TC Banana Farming

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1. Introduction

Bananas are a major staple food as well as a cash crop for thousands of small scale farmers in East Africa. In Kenya, bananas are mainly grown in the western and central provinces. In Tanzania, there is a concentration of banana production around Arusha while in Uganda banana production is widespread. Within the region, bananas are traditionally consumed either in the ripe state or cooked using different methods. Banana is considered a healthy and nutritious food and has traditionally been used as baby food.

Tissue culture (tc) techniques have been used in Kenya over the last ten years to produce large quantities of disease-free banana planting material. Tissue culture (tc) is a form of biotechnology that refers to the production of plants from very small plant parts, tissues or cells grown aseptically under laboratory conditions where the environment and nutrition are rigidly controlled. The basis of the tc technology lies on the ability of many plant species to regenerate a whole plant from a plant part. To ensure farmers' easy access to tc plantlets in various parts of the country, hardening nurseries are critical.

This Booklet presents the steps involved in the each stage of a tc banana farming from Hardening to processing of final product.
It draws out experience from a 5 - year ISAAA partnership project in East Africa with support from MATF of FARM Africa.

2. How to Establish a Tissue Culture Banana Hardening Nursery

The tissue culture banana plantlets production process

Multiplication of tissue culture derived banana plantlets entails 4 main stages;

Stage one: Sourcing of starter material

This involves selection and obtaining suitable young suckers from the desired cultivar in a healthy vigorously growing banana orchard. The suckers are washed with tap water and soap to remove soil. They are then reduced in size before being taken to the laboratory where they are sterilized with a disinfectant. The clean plants are then dissected leaving a small part of the corm which is placed into a growth media under sterile conditions. The plants (now referred to as explants) are then placed in a growth chamber under controlled temperature and humidity.

Stage two: Multiplication of explants

After about one month the explants start producing other small plants (referred to as plantlets). These are separated and placed into new media and consequently produce new plantlets. This multiplication process continues for a maximum of five cycles whereby each cycle multiplies at a factor of at least four shoots every month and about 1000 plantlets are produced in six months (Table 1).

Table 1: An example of a multiplication schedule of tc banana plantlets

Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Multiplication cycles	0	1/2	01	02	03	04	05
No. of plantlets	1	4	16	64	256	1024	4104

Fig 1 Stages of tc multiplication

Stage three: Rooting

The explants are then transferred to a medium which has a combination of hormones that makes them produce roots.

Stage four: Hardening

This entails nurturing the delicate plantlets to adjust to the outside environment in preparation for field planting in a hardening nursery.

What is a tc banana hardening nursery?

This is a structure in which the plantlets from the laboratory are kept before transferring them to the field.

The nursery is important because;

- It enables careful nursing of the delicate (juvenile) plantlets.
- The plantlets occupy little space and therefore save labor during their early unproductive life.
- The plantlets are protected from harsh field conditions in the early stages of growth.
- Ensures uniformity in establishment and production.

Banana hardening nursery under farmers' conditions

Establishing the hardening nursery

What criteria do you use for siting?

- Should be located in a banana growing area
- Accessibility
- Availability of water
- Area free from pests such as insects, fungi, nematodes, weevils
- Fenced to protect seedlings from external damage

Soil mixtures

The soil should comprise of top /forest soil plus any of the following; gravel, rice husks, sawdust, wood shavings, wood bark, or sand at a ratio of 6 parts to 1 part. Fertilizer application is not necessary at this stage.

Soil sterilization

It is important to sterilize soil to kill harmful organisms such as soil-borne fungal diseases, nematodes and weeds. This can be done through either steam sterilization, soil solarization or chemical sterilization.

a) Steam sterilization procedure

This involves heating soil with a steam-air mixture. A simple steam sterilization kit is illustrated in figure 2. Two drums are required, an upright drum filled with moist soil mixture and a horizontal one half-filled with water which is then heated at 60-70^0 C. The steam produced sterilizes the soil and then emerges through the top lid after which a thirty minutes (30) sterilization period is observed/recommended.

Steam sterilization improves the soil physical structure, is harmless to beneficial organisms in the soil, cheap and more effective than chemicals. The main disadvantage is the use of firewood which may be costly and environmentally unfriendly.

