A MANUAL ON PRODUCTION AND VALUE ADDITION OF COWPEA LEAVES: BRIDGING SEASONALITY IN VEGETABLE SUPPLY IN ARID AND SEMI-ARID AREAS

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Fruits and Vegetables for All Season Project

University of Nairobi

A manual prepared for dissemination of postharvest handling and processing technologies for cowpea leaves value chain

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1 INTRODUCTION

1.1 Background information

- Cowpea is a leguminous crop that grows in the tropical region of sub-Saharan Africa (SSA).
- The vegetable is the most consumed African Leafy vegetable in Kenya and is also known for its grains [1].
- The crop is drought tolerant and grows in diverse agro-ecological zones, thus cultivated in large amounts both in the western, central, eastern and coastal counties of Kenya.
- The leaves are a good source of iron, calcium, phosphorus, zinc, potassium, beta-carotene and vitamin C (Figure 1).
- Additionally, the vegetables are rich in phytochemicals (carotenoids, chlorophyll, phenolics) which are known to possess health enhancing properties.
- Communities sell the vegetables in their fresh forms at the local markets.
- Postharvest losses that reach up to 50% of the yield for the leaves result in economic losses as well as reduced levels of the vegetable available for utilization by the households.
- The situation is aggravated due to limited postharvest handling technologies and processing that are utilized in this value chain.

Nutritional information of fresh cowpea leaves (per 100g dry weight)

Nutrient	Amount
Protein	2.6g
Carbohydrate	5.6g
Fat	0.4g
Fiber	22.7g
Calcium	5.9mg
Zinc	1.7mg
Iron	2.9mg
Sodium	3.5mg
Vitamin C	21.1mg
Beta carotene	2.8mg

Figure 1: Nutrient composition of fresh cowpea leaves. Owade (2021)

1.2 Project Overview

The Fruits and Vegetables for All Seasons (FruVaSe) Project is being undertaken by a consortium of academic institutions from Germany, Kenya, Uganda and Tanzania with a focus of bridging seasonality in the availability of neglected fruits and vegetables. The focus of the dominant research work conducted by the University of Nairobi in the cowpea leaves value chain is aimed at addressing the postharvest losses and handling and promotion of value addition practices in the value chain.

1.3 Training objectives

The training has the overall objective of promoting adoption and uptake of postharvest handling and storage technologies and value addition practices for improved commercialization and off-season utilization of cowpea leaves. Through workshops and outfield training activities and exhibitions, this component of the project will seek disseminate skills on good postharvest practices, storage technologies and processing of cowpea leaves. Key activities to be undertaken include:

i. Training of individuals on proper postharvest handling to improve keeping qualities of fresh produce.
ii. Demonstration on postharvest handling technologies that improve the keeping quality of fresh produce and minimize postharvest losses.

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iii. Demonstration of low cost processing technologies for the value addition of cowpea leaves and improvement of economic returns realizable.
iv. Training on the utilization of products of cowpea leaves.
v. To improve the keeping quality of fresh produce of cowpea leaves.

1.4 Targeted audience

- Farmers involved in the production of cowpea leaves
- Women and farmer groups involved in cowpea leaves value addition
- County extension officers
- Wider value chain actors involved in the production and marketing of cowpea leaves.
- Policy makers

1.5 Things to note

- The trainings must be undertaken accompanied with practical demonstration of key aspects and technologies outlined in it.
- Video demonstration of procedures that require a lengthened period of time can be used as part of the training.
- Ensure that the public health guidelines as stipulated by the Ministry of Health are adhered to when on-site and field demonstrations are being done.
- It is important that the food safety knowledge and attitude before and after the training of the processors be evaluated.
- The manual is accompanied with brochures and fliers which can be used as aids in the training.
- There need to be prior preparation of all materials needed for the demonstration of the technologies.
- The learners must be equipped to learn through the process including carrying of note-taking materials.
- With the written consent of the trainees, a participatory video can be developed for future use of the trainees.

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2 PRODUCTION AND POSTHARVEST HANDLING OF COWPEA LEAVES

2.1 Local Names

- Kunde (Swahili, Kipsigis)
- Mathoroko (Kikuyu)
- Likhuvi (Luhya)
- Alot-bo (Luo)
- Nthooko (Kamba)
- Egesare (Kisii)
- Kiyindiru (Luganda).

