



University of Nairobi

## FRUITS AND VEGETABLES FOR ALL SEASONS PROJECT

### TRAINING MANUAL

#### INNOVATIVE POSTHARVEST HANDLING AND SMALL-SCALE LOCAL GUAVA PROCESSING TECHNOLOGIES



With Support from



by decision of the  
German Bundestag

© UNIVERSITY OF NAIROBI  
FACULTY OF AGRICULTURE

## CONTRIBUTORS

This manual is intended to facilitate the theoretical and practical training of farmers, processors, and entrepreneurs interested in processing and preserving the Kenyan guava fruits, which are a neglected crop.

The following contributors have authored this document:

- Mr. Duke Gekonge (Department of Food Science, Nutrition and Technology, University of Nairobi)
- Miss Judith Katumbi (Department of Food Science, Nutrition and Technology, University of Nairobi)
- Miss Edith Ogega (Department of Animal Production, University of Nairobi)
- Dr. George Abong' (Department of Food Science, Nutrition and Technology, University of Nairobi)
- Prof Michael Okoth (Department of Food Science, Nutrition and Technology, University of Nairobi)
- Prof. Charles Gachuri (Department of Animal Production, University of Nairobi)
- Prof. Agnes Mwang'ombe (Department of Plant Science and Crop Protection, University of Nairobi)

**With Support From**



**by decision of the  
German Bundestag**

## ACKNOWLEDGEMENT

The authors acknowledge the German Federal Ministry of Food and Agriculture (BMEL) 's financial support based on the Parliament of the Federal Republic of Germany's decision. Research grant no [2816PROC04] through the FruVaSe project at the University of Nairobi. Our sincere gratitude goes to the Staff of the University of Nairobi's Pilot plant, Departments of Food Science and Technology, and Animal production for their technical input that enabled the storage, fruit product development, and animal feed production from processed guavas.

# CONTENTS

CONTRIBUTORS .....	ii
ACKNOWLEDGEMENT .....	iii
SUMMARY .....	v
1: INTRODUCTION .....	1
1.1 Status of guava value chains in Kenya .....	1
Expected impact as a result of processing local guavas .....	2
2. POSTHARVEST HANDLING OF GUAVA FRUITS .....	3
2.1 Guava Harvesting.....	3
2.2 Transportation and storage of harvested Fruits.....	4
2.3 Processed Guava Products .....	6
2.3.1 Standards, Safety and quality requirements.....	6
3. PROCESSING OF GUAVA FRUITS .....	8
3.1 Guava fruits processing quality .....	8
3.1.1 Requirements for Processing facilities and equipment design .....	9
3.1.2 Good manufacturing practices .....	10
3.3 Processed Guava Products .....	10
3.3.1 Major equipment.....	10
3.3.2 Preliminary Guava processing .....	12
3.3.3 Guava Pulp.....	13
3.3.4 Finished Product handling and marketing .....	15
4.0 PROCESSING OF GUAVA wastes INTO value added BROILER FEEDS.....	16
4.1 Utilization of guava byproduct in chicken feed.....	16
4.2 How to prepare the chicken feed. ....	17
4.3 Feeding of the broiler chicken .....	18
5.0 COST BENEFIT ANALYSIS OF GUAVa PROCESSING .....	19

## SUMMARY

Guavas in Kenya undergo extremely high annual losses due to poor postharvest handling, lack of appropriate postharvest technologies, storage facilities, and limited value addition practices despite the fruits high yielding capacity, economic and nutritional potential. The fresh fruits have poor economic returns. The farm gate prices often range between a meager Ksh 3-10 (\$ 0.03-0.1) per kg. Guava postharvest handling practices are limited and extremely low, although this can be efficiently conducted at the household level, micro, small and medium enterprises (MSMEs). This is exacerbated by the low willingness for consumers to pay for marketed fruits,