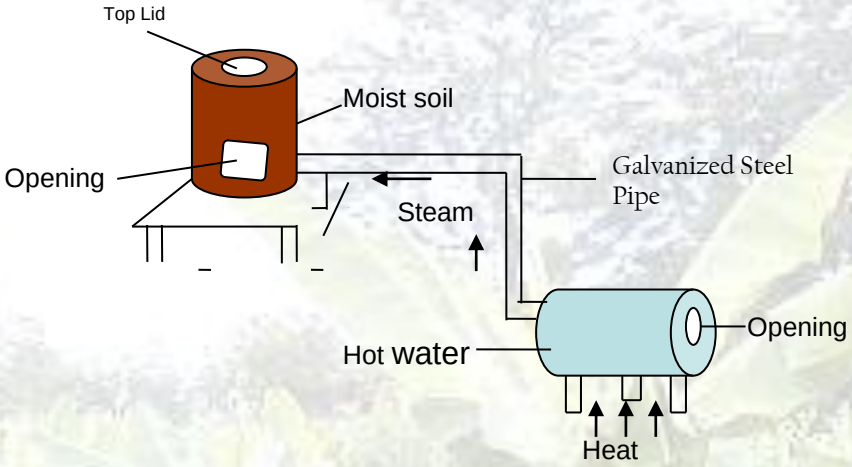

Fig. 2: A Simple Soil Steam Sterilization Kit

b) Soil Solarization

This involves using solar energy to heat the soil. The soil is collected and spread in a shallow 'pit' then covered with a clear polythene sheet in an open area to allow sunlight to penetrate. It takes 30-60 days depending on the weather.

c) Chemical Sterilization

This involves the use of chemicals. The commonly used chemicals are furadan (2kg per tonne of moist soil); mocap 10G (3kg per tonne) and Basamid (one tonne=2 pickup trucks =80 wheelbarrows). The soil is spread in a nursery-like bed and sprinkled with some water to moisten it. The chemical is mixed thoroughly with soil and mixture covered with polythene. After one week, the soil is turned over and covered again. After the second week the soil is completely uncovered, turned and left open for any leftover fumes to diffuse out. The soil is ready for use after three weeks.

Note: Manure and compost should not be sterilized, but added after the soil has been treated.

Nursery structure
The materials required for construction of a simple nursery shed and costs are given in Table 2. This cost can be reduced by utilizing locally available materials.

Nursery Tools and Equipment
Various tools are needed: potting bags, potting trays, polysheets, jembes, fork jembes, spades, rakes, trowels, buckets, wheel barrows, watering cans, horse pipes, and a store.

Transplanting of Plantlets from Laboratory to Nursery

- Tunnels and/or trays into which the plantlets will be transplanted are prepared by making a nursery bed containing sterile soil mixture.
- Rooted plantlets are removed from the growth chamber and removed from jars, variety per variety.
- The media is washed off gently without injuring the plantlet.
- The plantlets are taken to the hardening nursery shed as soon as possible preferably the same day and transplanted into seedling trays or tunnels in rows.
- They are then watered twice or once a day depending on weather conditions.
- One month later, they are transferred into 6 X 9 polythene bags containing sterilized soil and manure.

The seedlings are monitored regularly for somaclonal variants. Any plants showing unusual growth habits are removed and kept aside for further observation. Some varieties may show some purplish coloration on the leaves which is normal in the early stages of growth. The seedlings are ready for field transplanting after two months when they are about one foot tall and have at least five leaves.

Nursery hygiene and organization

- Should be kept clean and free from weeds
- Pests and diseases should be controlled immediately they are spotted.
- Seedlings should be arranged in neat rows with clear paths for walking and transportation.
- Varieties should be separated and labeled accordingly, showing date of transplanting and number of seedlings for ease of marketing.

Advantages of using tissue culture method for multiplication of banana seedlings

- The planting material produced is free from pest and disease
- It is a rapid method of multiplication
- Uniformity in establishment and production is achieved
- Production of banana fruits is obtained after 9-10 months
- The yields are higher
- Easy transportation and /or importation of new varieties is made possible

Challenges of using tissue culture method for multiplication of banana seedlings

- The price of tc plants is higher compared to conventional suckers.
- The plants require added care and management.
- The occurrence of off-types (somaclonal variants) is possible. These mutations are usually inferior and can lead to dwarfing or other undesired morphological features.
- Viruses are not eliminated through tissue culture process.