Cowpea leaves varieties (Kenya)

- Katumani 80 (K80)
- Kitui black eye
- Kunde 1
- Kunde Mboga (Figure 2)
- KVU 27-1, 419
- Machakos 66 (M66)
- Numerous landrace varieties

2.1.1 Challenges in the cowpea leaves value chain

1. High postharvest losses that resulting in loss of economic returns realizable among farmers
2. Limited value addition practices hence the pricing of the vegetable still remains low.
3. Poor postharvest handling practices due to limited equipment.
4. Limited policy focus given to the crop.
5. Marketing challenges thus majority of the households produce for subsistence
6. Production challenges including pest and disease which result in on-farm losses.

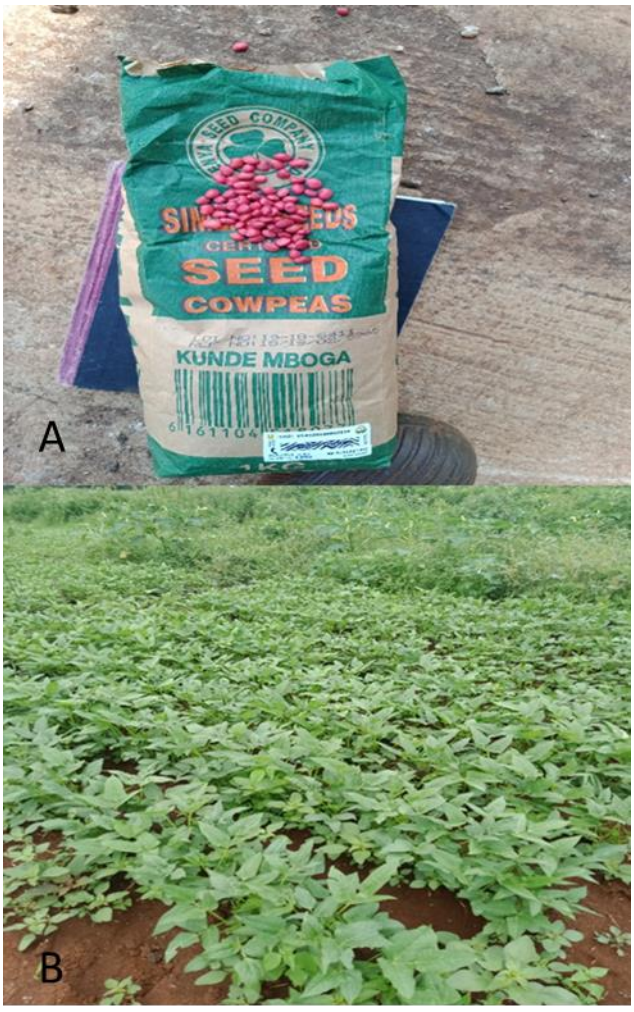

Figure 2: A: Cowpea leaves seed (Kunde mboga variety), B: Cowpea leaves growing. ©Owade 2021

2.2 Cowpea leaves production

- Cowpea leaves are cultivated either in a mono or inter-cropping systems [2].
- In mono-cropping systems (Figure 3), the crops are grown without mixing with other crops, however, in the inter-cropping system, the crop is cultivated in fields together with crops such as maize, sorghum, millet and many others.
- The crop has good shade-tolerance making it thrive in inter-cropping system.

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Figure 3: (A) Monocropping and (B) Intercropping cowpea leaves with maize. Source (Kamara [4]).

Major pests: Aphid, Blister Beetle, Thrips, Pod Borer, Root-knot Nematodes

Major diseases: Fusarium Wilt; b. Powdery Mildew; Cowpea Mosaic Virus; Damping-off; Cercospora Leaf Spot.

2.2.1 Ecological requirements

Altitude: The crop can be grown in areas of altitudes of 0-2000metres above sea level, depending on the variety.

Rainfall: Cowpeas are relatively drought tolerant and can give reasonable yields with minimal annual rainfall of between 300-700mm. Too much rain or long dry spells are reduce yields. Excessive rainfall during flowering causes flower abortion while dry weather conditions are important during harvesting.

Temperature: cowpeas perform best in warm conditions. An optimum temperature of between 20-35°C is fit for their growth. Extreme temperatures affect crop growth and development.

Soils; cowpeas can be grown on a wide range of soils. However, well drained fertile soils with an optimum PH of 5.5-6.5 promote better production.

2.2.2 Harvesting of cowpea leaves

The harvesting of cowpea leaves is started from as early as two weeks after emergence for those using the plucking of the leaves technique, See figure 4, until flowering (10-12 weeks after emergence). Those harvesting by uprooting the whole plant harvest the vegetables at 6-8 weeks after emergence which is the optimal maturity stage. Cowpea leaves yield up to 2400kg per acre.