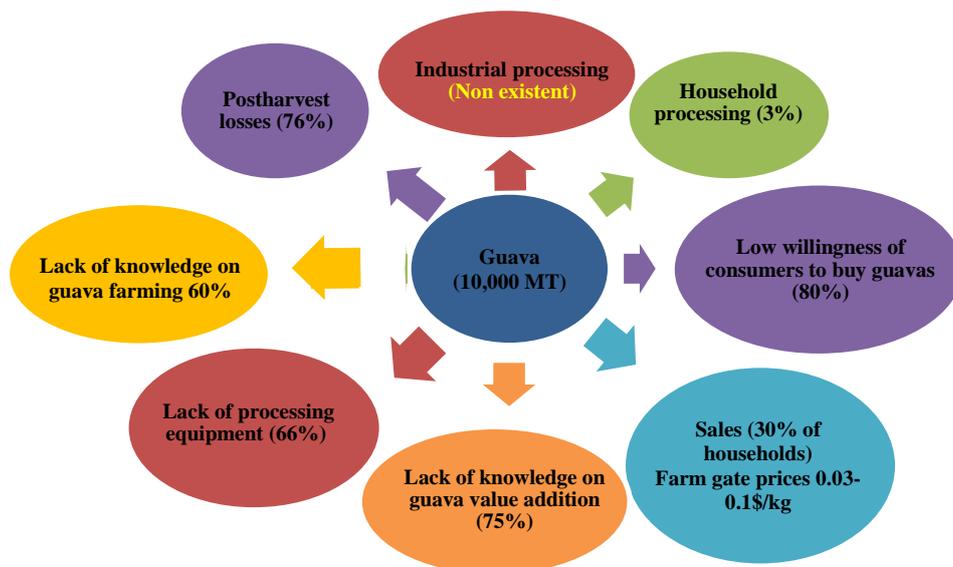
This manual is intended to guide trainees on proper postharvest handling of guavas and subsequent processing into shelf-stable nectars. Guavas are, however, suitable for processing into various other products, and trainees are encouraged to exploit additional value-added products to ensure the sustainability of the fruits' value chain.

The manual highlights the postharvest handling practices to minimize losses, processing the fruits and their by-products. The manual also outlines some general principles of good manufacturing practices to ensure safe and compliant processing of guava fruits

# 1: INTRODUCTION

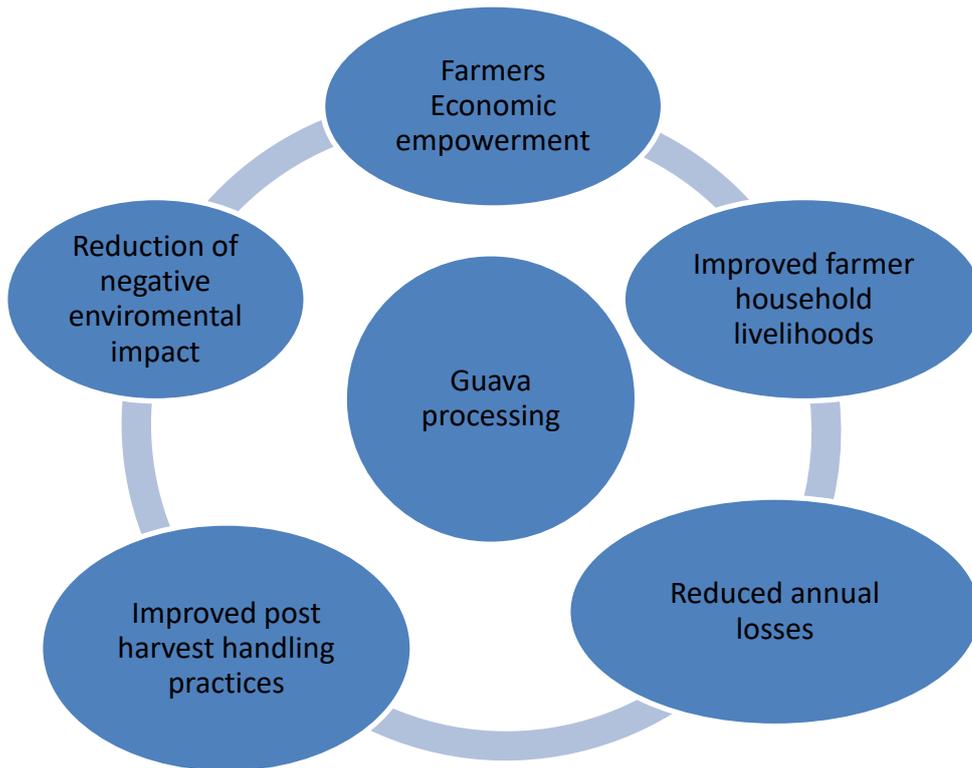
## 1.1 Status of guava value chains in Kenya