Some sources of tc banana plantlets

- Kenya Agricultural Research Institute-Thika
  P.O. BOX, 220 Thika Tel: +254 - 20 - 2055038

- Jomo Kenyatta University of Agriculture and Technology, P.O BOX, 62000, 00200 Nairobi Tel: +254 - 67 - 52711

- Genetics Technology International Limited,
  P.O. BOX, 47430, 00100 Nairobi

- Mimea International Limited
  P.O. BOX, 4583-00506, Nairobi Tel:+254-020-3540892

- Others are;
  OKOSAMBU nursery-Kisii, Gemack - Murang'a, Wangu investments - Murang'a, Catholic Diocese – Embu, Aberdare Technologies – Thika, Gakindu – Nyeri, Kibirigwi supported by JKUAT – Kirinyaga among many others

Some varieties that are available include;

Desert Varieties:
Grand Nain; Williams, Giant Cavendish, Dwarf Cavendish, Chinese Cavendish, Chinese Dwarf, Lacatan, Paz, Valery, Pelipita, Solio.

Cooking Varieties:
Ngomb'e, Nusu Ngo'mbe(gradi) and Uganda Green.

Cost of Establishing a Hardening Nursery

Capacity: About 2,000 plantlets
Size: 4 M (Width) X 7 M (Length) X 3 M (Height)

ITEM	Price per Unit	Total (KSH)
Shade net 74 M 2	54.00/m2	3,996
1 roll Chicken wire	5,000	5,000
8 Posts, 1 Door, Timber, 4 kg Nails, 1 Metal pipe, 2 Elbows, 1 union	-	9,440
2 soil sterilization drums, 1 drum for water storage, 1 hosepipe, 2 watering can,	-	8,100
1 ton Ballast	-	3,000
2,000 poly bags, 10 M Polythene sheet	-	4,500
Labour	5,000	5,000
Contingencies	10%	3,903
Total		**42,939**
Total cost in dollars approx.		**US$ 660**

Notes:

- **Invitro tc materials costs Ksh 40 – 60 approx. US$ 0.8 – 1**
- **Ready tc plantlets costs Ksh 80 – 100 approx US$ 1.2 - 1.5**
- **Profit margin of operating a tc hardening nursery is estimated to be 30%**

3. Banana Orchard Establishment and Management

Introduction

In Kenya, banana is an important horticultural crop in terms of area and income generation. The crop is predominantly grown by small scale farmers who have an average banana holding of 0.3 hectares making up to 13% of total farm area on average. Besides providing a continuous income to the farmer, banana is a staple food to the rural and urban populations, and it ensures food security all year round. Major cultivars in Kenya include Muraru, Cavendish, Ng'ombe, Grand Nain and Williams among others.

Climate and soil requirements

Banana is a tropical crop and thrives from 0 -1800 m above sea level, with rainfall requirements of 1000mm annually. Temperatures of 27˚C are optimal. The crop does well in deep, well drained loams of high fertility and high content of organic matter.

Planting Material

Bananas are asexually propagated using suckers or tissue cultured plantlets.

Tissue-cultured plantlets

Tissue culture (tc) is a technique that allows mass multiplication of planting materials. It is a form of biotechnology that refers to the production of plants from very small plant parts, tissues or cells grown aseptically under laboratory conditions where the environment and nutrition are rigidly controlled. The basis of the tc technology lies on the ability of many plant species to regenerate a whole plant from a plant part. Using tissue culture, it is possible to produce 1000 plantlets from one sucker in one year in comparison to ten suckers produced per banana in the same period.

Advantages of tc technology

- Plants are free from pests and diseases
- Faster growth and early maturity (9-10 months after planting)
- Uniformity in production, and hence essential in marketing
- Higher crop yields as compared to conventional bananas

Banana Orchard Establishment

A farmer should observe the following sequential stages in establishing an orchard

a) Site selection

The site should have shelter against winds, free from hail storms, should not be prone to water logging and salinity, and should be close to reliable water supply.

b) Land preparation

Deep plough the land (200 -300mm) until a fine tilth is reached. Install soil conservation measures on sloping land. Bench terraces and contour channel banks covered with grass are ideal.

c) Hole Preparation and Planting

Dimension of the holes should be 60cm x 60cm x 60cm. Dig deeper holes measuring 90cm x 90cm x 90cm in dry areas. Deeper holes are also recommended for tc plantlets due to their tendency to "push-up".

