GUIDELINES ON IMPLEMENTATION AND MANAGEMENT OF PRIMARY PROCESSING SYSTEMS

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GUIDELINES ON PRIMARY PROCESSING SYSTEMS

1.A Solar drying

Food Hub Jendouba (TN)

I. Objectives and description of the innovation

The primary objective of the solar dryer innovation is to enhance food preservation by efficiently reducing the moisture content in perishable products while maintaining their nutritional quality and safety. By utilizing solar energy, this solution minimizes dependency on conventional energy sources, making food drying more sustainable and cost-effective. The innovation aims to improve drying efficiency by optimizing airflow and temperature control, ensuring uniform dehydration that maintains the texture, color, and overall quality of dried products.

Another key objective is to promote food safety and hygiene by providing a controlled drying environment that prevents microbial contamination, spoilage, and nutrient degradation. The solar dryer is also designed to support small-scale farmers, cooperatives, and food processors, enabling them to add value to their produce by extending its shelf life. This helps increase market opportunities for dried food products at local and international levels. Additionally, the project seeks to contribute to economic and environmental sustainability by reducing energy costs and greenhouse gas emissions associated with traditional drying methods.

The solar dryer is an energy-efficient, passive solar drying system constructed with food-grade stainless steel, ensuring both durability and compliance with food safety standards. The system is modular and removable, allowing for easy cleaning and maintenance. It consists of a large drying chamber equipped with multiple drying racks, maximizing the drying capacity while ensuring optimal air circulation for uniform drying.

One of the key innovations of this dryer is its enhanced airflow and temperature control mechanism, which accelerates the drying process and prevents overheating or under-drying. The design incorporates natural convection principles to facilitate effective moisture removal, reducing the drying time while maintaining essential nutrients, color, and texture. Furthermore, the solar dryer supports various pre-treatment methods, such as osmotic dehydration and dry

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salting, which help lower initial moisture content and further improve drying efficiency.

II. Provisions regarding the quality of fresh tomatoes

At the beginning of each year, the producers of seasonal tomatoes have to launch their orders for plants of different varieties, of which the most demanded is the variety "Sabra".

II.1 Minimum quality characteristics of the raw material:

The tomatoes must be :

- Whole
- Fresh in appearance;
- healthy: products affected by rot or deterioration such as to make them unfit for consumption are excluded;
- Clean and practically free of :
    * Of visible foreign matter ;
    * abnormal external moisture,
    * pests affecting the general appearance of the produce;
    * damage caused by pests;
    * any foreign smell and/or taste

II.2.Category:

The tomatoes must belong to one of the two categories below:

- *Extra Category :* Tomatoes in this class must be of superior quality. They must have firm flesh and the characteristic shape, appearance and development of the variety.
  Their size must be uniform. Their colouring must be in accordance with the state of maturity. They must not have "green backs" or other defects, except for very slight superficial alterations of the skin, provided that these do not affect the general appearance of the product, the quality, the keeping quality and presentation in the package.

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- *Class 1 Category :* Tomatoes in this category must be of good quality. They should be sufficiently firm and have the characteristics of the variety in shape, appearance and development. They must be uniform in size. They must be free of cracks and "green backs". The following slight defects, however, may be allowed provided these do not affect the general appearance of the produce and its quality
  - a slight defect in shape and development;
  - a slight defect in coloring;
  - slight skin defects;
  - very slight bruising.

<u>II.3.Size :</u>

The accepted size of tomatoes is :

- Size 3: from 40 mm to 46 mm.

- Size 4: from 47 mm to 56 mm

- Size 5: from 57 mm to 66 mm.

<u>II.4. Color :</u>

The color of the accepted tomatoes is either:

- red: if more than 60%, but not more than 90% of the fruit is pink or red.

- Ripe red: if more than 90% of the surface of the fruit shows a red color.

<u>II.5. Defects and Tolerance:</u>

The maximum tolerances allowed in relation to the above specifications shall not exceed 20% of the delivered lot.

III. Growing conditions

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III.1. Use of fertilizers:

Fertilizers must be separated from young plants and fresh tomatoes by at least one partition.

III.2. Cultivation area:

Tomatoes must not be grown or harvested from polluted areas. The environment of the land where the tomatoes are grown must not be polluted by fumes, polluting discharges or landfills.

III.3. Irrigation water hygiene:

Untreated wastewater shall not be used for irrigation purposes. Irrigation water supplies must not be polluted.

III.4. Pest Control:

Treatments with synthetic or organic chemical agents must be applied according to Tunisian regulations regarding their authorization for use. The tomatoes delivered must not contain or carry residues of phytosanitary products exceeding the maximum permissible limits.

III.5. Pesticide Use:

Pesticides used for crop treatment shall be registered by the Department of Agriculture and shall be used according to the manufacturer's recommendations.