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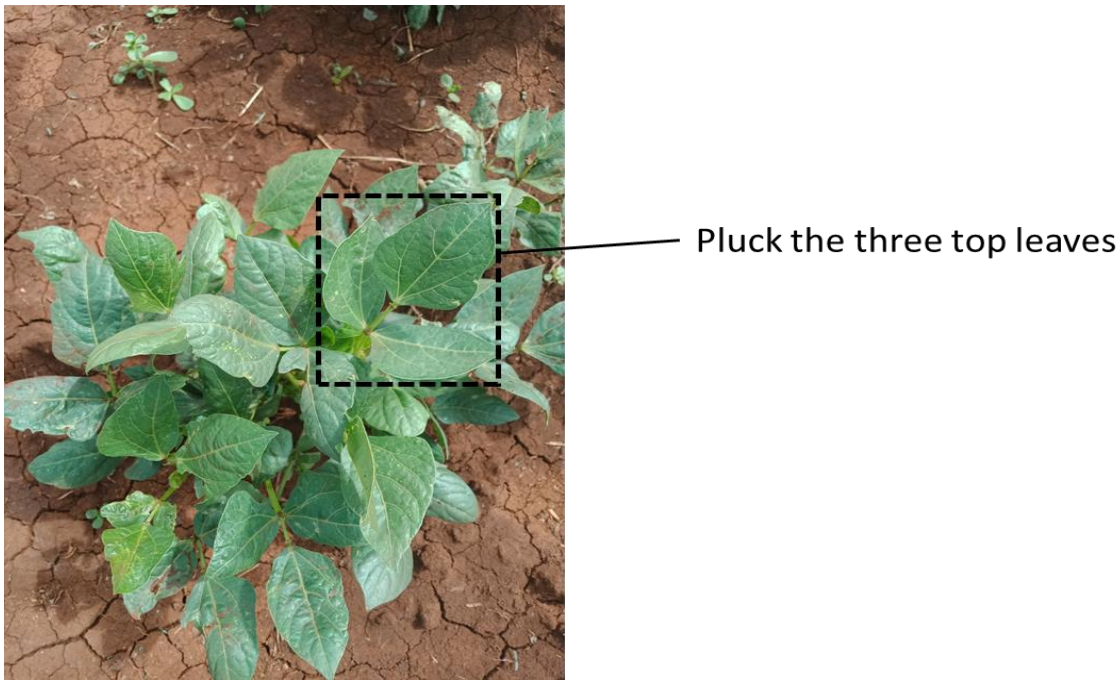

Figure 4: Harvesting of cowpea leaves by plucking. ©Owade 2021

During harvesting of cowpea leaves, the following are done to improve quality:

- Harvesting is done early in the morning or late in the evening
- Harvested vegetables are kept under a shade or sprinkled with water to remove the field heat that would otherwise result in shriveling of the produce.
- Avoid storing harvested vegetables immediately in a sack.
- Sorting of the vegetables (Figure 5) after harvesting can be done to remove damaged produce.

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Figure 5: Sorting of the vegetables after harvesting to remove damaged produce. ©Owade 2021

2.3 Good agricultural practices

- Soil preparation before planting of the crop
- Selection of good quality seeds. Majority of farmers prefer the landraces however the improved varieties such as Kunde Mboga give higher yields.
- Proper application of fertilizer would also help improve the crop yields.
- Timely weeding of the farm is also necessary
- Proper storage and handling of harvested produce to minimize postharvest losses.

2.4 Postharvest handling and storage

- Post-harvest technologies and treatments have been a major challenge in developing countries especially Kenya
- Lack of this and having inadequate treatments have been a contributing factor to post-harvest losses of the vegetables.
- Improper storage of the vegetables i.e. in ambient or high temperature occasion shriveling and degradation (Figure 6).
- Harvested vegetables should be kept at low temperatures to prevent shriveling, but extremely low temperature (<10^{o}C) results in chilling injury.
- Harvested leaves can keep for 2-3 days before spoilage. Modified Atmosphere Packaging, MAP (Figure 7) improve the keeping of fresh vegetables up to 7 days.

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Figure 6: Cowpea leaves deteriorating due to storage under ambient, cold and extreme temperatures

Figure 7: Modified Atmosphere Packaging (MAP) of cowpea leaves

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3 VALUE ADDITION TECHNOLOGIES OF COWPEA LEAVES

3.1 Preparation of cowpea leaves

Fresh cowpea leaves are consumed in various forms (Table 1), however, the challenges of limited availability in the off-season persist.

Table 1: Forms of cowpea leaves consumed

Consumed as vegetables with accompanying staples e.g. ugali	
Composite vegetable of cowpea leaves and jute mallow	
Dehydrated vegetable	

3.2 Processing of cowpea leaves

3.2.1 Good manufacturing practices

In food processing, there is need for good manufacturing practices in order to ensure safety of the resultant product.