Separate the top soil (0-30cm) from the sub-soil. Mix top soil with 2 -3 *debes* of well decomposed manure and 200g of DAP and return half of the mixture into the hole. Carefully remove the tc plantlet from the plastic bag making sure the soil in the bag does not break-up. Place the tc plantlet into the hole, and put the rest of the soil mixture. The plantlet should be covered up to the level where the soil in the plastic bag had reached. Use the sub-soil to make a basin around the plant.

d) Spacing

Spacing depends with the banana height. For tall varieties, space the plants at 4.0m x 4.0m (625 plants/ha). Medium height varieties can be spaced at 3.0m x 3.0m (1110 plants/ha), and 3.0m x 2.0m (1667 plants/ha) for short varieties.

e) Weed control

Remove the weeds regularly, especially when the leaf canopy is not well established. Herbicides can be used but only when the plants are over 2 m tall.

f) Fertilizing and manuring

Apply 200g of Calcium Ammonium Nitrate (CAN) and 2 debes of manure every year. This should be bone twice a year during the rainy seasons.

g) De-suckering, mulching and Leaf removal

Remove all suckers until the mother plant is 5-6 months old. Destroy the middle of the cut suckers to avoid re-sprouting. After 5-6 months select follower suckers to ensure the banana stool has 3 plants as follows: One bearing or nearly bearing mother plant, one large daughter, and one small granddaughter sucker. Remove dry leaves hanging down the plant and any leaves rubbing the banana fingers to avoid bruising and improve fruit quality. Use the leaves as mulch for conserving moisture, to reduce weed growth and improve soil nutrient level. Spread the mulch evenly at least six inches away from the stems.

h) Bunch trimming

Break off the male flower bud, once the bunch has fully emerged. The bud will otherwise compete for food and is often a shelter for banana pests.

i) Watering:

Irrigate your plants immediately after planting. Irrigate newly-planted tissue culture banana plants everyday for 2 weeks to protect leaves from heat stress. Water your orchard regularly especially during the dry spells. Water requirements vary with the area although banana does best with plenty of water.

j) Yield

Banana annual yield depends on climatic conditions, plant management and the banana variety. Below table shows average results of trials conducted in six sites across Kenya. Good orchard management is crucial for high yields.

Table 1 Yields of major banana dessert varieties in Kenya produced through tc

Banana variety	**Average Yield (tons/ha/yr)**
Chinese Cavendish	46.0
Dwarf Cavendish	43.3
Gold Finger	39.8
Grand Nain	50.1
Maturity Period (Av. no. of months)	11

Major Diseases and Pest

Diseases

a) Sigatoka leaf Spot

It is an important banana problem in most part of the country that causes up to 50% loss in yields.

Symptoms include; dark brown streaks on lower leaf surface that enlarges to necrotic lesions with yellow halos and grey centers.

Control:

- Chemical control – Alternate application of systemic and broad spectrum fungicides.
- Cultural Practices – Remove all infected leafs, observing good spacing and good drained soils.
- Resistance – Currently the FHIA varieties show resistance but they are mainly suitable for cooking

b) Cigar-end Rot:

It is an important disease in most banana growing areas.

Symptoms: A dry rot with an ashy appearance of the fruit tips. The rot affects a few centimeters of the tips and develops with the fruit growth. The pulp develops as a dry rot and becomes fibrous.

Control:

- Remove all dry floral parts from fruit tips.
- Remove flower parts 8-11 days after fruit bunch emergence.
- Space plants appropriately and prune out excess suckers.

c) Panama disease (*Fusarium* Wilt):
This is a soil-borne disease and infects the plant through roots, corn and wounds. it is a major problem all banana growing areas in Kenya.

Symptoms: Infected plants show yellowing of leaves starting with the old leaves. Petiole collapses causing the leaves to droop. Leaves become brown and die. In some cases, the outer leaf sheaths of the pseudostem may split longitudinally near the soil level. Eventually, large portions of the xylem turn a brick red to brown color.

Control:

- The most effective method of control is use of resistant plants. Resistant hybrids have been produced but they generally they lack desirable attributes such as flavor, taste or post-harvest qualities.

Pests

a) Nematodes

The root knot nematodes and burrowing nematodes are a big problem. They are dispersed through infested plant material.

Symptoms: Yellowing of the leaves, growth ceases retarded rhizome development and toppling of mature plants. Root examination show brown lesions.

