent along with starch, e.g., white sauce or cream soups.

Milk is also used in desserts, e.g., ice-cream, puddings.

Curd or buttermilk is used as a leavening agent and to improve the texture, e.g., dhokla, bhatura.

Curd is used as a marinating agent, e.g., marinating chicken and meat.

Curd is used as a souring agent, e.g., rava dosa, dry curd chillies.

Khoa is used as a binding agent, e.g., carrot halwa.

Milk and curd increase shelf-life poories preserve better when the dough is mixed with milk/curd.

To prevent browning in vegetables, e.g., butter milk is used for preventing browning when plantain stem is cut.

Variety to the diet, e.g., butter milk sambhar, avial and mutter paneer.

Cheese is used as garnishing agent.

Milk is used as clarifying agent in sugar syrup.

Salted butter milk is used for quenching thirst.

Effects of heat on milk constituents

Effect on milk proteins

When milk is sterilized, the albumin is completely coagulated. Even in the milk which has been boiled for 10 minutes, a greater part of the albumin is coagulated. When milk is boiled in an open pan and allowed to cool, the 'skin' formed at the surface contains about 13 per cent of the solids of milk. This includes a greater part of the albumin and about ¼ of the fat present in milk. Casein is relatively stable to heat. It does not coagulate at pasteurization temperature or when milk is boiled for 5 minutes. Casein undergoes coagulation when milk is heated at 100 0 C for 12 hours or 1 hour at 135 0 C or 3 minutes at 150 0 C.

Effect on fat

The layer of fat that may form on milk that has been boiled results from the breaking of the films of proteins that surround the fat globules in the unheated milk. The breaking of films of emulsifying agents permits the coalescence of fat globules.

Effect on milk salts and pH

The pH of fresh milk ranges from 6.5 - 6.7. When milk is heated at 80 0 C for 30 minutes there is loss of CO2, which causes an increase in pH. At the same time, some of the soluble calcium and phosphate are converted into insoluble calcium phosphate with the liberation of acid phosphates.

These two opposing factors counter balance each other and there is no net change in pH. Heat treatment at high temperature (110-120 0 C) leads to the production of lactic and formic acids.

Iodine is a volatile substance and when heated tends to be lost from milk. The dispersion of calcium phosphate in milk is decreased by heating and part of it is precipitated. Some of it collects on the bottom of the pan with coagulum of albumin and some is probably entangled in the scum on the top surface of the milk.

Processing: Processing helps to produce milk that has initial low bacterial count, good flavour and satisfactory keeping qualities. There are three operations of milk processing and they are clarification, pasteurisation and homogenisation.

Clarification: Milk is passed through a centrifugal clarifier. The speed is adjusted in such a way that cream is not separated but dirt, filth and cells from the udder and some bacteria are removed. The clarified milk is ready for pasteurisation.

Pasteurisation

Pasteurisation derives its name from the French scientist Louis Pasteur who, found that heating of certain liquids to a high temperature improved their keeping quality. In general terms, it is the heating of milk to a temperature which destroys organisms responsible for tuberculosis and fever and nearly all the other micro-organisms present in that product without seriously affecting the composition or properties of the product. Pasteurisation should be followed by immediate cooling of the product to the temperature sufficiently low to check the growth of micro-organisms which are resistant to the temperature used. At present, pasteurisation is considered as an essential feature in the manufacture of butter, ice-cream and also in cheese industries. Pasteurisation also inactivates some of the natural enzymes like lipase.

Three general methods are in use now days.

Holding or Batch System: The holding system consists in bringing the milk or cream to a temperature usually 65°C and holding at that point for at least 30 minutes followed by rapid cooling. A higher temperature is sometimes used in which case the time of holding may be shortened. For exampIe, holding at 68.3°C for 20 minutes. Careful control of both temperature and time of heating is important.

In more recent years it is found that the organism causing Q fever, coxiella bumetti, is slightly more resistant than the tuberculosis organism and required a treatment of 63°C for 30 minutes to ensure its destruction.

High Temperature Short Time Method (HTST) or the Continuous System: The machines are so constructed for continuous operation and for this reason the system is called as "continuous flow or flash pasteuriser." The system depends upon the raising of the temperature of the milk to at least *72oC* for 15 seconds as it passes through the machine. This is followed by cooling. This method does not impart cooked flavour and cream line is not affected.

Ultra High Temperature System: This UHTS system results in a complete pasteurisation of milk. In this system, milk is held for 3 seconds at 93.4°C or for one second at 149.5°C. This system is also used extensively for the treatment of milk or cream in dairy industries. This product has a longer shelf life than milk pasteurised by other methods. After pasteurisation, the milk is cooled rapidly to 70C or lower.

Pasteurised milk is not sterile. It must be quickly cooled following pasteurisation to prevent

multiplication of surviving bacteria.

Role of Phosphatase in Pasteurisation: Raw milk contains alkaline phosphatase. This enzyme serves as a built-in indicator by which the adequacy of pasteurisation may be gauged. This enzyme has heat destruction characteristic that closely approximates the time, temperature, exposures of proper pasteurisation. Therefore, if alkaline phosphatase activity beyond a certain level is found in pasteurised milk it indicates inadequate processing. This enzyme has the ability to liberate phenol from phenol phosphoric acid compound. The liberated phenol gives a deep blue colour with certain organic compounds. If the milk isincubated it does not give blue colour with the indicator it means the pasteurisation is complete.

So sensitive is this test that it gives positive in the presence of 0.1 per cent raw milk added or if the pasteurisation temperature is less by 1 oF.

Effect of Pasteurisation on nutritive value

Nutritive value: Due to pasteurisation, there is no important change in nutritive value, except for the slight decrease in the heat-labile vitamins like thiamine and ascorbic acid. Whey proteins are denatured only slightly and minerals are not appreciably precipitated. Pasteurised milk produces finer curd when milk is digested.

Flavour: Pasteurisation does not produce objectionable cooked flavour. The flavouring compounds present in milk are in no way destroyed by pasteurisation.

Micro-organisms: Pasteurised products are not sterile. They contain vegetative organisms and spores still capable of growth. Pathogens like mycobacterium tuberculosis, salmonella typhi, corynebacterium diphtheria *and* brucella are destroyed but non-pathogens remain in the milk even after the pasteurisation is complete. Approximately 99 per cent of bacteria, yeast and moulds are destroyed by pasteurisation. The milk does not contain heat resistance moulds and yeast.

Enzymes: Apart from phosphatase, lipase also gets inactivated which would have affected adversely the quality.

After pasteurisation, tests for temperature, fat, specific gravity, solids-non-fat, acidity and bacterial analysis are conducted. Pasteurised milk can be stored for a week or more in good condition. At room temperature it may spoilt in a day.

Schematic diagram shows the steps involved in pasteurising milk at Madhavaram Milk Dairy, Chennai.

Homogenisation

The process of making a stable emulsion of milk fat and milk serum by mechanical treatment

and rendering the mixture homogeneous is homogenisation. This is achieved by passing warm milk or cream through a small aperture under high pressure and velocity. Milk and cream have fat globules that vary from 0.1 to 20 µm in diameter. The fat globules have a tendency to gather into clumps and rise due to their lower density than skimmed milk. Homogenised milk fat globules size is 2 µm. The decrease in the size of the fat globules increases their number and surface area. A film of adsorbed protein or lipoprotein immediately surrounds each of the new globules, acting as an emulsifier and prevents them from reuniting. The newly formed fat droplets are no longer coated with the original membrane material. This brings about the stabilisation of milk emulsion and thus prevents the rising of the cream.

Homogenised milk has a creamier structure, bland flavour and whiter appearance. It has a greater Whitening power when added to coffee and tea. A soft curd is formed when coagulated and· is easily digested. In the manufacture of evaporated milk (condensed milk) and ice-cream homogenisation reduces the change of separation of fat resulting in a smoother texture of the finished product. Homogenisation accelerates the action of lipase and rancidity of fat takes place. Homogenisation is done beforepasteurisation.

Freezing: When milk or cream is frozen at a relatively slow rate, the film of protein that acts as an emulsifying agent around the fat globules is weakened and ruptured. As a result, the fat globules tend to coalesce. The dispersion of protein and calcium phosphate is also disturbed by freezing. Both constituents tend to settle out on thawing and standing, thus reducing the whiteness of milk.

Sugar- protein mixtures: Non-enzymatic browning of Maillard type occurs in evaporated milk. Maillard (1912) was the first to describe the development of brown colour in mixtures containing amino acids and reducing sugars. The maximum effect is with lysine followed by tryptophan and arginine. Glucose reacts more strongly with lysine than lactose or fructose, while lactose reacts most readily with tryptophan.

The steps involved in the Maillard reaction between reducing sugars and amino acids or proteins are as follows:

Condensation of the aldehyde or ketone group with the amino group.

Rearrangement of condensation products.

Dehydration of the rearranged products.

Further degradation.

Polymerization to brown pigments.
Sucrose does not react by itself as it has no reacting group but the hydrolytic products of sucrose, glucose and fructose react with amino acids. If proline is involved in the reaction the product may become bitter.

The rate of browning increases rapidly with a rise in temperature. The colour development increases with increasing pH above 6.8 for glucose – ? amino acid solutions and above pH 6.0 with glucose – ?-amino acids. The involved amino acids are no longer biologically available.

The reaction rate being decreased at low is very high water levels although the dry materials will react. The optimal moisture levels for the reaction range from 10 to 15 % in a dehydrated product. The reaction is catalysed by the presence of metals such as iron and copper and by phosphate ions.Concentrated milk products such as evaporated milk and sweetened condensed milk contain substantial amounts of both protein and the sugar lactose and develop some brown colour on heating. This reaction may also occur in dried milk stored for long periods.

Milk products

Milk is not only used as such but many products, non-fermented and fermented are used in cookery. About 30-50 % of the total milk production in the country is converted to milk products.

Types of milk on the market

Several types of fluid milk are marketed in many countries. These include

Homogenised milk: In homogenised milk, the fat globules are broken up mechanically to less than 1 micron in diameter so that fat does not rise to the surface to form a cream layer. The process consists of forcing milk heated to about 57 to 60 0 C (135-140 0 F) through a very small orifice at high pressure. All homogenised milk should be pasteurized after homogenisation to destroy the enzyme-lipase which otherwise would cause the milk to become unfit for human consumption within a few hours due to the development of bitterness and rancidity. One disadvantage of homogenised milk is that milk fat cannot be separated as cream in a cream separator. The fat in homogenised milk is more readily digested by infants than that from ordinary milk.

Standardised Milk: In standardised milk, the fat content is maintained at 4.5 per cent and S.N.F. at 8.5 per cent. It is prepared from the mixture of buffalo milk and skim milk.

Toned Milk: Toned milk is prepared by mixing reconstituted from skim milk powder with

buffalo milk containing 7.0 per cent fat. The fat content of the toned milk should not be less than 3 per cent and S.N.F. 8.5 per cent.

Double toned milk: This is prepared by admixture of cow's or buffalo's milk or both with fresh skimmed milk or by admixture with skim milk reconstituted from skim milk powder or by partial removal or addition of milk to skim milk. It should be pasteurised and show negative phosphatase test. Its fat content should be less than 1.5 per cent and S.N.F. not less than 9 per cent.

Recombined Milk: Recombined milk is a homogenised product prepared from milk fat, non-fat milk solids and water. It should be pasteurised and show a negative phosphatase test. Its fat content should be less than 3 per cent and S.N.F. 8.5 per cent.

Filled milk: Filled milk is a homogenised product prepared from refined vegetable oil and non-fat milk solids and water. Its fat content should not be less than 3 per cent and S.N.F. 8.5 per cent.

Sterilised milk: Standardised cow's or buffalo's milk is sterilised in bottles by heating continuously to a temperature of 115oC for 15 minutes to ensure destruction of all micro-organisms and preservation at room temperature for not less than 85 days from the date of manufacture. It shall be sold only in the container, in which milk was sterilised.

Ultra high temperature (UTH) processed milk : Milk is heated at temperatures higher than those used for pasteurisation, 138°-150°C for 2-6 seconds. Then, under sterile conditions it is packaged into presterilized containers, which are aseptically sealed so that spoilage organisms cannot enter. Hydrogen peroxide may be used to sterilise the milk packing materials. UHT milk can be stored unrefrigerated for at least 3 months.

UHT milk has cooked flavour due to denaturation of the whey protein ? lactoglobulin. Off flavours develop due to chemical and enzymatic activity. The addition of flavourings to milk masks off flavour.

Flavoured milk: Flavoured milk may contain cardamom, pista, banana, strawberry, chocolate, coffee or any other edible flavour, edible food colour and cane sugar. It is either pasteurised or sterilised. Shelf life can be high if it is sterilised.

Research has shown that carbon dioxide when added to milk creates a unique sensation in the mouth that actually makes milk more thirst quenching. It is also showed that carbon dioxide could extend the shelf life of dairy products by displacing some of the oxygen needed for spoilage bacteria to grow. A non-fat milk-based drink contains the same nutrition as skim milk. It is designed to appeal to kids through the addition of interesting flavours and a bit of

carbonation. It is being commercially produced.

Storage of milk at home

Once opened, milk is safe to consume for up to 3 days. This is why it is better to buy smaller amounts more often rather than keeping larger containers open in the refrigerator for too long.

Remember to open new milk containers in the same order in which you bought them. First in the fridge, first out.

Keep milk containers closed and stored away from strong-smelling food items in the fridge the milk can pick up these odours.

Store milk on refrigerator shelves where it is cooler, rather than in the refrigerator doors.

Whenever possible, leave milk in its original container to safeguard its flavour and nutritional value.

Avoid exposing milk to light, as light destroys certain vitamins, such as vitamin D and riboflavin.

To avoid spoilage, do not return unused milk from a serving pitcher to the original container.
UHT and canned milk found in the non-refrigerated aisle are perishable once opened. Opened UHT and canned milk must therefore be refrigerated. After opening canned milk, immediately transfer any unused portions to a clean, opaque and airtight container. These milk products should be used within 3 days of opening.
If stored in a cool, dry place, powdered milk will keep for up to 6 months. Once the package is opened, it should be used within 1 month. After being reconstituted, it should be stored and treated in the same way as regular fluid milk, meaning it should be refrigerated and used within 3 days.
Milk can be frozen for up to 6 weeks without any impact on its flavour and nutritional value; however, upon thawing, it can separate and lose its smooth texture. Partly skimmed and skim milk freeze better than whole milk (3.25%). Thaw milk in the fridge. If the milk separates upon thawing, beat it with an electric mixer or an immersion blender with the whip attachment.

Leftover evaporated milk can be frozen in an airtight container for up to 6 weeks with no adverse effects.

If you freeze foods such as soups or stews, add the milk after you reheat the thawed food.

What are some examples of food made with milk?

Butter. Butter and butter blends.

Cheese. Natural and processed cheese products.

Cultured Dairy. Yogurt, cottage cheese, sour cream, dips and other cultured dairy foods.

Frozen Desserts. Ice cream cakes other frozen desserts made with dairy ingredients.

Ice Cream/Novelties.

Milk.

Non-Dairy Beverages.

Whey, Milk Powder.

Custards

Milk shake



Figure: *Black Bottom Espresso Custard*



Figure: *Peanut Butter Chocolate Pots*



Figure: *Panettone Bread Pudding*

TOPIC 4.2: PROCESSING DOMESTIC MEAT PRODUCTS

Competency: The learner should be able to understand and follow safe and hygienic procedures when handling and processing meat

LEARNING OUTCOMES

The learner should be able to:

a) know the different sources of meat for processing and the meat products made
b) select, handle and process meat safely and hygienically
c) demonstrate basic practical skills such as the use of relevant tools in meat processing
d) show skill in meat processing different animals
e) know how to smoke meat

Introduction to meat and meat products

Meat and meat products are rich and concentrated sources of nutrients including fats, proteins, vitamin B12, zinc and iron.

Meat is categorized into red meat and white meat. Meat from any source is of similar nutritional value, whether it is white or red. The intensity of colour in meat depends on the amount of myoglobin it contains. It is incorrect to assume that white meat from birds is superior to red meat, or vice versa. Offal meat (i.e. internal organs such as liver and kidney), however, tends to have a higher nutritional value, and red meat is known to contain a rich source of iron.

The distinguishing element among the various sources of meat appears to be the fat content. Some scientists consider red meat (e.g. beef, pork and lamb) to be less healthy because it has a relatively higher fat content compared to white meat. Saturated fat in meat may predispose people to cardiovascular disease.

There are many reasons for people to eliminate meat and meat products from their diet. Some of these reasons may include health concerns, religion, cultural background, income and accessibility of meat.

Red meat

Red or dark meat is mainly made up of muscles with slow fibres**.** These muscles are used for

extended periods of activity, such as standing or walking, and need a steady energy source. Red meat refers to the muscle meat from cattle, sheep, goat and kangaroo and essentially provides considerable amounts of zinc and vitamin B12.

The pigment that is primarily responsible for the red colour of meat is myoglobin, a protein that can bind and store oxygen in cells. The amount of myoglobin in meat varies according to species, age of animal, amount of exercise, stress, condition of storage, exposure to oxygen, heat and processing.

Tissues and organs that require more oxygen for their functions have more myoglobin, and therefore are redder in colour. Beef is shown to contain more myoglobin in its tissue than lamb and pork.

Myoglobin levels also vary depending on muscle use. More active parts of an animal require more oxygen and will therefore have more myoglobin and consequently, be redder or darker in colour. For example, chicken legs are darker than chicken breasts because their legs are more active.

White meat

White meat is made up of muscles with fast fibres**.** Fast fibre muscles are used for quick bursts of activity, such as fleeing from danger. These muscles source their energy from glycogen, which is also stored in the muscles.



White meat is a valuable source of iron and zinc, however, the mineral content per unit weight of white meat is about half the mineral content of red meat per unit weight. Similarly, vitamin B12 content is less in white meat.

Myoglobin content is low in white meat. This explains why chicken breast, pork and veal are slightly pink or white. The colour of fish meat is white because it lives in water and does not need to support its own body weight, and therefore has no myoglobin in its muscles.

Nutritional value of meat

Protein

Protein is the fundamental structural and functional element within every cell, and is made up of 20 common amino acids. There are eight amino acids which are not produced in the body and must be supplied by food. These are classified as essential amino acids.

The majority of the foods we eat contribute some amounts of protein to our diet. Animal products have a higher protein content than fruits, vegetables and breads. Muscle meat is a good source of protein. Meat is rich in essential amino acids, particularly sulphur amino acids. White meat contains an equivalent amount of protein to red meat.

Protein from meats, fish and poultry are more easily digested than protein from beans and whole-wheat.