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GMPS also go a long way in ensuring that the expected product quality is attained in processing. Some of the GMPs to be preserved in the processing of cowpea leaves include:

- Proper personnel hygiene including designated handwashing places
- Proper equipment choice and hygiene
- Proper sanitary operation including scheduled and frequent cleaning of the facility and equipment.
- Pest control in order to avoid product contamination.
- Disease control especially among staff to ensure product safety.
- Proper storage of equipment and maintenance of the same.
- Handwashing and sanitation facilities such as toilets must be available.
- Raw material inspection in order to ensure product quality is maintained.
- Monitoring of process controls.
- Protection of food product from contamination through proper handling, packaging and storage.

3.3 Value addition techniques for cowpea leaves

3.3.1 Dehydrated cowpea leaves

- Drying of cowpea leaves is undertaken to ensure continued availability of the vegetables even in the dry season.
- It is recommended that hurdle technology (a combination of two preservation techniques such as blanching and drying or fermentation and drying) be used in order to maximize on the retention of product quality attributes including sensory, physical, keeping and nutritional.
- Drying of the vegetables excluding the hurdle technology results in significant losses such as low nutrient retention, deterioration of colour, poor sensory quality and poor texture.
- The processing of dehydrated cowpea leaves is undertaken as shown in Figure 8.

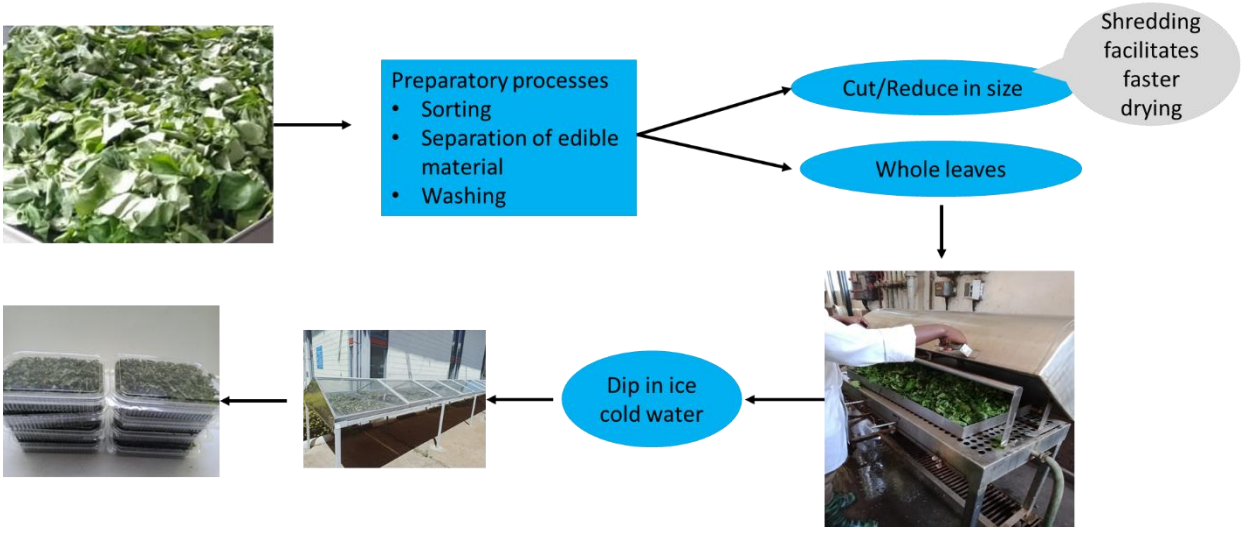

Figure 8: Dehydration of cowpea leaves

Dehydration of the vegetables can be undertaken using a variety of driers. Some of the techniques recommended for the drying of cowpea leaves include:

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a. Solar driers

- Tunnel solar driers (Figure 4) can reach up to 70°C and RH of 10%
- Facilitate drying of vegetables (5kg) within 5hrs, however, this depends on intensity of sun and capacity
- Fitted with forced ventilation (fan)
- Other types of solar driers are shown in Figure 5.