- Guava are hardy crops widely grown in the tropical and subtropical regions of the world
- In Kenya, the fruits commonly grow in the wild with no known commercial production and proper husbandry as the fruits' economic value remains extremely low.
- The fruits are commonly consumed fresh as there are limited household and industrial processing
- More than 50- 75% of the annual produce (10 Metric tonnes) is lost owing to poor postharvest handling, minimal consumption, and poorly established value chains
- Kenya's climatic conditions are favorable for the production with the crop growing in diverse agroecological zones across the country
- Generally, there are broadly white and red guava varieties of both exotic and indigenous origins dominating the Kenyan cultivars guava varieties. However, their genetic and morphological characteristics are diverse, resulting in the non-uniformity of the harvested fruits and processing qualities.
- The Kenyan guavas have a relatively high seed to pulp ratio, which limits their consumption due to constipation and a high percentage of wastes during processing
- The current guava value chain is hindered by multiple constraints limiting the exploitation of the crop's value.



Source : Omayio, et al (2020):Trends and Constraints in Guava Production, Utilization, Processing and Preservation in Kenya

- The guava fruits remain neglected with limited processing despite the economic potential if processed into shelf-stable products, which would ensure a constant supply of fruits after their season
- This training intends to capacity build farmers and small scale processors to exploit a share of the local market which sell imported guava products to ensure a sustainable guava value chain
- Processing of guava is expected to help counteract the high annual losses, provision of convenient fruit utilization forms and economic value for guava farmers,



**Expected impact as a result of processing local guavas**

## 2. POSTHARVEST HANDLING OF GUAVA FRUITS

- The guava fruits are climacteric and undergo quantitative and qualitative losses, which occur at all stages from pre-harvesting, harvesting, transportation, packaging, storage, and marketing.
- Due to limited processing and consumption, it is common to find rotting fruits under trees when in the season, as shown in the figure below;



**Guava losses – an annual occurrence**

- Losses are attributed to the fruits' physiological functions due to wilting, shriveling, chilling injuries, fungal and bacterial attacks, and physical damage besides high metabolic respiration rates.
- Guava fruit handlers should ensure adequate postharvest handling practices for longevity and maintenance of good processing quality given that the skin is delicate, and handling should therefore be gentle at each stage as described below

### 2.1 Guava Harvesting

- Harvesting of fruits should be done at the proper stages after attaining the correct maturity indices and should be mature green or firm-ripe. The stage of maturity affects fruit longevity and the quality of the processed products.
- Harvesting should be done after attainment of the optimal, flesh and skin color, shape, and sizes; At this stage, the fruits usually have attained the suitable sugar, acid levels and have the desirable processing qualities.