Control:

- Chemical control using nematicides
- Cultural control
    - Remove diseased tissues and expose them to sun.
    - Hot water treatment can also be used. Immerse suckers in hot water (55C) for 20 minutes.

b) **Banana Weevil:**
It is common in all banana growing areas of Kenya.

Symptoms: Irregular tunnels on the pseudostem and rhizome. Rhizome with numerous tunnels is reduced to blackened mass of rotten tissue. These tunnels may extend to a few meters up the pseudostem. Leaves turn yellow, wither and die prematurely.

Control:

- Chemical control
    - Dip suckers in a 20% neem seed solution at planting
- Cultural control
    - establish new orchards in uninfected fields using tissue cultured plantlets
    - Where tissue culture is not available, use pared suckers to remove weevil larvae and eggs.
    - Do not use badly damaged suckers for planting.
    - Immerse pared suckers in hot-water baths of 52-55°C for 15-27 minutes.
    - Trapping with pseudostem or rhizome pieces reduces populations of adult banana weevils.

- Crop sanitation (i.e. destruction of residues) eliminates weevil refuges and breeding sites

c) **Banana Silvering thrips:**
Fruit is attacked at all stages

Symptoms:. The damaged areas develop a silvery blemish, spotted with the thrips' dark excreta. In severe infestations the blemish may be reddish brown, and deep longitudinal cracks may develop in the blemished skin.

Control:

- New fields should be planted with tissue-cultured bananas.
- Keep the field weed free as silvering thrips breed on some weeds.
- Proper pruning and thinning of the orchard.

Post harvest handling and utilization

A. Harvesting

Harvest the banana when the fingers are three quarters round, appear light green and shiny. Remove bunch by cutting into pseudostem while supporting the bunch with a pole. Slowly lower it to the ground.

B. Packaging

Hang the bunch on a dehanding rail under shade. Use a sharp knife to detach the hand from the stalk. Immerse the detached hands into a water bath for 10 minutes. Dip the hands into fungicide solution to reduce incidences of crown rot. Then allow the hands to drip dry on clean benches.

C. Ripening

Use a ripening chamber (box) to get uniformly ripened bananas. Place bananas in the ripening chamber in crates or loose hands. Place passion fruit, avocado, pawpaw, peach or plum in the chamber to supply ethylene that initiates the ripening process. Close the chamber air-tightly, and only open every 24 hours for 2-3 days.

D. Banana Utilization and nutritional Value

Banana fruits can be consumed in raw or ripened forms (dessert). Banana fruits can also be processed to banana flour by dehydration and then milling. The flour can be used to fortify (add value) other products. It can also be used in bread, cakes, porridge and other banana confectionaries. Banana can also be processed to juice, wine, banana crisps.

E. Nutritional value

Composition	Percentage (%)
Moisture	75.6
Total sugar	20.4
Starch	1.2
Crude Fibre	0.6
Protein	1.2
Fat	0.2
Ash	0.8
Caloric value	95 calories per 100g

4. Processing: Drying and Milling Technology for Small-Scale Banana

Background:

Fresh bananas are highly perishable and post-harvest losses of 20-35% have been reported (FAO, 1987). With the recent and ongoing success in the use of tissue culture (tc) technology in banana production in the region (Wambugu and Kiome, 2001; Karembu 2007), there is a need for value-addition through preservation methods such as solar drying to create more stable products and diversify utilization of bananas. Against this background, ISAAA *Afri*Center with support from the Maendeleo Agricultural; Technology Fund (MATF) of FARM Africa, has been working with local and regional partners in the banana sub-sector value-chain to introduce several banana value-adding technologies.

Conversion of bananas into value-added products such as banana flour, baked products, banana juice, wine and snacks (crisps, dried fruit desert) offers broader utilization of the produce. Banana flour for example can be produced by solar or hot air drying followed by milling, resulting into a product with longer shelf-life at room temperatures, thereby reducing post-harvest losses. Banana flour is a high nutrient density product especially with respect to minerals and vitamins and can be mixed with cereal flours to produce composite flours with improved nutritional quality and sensory (taste, colour, appearance) properties in baked products. Other banana products such as crisps offer shelf-stable and healthy snack alternative to other snacks.

This bulletin outlines the process of making flour from bananas and includes conversion ratios and estimated costs associated with small scale banana flour production as drawn from project experiences.