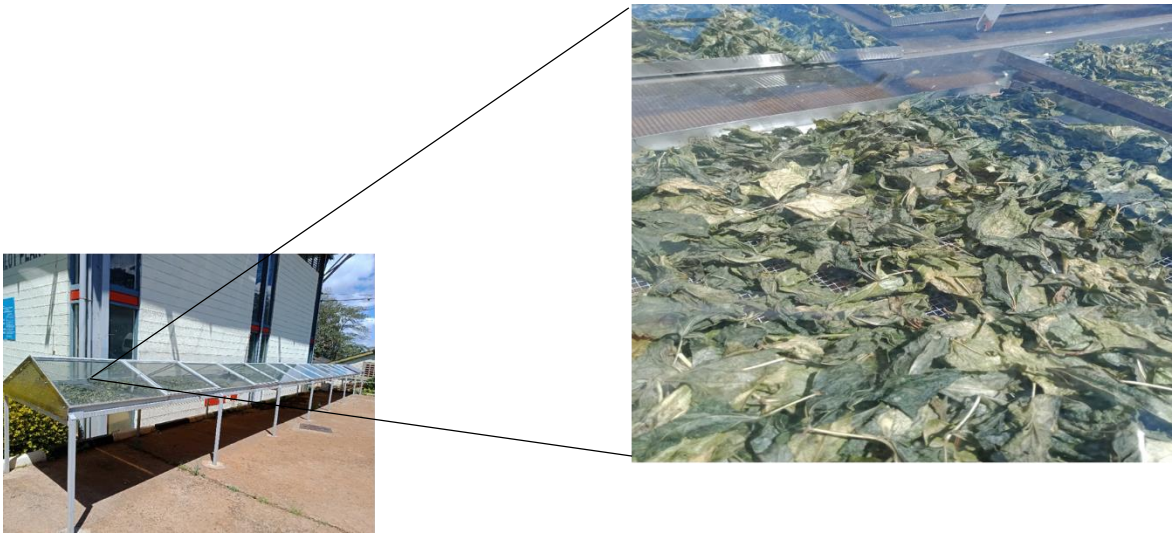

Figure 9: Tunnel solar driers

Indirect solar cabinet drier

Solar cabinet drier

Greenhouse solar drier

Figure 10: Different types of solar driers

b. Miniaturized solar drier

- The miniaturized solar drier (Figure 6) an be for household use
- Small capacity
- The temperature is slightly lower (40-50°C)
- Cost-effective and affordable
- The ambient temperature is doubled within the Dehytray by the absorbed heat radiating from the tray walls, the humidity in the dehydray is reduced in the process.
- Dehydration time varies with the weather condition.

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Figure 11: Miniaturized solar drier (Dehytray)

c. Other drying techniques

- Other drying techniques include the oven drying, sun drying and shadow drying (See Figure 12).
- Oven drying with forced air draught (Figure 7) is the fastest-Done at 50°C.
    - It has a higher retention of nutrients, colour and textural properties
- Sun drying results in the lowest retention of beta-carotene due to photo-oxidation by the sun.
- Shadow drying can only be done to unblanched leaves to avoid spoilage of the leaves.

Key aspects to consider on dehydrated leaves

- Drying the vegetables without blanching results in textural and colour degradation (Browning).
- Additionally, nutrient losses are aggravated when the dehydration is done without blanching or fermentation.

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- In order to keep the vegetables for a longer period, it is recommended that the vegetables be kept in air-tight packages in order to maintain a low moisture content of 8%.
- The dried vegetables kept under appropriate conditions can keep for one year.

Figure 12: Other techniques of dehydration of cowpea leaves. A-Sun-drying of blanched cowpea leaves, B-Forced air ventilation oven drier

3.3.1.1 Utilization of dehydrated cowpea leaves

In the utilization of the vegetables:

i. First the vegetables must be rehydrated (1 hour with cold water or 15 minutes with warm water)
ii. Cook the rehydrated cowpea leaves as fresh cowpea leaves are cooked
iii. If one is to boil the vegetables first, there is no need to rehydrate
iv. Consumed with delicacies (Ugali) as the fresh cowpea leaves

3.3.1.2 Quality control

- Dry the vegetables to below 8% moisture content (KS 435: 1992)
- Good hygiene practices must be observed
- Cover the vegetables during sun-drying to avoid dirt and bird droppings
- Good sanitation
- Always wash the fresh produce
- Use portable water including in the ice-cold water used
- Equipment must be free from contamination

3.4 Fermentation of cowpea leaves

- Fermented vegetables are likeable because of their improved sensory quality and rich-probiotic content.
- Communities practice spontaneous fermentation of vegetables including use of milk in fermentation.
- The resultant product usually has variable quality and the entire process tends to be slow.
- Additionally, without proper fermentation, the fermented product may have compromised safety and result in growth of spoilage microorganisms including the fungi.

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- Fermentation of the vegetables impart the desirable attribute of sourness in the product, inadvertently, enriching the product with the healthy bacteria that are known to have health benefits.
- Optimization of the fermentation process seeks to improve the domination of the heterofermentation over homofermentation; a process that further improves the sensory quality of the product.
- The targeted pH for fermented products (soured products) is pH of 3.5 and titratable acidity of 1.5%.