**Guava fruits should be harvested while firm ripe at the peak fruit size**

- To minimize field heat, harvesting should be done in the early morning or late evening hours should practice hand harvesting to reduce physical damage to fruits. However, mechanizations in commercial orchards are recommended. Harvesting tools should not induce mechanical injuries
- Harvested fruits should be stored in clean containers used purposely for fruits handling to avoid cross-contamination and should have minimal cross-contamination
- Harvested fruits should neither be placed on dirty surfaces nor exposed to direct sunlight by using appropriate container and holding them under shades



**Harvested fruits should not be collected on the ground or exposed to direct sunlight and**

**2.2 Transportation and storage of harvested Fruits**

- Guava transportation and storage are crucial. It is recommended that the equipment used should be hygienic and should safeguard the fruits against bruising and injury to the fruit by having these soft and smooth linings materials, e.g., paper or cardboard.
- During transportation, it is recommendable to use ventilated crates or boxes.
- Fruits should not be overstuffed in the transport containers. Use of aerated gunny bags or hermetically sealed gunnies can be adopted as long as they do not cause physical injuries.

- Before storing the fruits, sorting should be done to separate damaged, rotten, over-ripe guavas from the healthy ones. Sorted fruits should be grouped uniformly based on the maturity levels, size, color, weight, and desirable quality of the intended end-use



**Sorting of fruits before transportation**

- Stored fruits should ideally be stored in cool rooms as storage under typical room temperatures result in accelerated deterioration and hold for 3-5 days.
- Storage should be done at low temperatures of about 8-10°C, recommended as the optimum temperature for reduced physiological processes, and storage for up to 7-11 days.
- A combination of modified atmosphere packages and cold storage should be adopted as they extend shelf life by up to 11-18 more days than room temperatures.



**Fruits under modified atmosphere packaging**

- At the farm level, low temperatures can be achieved by using brick or charcoal coolers as these are easily constructed. Equally well-designated cooling areas could be alternatively be used

- Fruit intended for human consumption or processing should be stored in clean areas inaccessible to direct sunlight, have high humidity, foolproof against pests and insects, and minimal mechanical injuries on the fruits.
- Always process fruits based on the first in first out basis to prevent losses of overstayed fruits
- For processors, fruits should be inspected to ensure processing quality is met before receiving and storing at the processing.

## 2.3 Processed Guava Products

The guava fruit is highly perishable, with an average of 3-5 days once the climacteric peak has been achieved. However, the extraction of pulp from the fruits forms a basis for processing long after the fruits are out of season. The processed pulp can last for up to 12 months under hygienic and airtight conditions, therefore, ensuring constant processing of the nectars.

Before venturing into commercial guava products, the processors should meet the regulations set in place by the relevant county and national governments for safety and compliance.:

### 2.3.1 Standards, Safety and quality requirements

- Processed food must meet the Kenya Bureau of standards requirements KEBS for certification and authority to sell processed products. The minimum standard s requirements for both products and facility must be met
- The personnel handling foods must be healthy and compliant with the Kenya public health standards
- The nutritional requirements, quality, and shelf life should fit human consumption, with the microbial and chemical contamination being within acceptable limits and preferably none at all
- Traceability systems should be in place to ensure that fruits are sourced from farmers practicing good agricultural practices
- All personnel must implement hygienic practices to ensure finished products are free of coliforms and possible microbial contaminants such as E Coli and staphylococcus.
- Guava pulp and nectars are sugary, and the anaerobic packaging conditions create favorable conditions for yeast and mold growth. These need to be controlled by adequate heating and reducing the pH using acidulants such as citric acid.
- If chemical preservatives are used, ensure that only the generally recommended as safe are used, and their levels are strictly adherent to the limit levels. The personnel in production should be well trained to ensure the protection of consumer health.
- Ensure appropriate application of the food-grade preservatives within recommended levels for consumer health protection. Sodium or potassium metabisulphite, sodium benzoate, and sodium/potassium sorbate are commonly used in the food industries to prevent yeasts, molds, and bacterial contamination.
- Lowering the acidity should be done using either citric acid or lemon juices at rates of 0.2-0.3% and 5-10%, respectively, depending on the fruit acidity.
- As a processor, there is always a need to monitor and control the processing conditions to ensure compliance with the firm's set criteria and the standards used in processing.