Fat

Fat is distributed throughout meat. The fat content of meat varies depending on animal breed, age, amount of exercise and diet. Lean red meat provides 2-5g of fat per 100g of dietary fat. It has almost equal amounts of saturated and monounsaturated fats, and a small amount of polyunsaturated fat.

Lean pork and skinless chicken have the same fat content as lean red meat. Lean pork has more polyunsaturated fat compared with lean red meat, but equal amounts of saturated and monounsaturated fats.There is more monounsaturated fat and polyunsaturated fat in skinless chicken compared to other meats.

The fat content of meat varies as follows:

Red meat: beef (3.5-9.3 %), lamb (7.5-13.3%)

White meat: pork (3.7-10.1%), chicken (1.1-9.7 %), turkey (2.0-6.6 %)

Processed meat: Burgers and sausages have the highest fat content (up to 25%)

Iron

Iron deficiency is common in Uganda. Pregnant women, or those of childbearing age, require more iron than other people. Vegetarians and semi-vegetarians have a higher risk of developing an iron deficiency, as iron obtained from plants has a lower bioavailability.



The human body can absorb about 15% of iron from plants (non-haem iron), and about 25% of iron from meat (haem iron). Eating meat in a mixed meal can cause a two-fold increase in the absorption of non-haem iron.

Red meat (e.g. beef and lamb) is the best source of iron. Pork and chicken contain moderate amounts of iron, while fish has the least amount.

Iron deficiency is progressive. Anaemia develops at its final stage. When iron stores in the body are depleted, the amount of iron circulating in the blood is decreased, causing a fall in red blood cell production. Mild iron-deficiency anaemia leads to reduced work capacity, slower response to exercise, impaired immune function, and changes in mood and cognitive performance. In children, iron-deficiency anaemia is associated with psychomotor development. In pregnancy, iron-deficiency anaemia causes prematurity, low birth weight and increased perinatal mortality.

Zinc

Zinc is a trace mineral that can be found in almost every cell in the body. Zinc is essential to the human body because it stimulates enzyme activities, provides a healthy immune system, is used for wound healing, sustains senses of smell and taste, and is used for DNA synthesis. Zinc is also important for normal growth and development during pregnancy, childhood and adolescence.

Meat is a major source of readily available zinc. The liver and kidney are richer sources than

muscle meat, and pig liver is richer in zinc than sheep or beef liver. Zinc from animal sources (including eggs) is better absorbed than zinc from plant foods (e.g. wholemeal bread).

Vitamins

Vitamin B1 (thiamin) occurs naturally in pork, duck, oyster, and other meats. A deficiency of vitamin B1 can cause beri-beri and Wernicke-Korsakoff syndrome, which result in neurological and cardiovascular dysfunction. These two syndromes are normally seen in alcoholics, and seldom seen in vegans. Vegans can derive their vitamin B1 from plant sources (e.g. nuts, pulses, oatmeal, fortified breakfast cereals, etc).

Offal is the best source of vitamin B2 (riboflavin). Riboflavin aids the metabolism of carbohydrates, fats, and proteins. It plays an important role in reproduction, and in the growth and repair of joints, skin, hair, and nails. It also enhances the immune system's ability to fight disease.

Vitamin B3 (niacin) is found in foods that are high in protein (e.g. liver, kidney, poultry and fish). Vitamin B3 helps to remove toxic and harmful chemicals from the body. It helps produce various sex and stress-related hormones in the body. Vitamin B3 helps improve circulation and reduce blood cholesterol levels.

Vitamin B12 (Cobalamin) is necessary for cell division and blood formation. Vitamin B12 is synthesized by microorganisms and is found in bacterially fermented foods, meat, and offal from ruminant animals. Offal, particularly liver, contains more vitamin B12 as this is where the vitamin is stored. Occasionally, cobalamin is found in soil and water because they are contaminated with microbes that produce vitamin B12. This is how plants derive an inactive form of this vitamin. Shellfish, fish and meat are also rich in vitamin B12.

Health and nutritional benefits of meat

A study conducted in Perth, Australia showed that the per capita consumption of red meat had fallen steadily, while white meat consumption rose. One of the factors that contributed to this pattern was rising concerns about fat, cholesterol, nutritional value, calories, fibre, waste and artificial additives. Lean meat is rapidly becoming the preferred choice, but it is often more expensive.

Meat definitely has great nutritional value but consumers must be reminded that too much of a good thing can be harmful. Human population studies show that red and processed meats are associated with an increased risk of colorectal cancer, but white meat is not. The evidence is not yet conclusive, but consuming a lot of preserved meat probably increases the risk of

colorectal cancer.

Scientific studies have demonstrated that the key factor in disease outcomes is the dietary patterns rather than the individual food components. Dietary patterns that mainly contain processed meats are more associated with some diseases including CVD, colon cancer and type II diabetes, than dietary patterns that mainly contain poultry.

Dietary recommendations of meat consumption

Males aged 19-60 years: 1 serve of lean meat, fish, poultry, nuts and legumes each day

Females aged 19-60 years: 1 serve of lean meat, fish, poultry, nuts and legumes each day

Pregnant women: 1 ½ serves of lean meat, fish, poultry, nuts and legumes each day

Lactating women: 2 serves of lean meat, fish, poultry, nuts and legumes each day

Note: A sample serve is 65-100 grams of cooked meat or chicken (e.g. ½ cup mince, 2 small chops, or 2 slices of roast meat) or 80-120 grams of cooked fish fillet.

Lean red meat is consumed 3-4 times a week, and fish 1-2 meals per week.

Individuals that have high iron needs (e.g. girls, women, vegetarians and athletes) might require high-iron replacement foods.

Nutritive and dietetic value of meat

Meats such as fish, poultry, pork and beef contain essential nutrients such as protein and iron. People who do not eat meat can still get these nutrients from food sources, but must eat a combination of plant-based foods in order to get the same nutrients found in one serving of meat.

Benefits

Meat and fish are complete sources of protein, containing the nine amino acids that the body requires but cannot make for itself. Protein serves several important functions in the body, including tissue growth and repair. Meat and fish also contain heme iron, which is more useful to the body than non-heme iron, the type of iron found in plant-based foods. Iron is essential for healthy muscle growth and blood oxygenation. The Recommended Dietary Allowance, or RDA, for iron is about 8 mg per day for men, 18 mg for women and 10 mg for children.

Risks

Depending on the type and cut, meats can be high in fat and cholesterol. The University of Kentucky Cooperative Extension Service recommends that only about 30 percent of daily calories should come from fat, and that people should not consume more than 200 mg of cholesterol per day. According to the Vegetarian Resource Group, only about 10 percent of daily calories should be from protein sources. Over-consumption of protein may contribute to kidney disease.

Certain types of fish, such as swordfish and king mackerel, are high in mercury. The Department of Health and Human Services recommends that women who are nursing or pregnant avoid eating high-mercury fish.

Beef

A 3-oz. serving of beef sirloin contains about 170 calories, 22 g of protein, 1.5 mg of iron, 7 g of fat and 76 mg of cholesterol. Ground beef is typically graded by fat content. Seventy-five percent lean is one of the highest-fat grades available, containing 235 calories, 15 g of fat and 75 mg of cholesterol per serving. Beef cuts labeled loin or round tend to be lower in fat than other cuts.

Pork

Pork tends to be higher in cholesterol than other types of meat. For example, pork tenderloin, one of the leanest cuts of pork available, contains about 160 calories, 22 g of protein, 0.83 mg of iron, 5 g of fat and 80 mg of cholesterol per 3 oz. serving. Other cuts of pork are much higher in calories, such as bacon, which contains about 457caloreis per 3oz. serving.

Poultry

Turkey is the highest-protein poultry with about 23 g per 3oz serving, followed by duck with 20g and chicken with 18g. Poultry is leaner than most cuts of beef and pork, but also contains less iron. For example, chicken breast contains about 142 calories, 0.32mg of iron, 3g of fat and 73 mg of cholesterol per 3 oz. serving.

Fish

The National Institute of Health's Medline Plus program recommends fish as a lean protein alternative to red meat. For example, a serving of pink salmon contains only about 127 calories,

4g of fat and 57mg of cholesterol. Most types of fish contain about 20 to 25g of protein and 0.33mg of iron per serving. Fish also contains omega-3 fatty acids, which support brain and neural development.

Causes of toughness in meat

In general, exercise toughens muscles. Muscles also toughen with age, so a younger animal yields more tender meat. Additionally, overcooking meat, even meat that comes from the more tender muscles, can make it tough. That's because heat causes the proteins in the meat to firm up.

Age: Older animals have longer fibres and produce tougher meat; meat from younger animals is tender

Activity: Less activity parts of animal are tender, active parts of the animal are tender, active parts are tougher

Conditioning of animals: Resting before slaughter allows glycogen to build up in muscles hanging after slaughter changes glycogen to lactic acid- tenderises meat

Cooking method: Slow moist methods tenderise tough cuts of meat e.g stewing fast methods are better suited to tender cuts of meat. Nothing takes the wind out of your sails quite like biting into a hunk of steak only to find the sucker is chewy AF. Really, what's worse than tough meat? Either way, you don't have to suffer the tough consequences. There are methods for tenderizing your meat that don't even require an overnight marinade.

Here are six easy ways.

Beat it: Pounding meat with a mallet is a surprisingly effective way to tenderize it. The downside is that it can actually work too well, turning your meat into mush. Special tenderizer tools made up of dozens of sharp needles or points that pierce the meat (like this KitchenAid meat tenderizer or this Jaccard meat tenderizer) are a more delicate way of mechanically tenderizing your meat. This does less damage to the meat fibers.

Marinate with acid: Acids can help break down tough meat. Soaking meat in a marinade made with lemon or lime juice, vinegar, buttermilk or even yogurt can help tenderize tough proteins. The key is to not leave the meat in the marinade for too long, as acids can weaken the protein structure of the meat too much, making it too soft and mushy. Aim for 30 minutes to two hours,

but check periodically to see if the meat is starting to look cooked around the edges. That's how you'll know it's been marinating too long.

Marinate with enzymes: Several fruits, such as papaya, pineapple, kiwi and Asian pear, contain enzymes that help tenderize meat. Try puréeing theseadding some of your favorite seasonings to make a marinade that will leave you with juicy, tender meat. Just don't leave any meat in pineapple too long. Bromelain, the powerful enzyme found in this fruit, can work a little too well.

Salt it: Heavily salting a tough cut of meat and letting it sit an hour or two before you cook it is an effective way to break down tough muscle fibers, no fussy marinade needed. When you're ready to cook, just rinse off the salt, pat the meat dry and add it to a hot skillet.

Slice it right: There are a couple of clever knife tricks that can make meat seem more tender. One is scoring. That's when you make shallow cuts (not cutting all the way through) across the surface of a thin steak like skirt or flank. This method can help break up tough proteins and also helps the meat absorb tenderizing marinades more easily.

The second meat-tenderizing knife trick is slicing cooked steak thinly, across the grain. The idea is to break up the long, tough meat fibers so they are shorter and thus easier to chew.

Slow-cook it: Cooking tough cuts of meat with low-temperature heat over a long period of time is a great way to tenderize it. Tough fibers, collagen and connective tissues will break down, leaving you with tender meat. Try using a slow cooker, or braise with broth or other liquids in a covered dish in the oven.

Always let the meat rest before cutting it: Don't rush this final, crucial step! It's been proven beyond a shadow of a doubt by experts that short rest on the carving board before cutting makes all the difference. If you cut it right after removing it from the heat, about 40% more of the

meat's juice will end up on your cutting board, but if you give it time to rest, relax, and re-absorb all its own juice, your mouth will definitely notice the difference.

Use Baking Soda: How baking soda alkalizes the surface of the meat, hampering the proteins' bonds and making the meat more tender. Many people love this method, but some complain that even after rinsing, a vaguely alkaline taste remains.

Which meat or cuts work best?

Any kinds, but since it does affect both the taste and the texture of the meat, use only the cheapest, toughest cuts. Also, since it only works on the surface, this method should only be used on the smallest, thinnest, bite-sized pieces.

Dry-Age Meat for Tenderness

Dry-aging uses the meat's own enzymes to break muscle fiber down and results in a more tender and flavorful cut.

How long does it take to dry-age meat?

There is some debate about this.
Some, including Cook's Illustrated, say four days is probably the longest you should risk in a non-commercial cooling unit. Most recipes for roasting meat in Cook's Illustrated call for aging it for 1 to 4 days and they also recommend salting and rubbing it with butter.
If you have a large sub-primal cut of meat, most agree that a couple weeks of aging is enough. The older you leave it, the funkier it will get, but some people like it funky. I suggest you experiment in your fridge to discover what works best for you.

Use Fruit Enzymes

Some fruits contain protease, a kind of enzyme that's great for breaking down meat proteins. These fruits especially:

Kiwi is at the top of the list since it contains actinidin, which works gently and has a neutral flavor. Some cooks let the meat sit in a kiwi marinade for almost a week.

Pineapple contains bromelain, an enzyme that is so strong it will turn your meat to mush if

you're not careful.

Papaya

Asian pear

Fig

Mango

Factors to consider while selecting meat

Right cut: Let's start with the basics. There are two general types of cuts of meat: working cuts and luxury cuts. A luxury cut of beef or pork will come from the back of the animal (i.e., rump, rib, loin) and is more tender than a working cut. A working cut will come from an animal's shoulder, leg or flank. Any beef labeled "marinating," "stewing," "top round," "bottom round" or "top sirloin" will be a working cut. Working cuts need to be cooked slowly on low heat, while luxury cuts can be cooked quickly on high heat. Any beef or pork labeled "grilling," "tenderloin," "porterhouse," "rib eye" or "T-bone" will be a luxury cut.

Bone in or out? Bones can be tricky because they are great heat conductors, but it's such a pain to trim meat off the bones. Of course, you can buy boneless meat, but it will generally be more expensive than meat with the bone in. Not only are bones great heat conductors (which results in shorter cooking time), but they also help make great soup stock. Some even claim that cooking meat with bones gives the meat a more intense flavor.

Service: Service, or the butcher's term for how much work went into preparing the meat, is an important factor in the meat-buying process. The more service the butcher puts into a piece of meat, the more expensive it will be by the pound. So you will usually want to look for meats with less servicing, unless you need a lot of service done beforehand.

Marbling: Fats get a bad rap when it comes to meat. Of course, you don't want extremely fatty meat, but you do want to look for a well-marbled meat. A good piece of well-marbled meat will have small white flecks dispersed throughout, which means the meat will stay moist, juicy and tender while you're cooking it. Extremely lean cuts of meat will dry out quickly while cooking and have less flavor.

Firmness: You do not want your meats to be soft. The firmer, the better. Fresh meat should be firm, not tough or soft. A good, literal rule of thumb for fresh meat is to poke the fleshy part of your palm right below your thumb. That is how fresh meat should feel. A slightly obvious tip

is to smell it. If it smells bad, don't buy it.

Color: Different kinds of meats will obviously be different colors. Fresh beef will be a dark red or cherry red. You'll want to avoid brown colored beef, which is a pretty good indicator that it's been sitting there for a while. Fresh cuts of chicken and pork will be pink. You'll want to avoid gray chicken and pork for the same reason you'll want to avoid brown beef.

Grade: There are eight grades of meat: prime, choice, select, standard, commercial, utility, cutter and canner. You will most likely be buying choice or select, while restaurants and hotels use prime. Most utility, cutter and canner grades are used in ground beef and hot dogs.

As always, stick to smaller portion sizes when cooking. A portion should be about the size of your palm and the width of a deck of cards. Fresh veggies are always a good side dish when it comes to meat. Try one of our favorite recipes, Skinny Pineapple Teriyaki Pork Chops with some asparagus on the side.

The Effect of Heat on Meat

The fat of meat is melted by heat. The meat fiber shrinks and hardens with intense heat; on the other hand it softens at a temperature somewhat below the boiling point of water. The structure of the muscle must be studied further in order to make the principles of cooking perfectly clear. If you think of the structure of the muscle cell as somewhat resembling the structure of an orange, you can picture quite clearly what happens under different conditions. Open a section of orange and separate some of the single cells. These may represent the muscle cells of meat that can be seen only under the microscope. If you cut across one of these tiny cells, the contents will escape, and this is what happens when the muscle cells are cut across. Then, too, if the muscle is heated, the juices will pass through the membrane of the cell, and this happens, too, if the meat is put into cold water. The substances in the juices of the meat which are not coagulated by heat are called the extractives, because they can be extracted by hot water. The most valuable protein matter remains behind in the muscle cell, however. Among these proteins are those known as meat albumin, and this behaves in cooking very much as does the white of egg, - that is to say, it coagulates.

Determining the doneness temperature of meat is important for two main reasons:

Food Safety: It’s important that all possible foodborne pathogens are denatured before any meat is served. Professional cooks at restaurants know this fact well. Government regulations for sanitation and food safe doneness temperatures are in place to ensure public safety..

Food Quality: Eating quality of food is a subjective evaluation of texture, flavor, and general mouth feel (sensation in the mouth determined by such factors as moisture, richness, astringency, and temperature).

Principles of meat cookery as follows:

Juices retained: In broiling, pan broiling, roasting, and boiling the high temperature coagulates the meat albumin and hardens the fiber on the surface, thus forming a coating which prevents the further escape of juices. In the roasting and boiling of large pieces the temperature may then be lowered to prevent the further shrinking and hardening of the fiber in the interior of the meat, which comes from a protracted high temperature. With a very thick steak after the surface searing the cooking may be completed in the oven.

Juices extracted: In beef juice or beef tea, this may be made by placing the chopped beef in a jar and placing the jar in an oven, or in hot water; or for beef tea and ordinary soup by putting the chopped meat, or small pieces of meat, in cold water and heating the water slowly.

Juices partly retained and partly extracted: This is desirable in stews, in braised beef, and in pot roast. State for yourself just how this would be accomplished.

Connective tissue softened at low temperature, and with water.

Sterilization by continued heat which destroys parasites and bacteria.

Rapid cooling, when serving is not immediate.

Why we cook meat

We are more highly evolved than our primitive ancestors who hunted and ate raw meat for survival. We eat for nutrition and pleasure. Cooking meat causes chemical changes that make it easier to chew and transform it into a mouthwatering culinary experience.

Specific chemical reactions occur in meat at distinct temperatures regardless of the cooking method used. Knowing what those temperature landmarks are and using precision temperature tools to determine doneness are the keys to becoming a meat cooking master! Some of the changes we can easily see when cooking meat are in:

Opacity— the once translucent meat becomes opaque.

Firmness— Meat can be tender or tough.

Shrinking— Cuts of meat shrink in size as they approach doneness.

Browning— the meat changes color from pink to gray/brown. Seared meat develops a deeply-colored crust.

Moisture Loss— Liquid is expelled as the meat becomes more firm.