3.4.1.1 Materials

- Fermentation cans (a bucket and a polythene bag, 500 gauge or 125 microns)
- Water
- 5kg of cowpea leaves
- Sugar 250g
- Salt 100g

3.4.1.2 Processing of fermented cowpea leaves

The fermentation of cowpea leaves is done for 16 days as shown in Figures 8 and 9. Fermented products are packaged in appropriate packages including glass jars (Figure 10) for storage.

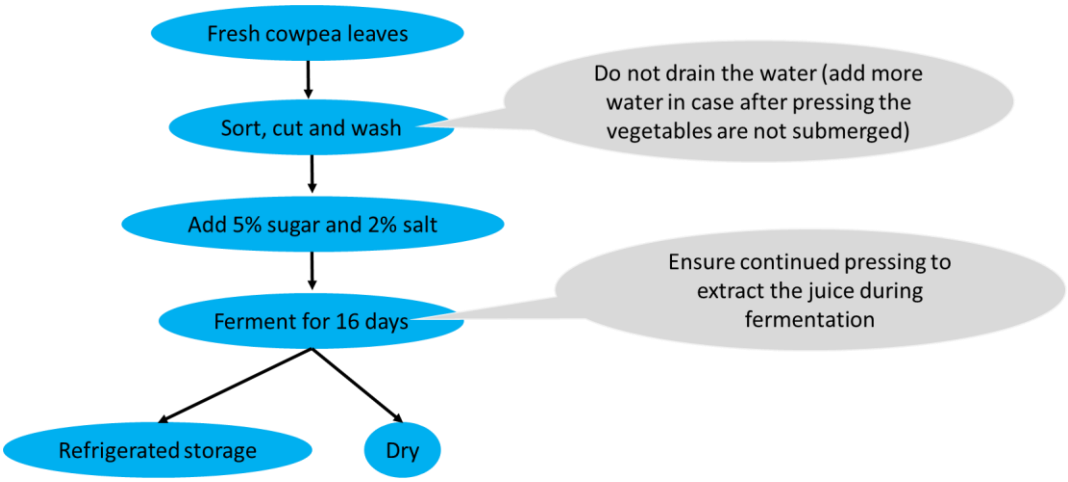

Figure 13: Fermentation process of cowpea leaves

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Figure 14: Cowpea leaves fermentation in progress

Figure 15: Fermented cowpea leaves

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3.4.1.3 Utilization

- The soured vegetables can be consumed raw after fermentation
    - The vegetables are cooked and consumed with staples including Ugali
- The cooking destroys the probiotic bacteria
- The fermented vegetables can keep for 3 months under refrigeration
- The dried leaves can keep for a year

3.4.1.4 Quality control

- Targeted acidity of 1% as lactic acid and pH <4.5.
- In processing portable water should be used
- The vegetables must be clean
- Good hygiene practices must be maintained
- Good sanitation
- The equipment used must be clean
- Good personnel hygiene

3.4.2 Cowpea leaves soup mix

- Cowpea leaves are derivative products from dehydrated leaves. Formulation of cowpea leaves soup mixes can be undertaken through seven different processing pathways as shown in Figure11.
- The processing pathways differ in terms of the costs and the benefits, with the pathway proven to have the highest benefit-cost ratio being the solar-drying pathway excluding extrusion.
- KEBS standards state that for any soup mix with any ingredient beyond 40% must contain the name of the ingredient ie Cowpea leaves soup mix has 49% cowpea leaves.