- Ensure regular monitoring and evaluation of HACCP for controlling all potential physical, chemical, and biological hazards.
- All processing records should be handled by responsible personnel be well kept; responsible personnel should be well kept and regularly inspected.
- Corrective actions implementations should be put into place, and the personnel work collaboratively toward set goals
- Good manufacturing and hygienic practices must be adhered to at all times with standard operational procedures well defined and understood by all personnel, especially those in the production section

### 3. PROCESSING OF GUAVA FRUITS

Although Several guava products can be processed from guava fruits, this manual shall focus on guava pulp and nectars as the main products with the by-products formulation into animal feeds



#### 3.1 Guava fruits processing quality

The quality of the raw materials affects the end product characteristics, and therefore, it is essential to ensure fruits for processing meet the minimum processing requirements as per the processors' criterion

- The pulping (mechanical juice extraction) stage is a critical stage as the pulp forms the essential ingredient for processing nectars
- Guava processing involves unit operations that must be optimized to achieve targeted end products. These are :
  - Sorting and grading of raw fruits
  - Cleaning and washing
  - Fruit crushing
  - Pulping
  - Pasteurization and packaging of pulp
  - Nectar formulations and processing
  - Packaging operations
  - Proper waste collation and disposal, among others.

- Processing often results to loss of some nutrients due to exposure to external environments, heat intensity, and the processing regimes
- Food preservatives such as sodium metabisulphites, lemon juice, citric acid, sorbate, and benzoates may be used, although the safety levels must be observed to ensure consumer protection
- Process monitoring and control must be implemented to ensure a desirable end product is obtained.

### 3.1.1 Requirements for Processing facilities and equipment design

- Hygiene and sanitation should always be conducted using standard operating procedures using water and permitted detergents.
- The water for processing should be potable – free from microbes, dissolved salts, sand and soil particles, and constant supply. Water for cleaning should always be reliable for adequate hygiene
- All major processing equipment and surfaces should be made of stainless steel with ease of cleaning
- Depending on the equipment, cleaning in and out of place (COP) should be easy to achieve.
- The equipment should be installed in a manner that prevents contamination of food with adequate operational spaces. They should be don't have dead spaces for ease of cleaning operations.
- The processing environment, facility, and surroundings, should be foolproof against insects and pests, dust, and direct sunlight, although there should b proper lighting.
- The processing facility environment should always be maintained clean to prevent cross-contamination - avoid areas where potentially harmful substances would lead to unacceptable levels in processed products.
- The establishments must implement and verify the pest control programs with and records kept. The chemicals used should not contaminate foods and should not harm the personnel
- The personnel should be regularly trained on the appropriate degree of personal hygiene within the processing premises and the implementation of good hygienic practices.
- The personnel should always wear clean protective clothing. There should be defined handwashing procedures adhered to by all people entering and leaving the processing area to avoid cross-contamination.
- Ensure scheduled cleaning and maintenance operations in and around the processing premises. Cleaning procedures and verification must be documented appropriately after every cycle

### 3.2.2 Good manufacturing practices

- Good manufacturing practices should be practiced to help eliminate inherently and introduced hazards, including
  - Microbiological – bacteria, viruses, yeasts, and molds
  - Physical – foreign bodies like glass, dead insects, metal, plastic, and wood fragments, body parts (hair, nails),
  - Chemical – pesticides, cleaning chemicals, lead, arsenic, mercury, cadmium, other chemicals. Most dangerous as they are not easily detected.
- Each handler at the processing premises should be assessed for health suitability after every six months. Sick handlers and those with open wounds, cuts, or bruises should be given off days.
- The raw material, ingredients, and packaging materials should be transported using a clean and hygienic medium regularly inspected for compliance.
- Sanitizers, detergents, and disinfectants should be well labeled and kept away from finished products and raw materials to avoid cross-contamination
- The washrooms and changing rooms should be clean, have good handwashing and sanitization points, and be far from the fruit handling and processing areas.
- Have properly designated waste disposal area. There should be a minimal accumulation of wastes in the processing sections with well-designated wastes disposal areas.
- Conduct regular inspections of suppliers' compliance with food safety requirements.
- The management should commit towards ensuring improvement of the good manufacturing practices