Fat Breakdown— Intramuscular fat dissolves in the temperature range of **125-130°F** (52-54°C), giving meat a succulent mouthfeel.



Color Changes C

Myoglobin in meat is what gives it its pink/red hue. Myoglobin denaturation is responsible for the color change between raw and cooked meat. This change occurs at **140°F** (60°C).

Opacity

When protein molecules denature, their coiled structure unfolds. These unfolded molecules then bump into each other and reconnect in a different configuration (coagulate), making it nearly impossible for light to pass through. This is what turns meat from translucent to opaque.

Moisture Loss

Juiciness is a considerable factor in determining the final eating quality of cooked meat. No matter how long it's brined, marinated, or even if it's cooked in liquid, moisture loss in meat is directly related to its final doneness temperature.

Meat Cooking Methods

Braise - Braising is a technique done by browning the meat on all sides in a heavy utensil. A small amount of water is added and then the meat is cooked until tender at a low temperature.



Broil - Broiling is done in an oven or outdoor grill. Cook the meat until it is browned on one side. Then broil the other side to the desired doneness.



Grill - Grilling is a variation of broiling, which is usually done on a grill with charcoal or gas flames. Charcoal briquettes are commonly used for grilling. When starting charcoal, highly flammable materials are used often used that cause large amounts of open flames.These flames should be allowed to burn off and the charcoal should become a gray color. Although they require a longer preparation time than gas they burn very hot and consistently for a long period of time.

When the charcoal becomes gray and the heat is even throughout the grill. The meat is placed on the grill and is browned on side, seasoned, and then the other side is grilled to the desired doneness. The flames from the charcoal or gas should never be aloud to come in contact with the meat. Flame-ups should be avoided by sprinkling with a small amount of water.



Cooking in Liquid - Cooking in liquid is often used to prepare less tender cuts of meat. The meat is covered in liquid, (usually water) and is simmered until tender. The process may require several hours because of the lower temperatures.

Pan Broil - Panbroiling is similar to oven broiling however it is faster and more convenient. A nonstick pan is used to cook the meat until brown on both sides due to occasional turning. There is no need to add water or cover the meat.

Pan Fry - Panfrying only differs from panbroiling in that a small amount of fat is added first. Panfrying is used on ground, or thin slices of meat.



Roast - Roasting is recommended on large cuts of meat such as Rib Eye Roast. The meat is placed on a rack or in roasting pan and cooked until the desired level of doneness. Roasting is usually done at 350-425 degrees F.



Stir Fry - Stir-frying is similar to pan-frying with the exception that the meat is constantly stirred. It is done with high heat, using small or thin pieces of meat.



Crock Pot



Meat can be safely prepared in a crock pot. Be sure to defrost it before placing it in the crock pot.

Cut up whole roasts and don’t fill the cooker more than 2/3 full.

Use a recipe that includes liquid and pre-heat the liquid in a saucepan on top of a stove before adding it to the cooker.

Always place the lid on top of the crock pot and set the cooker on high for 30 to 60 minutes, before reducing the temperature

Microwave Cooking



Processed meats, like bacon and ham, and most fresh meats may be cooked in a microwave. Cooking time typically increases with the amount of meat.

Bacon tip: When microwaving bacon, place four slices over a paper towel on a microwavable plate, and cover the strips with a paper towel. Microwave on high for 40 to 60 seconds per slice of bacon (2.5-4 minutes total).

Roast tip: When microwaving roasts, cook on 30 to 50 percent power for uniform doneness and less shrinkage. Smaller, tender, boneless roasts are most suitable for microwaving (typically 2 to 3 pounds)

Smoking



The smoking cooking technique can be used on any type of meat, but usually works best for tough cuts, including beef ribs, brisket, corned beef, ham, pork crown roast, pork spare ribs and turkey. Prior to smoking, the meat should be brought to room temperature to ensure it cooks evenly. Depending on the size of the cut, set the meat out 30 minutes to 2 hours before smoking. It's also common to use a brine, marinade or rub to add moisture and/or flavor to meat before smoking.

Determine the equipment you will use when smoking the meat. The heat should be kept steady and low throughout the process. If you are working with a standard charcoal grill, push the coals to one side after they are covered in gray ash. Meat should be smoked over indirect heat, instead of placing it above direct heat.

Keep a supply of charcoal handy and periodically add fresh coals to keep heat steady. You will also have to decide the type of wood to use, such as oak, apple, mesquite, pecan or hickory. Whatever type of wood you select, be sure to soak it in a bowl of water for at least an hour before it is added to the flames. If you are using wood chips, wrap them in tin foil with punctured holes to keep them smoking longer.

The goal is to keep the smoker in the range of 200–220 °F (93–104 °C) the whole time. The length of time it will take to completely cook your meat is determined by the heat of the grill,

the type of meat and the size of meat cut, but you should factor in at least 6 to 8 hours of cooking time - and sometimes many more. Pork and beef ribs typically take up to 8 hours, while a big cut of brisket could take 22. It’s important to follow the recipe instructions and use a meat thermometer to test for doneness.

THEME: CROP PRODUCTION

TOPIC 4.3: BIOTECHNOLOGY AND BIOSAFETY IN AGRICULTURE

Competency: The learner should be able to appreciate the emerging trends in agriculture production and their implications

LEARNING OUTCOMES

The learner should be able to:

a) know the meaning of biotechnology, bioengineering and biosafety
b) understand how genetic engineering is carried out in crops and animals
c) understand and put the case for the use and development of biotechnology in agricultural production
d) research and understand emerging trends in biotechnology, bioengineering and
e) biosafety

Introduction

Although the domestication and breeding of plants and animals to increase their utility to humans began about 8,000 years ago, the use of genetic technology for this purpose dates back only a few decades. Advances in biotechnology have led to the development of "transgenic" plants and animals incorporating snippets of DNA from other organisms that endow them with new traits, such as resistance to infectious diseases or the ability to produce human proteins of medicinal value. Because the foreign genes are inserted into the genetic material of single-cell embryos, all the cells of the adult organism contain the desired trait, which is passed on to future generations. A plant or animal incorporating one or more transgenes is termed a Genetically Modified Organism (GMO).

Genetic engineering has created new varieties of food crops, such as pest-resistant corn, as well as food animals with improved nutritional value and other useful characteristics. Despite these benefits, critics of genetically modified plants and animals have raised safety, security, and ethical concerns. This educational module describes some recent advances in agricultural biotechnology and assesses their benefits and risks.

Definitions

Agricultural biotechnology is a range of tools, including traditional breeding techniques that alter living organisms, or parts of organisms, to make or modify products; improve plants or animals; or develop microorganisms for specific agricultural uses

Biosafety in agriculture biosafety involves **assessing and monitoring the effects of possible gene flow, competitiveness and the effects on other organisms**, as well as possible deleterious effects of the products on health of animals and humans.

Genetic engineering is the technique of removing, modifying, or adding genes to a DNA molecule [of an organism] in order to change the information it contains. By changing this information, genetic engineering changes the type or amount of proteins an organism is capable of producing, thus enabling it to make new substances or perform new functions.

Agricultural Biotechnology?

Agricultural biotechnology is a range of tools, including traditional breeding techniques that alter living organisms, or parts of organisms, to make or modify products; improve plants or animals; or develop microorganisms for specific agricultural uses. Modern biotechnology today includes the tools of genetic engineering.

How is Agricultural Biotechnology being used?

Biotechnology provides farmers with tools that can make production cheaper and more manageable. For example, some biotechnology crops can be engineered to tolerate specific herbicides, which make weed control simpler and more efficient. Other crops have been engineered to be resistant to specific plant diseases and insect pests, which can make pest control more reliable and effective, and/or can decrease the use of synthetic pesticides. These crop production options can help countries keep pace with demands for food while reducing production costs. A number of biotechnology-derived crops that have been deregulated by the USDA and reviewed for food safety by the Food and Drug Administration (FDA) and/or the Environmental Protection Agency (EPA) have been adopted by growers.

Many other types of crops are now in the research and development stages. While it is not possible to know exactly which will come to fruition, certainly biotechnology will have highly varied uses for agriculture in the future. Advances in biotechnology may provide consumers with foods that are nutritionally-enriched or longer-lasting, or that contain lower levels of certain naturally occurring toxicants present in some food plants. Developers are using

biotechnology to try to reduce saturated fats in cooking oils, reduce allergens in foods, and increase disease-fighting nutrients in foods. They are also researching ways to use genetically engineered crops in the production of new medicines, which may lead to a new plant-made pharmaceutical industry that could reduce the costs of production using a sustainable resource. Genetically engineered plants are also being developed for a purpose known as phytoremediation in which the plants detoxify pollutants in the soil or absorb and accumulate polluting substances out of the soil so that the plants may be harvested and disposed of safely. In either case the result is improved soil quality at a polluted site. Biotechnology may also be used to conserve natural resources, enable animals to more effectively use nutrients present in feed, decrease nutrient runoff into rivers and bays, and help meet the increasing world food and land demands. Researchers are at work to produce hardier crops that will flourish in even the harshest environments and that will require less fuel, labor, fertilizer, and water, helping to decrease the pressures on land and wildlife habitats.

In addition to genetically engineered crops, biotechnology has helped make other improvements in agriculture not involving plants. Examples of such advances include making antibiotic production more efficient through microbial fermentation and producing new animal vaccines through genetic engineering for diseases such as foot and mouth disease and rabies.

Benefits of Agricultural Biotechnology

The application of biotechnology in agriculture has resulted in benefits to farmers, producers, and consumers. Biotechnology has helped to make both insect pest control and weed management safer and easier while safeguarding crops against disease. For example, genetically engineered insect-resistant cotton has allowed for a significant reduction in the use of persistent, synthetic pesticides that may contaminate groundwater and the environment.

In terms of improved weed control, herbicide-tolerant soybeans, cotton, and corn enable the use of reduced-risk herbicides that break down more quickly in soil and are non-toxic to wildlife and humans. Herbicide-tolerant crops are particularly compatible with no-till or reduced tillage agriculture systems that help preserve topsoil from erosion.

Agricultural biotechnology has been used to protect crops from devastating diseases. The papaya ringspot virus threatened to derail the Hawaiian papaya industry until papayas resistant to the disease were developed through genetic engineering. This saved the U.S. papaya

industry. Research on potatoes, squash, tomatoes, and other crops continues in a similar manner to provide resistance to viral diseases that otherwise are very difficult to control.

Biotech crops can make farming more profitable by increasing crop quality and may in some cases increase yields. The use of some of these crops can simplify work and improve safety for farmers. This allows farmers to spend less of their time managing their crops and more time on other profitable activities.

Biotech crops may provide enhanced quality traits such as increased levels of beta-carotene in rice to aid in reducing vitamin A deficiencies and improved oil compositions in canola, soybean, and corn. Crops with the ability to grow in salty soils or better withstand drought conditions are also in the works and the first such products are just entering the marketplace. Such innovations may be increasingly important in adapting to or in some cases helping to mitigate the effects of climate change.

The tools of agricultural biotechnology have been invaluable for researchers in helping to understand the basic biology of living organisms. For example, scientists have identified the complete genetic structure of several strains of Listeria and Campylobacter, the bacteria often responsible for major outbreaks of food-borne illness in people. This genetic information is providing a wealth of opportunities that help researchers improve the safety of our food supply. The tools of biotechnology have "unlocked doors" and are also helping in the development of improved animal and plant varieties, both those produced by conventional means as well as those produced through genetic engineering.

Biosafety (What are the safety considerations with Agricultural Biotechnology?

In agriculture, (including animal husbandry, fishery and forestry), the concept of **biosafety** involves **assessing and monitoring the effects of possible gene flow, competitiveness and the effects on other organisms**, as well as possible deleterious effects of the products on health of animals and humans.

Breeders have been evaluating new products developed through agricultural biotechnology for centuries. In addition to these efforts, the United States Department of Agriculture (USDA), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA) work to ensure that crops produced through genetic engineering for commercial use are properly tested and studied to make sure they pose no significant risk to consumers or the environment.

Crops produced through genetic engineering are the only ones formally reviewed to assess the potential for transfer of novel traits to wild relatives. When new traits are genetically engineered into a crop, the new plants are evaluated to ensure that they do not have characteristics of weeds. Where biotech crops are grown in proximity to related plants, the potential for the two plants to exchange traits via pollen must be evaluated before release. Crop plants of all kinds can exchange traits with their close wild relatives (which may be weeds or wildflowers) when they are in proximity. In the case of biotech-derived crops, the EPA and USDA perform risk assessments to evaluate this possibility and minimize potential harmful consequences, if any.

Other potential risks considered in the assessment of genetically engineered organisms include any environmental effects on birds, mammals, insects, worms, and other organisms, especially in the case of insect or disease resistance traits. This is why the USDA's Animal and Plant Health Inspection Service (APHIS) and the EPA review any environmental impacts of such pest-resistant biotechnology derived crops prior to approval of field-testing and commercial release. Testing on many types of organisms such as honeybees, other beneficial insects, earthworms, and fish is performed to ensure that there are no unintended consequences associated with these crops.

With respect to food safety, when new traits introduced to biotech-derived plants are examined by the EPA and the FDA, the proteins produced by these traits are studied for their potential toxicity and potential to cause an allergic response. Tests designed to examine the heat and digestive stability of these proteins, as well as their similarity to known allergenic proteins, are completed prior to entry into the food or feed supply. To put these considerations in perspective, it is useful to note that while the particular biotech traits being used are often new to crops in that they often do not come from plants (many are from bacteria and viruses), the same basic types of traits often can be found naturally in most plants. These basic traits, like insect and disease resistance, have allowed plants to survive and evolve over time.

THEME: AGRICULTURAL ECONOMICS

TOPIC 4.4: LAND TENURE SYSTEM

Competency: The learner should be able to appreciate land reforms in Uganda

LEARNING OUTCOMES

The learner should be able to:

- know and understand the land tenure system, tenure types and land legislation of Uganda
- obtain information from land tenure documents and maps
- distinguish between land reform and land registration
- promote land reforms

Introduction

Land tenure refers to the rules and conditions governing the ownership of land in a specific area.

Any system or method by which an individual or group of people acquires the right to use land in any place is called land tenure.

Land tenure refers to possession of legal right like to the sale of land and to the use of land like cropping on the land

Types of land tenure system

Individual ownership of land

This is also known as freehold land tenure, landlordism or private ownership of land. The individual landowner (landlord) can register the land and get a certificate called the land title deed which allows him/her to own and utilize the land as he/she wishes. Landlord may have acquired land through inheritance from parents or purchasing it. The landlord is free to sell or transfer (hand over) the land title to another person if he/she wishes to do so. He/she can rent that land or part of it to other people, who are then referred to as tenants, and are expected to pay land rent to the landlord.

Advantages of individual ownership of land

- The landlord feels secure and is free to set up long-term developmental projects on that land.
- The landlord uses the land with care so as to conserve its productivity.
- The landlord can use the title deed as security to get loans from banks.
- If the landlord does not sell off the land, his children are assured of having land for future developments.
- It is easy for the land owner to get agricultural extension advice from extension workers.
- Management failures usually affects small units of production and are therefore negligible
- It safeguards the position of the local community if land is in short supply since it avoids demarcation disputes.

Disadvantages of Individual ownership of land

- The landlord may fail to pay back the loans and end up losing the land and its title to the banks
- Some landlords lack capital to set up projects on the land, hence leaving the land to stay idle or undeveloped.
- Land disputes are likely to come up between tenants and the landlord in case they fail to pay the land rent, or the landlord decides to sell the land to another person.
- Landlordism encourages unfair land distribution among the people, as some have plenty of land and others have nothing. People who do not have land at all are likely to encroach that of the landlord.
- Farmers may experience a problem in paying loan unless they plan well.
- It may lead to further sub-division of land resulting to very small pieces of land which are uneconomical to produce in.
- Some farms are owned by lazy farmers, making thefarms to stay idle and unproductive
- Land can be sold and bought at will, this means that tenants may turned out any time with no means of livelihood.

Communal land tenure system

This is also known as customary land tenure. Under this system, the land belongs to a clearly defined group of people (e.g., clan) or a whole community in a specified areas / place (as in

Karamoja). All the members of the community have the right to use that land according to the rules and regulations governing its use.

Advantages of communal land tenure

- Every member of the community has access to any part of the land, thus there are no landless people.
- No serious land disputes, since the regulations of occupancy are very clear to every member of the community.
- There is no land fragmentation since no individual is allowed to demarcate part of the land for his/her own use.

Disadvantages of communal land tenure

- Land resources are poorly utilized, e.g., where grazing is practiced there is overstocking and overgrazing due to uncontrolled livestock numbers. In areas where cropping is practices, there is over cropping leading to land degradation
- Land users have no interest in maintaining the productivity of such land since it does not belong to any individual.
- Farmers fear to invest in long-term projects and improved farming techniques since they can lose such land at anytime. Also, since the land belongs to the community, an individual is not allowed to use the land as he/she wishes. Everyone has to use the land according the regulations of occupancy.
- It's difficult to acquire a title deed for communal land, which makes it impossible to use such land to get loans from banks
- It is impossible to control crop and livestock diseases and pests.
- No or limited use of fertilizers and modern methods of production.

Co-operative land tenure

It is a system where land is owned by a group of farmers who have come together to form a cooperative society. The society is given one land title deed and no individual member can claim to be the sole owner of that land. Each individual in that society is given a share according to his contribution to the purchase of that land. Members may own their plots within the block, or the whole land unit may be operated on a co-operative basis.

Advantages of co-operative land tenure

- Land disputes are minimized since no individual can claim to be the sole owner.
- Encourages large scale farming.
- Cooperatives may use their title deed to borrow loans.
- Cooperatives may purchase inputs at lower prices.
- Members are allowed to grow subsistence crops.
- Members earn dividends.
- It is easy for members to raise capital

Disadvantages of co-operative land tenure

- Individual incentives to work hard are lacking in cooperatives.
- Poor management and embezzlement of funds by the leaders can lead to the collapse of the society.
- The society may not achieve its objectives if some of the members do not work hard.

Leasehold land tenure

It is a system where the state or landlord gives land to an individual to use for a specified period of time. When the lease period expires, the lease can be renewed. The leaseholder pays land rent to the government or landlord. When an individual leases land from the government, the lease period is usually effective for 49, 99 and 999 years.

Advantages of leasehold land tenure

The leaseholder feels secure to Invest In long-term projects, like growing perennial crops and setting up industries.

No land disputes are experiences since the state or landlord allocates land.

The system gives an opportunity to those who are unable to purchase land to rent land for farming and other activities.

It enables the government and landlords to earn income in form of rent from the land that would otherwise remain idle.

Since the leaseholder is given a lease certificate, he/she is able to obtain loans from money lending institutions.