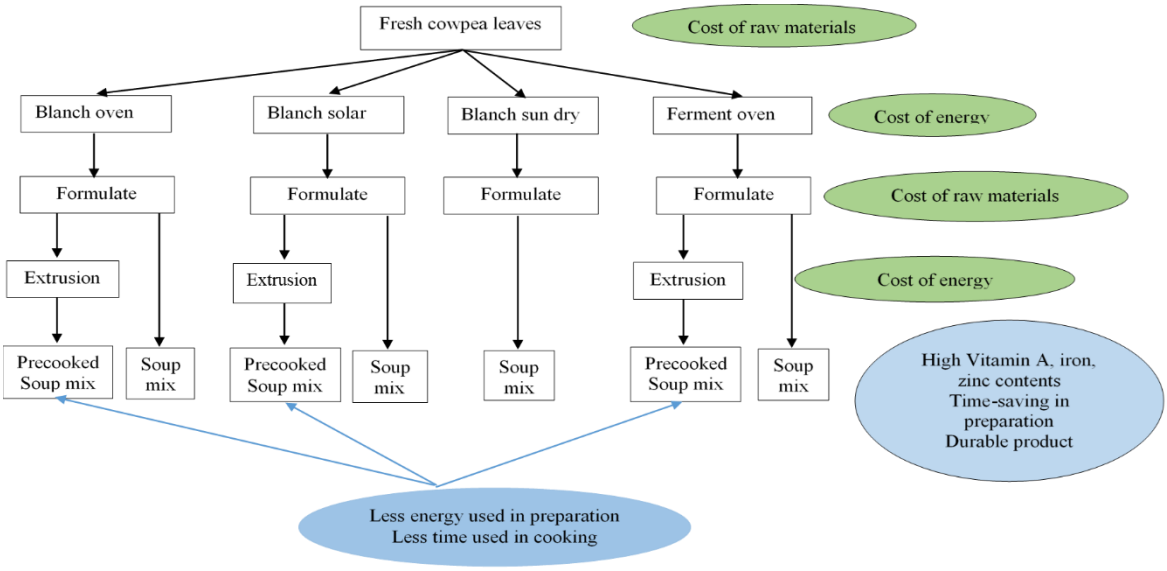

Figure 16: Processing of cowpea leaves soup mixes

3.4.2.1 Materials

- Dried cowpea leaves/dried fermented cowpea leaves/cowpea leaf powder (49g)

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- 27g starch (maize flour), 4g salt, 7g tomato powder, 7g coriander powder, 2g onion powder, 2 g garlic powder, 4g fat.
- Blender/mixer
- 250micrometer sieve
- Heat source

3.4.2.2 Processing of cowpea leaves soup mixes

The processing of cowpea leaves soup mixes is undertaken as illustrated in Figure 12. In order to instantize the product, extrusion of the product is done as shown in Figure 13.