Process Steps in Conversion of Bananas into Flour

Receiving:
Bananas delivered by farmers are separated by variety, sorted for defects and acceptable bananas are weighed and weight recorded. A receipt is issue to the supplier showing weight and price.

Storage:
The sorted bananas are stored in a secured area with restricted access outside the processing area. Green bananas should be processed within 2-3 days. If ripening is required, the bananas are placed in a ripening chamber in the storage area and removed for snack processing after 3-4 days at the early ripening stage.

Pre-Cleaning:
Before transferring bananas to the processing area, wash banana bunches with clean tap water to remove excess dirt and drain excess water. This prevents transfer of excess dirt and debris into the processing area and reduces the level of contamination in later stages of processing.

1. Cleaned bananas in aluminum basket

Blanching and Peeling:
To soften and loosen the peel, soak bananas in boiling water or steam for 5-10 minutes. This makes peeling easier and reduces the stickiness as well reducing the surface contamination (microbial load) which otherwise can contaminate the peeled banana pulp. During peeling, high standards of personnel hygiene and use

2. Bananas in a blancher

of clean sanitized knives should be observed.

3. Blanched bananas

4. Peeling & slicing bananas blancher

Slicing and Sulfite Treatment:

Peeled bananas are sliced and immediately soaked in 0.05% potassium metabisulfite (KMS) solution in a plastic bucket for 3-5 minutes. This treatment prevents oxidation which causes discolouration (browning). Alternatively, the slices can be soaked in 5% critic acid solution for 3-5 minutes to inhibit browning and also impart a desired flavour in the final product.

The treated banana slices are removed from the sulfite or citric acid solution using a mesh sieve, allowing solution to drain back into the bucket. The drained slices are spread onto clean, dry pre-weighed drying trays in a single layer. The initial weight of each tray loaded tray is taken and recorded.

5. Sulfite treatment banana slices

6. Transfer of banana slices from sulfite solution treatment

Throughout this process, ensure high standards of hygiene of utensils and personnel handling the product.

Solar Drying:

Loaded trays with banana slices are placed on individual drying racks in the solar dryer. Weigh and record the weight of each tray three times daily (morning, mid-day, evening). Continue drying and weighing until the product weights are constant (2-3 days depending on weather conditions). Record the final combined product weight at end of drying process (constant weight stage). Transfer the dried product into sanitized plastic buckets and close with lids.

7. Banana slices on drier trays

As in previous steps, ensure high standards of hygiene of utensils and personnel handling the product during weighing and transfer of dried product into clean sanitized buckets before packaging.

8. Weighing dried banana

9. Dry banana slices on mesh

Packaging:
Bulk pack dried product in moisture proof pre-labeled plastic bags (label information to include variety, and product weight). For each production batch, keep retention samples for quality analysis which should include proximate composition and microbial levels.

10. Packaged dry banana slices

Milling:
The dried product is transferred to the mill house and ground into flour using a "posho" (hammer) mill with appropriate sieve screen. The flour can absorb moisture from the atmosphere and should be packed immediately in pre-labelled (label information on product weight, proximate composition and company name) moisture proof bags in 5-25 Kg packages. The flour can be used as an ingredient in food products). For each production batch, prepare 100 gm retention samples for quality analysis which should include proximate (nutritional) composition and microbial levels for internal product quality records.

Results:
Starting from fresh unpeeled bananas, the dried product yield was 6-7.6% which compares well with the expected yield of 10-14% reported in other studies. The final product moisture content of 12.2-12.6% is very low, limits microbial growth and hence the product has a longer shelf life of over a year. Banana flour obtained in this study has high carbohydrate content of 74-78%, high mineral content, especially potassium: 6-10 g/kg, iron: 15-20 mg/kg, calcium: 8.9-10.2 mg/kg) and a protein content of 5.8-

6.5%. The protein content in banana flour is similar to cereal flours. The level of simple sugars (reducing sugars) in bananas is low, which is beneficial for diabetic individuals.
Bananas are also a good source vitamin B_6, vitamin C, and carotene. With respect to mineral levels, banana flour is superior to cereal flours. The overall composition of banana flour is comparable to cereal flours and can therefore be used to supplement cereal flours in baked products. Formulations of baked products based on composite flours consisting of banana flour are ongoing and should be encouraged to promote broader utilization of bananas.

To ensure high quality and safe products, banana processors will require training on processing technology, basic personnel hygiene and good manufacturing practices (GMPs). Sulfite treatment of banana slices before drying is recommended as it results in a product with better physical properties, especially colour and reduces the levels of microbial loads.