### 3.3 Processed Guava Products

Several guava products can be developed depending on the capacity of the facility. We shall, however, focus on the following:

1. Guava pulp
2. Guava nectars

#### 3.3.1 Major equipment

Processing of guavas should be carried out using

The primary machines for guava processing include

1. **Fruit crushers:** These are used to macerate the guava fruit before pulping. Commercial or fabricated models are locally available and are good enough as long as the efficiency is attained
2. **Pulpers** - for guava juice extraction from guava flesh. Pulpers should be well fitted with appropriate sieve sizes to ease the separation of seeds and peels.



**Pulpers are fitted with sieves to separate the seeds and peels from crushed fruit**

3. **Working tables** – these are used for sorting, packaging, holding fruits, etc. they should be stainless steel and large enough for working (stainless steel is recommended as the materials don't chip, easy to clean, and do not interfere with product quality)
4. **Troughs** – for washing fruits. They should be easy to use by holding water and fitted with continuously running water where possible
5. **Pasteurizer** – used to heat guava pulp and nectars to deactivate enzymes and microorganisms responsible for processed guava spoilage. At scale levels, heating pans used should be thick enough to prevent burnt flavor.

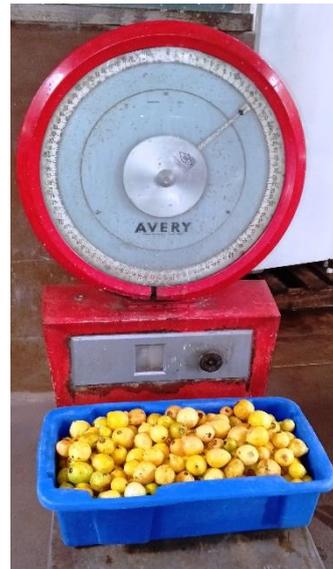


**Commercial pasteurizer pulper and harvesting of pasteurized pulp**

- Commercial pasteurizers heat products indirectly through heat transfer using heated water or steam

- Weighing balance-** for measuring Ingredients and raw materials. They It should be well-calibrated and must be reliable.

Smaller and more sensitive weighing scales Recommended for smaller quantities e.g, stabilizers and preservatives



are

- Storage facility** – for raw materials, finished products, other food and non-food required during processing. The facility should be adequately cleaned, sanitized, and well-demarcated to prevent cross-contamination, especially of the finished products.

### 3.3.2 Preliminary Guava processing

- The processor should always consider the first in first out principle to avoid losses during storage
- Fruits for processing should be well sorted to ensure uniformity in ripeness and maximum ripeness for optimal pulp extraction, remove overripe and rotting fruits.
- Record keeping at each major unit conversions must be recorded to help in quality control.
- The fruits should be cleaned using running water to reduce the microbial load and adherent dirt.



**Sorting and washing of fruits intended for processing**

### 3.3.3 Guava Pulp



- Guava pulp is a crucial ingredient in the processing of guava nectars.
- The pulp is extracted from well-ripened and cleaned fruits
- Guavas for processing should be well ripened sorted fruits for optimum pulp yield. Underripened fruits have high dry mass; therefore, more loss while over ripened may result in quality products
- Pulping the fruits is convenient and economical as these are shelf-stable, easy to store, and will ensure a constant supply of raw material during off-seasons.
- Pulp for storage should be pasteurized to at least 65°C and aseptically packaged and stored under cold temperatures
- Guava pulp should be preserved with acceptable food-grade preservatives at the recommended levels. Usually, sorbates and sulfites at 300- 600ppm are used to ensure color stability and prevent yeast molds.