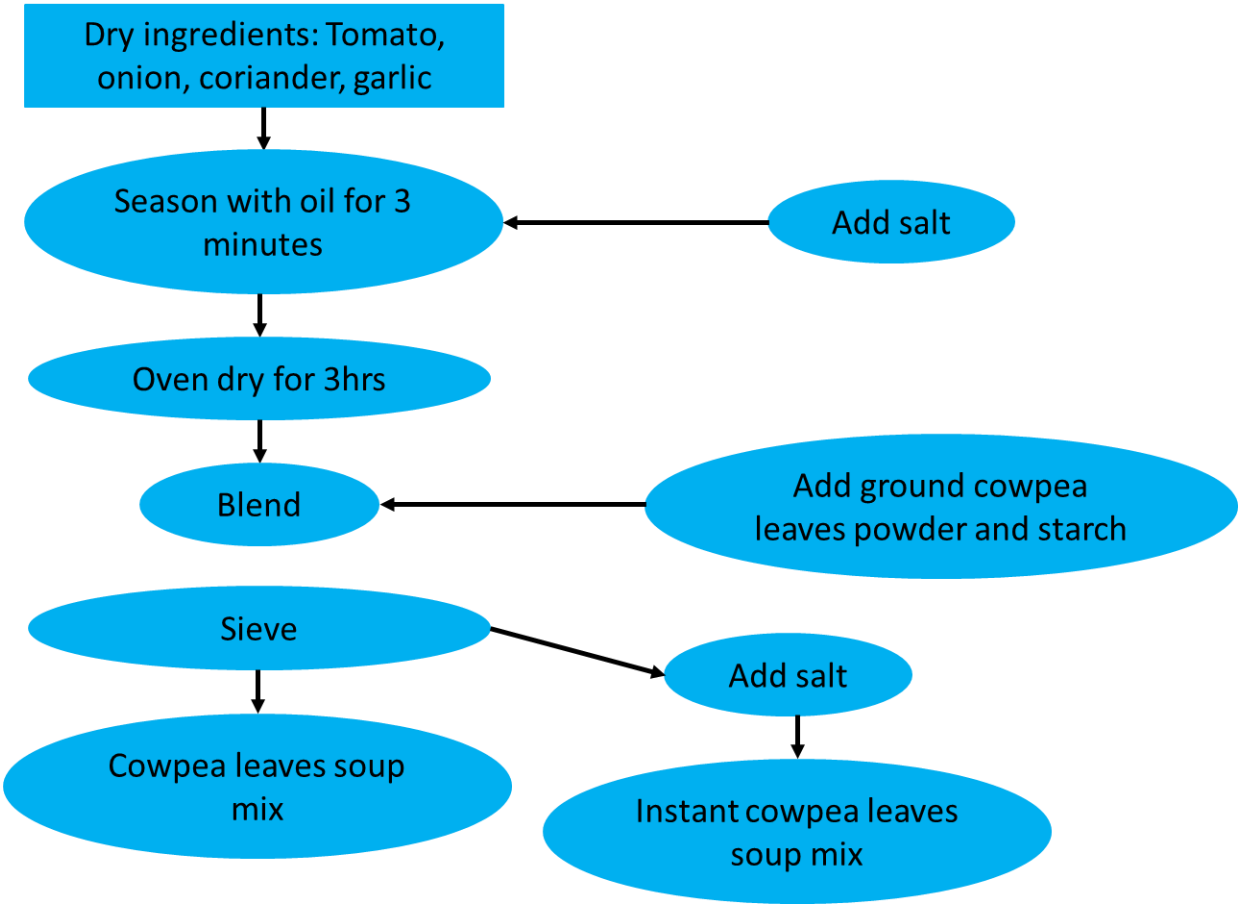

Figure 17: Schematic processing procedure for cowpea leaves soup mixes

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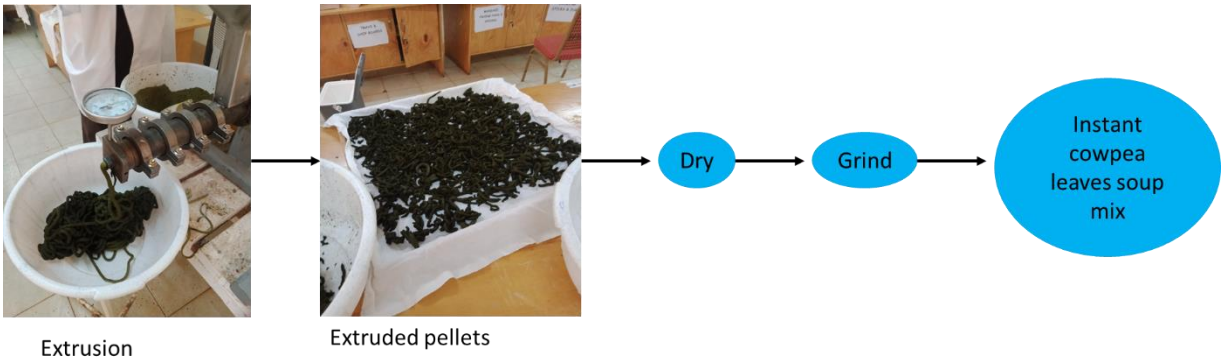

Figure 18: Processing of instant cowpea leaves soup mixes

3.4.2.3 Utilization

- Consumed as soup
  - Mix with cold water:soup mix at ratio of 9:1.
  - Boil while stirring
  - For instant soup mix; just heat to boil
  - Serve while hot
  - A cup serves 1 person
- Taken with staples like Ugali, Chapatti and rice
- A weaning diet

Some of the derivative benefits of utilization of cowpea leaves soup mixes include:

- The fermented cowpea leaves (Figure 14) serve as food vehicles for Beta-carotene (15 mg/100g dwb), iron (38.80 mg/100g dwb) and zinc (13.92mg/100g dwb).
- Reduced cooking time
- The shelf-life of the soup mix in six months

Figure 19: Cowpea leaves soup mixes

3.4.2.4 Quality control

- In processing of the soup mix, good personnel hygiene and sanitation be observed to avoid contamination of the product.

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- Dehydrated soup mix must be packaged free from moisture ie airtight aluminium pouches
    - Tanzanian standard permit storage in transparent containers, Kenya does not
- Free from pathogenic micro-organisms ie E. coli, C. botulinum, Salmonella.

3.5 Product labelling

- In labelling of the product, state the ingredients, a statement of identity of the product/description, the date of manufacture and expiry, the name and address of the manufacturer, nutrient composition and any instruction for use.
- KS 1088-1: 2001- Dehydrated soup mix with any ingredient beyond 40% must contain the name of the ingredient ie Cowpea leaves soup mix has 49% cowpea leaves.
    - Tanzanian Standard too

3.6 Product marketing and costs

- Fresh produce is sold at USD 1 (KES. 100) per kg
- For a 10kg of fresh vegetable, one yields 1kg of dehydrated vegetables.
- For a 10kg of fresh vegetable, one yields 1.3kg of fermented vegetable.
- For a 1kg of dried vegetables, one yields 1.5kg of cowpea leaves soup mix.
- For a 1kg of dried vegetables, one yields 1.1kg of instant cowpea leaves soup mix.
- The demand curves for the cowpea leaves soup mixes showed highest willingness to pay at KES. 50 (USD. 0.5) for a 75g package.
    - A profit of KES. 10 realizable (25% profit).

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