The cost of raw unpeeled bananas used in this study was about US$ 0.15 per kilo. The yield per 100 kilos unpeeled bananas was about 6-8 kilos dried product. This translates to US$ 15 for 6 kilos of flour or US$ 2.5 per kilo of banana flour, compared to about US$ 1.0 per kilo of wheat flour. However, because of its higher nutrient value compared to most cereal flours, banana flour can be used in high nutrient density foods for feeding vulnerable groups such as babies, infants and the elderly.

5. Record-Keeping and Good Hygiene Practices

Activity 1-Process Mapping

Out-put 1: Banana Crisps

1. Receiving-Inspection
2. Sorting
3. Pre-washing-Whole Bunch
4. De-fingering
5. Weighing
6. Storage
7. Blanching (Hot water-Soaking)
8. Peeling & Slicing-weigh peels
9. Rinsing-salt/spices or lemon juice
10. Draining & weighing
11. Deep oil frying
12. Draining excess oil
13. Packaging & Weighing
14. Labeling Packages-external

Activity 2: Record Keeping

Out-put 2: Develop a record-keeping system for the process and products

Records for a small-scale food processing business

Type of Record	**Information to be recorded**
Production records	Recipes-types of products Raw materials & ingredients received (bought) Stocks of each ingredient Production volumes and measurements Wastage % at different stages in process Cleaning program
Quality records	Target amounts of each ingredient and actual usage Measurements on process control Batch numbers for each production Cleaning procedures & schedules
Sales records	Names of customers and amount sold to each Weekly & monthly sales volume
Financial records	Cost of all process inputs Rent Cash in-out flow Profit/loss Bank statements/banking slips Income from sales Staff records Tax records

Examples of records

- Weight and cost of fresh bananas-after de-fingering
- Weight of banana peels/fresh or dried
- Weight of peeled/sliced bananas before frying
- Weight/volume and cost of oil used at start of frying, record weight of any oil added later in the process
- Weight/packages of banana crisps for each day and expenses
- Weight oil at end of each day and cost
- Cost of packaging and labels
- Cost of transport of product to markets

Activity 3: Product Cost Analysis and Pricing

Out-put 3: Establish product costing and pricing based on real data

Cost Elements:

- Raw materials-bananas, oil, spices, water, packages etc
- Labor/production
- Fuel, electricity, cleaning materials
- Equipment wear and tear-replacement allowance
- Marketing-transport
- Other-product spoilage/returns/replacements

See record format table-1 next page

*Divide cost of equipment by 12 months e.g. Ksh 6,000/12 = KSh 500 pm, Assume monthly production is 1,000 packets; 500/1,000 = Ksh 0.5 per packet for equipment

®Rent: Divide monthly rent by production days then by units produced per day

Record Format table-1

No.	Item	Quantity	Unit Cost (KSh)	Total Cost (KSh)
1	Banana (Kg)			
2	Oil			
3	Packaging			
4	carton			
5	Labour			
6	Transport			
Total Cost				
Cost per unit finished product (TC/Units)				
*Equipment wear/tear				
®Rent (daily rate/units produced)				
Product cost per unit				
Selling price (add 25% profit)				

Activity 4: Food Law: Hygiene and Safety Practices

Out-put 4: Create awareness on food law and good hygiene and food safety practices

Why Hygiene is important

- The law, Licenses-requirements
- Food hazards -physical, chemical, germs
- Sources of hazards-bad practices-Environment, people & equipment (utensils)
- Keeping food safe-hygiene & practices-facility design (environment), staff practices (people), equipment (utensils), ingredients (raw materials)

Proper Hand Washing Steps:

- Wet hands with clean water
- Apply soap to hands up to the wrists
- Rub and scrub hands and nails thoroughly
- Rinse hands thoroughly with clean water to remove all traces of soap
- Wipe hands dry with paper towels or apply disinfectant (alcohol)

Table-2 Hazards in Food (Contamination)-Avoid

Type	Example	Sources
Physical materials (foreign)	Hair, stones, sand, metals (nails, coins), paint flakes, bones	People, Utensils, Environment, Pests
Chemical	Soap, cleaning detergent, kerosene,	Cleaning chemicals, cooking fuels
Germs (bacteria, mold, yeast)	Bacteria Mold Yeast	People, Equipment Environment-dirty Pests-rats & insects