Disadvantages of leasehold land tenure

- Sometimes the state or landlords can refuse to renew the lease when it expires, and the leaseholder loses the property if he/she invested heavily on the land.
- The state can terminate the lease before the lease period expires, and then decide to compensate the leaseholder.

State ownership

In Uganda, some land belongs to the government and no person can claim ownership. People are allowed to settle on such land but can as well be displaced any time the government wishes to set up developmental projects on that land. The government may or may not compensate them. Usually, the state leases the land it owns and gives land titles to individuals who wish to set up long-term developmental projects, such as industries.

Procedures/ Ways of acquiring land (gaining access to land)

- Becoming part of collective farming group like in a tribe, clan, cooperative farming
- Borrowing land from people having plenty of land
- Getting a piece of land by being resettled or settled by government
- Hiring a piece of land from those having plenty of land
- Inheritance or gaining access to land as an heir.
- Leasing, or gaining access to land by paying rent to the owner.
- Parents and relatives allocating a piece of land to children.
- Purchase, often using capital accumulated from those having plenty of land
- Sharecropping, or gaining access to land in return for paying the owner a percentage of the production.
- Squatting illegally on the piece of land.

Features of a good land tenure system

- It should allow resettlement of the population
- It should enable effective and efficient use of modern techniques of farm production It should encourage and promote commercialization of agriculture
- It should encourage and promote soil and water conservation
- It should facilitate labour mobility both geographically and occupational
- It should give opportunity for land amalgamation programmes
- It should improve agricultural productivity per unit area

Land reforms

Land reform is a programme undertaken by government to reorganize or restructure the land tenure so as to permit better utilization of land resources

Reasons for land reform

To promote increased production: People can be able to produce more if they have full rights to freely use the land under their care or possession. Registering and acquiring land titles can give security to those who feel insecure and are unable to invest in long-term agricultural programmes like dairy farming, tree planting and growing perennial crops. Idle land can be put to use when distributed to those who are able to make use of it.

To attain flexibility in farming: The needs and interests of the people keep changing from time to time, e.g., there may be increased demand for rice and a fall in the demand for maize, or an increase in demand for coffee and a fall in demand for cocoa on the market. Such changes in demands call for a change in farming patterns if the human needs are to be supplied as required.

To attain efficient utilization of land and labour resources: Land reform programmes such as land consolidation and land redistribution promote efficient utilisation of land and labour. For example, land consolidation can allow setting up estates and plantations that lead to increased output as compared to land fragmentation. In addition, estates such as Kakira and Kinyala sugar works provide' employment to many people, thus making use of human labour that would otherwise be redundant.

Redistribution of land enables individuals interested in farming to acquire land which they can use to express their talents in farming

To promote commercialization of agriculture: Land reforms such as land consolidation encourage production for the market instead of subsistence. This is so because, with larger pieces of land the farmers are able to produce more output than what could be consumed at home.

To promote the conservation and improvement of the land: When landowners are assured

of the security of tenure, they can take full responsibility of making sure that its productivity is sustained for a long time. They can invest in long-term erosion control practices such as terracing and tree planting. They can also invest in land improvement structures such as Irrigation.

Forms of land reforms:

Land Adjudication and Registration

Land adjudication: Land adjudication involves establishing the legitimate ownership, measurements (to make permanent boundaries) and recording of land details. Once land has been adjudicated and any disputes concerning the same land are settled, it is then registered in the "Register of Land" and the owner is issued with a land title deed or certificate of legal ownership.

Steps of land adjudication:Establishment of land ownership; measurement of land size; description of land; surveying, recording and mapping of land; checking register of land owners and settling objectionable cases, if found; settling land boundary disputes and then-obtaining land title.

Land registration: Refers to recording of rights to land in some form of public register. An official document called a **title deed** is given to establish ownership.

Elements of a title deed: Number of the land title, size of the land, name of the land owner, State of registration, signature of district (area) land registrar, issuing officer, etc.

Advantages of Land adjudication and Registration

The legal owner of the land has security of tenure and hence an incentive to invest and improve productivity.

A farmer can mortgage the land by offering land title certificate as a security to loaning agencies to secure capital to finance development projects.

If a farmer who cannot operate the farm, he can still earn income from it by leasing it.

Disputes concerning land boundaries and/or land ownership no longer arise.

The farmer can earn Income by leasing part of the land.

Land title deed

This is a legal document that confers rights of land ownership to an individual. It acts as a security to land ownership, It acts as an encouragement to the farmer t carry out long term investment on the land; It acts as security to get a loan and minimizes land disputes

LAND FRAGMENTATION

It is a situation where a farmer owns a number of small plots of land that are scattered in different places. It's common in highly populated areas and also where customary laws of property inheritance encourage sharing of the land among the heirs. If registered land is to be shared out or sold off, the current owner has to apply to the District Land Board so that such transfers of ownership are approved and recorded in the Land Registrar's Office.

Disadvantages of land fragmentation

It is difficult for the farmer to have easy access to all his/her plots, especially when using machinery, as there may be no direct route from one plot to another.

It is difficult for the farmer to efficiently supervise the activities being carried out on each of the plots.

The farmer wastes time in travelling from one plot to another.

It's difficult to make and follow a sound farm plan for all the plots, especially when distances between them are great

Since there is no sound farm plan made for the on-going farming activities, it is difficult for the farmer to get advice from the agricultural extension service.

It's difficult for a farmer to control diseases and pests of crops and livestock on his/her plots, because the neglected plots in the neighbourhood act as sources of infestation.

It is difficult for an individual farmer to carry out soil conservation measures, as this requires collective effort by all farmers. The run-off from other farmers' fields cannot spare the conservation devices made on small plots.

Land fragmentation results in low agricultural productivity, which in turn leads to low standards of living and national economic development.

LAND CONSOLIDATION

Land consolidation is one of the land reform programmes that can be undertaken by the government. It involves consolidating or joining together small scattered plots of land owned by farmers so that an individual gets one large piece of land instead of scattered plots. It is a give and take situation where farmers accept to exchange plots. Each farmer surrenders those

plots that are far away from his/her homestead in exchange of other plots of land that are neighboring his/her homestead. These arrangements enable farmers to acquire bigger units of land that can be economically operated.

Advantages of land consolidation

Each farmer acquires a large single unit of land that can be used to carry out meaningful business.

It becomes possible for farmers to carry out soil conservation measures.

Each farmer can register his/her land and acquire a land title deed, which he/she can use to obtain loans from money lending institutions. Also, farmer becomes secure to invest in long-term programmes and to conserve land.

It is possible for those farmers who wish to practice mechanization to do so.

The time that was being wasted while moving from one plot to another is saved.

Supervision of the activities going on becomes easier and more efficient.

It is possible for the farmers to carry out sound farm planning before undertaking any activity, (viii) Since the farming activities being undertaken are planned, it is possible for extension service officials to offer advice based on spot inspection to the farmer.

TOPIC 4.5: COOPERATIVES AND SELF-HELP GROUPS IN AGRICULTURE

Competency: The learner should be able to organize and participate in farmers' organisations

LEARNING OUTCOMES

The learner should be able to:

a) know the different types of farmers' organisations in Uganda and understand their purposes
b) explain the principles that govern cooperatives and self-help groups
c) understand how to participate in a meeting following parliamentary procedures

COOPERATIVES

They are voluntarily formed organizations by members who have agreed to come together for their mutual, social and economic benefit.

Benefits of being members of cooperatives

- It is easy to access financial assistance in form of loans
- Members get higher profits due to low production and marketing costs.
- Marketing of farmers' produce is easy because of the good organization that is put in place. For example, collection, transportation, processing and storage of produce are done collectively.
- Members access farm inputs easily and at reduced prices.
- Members are able to sell their produce at fair prices due to high bargaining power of the group.
- Members are able to access consumer goods at reduced prices, since they buy in bulk as a group and share accordingly.
- Members are able to learn new farming techniques from each other and to share information about market trends
- All the members share equally the overhead costs and society benefits.

General functions of cooperatives

Reducing marketing costs: Co-operatives reduce marketing costs because they are able to handle (store, transport, etc.) large volumes of commodities, which enable them to reap from economies of large scale.

Collecting produce from farmers: They save farmers from costs of transporting produce to the markets by sending lorries to collect the produce directly from farmers or rural stores to the processing centres and markets.

Storage of farmers produce: They own stores where they store commodities before transporting them to the processing centres and markets. They also store farm inputs and consumer goods before they, are distributed to the members.

Raising government revenue by increasing foreign exchange earnings: After collecting and processing, the produce can be exported. Thus, they serve as market outlets for the farmers' produce.

Provision of employment: The co-operative movement currently employs millions of people worldwide in various fields such as trade, transport, accounting, banking, management, manufacturing and research.

Education and training: These services are available to all members. Through co-operatives, farmers are taught modern production and management techniques so as to use resources efficiently and improve productivity.

Encouraging unity among farmers: Co-operation enables farmers to assist one another in matters relating to farming and marketing information, learning from each other the techniques of undertaking new enterprises. Farmers can also freely share the costs of purchasing expensive equipment

Mobilizing savings and advancing loans: Co-operatives offer an opportunity to the members to save their funds, which are then used to provide services like supplying farm inputs on credit, short-term loans, constructing stores, etc.

Stabilizing agricultural prices: After the harvesting season, prices of commodities drop so low such that farmers can't make profit if they sold their produce at that time. Co-operatives buy commodities from members at fair prices and store them until the prices normalize.

Processing farmers produce: Some co-operatives are involved in processing farmers' produce, e.g., milk, oil extraction from sunflower and cotton ginning.

Problems faced by cooperatives

Unfair public policies: In Uganda, the production potential of farmers has been weakened by the adoption of policies that cripple the operations of markets. For instance, trade liberalization and privatization have indeed killed the patronage, commitment and loyalty of co-operative membership and the co-operative spirit as a whole. Co-operatives were further affected by the abolition of marketing boards and the government's halt to remit funds to the co-operatives.

No incentives offered to farmers: There were no incentives offered to farmers to encourage them, especially during and after the crisis periods. Farmers were no longer receiving services they expected and as a result they lost interest in co-operatives.

Mismanagement by leaders: Co-operatives declined due to inefficiency and mismanagement by managers who lacked the required knowledge, training and ideological orientation. Leaders saw their positions as a gateway into national politics.

Interference by the state: In Uganda, co-operatives were promoted by their members with the aim of gaining control over the agricultural business. But instead they were eventually owned and funded by the state. Co-operatives became an integral part of the marketing sector on which the state depended to earn most of the foreign exchange. Governments monopolized the marketing boards and cooperatives simply became collecting agents of produce for the marketing boards.

Poor service delivery: Co-operatives held the members at ransom by borrowing their produce and sometimes not paying for them. That is why the government ended up embracing the policy of liberalization to break the monopoly of co-operatives and yet offering poor services to members.

Greed and selfishness of some members: Co-operatives were run down by vested interest groups which viciously sought financial benefits accruing from the business operations.

Preference of manufacturing industry to agricultural industry: Co-operatives suffered neglect because governments deliberately shifted resources from agricultural sector in favour of manufacturing industry with a hope of initiating rapid development.

Poor organizational structure: Co-operatives in developing countries (Uganda inclusive) were never given a production role at the primary society level, but only concentrated on rural agricultural marketing.

Political insecurity: Co-operatives deteriorated rapidly in their performance during Amin era. Many top leaders of the co-operatives were exiled

Principles of cooperatives

Capital shares: A person is considered to be a member of a co-operative after contributing to the required capital for the operations by buying a share.

Continuous expansion: The membership and physical facilities (e.g., buildings, machinery) of a viable cooperative society are expected to increase over time.

Cooperation. A co-operative society must work, with others if it Is to function efficiently and serve better its members. Primary co-operative societies with common functions that would be better done by these societies working together unite to form a co-operative union. Similarly, the co-operative unions whose functions can be better performed in co-operation with other unions join together to form a national union.

Democracy: A cooperative society is a democratic institution that is run on a democratic basis. Every member, irrespective of status, is entitled to one vote.

Dividends and interest. Dividends and interest on capital shares must be shared by members according to each member's contribution to the society. No member should gain at the expense of others.

Education: It is one of the duties of a cooperative society to teach its members the principles and techniques of co-operatives including how to produce economically, how to make use of new technologies, etc.

Neutrality: A cooperative is expected to be free from the influence of politics, tribal affiliation, religion and other bias that can affect its performance.

Open membership: A co-operative society is open to all those willing to join and make use of its services irrespective of religion, race, tribe, language or sex.

Some of the solutions to the problems of co-operatives

Steering awareness programmes on the role of cooperatives to the population.

Encouragement of co-operative activities through favourable importation policies.

Establishing crop finance to ensure that farmers are paid promptly after delivering their produce.

Expansion of both domestic and foreign markets for the produce through common markets for eastern and southern Africa (COMESA), African Growth Opportunity Act (AGOA), etc.

Fighting corruption as much as possible.

Government should endeavour to provide peace and security in all parts of the county.

Government should offer subsidies from the co-operative societies.

Improving the co-operative management through in service courses and seminars.

Promotion of extension services by the Ministries of Trade and Industry, Agriculture and NGOs.

Rehabilitating trunk roads and opening up feeder roads in rural areas.

Provision of credit facilities with fair interest rates. Government introduced Prosperity for All "Bonna bagagawal" in Uganda

Provision of farm inputs to the farmer members, e.g., machines and tools, fertilizers, planting materials, agrochemicals.

Putting up more storage facilities. Government can be of great help on the matter.

Types of co-operative societies

Cooperatives are classified according to the activities they perform, and they include the following.

Producer or growers co-operatives/Agricultural marketing co-operatives: Their main activities are to avail inputs to members at reasonable prices and to market the members' crop products.

Consumer co-operatives: These operate wholesale or retail shops. Their main objective is to assist members. They give special consideration to members by supplying consumer goods and services at slightly lower prices than non-members.

Savings and credit co-operatives: These provide members with loan facilities for investment. Members keep on depositing money on their accounts, and are given credit proportional to their savings.

Service co-operatives: These provide a variety of services to their members, e.g., transporting and storage of products and insurance. Members of service cooperatives make savings because of their ability to provide specialized services.

Processing co-operatives: These add value to agricultural products by changing them into a form that is more appealing to consumers. Processing also increases the shelf life of products, such as milk, meat and fruit processing cooperatives.

THEME: CROP PRODUCTION AND ANIMAL PRODUCTION

TOPIC 4.6: AGRO WASTES AND BY-PRODUCTS MANUFACTURING

Competency: The learner should be able to manufacture biofuels and handmade paper to preserve the environment

LEARNING OUTCOMES

The learner should be able to:

a) know materials used in making paper, biogas and briquettes
b) show creativity and skills in utilising domestic animal wastes
c) make un carbonized and carbonized briquettes from crop and animal domestic waste

Introduction

Current innovations in value-addition of agricultural by-products included the making of briquettes, organic fertilizers, biogas, biochar, pellets and organic pesticides from the crop subsector. Cow dung from the livestock is used for plastering walls of houses, used as fertilizer and used for the production of biogas.

Chicken droppings are as well used as fertilizer and for production of biogas.

Fish frames and skins are mainly consumed in smoked form whereas trimmings are usually rolled into fish balls and then fried for people to eat while the fats are used for frying the fish balls.

Sawdust has been mixed with cement to make wood-cement composite bricks that reduce the overall weight of the building.

It is also being used as feed in the Indigenous Micro-Organisms (IMO) technology in the production of pigs. Proposed innovations include the use of bones to produce soft tissue, buttons, knife handles and bone meal.

Blood can be used in making adhesives and fertilizers while fish oil is a major dietary source of long chain omega-3 polyunsaturated fatty acids and so can be utilized to enrich different food products.

By-Products from Agricultural Production and Processing

Agricultural by-products produced before and after processing include farm and market residues and by-products from processing plants. Farm by-products include mainly biomass

which is sometimes dried and stored as forage supplement for ruminants. There is also biomass from wood when trees are cut down to produce timber. Other by-products include; animal dung and urine from cattle and goats, droppings and feathers from poultry. By-products from processing plants highly depend on the raw material being processed and kind of processing plant. Such plants include; diary processing factories, maize mills, fish processing factories, fruit processing factories, meat slaughtering and processing factories, sugar factories, tea factories, coffee factories, cotton factories amongst others. The processing by-products can be categorized into, hides, hoofs, heads, offal, bones, blood, fat and trimmings from animals; milk sludge, and curd from dairy factories; peelings, stems, seeds, shells, trimmings, residues from fruits factories and offal, bones, scales and others from the fish factories.

Crop products

Uganda produces about 1.4 million tons of agro-processing vegetal waste and bagasse and 6,449,111 tons of farm level crop residues annually. Unfortunately, most of this waste is not used but just disposed into the landfill. In other cases, these wastes are disposed by burning which is not environmentally acceptable due to its associated negative consequences. Besides the mango wastes and other vegetal wastes, it is estimated that 280,000 tons coffee husks are generated from coffee hullers in Uganda annually. Another important agricultural by-product is the cotton seeds which are produced alongside cotton wool. The sugar production recorded in Uganda in 2009 was 287,387 tons which were a rise of 20% over 2008 production. The major by-products from sugar factories are; bagasse, molasses and Filter press cake.

Livestock products

Cattle and Chicken are considered for this review because they are the commonest amongst the Ugandan farmers in the livestock sub-sector. The national cattle herd is about 11.4 million cattle. Most of it comes from the western and eastern regions of the country. With a few from the central region, northern region and the Karamoja sub-region. By-products from cattle include cow dung, urine, hides, hoofs, heads, and offal, bones, and blood, fat and meat trimmings. Cow dung is the main by-product from the livestock industry followed by skins and hides. An average cow in Uganda produces about 20 tons of dung per annum implying a total cow dung production of 2,280 million tons annually. The total annual production of skins and hides is 6.69 million pieces with 1.94 million hides, 1.02 million sheep skins and 3.73 million goat skins. The nation chicken flock for Uganda was estimated to be 37.4 million with eastern region having the highest number of 10.7 million birds and the western region with the least number of 7.2 million birds. Estimates of the chicken dung excreted by 1000 birds per day are

120 kg for layers and 80 kg for broilers implying an average production of about 0.1 kg per bird per day giving an annual total production of over 390,550 tons of chicken dung.

Fish products

Fillet constitutes about 37% - 40% of the total fish and the remaining 60% - 63% is basically by-products which in most cases have low commercial value. The major type of fish being dealt with in Uganda is Nile perch because of its availability and high demand in the export market. Uganda produces over 36,000 tons of fish by-products annually with several distribution channels for fish by-products. Nile Perch skins are being processed into leather at an on-site tannery on a pilot scale by Gomba Fishing Industries, a fish processing plant in Uganda on the shores of Lake Victoria. It is hoped that this leather may be sold into the international fashion world in the future.