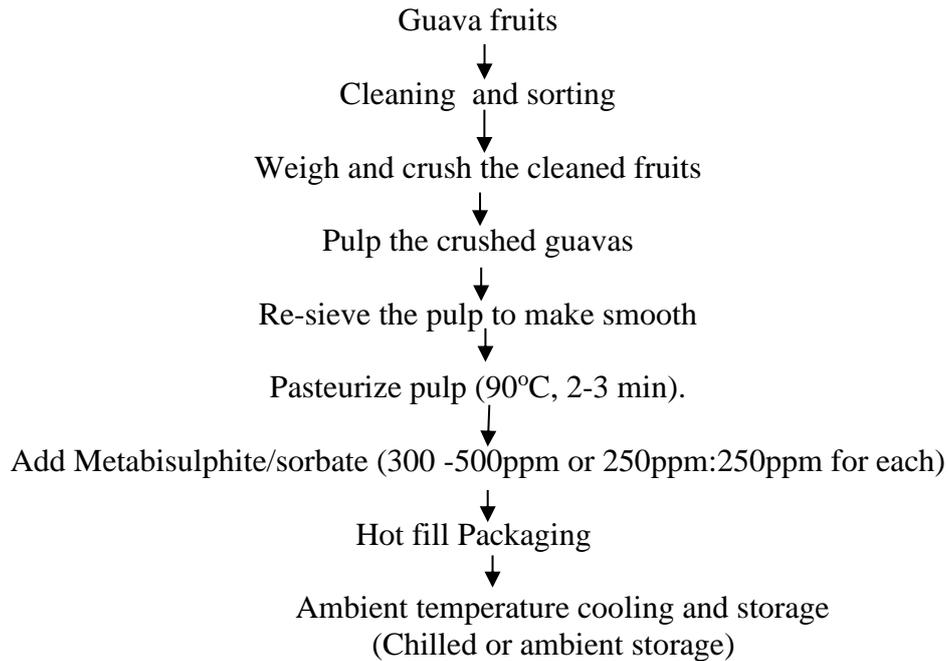
#### Guava Pulp extraction

#### 3.3.3.1 Processing of Guava pulp

##### *Materials and equipment*

- Well ripened Guava fruit (Red variety preferably)
- Fruit crusher
- Pulper
- Pasteurizer
- Clean working stainless steel table/chopping boards
- Thermometer (Infrared recommended)
- Weighing balance
- Plastic buckets
- Preservatives (potassium/sodium metabisulphite and sorbate)

### Guava pulp process flow diagram



#### 3.3.3.2 Guava nectars

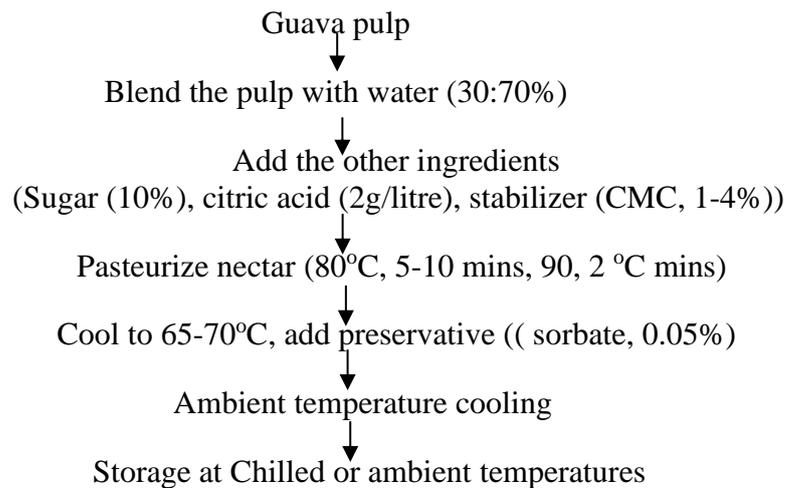
**Guava Nectar**- Guava nectars are whole fruit ready to drink quickly processed beverages using the fruit pulp (25% - 30%) sugar, citric acid water, and any other optional ingredients such as moringa juice extracts. This innovation makes use of 30% fruit pulp. Nectars are convenient and nutritious as they are stable and have retained nutrients from the raw fruits.