Hazards cause disease and product spoilage

The Law requires:
"All food production facilities must comply with the Code of Practice for Hygiene in the Food and Drink Manufacturing Industry"

There are four types of general food laws that govern the sale of all goods, including fruit and vegetable products. These state that;

1. The product should be suitable for its intended purpose
2. It is an offence for anyone to add anything to food, to process it or to sell food for human consumption if it harms consumers' health
3. To protect customers from adulteration of foods or other forms of cheating, it is an offence to sell food that is not of the nature, substance or quality demanded by the purchaser
4. It is an offence to falsely describe a food on the label or in advertising, with the intention of misleading the customer. There are also laws dealing with the safety of foods, the hygiene of operators and sanitation of premises where foods are made.

These laws are concerned with the following aspects of health, hygiene and sanitation:

- Processing that is carried out in unsanitary conditions or where food is exposed to the risk of contamination
- Equipment (which must be able to be cleaned and kept clean)
- Persons handling food and their responsibilities to protect it from contamination
- Building design and construction including water supplies, drainage, toilet facilities, wash-hand basins, provision of first aid facilities, places to store clothing, facilities for washing food and equipment, lighting, ventilation, protection against infestation by rats and insects and removal of wastes. There are also laws dealing with the safety of foods, the hygiene of operators and sanitation of premises where foods are made.

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1. Processing that is carried out in unsanitary conditions or where food is exposed to the risk of contamination
2. Equipment (which must be able to be cleaned and kept clean)
3. Persons handling food and their responsibilities to protect it from contamination
4. Building design and construction including water supplies, drainage, toilet facilities, wash-hand basins, provision of first aid facilities, places to store clothing, facilities for washing food and equipment, lighting, ventilation, protection against infestation by rats and insects and removal of wastes.

Seek advice from Kenya Bureau of Standards, Public Health Officers.

Basic hygiene and sanitation in fruit and vegetable processing

To meet the requirements of the law, the following practices are necessary:

Facilities required in the processing room-Use examples from facility

Discuss Product flow and facility design:

- Foot baths at entrances to premises
- Positioning of lamps/bulbs not directly above
- product handling area

- A changing room where clothing and shoes that are not worn for work can be stored
- Separate hand-washing facilities for staff, with soap, clean water, nail brushes and clean towels
- Toilets, which should be separated from the processing room by two doors or located in a nearby building
- First aid materials/kit
- Protective aprons or coats washed regularly, hats/hairnets and if necessary, gloves and shoes.
- Cleaning chemicals, stored away from the processing room\
- Control of pests, insects etc in processing area
- Security for finished product storage

Ways of working-Good Practices-Use practical examples from facility

- Clean the processing room, toilets, washing facilities and storerooms daily
- Use the correct chemicals to clean equipment, make sure there are no food residues and rinse the equipment with clean water.

- Make sure all cleaning cloths are washed and boiled each day. Do not hang them on equipment, or put them on products or window ledges to dry.
- Do not leave dirty equipment until end of day-cleaning it.
- Keep the area around the processing room clean and tidy. Keep grass cut short.
- Put all wastes into bins that are not used for anything else. Empty the bins regularly during the day away from the processing site. Clean up any spillages as they occur.
- Prevent all animals from entering the processing area or storerooms.
- Visitors should only enter the processing room wearing protective clothing and under supervision.
- No clothes/ or jewellery that can get caught in machinery
- Wear a hat that completely covers the hair. Do not comb your hair in a processing room or storeroom.
- Cover all cuts, burns and sores with a clean, waterproof dressing. Do not handle any food if you have sores, boils, septic spots, a bad cold, sore throat or a stomach upset. Report any of these to the manager and do alternative work
- Do not smoke, chew gum or eat in any room where there is open food because bacteria can be transferred from the mouth to the food.
- Do not spit in processing s/storage room.
- Wash and dry hands thoroughly after using the toilet, eating, smoking, coughing, blowing your nose, combing your hair, handling waste food, rubbish or cleaning chemicals.
- Keep fingernails cut short.
- Do not wear perfume or nail varnish as these can contaminate products.
- Do not cough or sneeze near food.
- Keep food covered wherever possible.
- Keep food, tools and equipment off the floor.
- Keep ingredients in sealed containers.
- Do not use broken or dirty equipment.

- Do not use broken or dirty equipment.

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