Current Innovations of Agricultural By-Products

The final disposal of agricultural waste/by-products is usually an environmental problem. This has raised concerns amongst scientists in the country and several innovative solutions have been provided to make different value-added products from these agricultural wastes.

Different innovations have suggested making briquettes, fertilizers, biogas, biochar, biodiesel, pellets and organic pesticides from these agricultural wastes.

Making briquettes

Mango waste such as seed covers are potential raw materials for making briquettes and the quality produced when seed covers are used is highly influenced by the binder types used with starch being the best binder recommended.

Making edible products

Edible Oil has been extracted from the cotton seed using the expeller-pressing method, coupled with chemical refining. Besides the edible oil, cotton seed oil is a raw material in making soap industrially. Cotton seed cake, a by-product of cotton seed oil extraction, is used for making animal feeds.

Sugarcane by-products are being consumed by both humans and animals and they are good sources of renewable energy. Molasses are being used as binders for making of briquettes from coffee husks. Bagasse is being utilized on a large scale by the major sugar industries which

include Kakira Sugar Works, Sugar Corporation of Uganda Limited (SCOUL) and Kinyara Sugar Works in meeting their internal thermal energy and electric power. This process is called cogeneration. About 3.35 tons of bagasse produces per ton of sugar. The filter cake is not of great concern in Uganda

Bio fuel production

Bio-fuels remain significant because they are used as substitute for fossil fuels

Coffee husks are another form of fuel in Uganda though its use is not widespread. This is because in loose form, coffee husks burn with low efficiency and high rates of pollution. Also, loose coffee husks are bulky and so difficult to handle, transport and store. Therefore, biomass densification which is defined as application of mechanical pressure to loose biomass to convert it into a high density solid material is employed to reduce these limitations.
It is possible to make long-lasting briquettes using molasses as a binder. The briquettes have been used to provide fuel for cooking at home which reduces the over reliance on charcoal and wood. For example Hima cement factory uses coffee husks on a large scale (24 ton/day) in the calcination of lime and in addition, Uganda Clays Ltd and Kajjansi Clays use 140 and 100 tons of coffee husks every month respectively in their kilns. Coffee husks are also being poured on the floor of chicken houses to form a deep litter. Fuel briquettes have also been made from agricultural and commercial residues other than from coffee husks and mango waste such as weeds, leaves, rice husks which are unique, yet well proven technology for an alternative energy source

Maize residues have been used as a raw material in pyrolysis to produce biochar and biodiesel. Pyrolysis is the thermo-chemical conversion of biomass under limited supply of oxygen at temperatures ranging from 350˚C to 700˚C. Products of pyrolysis include charcoal, biodiesel and biochar, the proportion of which varies with the temperature and time taken by the biomass material in the reactor. In Uganda, research on biochar and biodiesel from maize residues is still at its infant stage but with promising results so far. Because biochar has a high porosity when it is mixed with the soil, it increases the general porosity and enhances distribution of micro pores in the soil. Therefore, biochar technology has been found to be a feasible way of working around the problem of limited land while solving the problem of soil fertility.

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Fresh matooke peels have a higher C/N ratio than the optimum range for anaerobic digestion and thus not suitable feedstock unless the C/N ratio is adjusted. However, pretreatment of the matooke peels by storage under ambient condition for maximum four days, adjusts the C/N ratio to the optimum range that favors anaerobic digestion without affecting other peel constituents important in aerobic digestion process. Therefore, producing biogas using matooke peels has been found possible under these conditions. This biogas is being used to meet some of the farmers' cooking and lighting needs. Besides making biogas from banana peels, banana waste biomass is a potential raw material for slow pyrolysis of wood vinegar and tar which are potential organic pesticides.

Husks from the different varieties of rice in Uganda were characterized for bio-fuels and their techno-economic feasibility in gasification. Several techniques to convert rice husks into energy have been suggested. These include thermo-chemical, bio-chemical and physical-chemical conversion techniques. The burning of rice husk under controlled conditions produces rice husk ash (RHA), which is used industrially as a raw material because of its high silica content. Rice husks generated in Uganda have an electricity generation potential of 15,310 MWh/year giving an annual diesel saving of $4,903,636 and carbon dioxide saving of 14,045 tCO_2/year.

Organic fertilizer production

Agricultural wastes in Uganda are being used as animal feeds and as fertilizers. Many small scale farmers in Kampala have increased the quantities of their milk by feeding animals with a number of agricultural wastes combined together and others have used this waste to add more nutrients to the soils. This has been done by applying organic manure and their crop yields have greatly improved, particularly vegetables and maize that fetch them more money.

About 70% of Ugandan farmers in the main farming districts grow matooke as a primary crop and over 50% depend on this crop for food and money. However, 33% of each bunch of matooke peeled is **organic waste**. When organic waste is buried in pits under partially anaerobic conditions, it is broken down under low oxygen conditions to give off methane and carbon dioxide which is biogas. Hence the potential of **matooke peels as a raw material for biogas production by anaerobic digestion has been a concern to scientists in Uganda**

In Uganda, **cow dung** is used as a construction material on wall finishing by plastering.

Cow dung is also used as a source of on farm manure and a valuable source of plant nutrients

to meet N, P and K requirements in the country. However, the dung quality has been found to be poor due to poor manure management practices. Cow dung has been discovered to improve the pH of acid soil instead of using lime. It is also being used for improving the texture and the ability of the soil to absorb water. Besides, cow dung is a traditional source for biogas production

The main by-product from chicken are feathers and chicken manure. Chicken feathers and droppings are usually disposed-off to the soil as manure. No value addition on these two by-products has been reported so far.

USE OF AGRICULTURAL WASTE IN THE PULP AND PAPER

Non-wood fiber is one of the major sources for the pulp and paper industry in developing countries due to their abundance and cost-effectiveness. These non-wood materials have considerable potential to be used as alternative choices in many paper grades, including writing and printing papers. This paper provides an overview of how agricultural fibers can be used for this purpose. Fibrous materials that such as bagasse, cereal straw, and cotton stalks, are being used for pulp and paper manufacturing purposes

Bagasse

Bagasse is the residue fiber remaining when sugar cane is pressed to extract the sugar. Some bagasse is burned to supply heat to the sugar refining operation; some is returned to the fields; some finds its way into various panel products.

Cotton stalks

Cotton is cultivated primarily for its fiber; little use is made of the plant stalk. Stalk harvest yields tend to be low and storage can be a problem. Cotton stalks can be an excellent source of fiber. With regards to structure and dimensions, cotton stalk fiber is similar to common species of hardwood fibre. As such, de barked cotton stalks can be used to make high grades of paper. The stalk is about 33 percent bark and quite fibrous. Newsprint quality paper can be made from whole cotton stalk.

Cereal straw

Cereal straw is meant to include straw from wheat, rye, barley, oats, and rice. Straw, like bagasse, is an agricultural residue. Unlike bagasse, large quantities are generally not available at one location. Straw has a high ash content and they tend to fill up fire boxes in boilers and increase the wear rate on cutting tools. Their high silica content tends to make them naturally fire resistant.

Production of pulp from non-wood resources has many advantages such as easy pulping

capability, excellent fibers for the special types of paper and high-quality bleached pulp and they can be used perpetually as an effective substitute where forest wood resources are being decreased.

Pulp and Paper Manufacturing Process in the paper industry

Paper plays a key role in our daily life and papers have been used for many years from now. Papers are made with the pulp of the woods, which is an Eco-friendly product.

Paper is made through the following processes:

1) Pulping procedure will be done to separate and clean the fibers
2) Refining procedure will be followed after pulping processes
3) Dilution process to form a thin fiber mixture
4) Formation of fibers on a thin screened
5) Pressurization to enhance the materials density
6) Drying to eliminate the density of materials
7) Finishing procedure to provide a suitable surface for usgae

Steps involved in the Pulp and Papermaking Procedure:

Preparation of raw Material

Wood that has been received at a pulp mill can be in different forms. It depends on the pulping process and the origin of the raw material. It may be received as bolts (short logs) of round-wood with the bark still attached, as chips about the size of a half-dollar that may have been produced from sawmill from debarked round wood elsewhere.

If round wood is used, it is first debarked, usually by tumbling in large steel drums where wash water may be applied. Those debarked wood bolts are then chipped in a chipper if the pulping process calls for chemical digestion. Chips are then screened for size, cleaned, and temporarily stored for further processing.

Separation of Fiber

In the fiber separation stage, several pulping technologies will be diverged. The chips are kept into a large pressure cooker (digester), into which is added the appropriate chemicals in kraft chemical pulping.

The chips are then digested with steam at specific temperatures to separate the fibers and partially dissolve the lignin and other extractives. Some digesters operate continuously with a

constant feed of chips (furnish) and liquor are charged intermittently and treat a batch at a time. After the digestion process, the cooked pulp is discharged into a pressure vessel. Here the steam and volatile materials are tubed off. After that, this cooked pulp is returned to the chemical recovery cycle. Fiber separation in mechanical pulping is less dramatic.

Debarked logs are forced against rotating stone grinding wheels in the stone ground-wood procedure. Refiner pulp and thermo-mechanical pulp are produced by chips. These chips are ground by passing them through rapidly rotating in both processes.

In the second stage after refining, the pulp is screened, cleaned, and most of the process water is removed in preparation for paper making.

Bleaching Process

Raw pulp contains an appreciable amount of lignin and other discoloration, it must be bleached to produce light colored or white papers preferred for many products. The fibers are further delignified by solubilizing additional lignin from the cellulose through chlorination and oxidation. These include chlorine dioxide, chlorine gas, sodium hypochlorite, hydrogen perioxide, and oxygen.

Sodium Hydroxide, a strong alkali is used to extract the dissolved lignin from fibers surface. The bleaching agents and the sequence in which they are used depend on a number of factors, such as the relative cost of the bleaching chemicals, type and condition of the pulp.

Mechanical pulp bleaching varies from chemical pulp bleaching. Bleaching of mechanical pulp is designed to minimize the removal of the lignin that would reduce fiber yields.

Chemicals used for bleaching mechanical pulps selectively destroy coloring impurities but leave the lignin and cellulosic materials intact, These include sodium bisulfite, sodium or zinc hydrosulfite (no longer used in the United States), calcium or sodium hypochlorite, hydrogen or sodium peroxide, and the Sulfur Dioxide-Borol Process (a variation of the sodium hydrosulfite method).

Papermaking Procedure

Bleached or unbleached pulp may be further refined to cut the fibers and roughen the surface of the fibers to enhance formation and bonding of the fibers as they enter the paper machine.

Water is added to the pulp slurry to make a thin mixture normally containing less than 1 percent fiber. The dilute slurry is then cleaned in cyclone cleaners and screened in centrifugal screens before being fed into the ‘wet end’ of the paper-forming machine. The dilute stock passes through a head-box that distributes the fiber slurry uniformly over the width of the paper sheet to be formed.

THEME: CROP PRODUCTION

TOPIC 4.7: VEGETABLE PROCESSING

Competency: The learner should be able to process vegetables for sale

LEARNING OUTCOMES

The learner should be able to:

a) know how to find information on vegetable processing
b) understand the principles of, and show skills in using, different methods of drying vegetables
c) understand the principles of, and demonstrate methods of, preserving vegetables with acids, salt and sugar
d) market processed vegetable products

Introduction

Vegetables contain important vitamins, minerals and plant chemicals. They also contain fibre. There are many varieties of fruit and vegetables available and many ways to prepare, cook and serve them. A diet high in fruit and vegetables can help protect you against cancer, diabetes and heart disease.

Types of vegetables that can be processed

Vegetables are available in many varieties and can be classified into biological groups or 'families', including:

Leafy green – lettuce, spinach and silver beet

Cruciferous – cabbage, cauliflower, Brussels sprouts and broccoli

Marrow – pumpkin, cucumber and zucchini

Root – potato, sweet potato and yam

Edible plant stem – celery and asparagus

Allium – onion, garlic and shallot.

Cooking Methods to Preserve Nutrients in Vegetables

How foods are cooked can have a big impact on their nutrient content. That's because many vitamins are sensitive to heat and air exposure (vitamin C, the B vitamins, and folate in particular). Loss of nutrients increases as cooking time increases and with higher temperatures.

Cooking methods that minimize the time, temperature, and amount of water needed will help to preserve nutrients. Steaming is a great way to cook vegetables quickly and retain valuable nutrients. Microwave cooking is also good because it uses minimal water, and the cooking time is very short. Stir frying is another way to quickly cook a variety of vegetables.



Here are other tricks you can use to preserve nutrients:

Leave vegetables in big pieces. That way fewer vitamins are destroyed when they are exposed to air.

Always cover your pot to hold in steam and heat. This will also help to reduce cooking time.
Use any leftover cooking water for soups and stews, sauces, or vegetable juice drinks.
Eat vegetables raw whenever possible in salads and smoothies or as whole vegetables.
Cook vegetables until crisp. Don't overcook.
Use as little water as possible when cooking.

Retain the Peel: When you peel vegetables you throw away a large chunk of their nutritional value. Such as a large dietary fiber loss when you throw out an apple skin, along with vitamin C, and various other minerals.

You may be tempted to throw out produce skin due to pesticides. Instead opt to thoroughly wash your produce to remove potential contaminants. If you are especially concerned, consider selecting organic produce.

Cook before Chopping: Don't chop your vegetables before cooking. The larger exposed surface area increases nutrient loses. A study found that carrots left whole when cooked retained 25% more of certain nutrients. This is likely due to the increased surface area exposed

for nutrients to leach out of vegetables while they are in water. A taste test was also completed and the carrots that were cooked whole were preferred based on flavor. Cooking carrots whole preserves nutrients and natural sugars that impact flavor. So, chop after cooking.

Store Properly: Where you keep yourvegetables has an impact on the amount of vitamins and minerals you are able to get from them. The Cooperative Extension System recommends storing your produce in the refrigerator to preserve nutrition and flavor. One exception is tomatoes, which should be stored at room temperature. If you don't plan to eat yourvegetables within a couple days they should be frozen, which stops nutrient loss until they are thawed. If possible, choosevegetables that are kept cold at the supermarket since you can never be sure how long they have sat there. Reducing contact with air further slows nutrient loss so placing your produce in air tight containers is another step for preservation of vitamins and minerals.

Dehydrate

Dehydrating vegetables is a good way to preserve the nutrients they contain. Dehydrating produce on a low setting preserves most if not all of the nutrients they have available. Dehydratedvegetables make a good snack and are simple to prepare. Choices that work well in a dehydrator include pears, apples, pineapples, corn, carrots, beets, peaches and potatoes. It is also possible to dryvegetables in the oven or in the sun. The foods you choose will need to blanched before you attempt to dry them.

Don’t soak vegetables in water to prevent discoloration-Almost 40% of water-soluble vitamins and minerals are lost in the water. If you must soak, use up the soaking water to knead the dough, prepare soups and gravies

Salads should be prepared just before serving and should be served in closed dishes to avoid excessive exposure to air.

Root vegetables should be boiled with skins on and then peeled after boiling. This helps the nutrients to migrate to the centre of the vegetables, helping better retention of its nutrients. Do

eat with skin on whenever possible.

Baking soda makes cooking water alkaline and thus helps retain the colour of vegetables as well as speed up the cooking process, BUT it destroys thiamine and vitamin C.

Deep frying and heating for a long time or heating at a high temperature should be avoided during cooking. If food material is heated above 700 C for a long duration, proteins become hard and coagulated. In this form, they are not easily absorbed by the body. Thus, overcooking results in loss of precious nutrients.

What to Look For When Picking Vegetables

Most people know instinctively to avoid bruised or blemished produce, but there is much more involved in the art of choosing vegetables.

While buying fresh food is always a little bit of a craps shoot (and not every rule will apply to every piece of produce), these tips will give you the basic skills you need to hold your own at the farmers market.

Bright color

After you've checked for bruises, blemishes and pests (harder to see on vegetables like cauliflower and cabbage, so double check), look forvegetables with the brightest, most inviting colors. The tastiest, vine-ripened produce should be vibrant, with its skin entirely saturated with color. If the item has a dull color or whitish sheen that means it is either not fully ripe or was deprived of sun or nutrients.

For fruits like cherries look for stems that are green instead of brown, since these fruits will be fresher.

Heavy weight

Generally you want to pick produce that is the heaviest relative to the rest of your options. Light weight produce is more likely to be dry and mealy, but heavier produce will be juicy and crisp.

The best way to tell is to pick up two similarly sized fruits, one with each hand. After you've tried a few it will be obvious that certain fruits are much heavier than the rest, and those are your best bets. This applies to bothvegetables, but mostly to fruits.

Firm, but not hard

Because the best produce is moist and juicy, it should also be perfectly plump. This means that

it will be firm to the touch—think crisp and succulent—but not hard, squishy or limp.

While the perfect amount of firmness will vary for each type of produce, comparing within the batch can be very informative. For soft fruits, gently picking a piece up should tell you if it's too soft or hard.

For vegetables with stalks like carrots and broccoli, be sure the ends don't give too much when you try to bend them (but don't try too hard or they

While this tip works as a general rule, keep in mind that it doesn't apply to everything. Figs, for example, are better very soft, as are certain kinds of persimmons.

Fragrant aroma

Probably the most telling test of the quality of your fruit is how it smells. Unripe fruits smell like nothing, or at best the cardboard it was packed in. But ripe produce almost always smells faintly (and often overwhelmingly) of how it is supposed to taste.

Hold the part of the fruit that was attached to the stem close to your nose and breathe deeply. Compare a few of your options. The strongest smelling fruit will be the most ripe and ready to eat immediately. If you'd like your fruit to last for a few days, it is best to go with a piece that still smells good, but has a less overwhelming scent.

It's also worth smelling your vegetables, though this tip does not apply to them all (eggplant is a notable exception). Green leafy vegetables and herbs are particularly fragrant. But even carrots, artichokes and squash can have a distinctive smell. Peppers are my personal favorite.



Choose produce carefully

Avoidvegetables with cuts, bruises, insect holes, mold or decay. At the same time, fruit does not need to be "perfect" to taste wonderful. All shapes and sizes make great fruit and vegetables.

Fresh may not always be the best

Fresh produce is best when bought in season and locally for maximum flavor and nutrition. Research has shown that frozen vegetables are just as nutritious as fresh vegetables and have less waste.

Be mindful when buying canned fruits or vegetables. Canned vegetables are also nutritious but often have added salt and corn syrup- and nutrients may be lost in the liquid in the can. Avoid those with added corn syrups and added salt.