#### *Materials and equipment*

- Sugar
- Heat source
- Sufuria/vat pasteurizer
- Citric acid
- Stabilizer (CMC- 1-2%)
- Fruit pulp (30%)
- Plastic packaging bottles/ Tetra packs
- Metabisulphite/sorbate (preservatives)
- pH meter
- Refractometer



### Guava Nectars process flow diagram



#### 3.3.4 Finished Product handling and marketing

- The processed nectars must meet the standards as required by KEBS before sales to the public
- Products should be labeled appropriately. The product batch, brand, ingredients, net weight, and place of manufacture should be declared on the finished products
- Ensure constant monitoring of stored samples to ensure leakproof and package integrity



#### 4.0 PROCESSING OF GUAVA WASTES INTO VALUE ADDED BROILER FEEDS

- The Kenyan guavas characteristically high seed to pulp ratio results in the production of relatively high.
- Agricultural wastes, including guava by-products, need to be regulated and discarded properly to avoid pollution and contamination of processed foods.
- It is advisable to make alternative use of these wastes, including processing into animal feeds, biogas production, decomposition, and beneficial nutrients.
- The by-products from guava fruit processing include seeds, peels, and fibrous tissue from the skin resulting from pulping. They have a high concentration of bioactive compounds and dietary fibers.
- Guava by-products have a suitable nutritional profile that makes them suitable as animal feeds

##### Nutrient composition of guava by-product

Parameter	Levels
Dry matter	88.51
Ash	3.1
Crude fiber	46.46
Crude protein	5.41
Ether extracts	6.32
Nitrogen free extracts	38.71

#### 4.1 Utilization of guava by-product in chicken feed

- The by-products' alternative utilization is likely to mitigate against environmental problems that arise due to decomposing the agricultural wastes.
- The use of these wastes is also likely to reduce the cost of feeding, resulting in higher profits for animal keepers.
- Guava by-products have been used in the animal feed industry and have been fed to poultry (both layers and broilers) and pigs in other countries.

#### 4.2 How to prepare the chicken feed.

1. Sundry the guava by product
2. Grind the guava by-product and store it in sacks



**Sundried and ground guava by products**

3. Using the Kenya Bureau of Standards requirements for the broiler starter and finisher diets: a minimum of 3000Kcal/kg and 22% crude protein content for the starter diets and a minimum of 3000Kcal/kg and an 18% crude protein content for the finisher diets.
4. Prepare a formulation using an excel sheet (Will be demonstrated practically) with the available macro and micro ingredients.



**Preparation of micro and macro ingredients and mixing with the feed formulations**

5. Include 5% guava by-product in the formulation
6. Measure all the ingredients in the formulation and put them in an industrial mixer.
7. Mix them for 45 minutes to ensure homogeneity.
8. Pack the feed into a sack
9. Take a sample from the sack for lab analysis. This is to confirm the nutrient composition
10. of the formulated feed
11. After lab confirmation, the feed is ready to be fed to the broiler chicken.

#### 4.3 Feeding of the broiler chicken

- This is usually done in two phases; the starter phase and the finisher phase.
- Avail feed and water to the chicken throughout the experimental period



**Broilers feeding on the formulations**

## 5.0 COST-BENEFIT ANALYSIS OF GUAVA PROCESSING

- Commercially processed guavas fetch high income
- Assuming all production and processing factors remain constant, the marketed products fetch profits ranging 1.2-1.6 \$ per kg compared with the raw fruits that fetch a gross of \$ 0.02-0.10 per kg.
- Kenya's current market size for similar fruit products is estimated to be over \$ 100 million annually.
- The processed guavas target market should be urban and peri-urban consumers through retail shops, supermarkets, institutions, and exhibitions.

© Fruvase Project team,  
University of Nairobi



**Seed Management Institute (SEMI),  
Department Of Plant Science and Crop Protection,  
The University of Nairobi,  
P.O.Box 30197-00100  
Nairobi, Kenya**