Uses of vegetables in cookery

As consumers demand healthier menu options, professional kitchens today are incorporating more vegetables into their menus. The popularity of locally grown and organic foods, along with the rise of vegetarian and Mediterranean diets, has made vegetables very much in demand. Because vegetables are delicate in nature and deteriorate quite rapidly, they must be handled with extra care to maintain their integrity.

Vegetables are cooked to develop color, texture, and flavor. Because of the vast varieties, cooking methods vary depending on the desired end result. In professional foodservice production vegetables are often blanched or par cooked in boiling salted water as a mise en place step, and finished by other cooking methods such as sautéing, frying, or roasting.

Equally important in this process is the added step of shocking the vegetables in an ice water bath, which brightens and sets the color making them more visually appealing. Some vegetables like roots or dried legumes need prolonged cooking to tenderize and make them digestible, while others like tender leafy greens, may only need a few seconds to help set their color. Deep-frying, grilling, braising, and roasting develop distinct textures, colors and flavors through carmelization or the addition of flavorful liquids.

Vegetables are made up of countless little cells containing water, sugar, starch, mineral salts, etc., and are valuable to the diet as bulk food and for these mineral salts. The careful housewife will see that vegetables are cooked so as to retain most of these valuable elements. All vegetables should be cooked in boiling water, as this bursts the starch grains at once, which will hold the nutriment of the vegetable. If cold or just warm water is used, the starchy frame of the vegetable will become soaked with water, and in the case of very starchy vegetables, such as potatoes, they will become water-soaked and soggy - an unappetizing and indigestible dish. The vegetables deficient in starch should be cooked in boiling hot water also, in order to retain the flavor, and delicate vegetables should not be cooked in a quantity of water or the

flavor will be impaired and much of the mineral salts lost. Steamed vegetables retain nearly all the valuable qualities and is a very satisfactory method for cooking many vegetables.

Foods containing starch must be well cooked. Such vegetables as potatoes, turnips and those containing starch in the form of woody fiber must be thoroughly cooked or they will be unwholesome. Green peas and asparagus contain sufficient starch to require thorough cooking, but in order to retain the flavor (sugar and other elements) there should not be a quantity of water used, and while the water should be at the boiling point it should not be allowed to boil violently; in the case of peas all water should either be absorbed, or whatever liquid remains should be served with the vegetables.

The liquid from asparagus can form the base for a cream soup or can be used to make a sauce to pour over the vegetable. Spinach, after being carefully cleaned, should be cooked in the water which clings to the leaves, or if any water is added it should be only sufficient to cover the bottom of the kettle. The length of time required to cook vegetables depends upon their age and how long they have been gathered

Some vegetables are strong flavored and for this type a quantity of water may be used. Cabbage, onions, etc., come under this class. These vegetables may be blanched. By that is meant placing the vegetables in a quantity of cold water and then brought quickly to the boiling point, boiled not more than 5 minutes, drained and cooked in boiling water as directed.

Hard water has a tendency to toughen and harden woody fiber, and thus keep the sweet juices and other valuable compounds within the article cooked; soft water acts in just the opposite manner. For that reason we salt the water for all green vegetables, which assists them in retaining flavor and color. Vegetables containing much woody fiber are better cooked in soft water, adding salt when half cooked.

Green vegetables will retain their color better if cooked in an uncovered kettle. Strong flavored vegetables, such as cabbage and cauliflower, will not give off as unpleasant an odor if cooked in an uncovered kettle.

Steam until vegetable is tender. This will take a little longer than boiling, but they will be of a good flavor and there will be scarcely any loss of mineral salts or other nutritive content. This method of cooking may be used for all vegetables firm in texture. Where possible, steam vegetables without removing the skins. The flavor of the food will be greatly improved and the skins may be more quickly and easily removed after cooking. In baking there is very little loss of material except water, which is driven off by the heat. Baked potatoes, both white and sweet, are among the most easily digested and wholesome vegetables.

Cooking Vegetables

Cooking activates flavor molecules and provides important textural changes to vegetables

Use optimal cooking methods and techniques to preserve color, flavor, texture and nutrients

Overcooking can create bitter or unpleasant flavors to develop in vegetables from the cabbage family; avoid overcooking

Vegetables in the onion family mellow and sweeten when cooked

Effect of heat on vegetables

The various ways in which cooking affects vegetables should be thoroughly understood. In the first place, some methods conserve the food material whereas others waste it.

For instance, boiling in water, which is probably one of the most common ways of cooking vegetables, is decidedly advantageous in some respects, but the water dissolves much of the soluble material, such as mineral salts, sugar, etc., found in the vegetables, so that unless some use is made of this water in the cooking of other foods, considerable waste results.

On the other hand, steaming and baking permit no loss of food material, and so they should be applied to vegetables whenever it is desired to conserve food substances.

Instructions:

The flavors of vegetables are greatly changed during the process of cooking, being increased in some cases and decreased in others. In the case of such strongly flavored vegetables as cabbage, cauliflower, onions, etc., it is advisable to dissipate part of the flavor.

Therefore such vegetables should be cooked in an open vessel in order that the flavor may be decreased by evaporation. Vegetables mild in flavor, however, are improved by being cooked in a closed vessel, for all their flavor should be retained.

The overcooking of vegetables is sometimes responsible for an increase of a disagreeable flavor. Another feature of vegetables often changed by cooking is their color. For instance, green vegetables do not, upon cooking, always remain green. In many cases, the color may be improved by adding a very small quantity of soda to the water in which the vegetables are cooked.

Attention should also be given to the length of time vegetables are subjected to heat, for the over boiling of some vegetables is liable to develop an unattractive color in them.

This is particularly the case with cabbage, cauliflower, and Brussels sprouts, which develop not only a strong, disagreeable flavor but also a reddish color when cooked too long.

The application of heat to vegetables also has a definite effect on them. By sufficient cooking,

the cellulose of vegetables is softened to the extent that it is less irritating and much more likely to be partly digested than that of raw vegetables. The acids of fruits increase upon cooking, and so the acidity of vegetables is increased to a certain extent.

Vegetables that contain starch are rendered digestible in no other way than by cooking. On the other hand, the protein material of this food is coagulated by the application of heat, just as the white of an egg or the tissue of meat is coagulated and hardened. However, cooking is the only means of softening the cellulose that surrounds this material.

Still, high-protein foods, such as beans, peas, and lentils, can be much improved if they are cooked in water that is not very hard. The lime in hard water has a tendency to harden them to the extent that they require a much longer time to cook than when soft water is used.

These vegetables may be still further softened by the addition of a small quantity of soda to the water in which they are cooked, but care should be taken not to use too much soda, as it will injure the flavor.

When soda is used, the vegetable should be parboiled for 10 or 15 minutes in the soda water and then drained and cooked in fresh water. This method, of course, does not apply to vegetables that are cooked in soda water to retain their color.

Salt is always added in the cooking of vegetables to season them. In the use of salt, two important points must be borne in mind: first, that it has the effect of hardening the tissues of the vegetable in much the same manner as it hardens the tissues of meat; and, secondly, that it helps to draw out the flavor of the vegetables.

These two facts determine largely the time for adding the salt. If an old, tough, winter vegetable is to be prepared, it should be cooked until nearly soft in water that contains no salt, and the salt should be added just before the cooking is finished.

When it is desired to draw out the flavor, as, for instance, when vegetables are cooked for soup or stews, the salt should be supplied when the vegetables are put on to cook.

Young tender vegetables may be cooked in salt water, but as such water extracts a certain amount of flavor, an effort should be made to use it in the preparation of stews, sauces, and soups.

MOIST HEAT COOKING METHODS

Boil/A l'anglaise

The French term "a l'anglaise" refers to cooking foods in water or other liquids. Chef Thomas Keller of the French Laundry and Per Se restaurants calls this "Big Pot Blanching". It is a mise en place method commonly used in professional kitchens when prepping quantities of vegetables for service.

Most any vegetable can be blanched, par-cooked, or fully cooked in this fashion. The vegetables are submerged in a large quantity of rapidly boiling water that is highly salted and then cooked for a proscribed amount of time. They are then drained and plunged into an ice water bath to stop the cooking process.

The blanching and shocking method brightens and sets the color of the vegetables, especially green varieties.
Additionally, blanching acts as a preservative because the process deactivates enzymes that turn plants soft, brown, or otherwise unsavory.

Blanching Vegetables



Ratio	Ingredient	Quantity
16 Parts	Water	1 Gal/4 l
½ - 1 Part	Salt	4oz./120 g-8 oz./240 g
1 Part	Vegetables	1 lb./450 g

White & Red Vegetables
Add a dash of vinegar or lemon juice to set the color

Method

1. Wash vegetables and cut them into uniform sizes
2. Assemble a cold water ice bath for shocking the vegetables
3. Bring a large pot of water to a boil
4. Add salt and return to a boil
5. Add the vegetables but don't crowd the pot
6. Return to a boil and cook for the desired amount of time
7. Check for doneness by tasting the texture of the vegetables
8. Remove the vegetables with a skimmer and immediately plunge into a cold water ice bath to stop the cooking process and set the color
9. Drain immediately after the vegetables are cool





Blanch	Par-Cook	Al Dente	Fully Cook
30-60 Seconds	***1-2 Minutes***	***3-4 Minutes***	***5 minutes or more***
Crudités	Asparagus	Broccoli	Artichokes
Fresh Herbs	Cabbage	Brussels Sprouts	Beets
Tender vegetables	Summer Squash	Cauliflower	Carrots
Tender greens	Zucchini	Corn	Celery Root
Tomato Concassé		Green Beans	Parsnips
		Peas	Rutabagas
			Turnips

Simmer

Some vegetables require a gentler moist heat cooking process. Potatoes, when cooked by moist heat methods, should be simmered and not boiled, because boiling will break down and disintegrate the potatoes leaving some of it behind in the cooking liquids.

Potatoes are one of the exceptions to the moist heat cooking process because they are started in cold water and slowly brought to a simmer. This cooks the potato more evenly and reduces

the risk of overcooking.

Poach

Poaching is a low-heat cooking method, from 180-190?F/82-88?C, in aromatic liquids including court bouillon, stock, broth, coconut milk, juice, butter or oil. This method is used for hearty root vegetables with stable pigment colors including carrots, parsnips, rutabagas and turnips. Other vegetables including fennel, onions, artichokes and leeks also can be cooked in this style.

The butter or oil poaching method is similar to a confit cooking method. It requires more cooking time, from 10 minutes up to an hour, depending on the type of vegetable and its size.

Sous Vide



Cooking by the sous vide method is done in a vacuum package with an immersion circulator or hot water bath at190 °F / 88 °C. The vegetables are trimmed, lightly seasoned, oiled and sealed. The cooking temperature and method are similar to poaching. The advantage of vacuum packaging is that it locks in all the flavors of the vegetables. The process can be used for any type of vegetables.

Steam

Steaming Method



Foods steamed in a vapor bath are considered the healthiest cooking method, because when done properly they retain more nutrients, plus unlike the boiling process there is no flavor or texture loss. The simplest method for steaming foods is to place the ingredients on a rack over boiling water, cover tightly, and cook in the steam. This can be done with a pot, or steam table pan with a perforated insert, and a tight-fitting lid. Convection steamers are also used in many food service operations for practical and efficient large scale cooking. Finish with fresh herbs, butter, oil, or a prepared marinade.

Preparation Method	
Step 1 - Mise en Place ➢ Season the vegetables ➢ Heat liquid to a boil and place the vegetables on the insert ➢ Cover the container with a tight-fitting lid and cook to the desired degree of doneness ➢ Alternately arrange vegetables in a perforated pan and cook in a convection steamer	**Step 2 – Remove and Serve** ➢ Remove steamed vegetables from the heat and served immediately ➢ *Butter or oils including sesame, olive, and infused varieties provide a finishing touch*

Glaze

Sometimes called pan-steaming, the method of glazing is used for a wide variety of vegetables. Glazing is done in a shallow pan with a small amount of water, along with butter, sugar and salt. Add other herbs and spices as desired. Various liquids including wine, stock, or juice can be incorporated. Substitute olive oil or other infused oils for butter, and other sweeteners including honey and maple syrup for sugar. Start the vegetables from a raw state or par-cook and finished to order with a prepared glaze.

Preparation Method

Step 1 **– Mise en Place**

- Cut vegetables into uniform shapes
- Combine vegetables in a rondeau (braising pan) with salt, butter, and sugar
- Add a small amount of water to coat the vegetables (avoid drowning the vegetables in water because the result will be boiled vegetables rather than glazed)
- Begin to heat the vegetables on the stovetop and toss occasionally to coat the food with the liquid while cooking



Step 2 – Add Liquid and Heat

- Cover with a cartouche (parchment paper lid) and cook until al dente (tender but not soft); toss the vegetables periodically and add more liquid as needed



Step 3 –Glaze and Finish

- The liquid should reduce to a glaze as the vegetables become tender
- If the glaze has not reduced and thickened properly, strain it and reduce separately to desired consistency before combining with the vegetables



Glazed Root Vegetable Ratios and Variations

Vegetable Variations	***Liquid***	***Sugar ½ - 1 oz./30 g per lb./450 g***	***Fat 2 oz./ 60 g per lb./450 g***	***Garnishes***
Beets Carrots Celery root Parsnips Rutabaga Turnips	Fruit juice Water Stock Wine	Agave nectar Brown sugar Honey Maple syrup Sorghum	Bacon Butter Hazelnut oil Olive oil Walnut oil	Citrus zest Fresh herbs

Glaze Production Method

This method is intended for large production cooking. Vegetables are par cooked, and the glaze is prepared separately. The vegetables are sautéed and then glazed to finish.

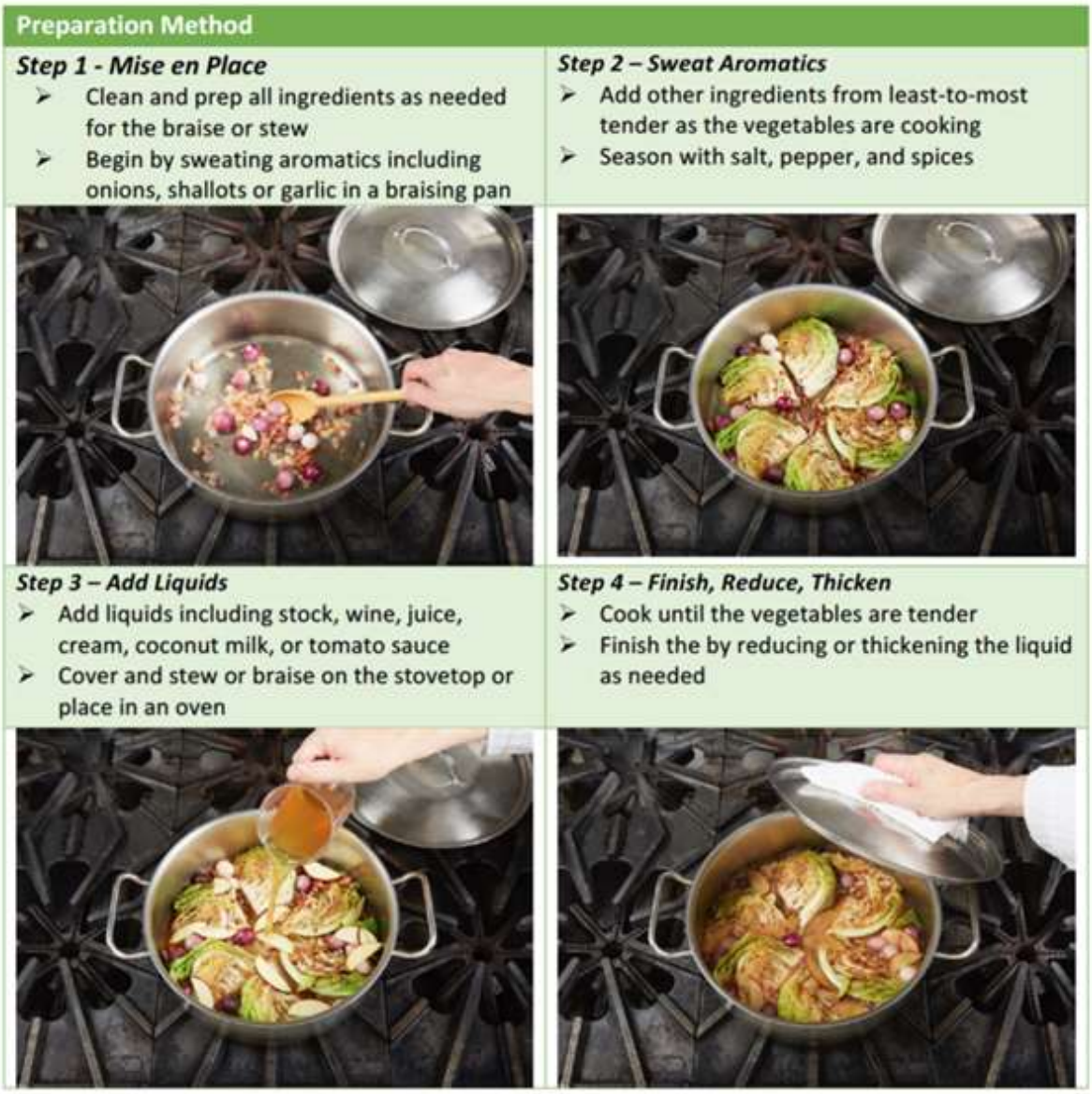
Quantity	Ingredient
16 oz./ 450 g	Sugar
16 oz./475 ml	Water
As needed	Citrus, wine, flavored vinegar
As needed	Fresh herbs (thyme, rosemary, dill)
To Taste	Salt and pepper
*** See chart for variations and substitutions on a standard glaze**	

Preparation Method
Step 1 –Mise en Place ➢ Prepare the glaze by combining equal parts water and sugar, heat to dissolve the sugar, and add other ingredients and flavors as desired
Step 2 – Par Cook Vegetables ➢ Cook vegetables in boiling salted water until 75% cooked (the vegetables should be cooked al dente) ➢ Cool in ice water and drain well
Step 3 – Sauté and Glaze ➢ Sauté in batches with butter or oil and finish with the glaze and additional seasoning

Braise/Stew

Combination cooking methods, braising and stewing, begin by searing or sweating the ingredients in fats and then adding liquids. Braises are simple preparations of leeks or celery, heartier items of braised cabbage or sauerkraut, or complex ones including ratatouille and Moroccan vegetable tagine. Aromatics including onions or shallots, and garlic are layered with bacon, ham, or salt pork. Peppers add a spicy heat. Wine or citrus juices brighten up the preparation. Herbs and spices add depth and finish.

Braise Method



DRY HEAT COOKING METHODS

Sauté

Sautéing vegetables are done from either a raw or a par cooked state. If the vegetables are naturally tender like spinach, they can be quickly sautéed with a little shallot and garlic in olive oil or butter and finished with seasoning. Green beans, carrots and other vegetables are usually par-cooked a l'anglaise and finished a la minute, in the same manner as tender raw vegetables. Remember to have the pan hot.

Avoid overloading the pan because it causes the temperature to drop and creates a steaming

effect instead of sautéing. Stir-Frying is a sautéing process achieved in a wok. The technique is similar to sautéing and can be done in a sauté pan if a wok is not available.

Instructions for Sautéing

- Clean and cut vegetables into uniform shapes.
- Blanch or par cook vegetables as needed.
- Heat a sauté pan to a medium high temperature.
- Add the oil or fat to the pan.
- Add aromatics including shallots and garlic if desired.
- Add the vegetables to the pan.
- Avoid overloading the pan which drops the temperature and creates a steamed effect.
- Cook the vegetables tossing occasionally to heat and cook evenly.
- Season with salt, pepper, herbs and/or spices.
- Serve immediately

Preparation Method	
Step 1 - Mise en Place ➢ Clean and cut vegetables into uniform shapes ➢ Blanch or par cook vegetables as needed	***Step 2 – Pre-heat Pan*** ➢ Heat a sauté pan to a medium high temperature ➢ Add the oil or fat to the pan
Step 3 – Sweat Aromatics ➢ Add aromatics including shallots and garlic	***Step 4 – Add Vegetables*** ➢ Add the vegetables to the pan ➢ Cook the vegetables tossing occasionally to develop desired color and texture ➢ Season with salt, pepper, herbs, and spices
	

Fry

Frying vegetables produces a crisp texture with a caramelized taste. It uses more fats or oils in the cooking process than sautéing and is divided into two categories; Pan-Fried and Deep-Fried. Vegetables cooked using these methods are often coated with breading or are batter

dipped to create fritters, tempura. The product may be pre-cooked or par-cooked before being finished by frying. Proper oil temperature is important to evenly cook the product, and provide a crisp texture and a golden color. Too much heat will overcook the coating while leaving the vegetables cold or raw. Too little heat and the product will be soggy and oily. For most frying methods, a temperature of 325-3500F/160-1800C is ideal.



Instructions for Pan-Frying Vegetables

Prep ingredients and if desired bread the items with a three stage breading process of flour, egg wash and breadcrumbs.

Heat a large sauté pan or cast iron skillet

Add oil to a depth of ?-¼”/3-6mm. Heat to approximately 325-350^{0}F/160-180^{0}C

Add the items and cook to a golden brown.

Avoid crowding the pan as this will slow the cooking process, lower the cooking temperature and produce a soggy product from the increased moisture in the pan.

Turn the items as needed to evenly cook the product on all sides.

Drain on paper towels and season with salt and pepper.

Serve immediately or hold hot to maintain texture.

Deep-Fry



Tempura Shrimp

Deep frying is submerging food in hot oil at a temperature between 325-375?F/160-190°C. When food is surrounded by hot fat, the surface quickly seals preventing moisture from seeping out of the product. Successful deep frying produces a crisp texture and a moist cooked filling on the inside.

As with pan frying, the foods are often breaded with a three stage process. Vegetables can be sliced or julienne before breading to produce onion rings or eggplant fries. **Croquettes** can be prepared with cooked and diced vegetables and other ingredients bound with a sauce which are then shaped and breaded. Or in the case of potatoes

Deep-frying involves two methods for cooking items depending on whether they are breaded or batter fried. Breaded products usually use the **basket method** and batter

frying uses the **swimming method** to avoid the problem of the batter sticking to the basket. Batter-fried items are dipped with a tongs and added to the fryer. A tongs, spider, or skimmer is used to turn and lift the product from the fryer once finished cooking.



Fritters

Grill/Broil

Grilling and broiling vegetables provides a rustic compliment to menus. A variety of vegetables do well on the grill, but some stand outs include asparagus, corn, eggplant, mushrooms, peppers, onions, tomatoes, along with summer and winter squash varieties. With extra care, cabbage and other leaf vegetables like radicchio, endive, or romaine can also be grilled.

Grilling and broiling of vegetables is typically done at a lower temperature than meats, from approximately 375-450 °F/190-230?C.

The vegetables are often sliced, seasoned, and tossed or brushed with oil before grilling. Marinades or vinaigrettes can also be incorporated either before or after cooking. Radicchio and other leafy vegetables can be cut into wedges with the core intact to hold them together. They can also be cut into various shapes and skewered to make kabobs as vegetarian options or combined with meats, poultry or seafood.

Broiling of vegetables is performed similar to grilling. Prepping is the same but the vegetables are placed on a broiler pan and set under the heat element. As with grilling, the vegetables

should be turned so they brown and cook uniformly.Broiling is often done to char peppers and tomatoes for use in sauces and salsa.



Instructions for Grilling and Broiling Vegetables

Prep-heat the grill or broiler between 375-450 °F/190-230?C

Clean and cut vegetables into uniform shapes

Season with salt and pepper, brush or toss with oil or marinade

Place on grill and begin cooking

Turn vegetables to brown and score and brush with additional marinade or oil to prevent drying

Remove vegetables when the skin begins to blister and the middle becomes soft.

Remove when done and serve

Different vegetables will take different amounts of time to cook. Plan on grilling for 5 to 20 minutes

Place small vegetables on skewers or use a grilling basket

Roast/Bake



Roasting brings out the natural sweetness in vegetables by concentrating the flavors and caramelizing the natural sugars in them. Almost any vegetable, including artichokes, beans, cauliflower, and winter squash are good candidates for roasting.

Heat and surface area are important in roasting because the smaller the vegetables are cut the higher the oven temperature needs to be. Halved winter squashes should be cooked at 350?F/175?C degrees while smaller cut vegetables including asparagus, beans, or zucchini will need a hotter oven, about 425?F/220?C. The vegetables are tossed with salt, pepper and oil. Additional spices can be added as desired. Fresh herbs are usually added at the end of the roasting process. Spread the vegetables out in a single layer to facilitate browning.

Instructions for Roasting and Baking Vegetables

- Preheat oven between 350-425?F/175-220?C
- Cut vegetables in uniform shapes
- Toss the vegetables with salt, pepper, spices, and oil
- Spread the vegetables out in a single layer on a sheet pan lined with parchment paper
- Place in oven and check after 10-12 minutes
- Turn the vegetables so they brown evenly
- Continue to cook until the desired degree of doneness is reached
- Check the doneness by tasting a piece for its texture
- If the vegetables are browned but not tender add a few drops of water to stop the browning process and continue to cook in the oven

Methods of preserving vegetables-

Freezing:

Freezing is one of the easiest ways to preserve vegetables for winter, and almost all vegetables are suitable, with the exception of cabbage and potatoes, which tend to become limp and waterlogged.

Most vegetables need to be blanched first, which involves boiling them for a set amount of time – usually one to three minutes. Blanching stops the development of enzymes, thus preserving color, flavor and nutrition. Once blanched, vegetables are dunked into ice water to cool them quickly, and then packed for freezing. As a general rule, vegetables are packed in plastic containers or freezer bags.

Canning

Canning involves placing fruit and vegetables in airtight containers, typically glass jars, and so prevent bacteria getting to them. Canned good can be stored on shelves for years, if required. There are two methods, although one requires a specialist machine so may not be practical or cost-efficient for many people. This is the pressure canning method, which enables you to achieve temperatures above boiling point that foods with low acidity require to effectively neutralise the threat of the botulism bacteria remaining active. It requires a pressure canning machine and is the method used to can most vegetables, as they are low in acid. Fruit, being high in acid, does not have the threat of botulism, so can be canned using a simpler method. Just place your fruit in the jar, top with boiling water, leaving an inch or so of space at the top of the jar (to allow space for the fruit to expand), run a spatula around the inside edge to remove any air bubbles, then close with a threaded lid.

Pressure canning low-acid foods such as plain vegetables requires a pressure canner. A pressure canner reaches 240°F, which destroys heat-resistant organisms that can cause food poisoning, primarily botulism. Contrary to what some cooks believe, you cannot safely put any food in a jar and process in a canner. To make foods safely, such as canned soups and spaghetti sauce (with or without meat), be sure to use a tested recipe and prepare and process canned foods correctly

Drying

Drying dehydrates the fruit or vegetables, removing all the water along with the bacteria, yeasts and mold that live in the moisture. Besides altering the texture of the food, drying also modifies the taste, typically concentrating it. Dried food has the added benefit of being safe to store as is on your pantry shelf – you don't need special packaging to keep it in or to keep it in the refrigerator. In some countries solar drying of food is a part of life, and if you live in an area that receives high levels of consistent sunshine, you may be able to dry food that way. More likely however, is drying in an oven. The technique requires low temperature and good air circulation so use the lowest setting and prop the oven door open – this allows the air that the moisture has evaporated into to escape.

Pickling

Cucumbers are the most familiar choice for pickling, but you can also pickle a variety of vegetables, including: Beets Carrots Cabbage Asparagus Beans Peppers Tomatoes Firmer foods, such as beets and carrots, may need a short blanching period to make them tender. Pickling involves arranging the vegetables in a glass canning jar with your choice of seasonings such as: Dill Celery seeds Mustard seeds

Storage

Some vegetables can be safely stored in a cool, clean location for as long as 12 months. Vegetables suitable for storing include winter squash, potatoes and dry onions. Some root crops, like beets and carrots, are suitable for storing in a container filled with moist sand. In cool climates, roots crops can be left in the ground through the winter months. Cover them with a 12- to 18-inch layer of mulch such as leaves or straw.

Salting

One of the oldest methods of preserving food, salting can be used for meat and fish, as well as sliced vegetables. There are two methods. The first uses a low salt to vegetable ratio (between two and five percent salt per weight of vegetables). This level of salting promotes the growth of the lactic acid bacteria, which in turn inhibits the growth of other bacterial forms that could spoil the food. It also serves to slightly pickle the vegetables. The second method uses a higher

percentage of salt (between twenty and twenty-five percent), preserving the freshness of the produce but adding a salty flavour when used, even after the salt has been washed off. Whichever method of salting you use, you need to store the produce in the refrigerator.

TOPIC 4.8: FRUIT PROCESSING

Competency: The learner should be able to process and market quality fruit products

LEARNING OUTCOMES
The learner should be able to:

a) show skills in planning and budgeting (using Excel/spreadsheets or books and calculators) for a recipe, and purchasing
b) know and understand the requirements regarding quality of water to use in processing fruit, and apply basic methods of water treatment
c) plan and prepare processing premises, taking account of the importance of premises hygiene
d) know the different types of fruit beverages and their specifications
e) show skills in juice and pulp extraction, processing and preservation, taking account of good manufacturing practices
f) understand the principles of, and demonstrate methods of, preserving fruit with acids, salt and sugar
g) know how to advertise and market processed fruits

Introduction

Food processing aims to make food more marketable and attractive to potential consumers, often giving the processed food a longer shelf-life.

Fruit can go through numerous types of processing, including **canning, drying, and juicing**. Some types of processed fruit are fruit preserves, canned fruit, and fruit juices. Processed fruit is generally not as healthy as fresh, raw fruit.

Washing, drying, and packaging fruit is usually not considered processing. Processing begins when the fruit is turned into something other than raw fruit by cooking or preserving it. Even if this process is as simple as cutting an apple and drying it to preserve it, that apple is no longer raw fruit. Sometimes additives, preservatives, and sugar is added to processed fruit to make it look and taste better than it normally would when a customer finally opens the product to consume it.

After fruit is washed multiple times, the processing begins. As an example, if the fruit is to be turned into fruit preserves, it is first cooked until soft. A sugary syrup and sometimes additives and preservatives are added. The fruit is then sealed into a jar, or in some cases, placed in a squeeze bottle. As another example, the fruit is dried and packaged, sometimes with sugar added depending on how sweet the fruit is naturally.



Methods of fruit processing:

Processing of fruits is very important to produce products for direct consumption and as food ingredients.

There are three major processes,

1) Canning
2) Freezing
3) Drying

1. Canning

Canning is defined as preservation of foods in hermetically sealed containers and usually implies heat treatment as the principal factor in prevention of spoilage. Canning was invented by Nicholas Appert in 1910 so also termed as Appertization.

Foods that are canned have the following characteristics

- Low acid foods: Meat, fish, poultry, dairy fall into a pH range of 5.0 to 6.8. This large group is commonly referred to as the low acid group.
- Acid foods: With pH values between 4.5 and 3.7. Fruits such as pear, oranges, apricots and tomatoes fall in this class.
- High acid foods: Such as pickled products and fermented foods. The pH values range from 3.7 down to 2.3, also Jams and Jellies are in this classification.

1.1. Principle of canning:



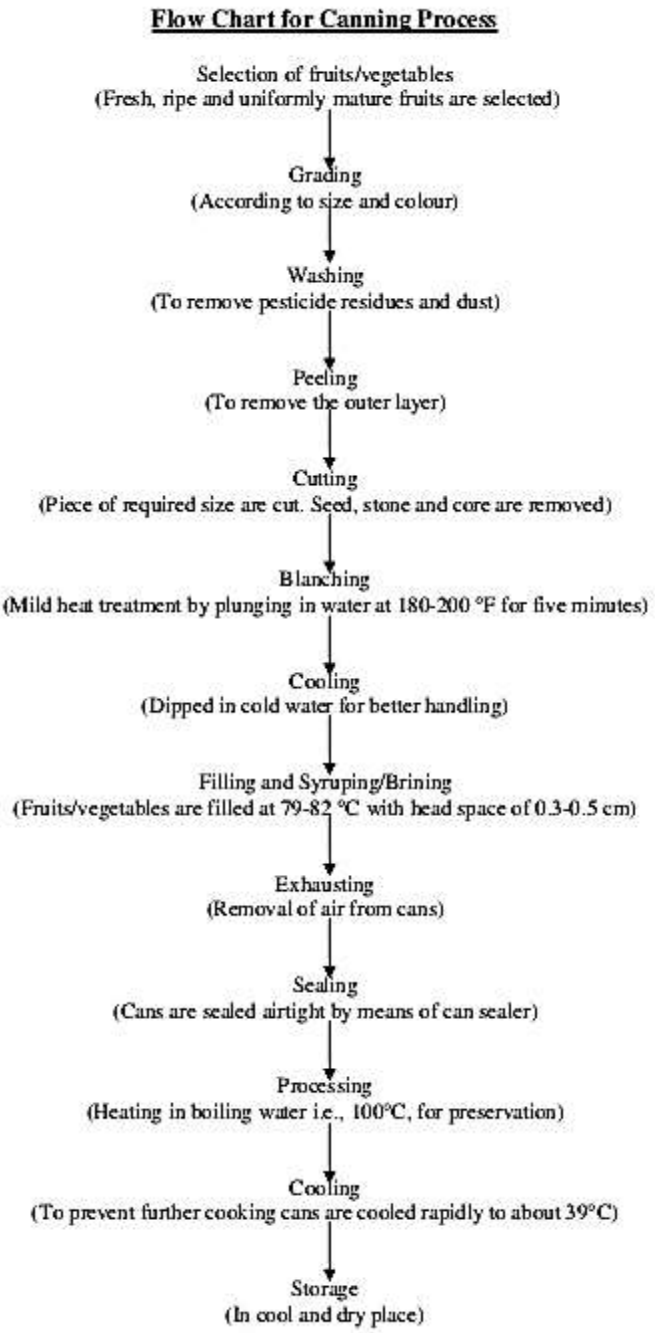
Destruction of spoilage microorganism within a container by means of heat.

Preserving using a canning method involves placing food in specified canning jars that are sealed with two-piece lids.

The jars are heated to a temperature that destroys harmful microorganisms and inactivates enzymes. This heating, and later cooling, forms a vacuum seal.

This vacuum seal prevents further microorganisms from entering the jar and contaminating the foods during storage.

1.2 Canning Process flow chart:



2. Freezing

Freezing is a low temperature preservation process where the product is frozen at -38 0C and stored -18 0C. Freezing is cheaper than canning and frozen products are close to fresh products and of better quality the metabolic activity and spoilage due to post harvest chemical are retarded by freezing. Through the product preserved by freezing retains their quality appreciably, the major disadvantage of the process is that the low temperature has been maintained during handling, transportation and storage before the product is finally consumed.

Suitablevegetables for freezing are mango slices, pulp, pineapple slices, guava slices, orange segments, peas, carrot, cauliflower, beans, etc.

IQF refers to **Individual Quick Freezing** of every particle/aggregate using fluidization in a stream of very cold air. Fluidization leads to high heat transfer co-efficient and therefore very rapid freezing and hence better quality. For example, freezing of green peas in an air blast freezer may take 3-4 h whereas it is only 10-12 min by IQF. This results in for better texture and there is no humb or block formation. Some of other important IQF products are frozen fruit dices.

- Easy, convenient and the least time consuming
- Slows growth of microorganisms and chemical changes
- Preserves the greatest quantity of nutrients

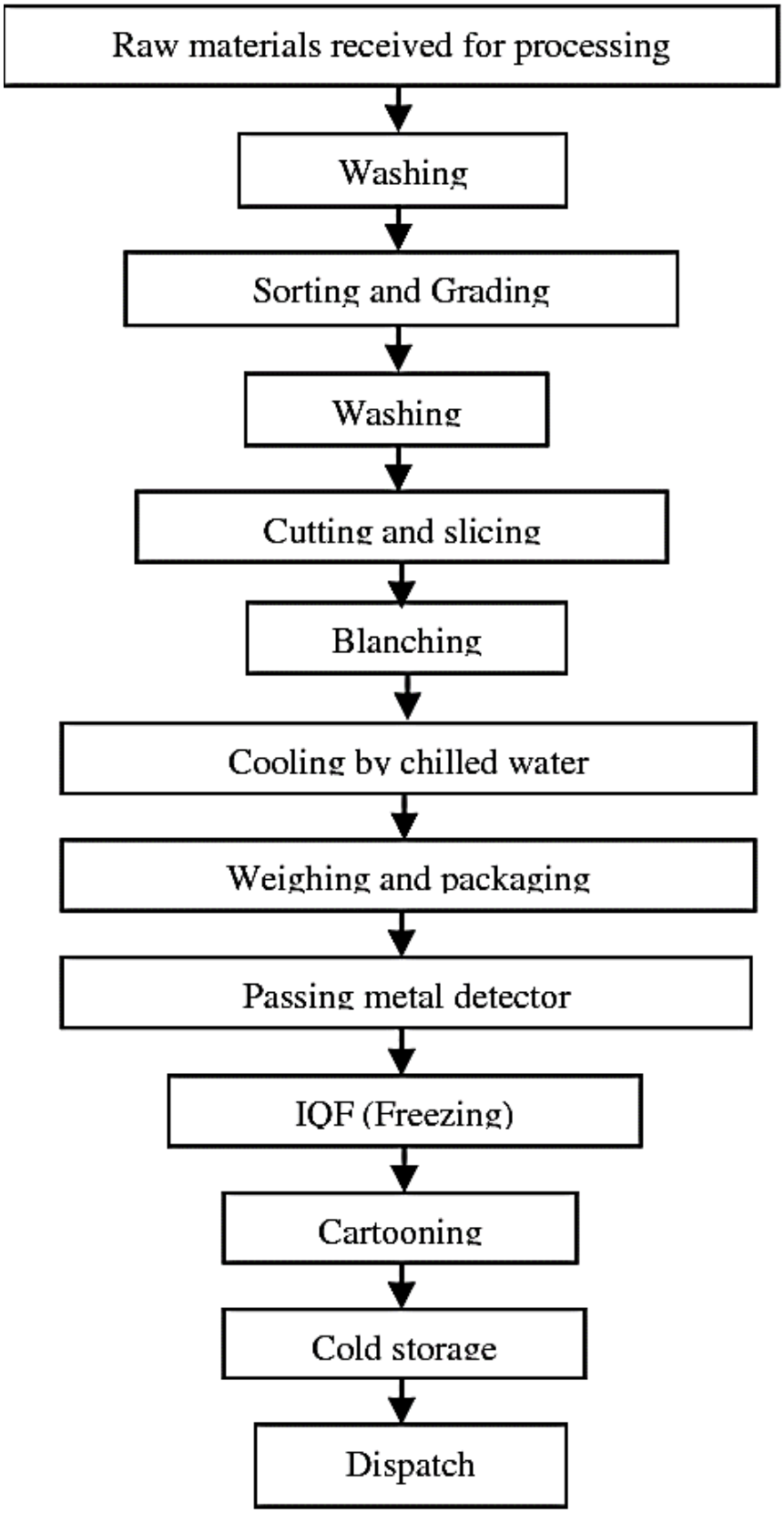
2.1 Equipments of freezing

1) Freezer/cold room
2) Quick freezing Equipments- fluidized bed freezer, automatic package freezer, continuous plate freezer, continuous can freezer
3) Direct Immersion equipments- Brine Freezer, Frog freezer, and Bartlett freezer
4) Rotating cold drum
5) Foot operated polythene bag sealer- sealing polyethylene bags of different gauges after filling ofvegetables

2.2 Methods of freezing

i. Quick (0 to -40 0C for 30 min.)
ii. Sharp (-15 to -29 0C for 3-72 h)
iii. Cryogenic (-196 0C)
iv. Dehydro-freeing (50 % moisture removed)

2.3 Freezing Process Flow chart



2.4 Freezing Overview

- Frozen in many forms – Whole, sliced, crushed, juiced etc.

- Best quality- choose fully ripe, but firm, fruit – Immature or overripe produce lower quality when frozen

2.5 Types of Packs; – Syrup pack, Sugar pack, Dry pack, unsweetened and water packs.

2.6 Storage Times

Fruits – Most frozen fruits maintain high quality for 8 to 12 months – Unsweetened fruits lose quality faster than fruits packed in sugar or sugar syrups.

2.7 Summary

- Freezing fruits is a safe, easy way to preserve foods
- Wash allvegetables thoroughly
- Follow blanching charts for vegetables
- Use proper procedures and equipment, including freezer-safe materials
- Use the freezing process that works best for your family meal needs

3. Drying method:

One of the oldest methods of preserving food and its alternative to canning & freezing.

It is Simple, safe and easy to learn, in this no refrigeration needed and it takes little space.

It removes moisture from food so bacteria, yeasts and molds can't grow and spoil food.

It slows down action of enzymes but doesn't inactivate them.

3.1 Factors affecting drying of fruits

- Surface area – The greater the faster the product dries
- Temperature – The greater the difference between the product and drying medium, the greater the rate of drying
- Humidity – The higher, the slower the drying
- Atmospheric pressure – The lower, the lower the temperature required to remove water.

3.2 Binding of Water

As a product dries, its free and water is removed .This water evaporates first, water in colloidal gels, such as starch, pectin or other gums is more difficult to remove. Water that is most difficult to remove is that chemically bound in the form of hydrates.

3.3 Methods of Drying

- Sun drying: in Dry, warm climates
- Spray drying – Tray (air) drying
- Tunnel drying – The **tunnel dryer** is a machine where a container (tray) filled with the material is placed on a trolley or the material is loaded directly on the trolley, and the

trolley is pushed in from the **tunnel** chamber entrance. The material is **dried** while being moved through the **drying** chamber.

Juicing

What is juicing?

Juicing is a process that extracts the juices from fresh fruits. The resulting liquid contains most of the vitamins, minerals, and antioxidants naturally present in the whole fruit or vegetable.

A wide range of drinks can be made using extracted fruit juice or fruit pulp as the base material.Many are drunk as a pure juice without the addition of any other ingredients, but some are diluted with sugar syrup.The types of drink made from fruit can be separated into two basic types;

- those that are drunk straight after opening
- those that are used little by little from bottles which are stored between use.

The former groups should not require any preservative if they are processed and packaged properly. However, the latter group must contain a certain amount of permitted preservatives to have a long shelf-life after opening. The different types of drink are classified according to the following criteria:

Type	**Description**
Juices	Pure fruit juice with nothing added
Nectars	Normally contain 30% fruit solids and are drunk immediately after opening
Squashes	Normally contain at least 25% fruit pulp mixed with sugar syrup. They are diluted to taste with water and may contain preservatives
Cordials	Are crystal-clear squashes
Syrups	Are concentrated clear juices. They normally have a high sugar content

Each of the above products is preserved by a combination of natural acidity, pasteurisation and packaging in sealed containers. Some drinks (syrups and squashes) also contain a high concentration of sugar which helps to preserve them.

Equipment required

- Peeler
- Measuring cylinder
- Knives (stainless steel)
- Capping machine
- Cutting boards

- Wooden spoons
- Juice extractor
- Plastic funnels
- Thermometer
- Plastic buckets
- Analytical balance
- Strainers
- Stainless steel saucepan
- 10kg scales
- Cleaning equipment (brushes, scourers, cloths, hosepipes etc) 2 gas cylinders, 2- or 3-ring burners.

Method of production

For all the fruit based beverages, the first stage is the extraction of juice or pulp from the fruit.The following are the key manufacturing stages:

1. Selection and preparation of raw material
2. Juice extraction
3. Filtration (optional)
4. Batch preparation
   Pasteurisation
5. Filling and bottling.

Any fruit can be used to make fruit juice, but the most common ones include pineapple, orange, grapefruit, mango and passion fruit.Some juices, such as guava juice, are not filtered after extraction and are sold as fruit nectars.

Preparation of raw material

Select mature, undamaged fruits.Any fruits that are mouldy or under-ripe should be sorted and removed.Wash the fruit in clean water.It may be necessary to chlorinate the water by adding 1 tablespoon of bleach to 5 litres of water. Peel the fruit and remove stones or seeds. If necessary, chop the fruit into pieces that will fit into the liquidiser or pulper.Remember that at this stage, you are exposing the clean flesh of the fruit to the external environment.Make sure that the utensils are clean.Do not leave the cut surfaces exposed to the air for long periods of time or they may start to turn brown and this will discolour the juice.The fruit pieces can be placed in water that contains lemon juice (250ml lemon juice per litre of water) to stop them browning.

Juice extraction

There are several methods to extract juice depending on the type of fruit you use. For citrus fruits which are naturally juicy, the best option is to use a hand presser (see figure 1) or a revolving citrus 'rose'.Some fruits such as melon and papaya are steamed to release the juice.Apples are pressed and fruits such as mango, guava, soursop, pineapple, strawberry must be pulped to extract the juice.The fruit pieces are pushed through a perforated metal plate that crushes and turns them into a pulp.Some fruits can be pulped in a liquidiser and then filtered to remove the fruit pieces.There is a range of equipment available that varies in size and in the type of power supply (some are manual while the larger ones requireelectricity). For the small scale processor, the Figure 1below: **Hand presser**



At slightly higher production levels, it is necessary to use a power source to achieve a higher throughput of juice. The multi-purpose food mixers are strongly recommended.

For large-scale production, an industrial pulper-sieving machine is necessary.This also acts by forcing the fruit pulp through a fine cylindrical mesh.

Filtering

To make a clear juice, the extracted juice or pulp is filtered through a muslin cloth or a stainless steel filter.Some of the larger filter presses have a filter included.Although juice is naturally cloudy, some consumers prefer a clear product.It may be necessary to use pectic enzymes to break down the pectin and to help clear the juice.Pectic enzymes may be difficult to find and expensive and therefore should only be used if really necessary and readily available.

Batch preparation

When the juice or pulp has been collected, it is necessary to prepare the batch according to the chosen recipe.This is very much a matter of choice and judgement, and must be done carefully to suit local tastes.Juices are sold either pure or sweetened.Fruit squashes would normally contain about 25% fruit material mixed with a sugar syrup to give a final sugar concentration of about 40%.Squashes are diluted with water prior to use and, as the bottle is opened, partly used and then stored, it is necessary to add a preservative (for example 800ppm sodium benzoate).

Another popular product is fruit nectar, which is a sweet mixture of fruit pulp, sugar and water which is consumed on a 'one shot' basis.Essentially, these consist of a 30% mix of fruit pulp and sugar syrup to give a final sugar level of about 12-14%.

All fruits contain sugar, usually around 8-10%.The actual levels vary from fruit to fruit and with the stage of ripeness of the fruit. They also vary within the same fruit grown in different parts of the world.The addition of sugar to the fruit pulp to achieve the recommended levels for preservation must take into account the amount of sugar already present in the juice. It is important to achieve the minimum level that will prevent the growth of bacteria, however, once that level has been achieved, it is possible to add more if the consumers require a sweeter product. The amount of sugar added in practice is usually decided by what the purchasers actually want. The Pearson Square is a useful tool to use to help with batch formulation (see the appendix) and to calculate the amount of sugar to be added for preservation.

In all cases, sugar should be added to the fruit juice as a sugar syrup. The syrup should be filtered through a muslin cloth prior to mixing to remove particles of dirt which are always present.This gives a clearer, higher quality product.

Pasteurisation

All the products mentioned above need to be pasteurised at 80-95°C for 1-10 minutes prior to hot-filling into bottles.At the simplest level, this may be carried out in a stainless steel, enamelled or aluminium saucepan over a gas flame, but this can result in localised overheating at the base of the pan, with consequent flavour changes.

Care is needed when producing pineapple juice due to a heat resistant enzyme in the juice.The enzyme damages skin after prolonged contact and workers should therefore wear gloves to

protect their hands.The juice must be heated to a higher temperature for a longer time to destroy the enzyme (eg boiling for 20 minutes).

It is best to use stainless steel pans to heat fruit juice as the acidity of the juice can react with aluminium in aluminium pans during prolonged heating. However, large stainless steel pans are very expensive and may not be affordable by the small scale processors.To get round this problem, it is possible to use a large aluminium pan to boil the sugar syrup.The boiling syrup can then be added to a given amount of fruit juice in a small stainless steel pan.This increases the temperature of the juice to 60-70°C.The juice/syrup mixture is then quickly heated to pasteurising temperature.

Table 1: Pasteurisation times at 80°C

Bottle size (litres)	**Pasteurisation time at 80°C (minutes)**
0.33	10
0.5	15
0.75	20

Another option is to pasteurise the juices once they have been bottled.The bottles are placed in a hot water bath which is heated to 80°C. The bottles are held in the hot water for the given amount of time until the contents reach the desired temperature.The length of time required in the water bath depends on the size and volume of the bottles (see table 1).A thermometer should be placed in one of the bottles, which is used as a test bottle per batch, to monitor the temperature and to ensure that

Table 1: Pasteurisation times at 80°C for the correct temperature has been reached. This different bottle sizes method of pasteurisation has benefits but also has problems.

Table 2: The pros and cons of pasteurising within after bottling

Benefits	**Problems**
Juice is pasteurised within the bottle so the chance for re-contamination of the juice is reduced	Difficult to ensure the internal temperature of the bottles reaches the desired pasteurising temperature
No need for large stainless steel pans for pasteurisation	Require glass bottles for pasteurising

The next industrial jump in pasteurisation is an expensive option that involves the purchase of a double-jacketed steam kettle in stainless steel and a small boiler.The total cost is likely to be

in the region of £5-10,000, which is only viable for larger scale operations.

Filling and bottling

In all cases, the products should be hot-filled into clean, sterilised bottles.A stainless steel bucket, drilled to accept a small outlet tap, is a very effective bottle filler.The output can be doubled quite simply by fitting a second tap on the other side of the bucket.This system has been used to produce 500-600 bottles of fruit juice per day in the West Indies.

After filling hot, the bottles are capped and laid on their sides to cool prior to labelling.

Quality control

The freshness and quality of the expressed fruit juice is central to the quality of the final product.As soon as the juice is expressed from the fruit it starts to deteriorate, both as a result of chemical activity (enzyme action) and bacterial spoilage.It is important to move from the juice extraction stage to pasteurisation as quickly as possible to minimise any spoilage.

Extracted fruit juice that is left to stand for long periods in the heat will start to ferment and may start to discolour due to enzyme activity. The juice should be stored in a refrigerator (if one is available) or in a cool place and away from the direct sunlight.It should be collected into a clean, sterile container (food grade plastic buckets is the best option) and covered to keep out dirt, dust and insects.For the best quality product, it is essential to work quickly between the extraction of the juice and the bottling stage. The longer the juice is out of the bottles, the more chance there is of contamination.

As in all food processing enterprises it is necessary to ensure that the fruit products are correctly formulated and priced to meet the customer's requirements, and that production costs are minimised to ensure that a profit is made.The quality of each day's production should be monitored and controlled to ensure that every bottle of juice has the correct keeping and drinking qualities.In particular the following points should be observed:

- Only fresh, fully ripe fruit should be used; mouldy or insect damaged fruit should be thrown away.All unwanted parts (dirt, skins, stones etc) should be removed.
- All equipment, surfaces and floors should be thoroughly cleaned after each day's production.
- Water quality is critical. If in doubt use boiled water or add one tablespoon of bleach to

5 litres of water to sterilise it.If water is cloudy, a water filter should be used.

- Pay particular attention to the quality of re-usable bottles, check for cracks, chips etc and wash thoroughly before using.Always use new caps or lids.
- The concentration of preservative should be carefully controlled for correct preservation of squashes and cordials, and may be subject to local laws.Check first and use accurate scales to measure the preservative.
- The temperature and time of heating are critical for achieving both the correct shelf life of the drink and retaining a good colour and flavour.A thermometer and clock are therefore needed.
- The correct weight should be filled into the bottles each time.

These factors are important because a customer will stop buying the products if the quality varies with each purchase.

The use of chemical preservatives in fruit juices and fruit drinks

As the name suggests, pure fruit juice is solely the extracted juice of fruit and should not have any preservative, or any other ingredients (such as sugar) added.

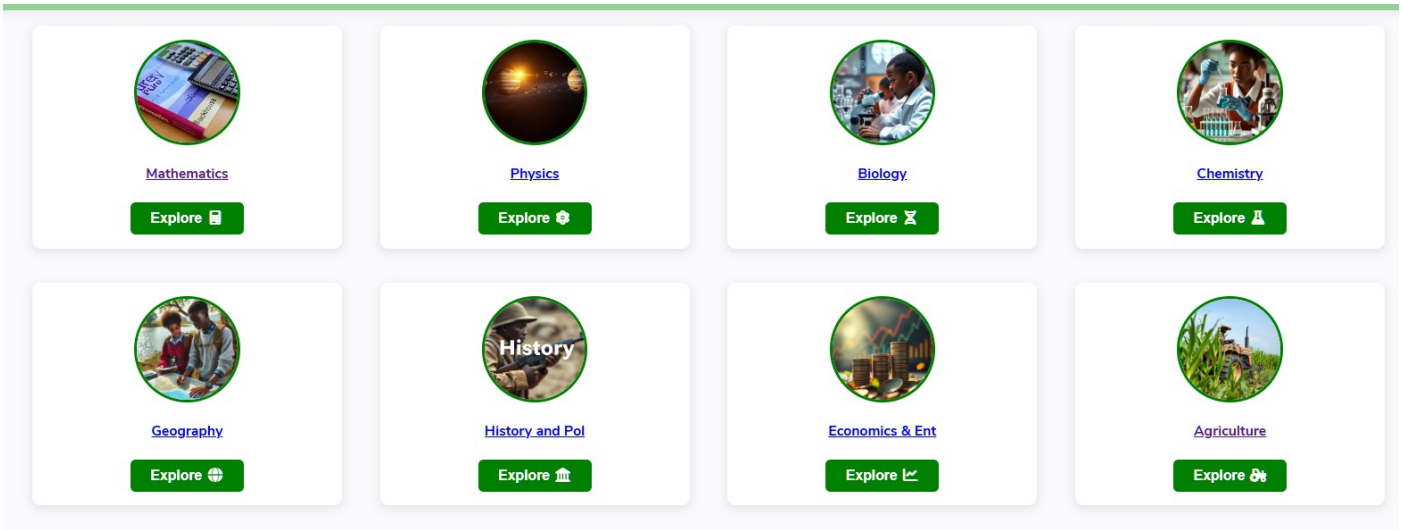
Fruit drinks that are not consumed in one go can have preservatives added to help prolong the shelf life once they have been opened.

There are several chemical preservatives that can be added to fruit juices.Processors need to check with local authorities or standards agencies to find the maximum permitted levels.

Table 3: Permitted preservatives used in fruit juices and beverages.

Compound	Comments	Commonly used levels
Sulphites and sulphur dioxide	Sulphur dioxide gas and the sodium or potassium salts of sulphite, bisulphite or metabisulphite are the most commonly used forms. Sulphurous acid inhibits yeasts,	0.005-0.2%
	moulds and bacteria. Sulphur dioxide is mainly used to preserve the colour of fruits during drying.	
Sorbic acid	Sorbic acid and sodium and potassium sorbate are widely used to inhibit the growth of moulds and yeasts. The activity of sorbic acid increases as the pH decreases. Sorbic acid and its salts are practically tasteless and odourless in foods when used at levels less than 0.3%.	0.05-0.2
Benzoic acid	Benzoic acid, in the form of sodium benzoate is a widely used preservative.It occurs naturally in cranberries, cinnamon and cloves and is well suited for used in acid foods. It is often used in combination with sorbic acid at levels from 0.05-0.1% b y weight.	0.03-0.2%
Citric acid	Citric acid is the main acid found naturally in citrus fruits. It is widely used in carbonated beverages and as an acidifier of foods. It is a less effective anti-microbial agent than other acids.	No limit

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