III.6. Pre-harvest interval:

A minimum period of time respecting the instructions for the use of phytosanitary products between the application of the treatment and the date of harvest must be respected (minimum 15 days).

IV. Harvest and transportation hygienic

The harvesting and cultivation techniques must be hygienic.

IV.1. Materials and containers

- The tomatoes delivered must be transported in clean plastic crates and kept in good condition.

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- Containers that have contained dangerous substances must not be used to receive the tomatoes.

IV.2. Transportation

- Transport equipment (truck, tractor trailer) must be maintained in good condition and cleaned before each delivery.
- No chemicals or other hazardous materials should be transported with the tomatoes.
- The delivery time to the factory should not exceed 24 hours after collection,
- The use of aerated packaging (aerated boxes) preserves the quality of fresh tomatoes.
- The boxes should never be filled to the brim to avoid overcrowding.

	Outside dimensions	**Inside dimensions**	**Weight**	**Capacity**
length	54 Cm	51 Cm		
width	36 Cm	32.5 Cm	2000 Kg	35 Liter
height	27 Cm	21 Cm		

Fig. 1. Example of a high density polyethylene (HDPE) box, food grade and inert to chemical products, stackable and collapsible, used in the tomato production activity

V. Production process of dried tomatoes

1.Receipt and unloading of fresh tomatoes

2.Temporary storage

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3. Washing and rinse cycle

4. Cutting

5 . Osmotic Dehydration

6. Drying

7. Sorting of dried tomatoes

8. Packaging

9. Storage

V.1. Receipt and unloading of fresh tomatoes

Received raw materials shall be :

- Inspected to ensure compliance with raw material quality criteria.

- Sorted to eliminate all foreign bodies, tomatoes that are damaged, spotted and those that do not have the typical red color of ripe tomatoes.

- Calibrated and classified in lots according to the diameter of the fruit and put in clean boxes.

	small size	**Medium size**	**Big size**
Slender Tomato	size 3 **40 mm < Φ < 46mm**	size 4 **47 mm < Φ < 56 mm**	size 5 **57 m < Φ < 66 mm**

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V.2. Temporary storage

Upon receipt, fresh tomatoes are unloaded in a clean, ventilated area and should not be exposed to direct sunlight. Storage of fresh tomatoes should be done in a way that prevents physical damage to the tomatoes. An environment that minimizes the deterioration of the tomatoes (temperature, relative humidity...) and protects them from contamination during storage must be guaranteed. The duration of intermediate storage of fresh tomatoes should be short in order to preserve quality.

V.3 Washing and rinse cycle

The washing of tomatoes allows to remove all foreign bodies (leaves, sand, ..) and to ensure the disinfection with bleach, this operation must be done the following way:

- Fill the two stainless steel tanks with water up to the level of 50 L of water each.
- Add 0.03 L of bleach (12° hydrochloric acid) to the first wash tank,
- Empty up to 2 boxes of fresh tomatoes into the basin,
- Let it work for 10 minutes, then put the tomatoes in the second basin for rinsing.

V.4. Cutting

The fresh tomato is cut lengthwise into two equal halves on the middle of the longitudinal axis. The cutting operation is carried out with a stainless, sharp and clean instrument. The interval between cutting and drying must be as short as possible in order to avoid the alteration of the fresh cut tomatoes and the microbial proliferation.

V.5. Osmotic Dehydration

To reduce drying time pretreatments were applied mainly osmotic dehydration (OD) and dry salting. These pretreatments would allow a decrease in initial moisture content. In case of tomato, OD was performed using salty solution (30%+10% sucrose) during 8h

V.6. Drying

- Put the cut tomato quarters back on the drying racks and distribute them evenly.

- The racks are then weighed to determine the quantity of tomatoes per rack.

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- Follow the drying process by rotating and swapping the racks after three hours of drying.

- Monitor the temperature of the drying racks during the drying cycle.

- Remove the product after reaching the calculated theoretical drying weight and put the product immediately into the packing room.

- The target value of drying is to have a final moisture content of 15% (W/W)

Samples are kept 9h per day until reaching a constant weight. Drying kinetics were determined through mass loss: The curves were plotted through points, obtained by weighing the samples at regular time intervals: each 15min for the first two hours, each 30min for two hours, each 1h then each 2h until obtaining constant weight. Each day samples were dried for 9h then stored and put the day after again in dryer

V.7. Sorting of dried tomatoes

After drying, let the dried tomato carts cool down in the packaging room until they reach room temperature. A sorting is carried out before the conditioning to eliminate the tomatoes presenting defects of color, aspect and shape as well as the pieces of tomatoes which are not sufficiently dry. The dried tomatoes are sorted on a stainless steel table and classified into categories.

V.8. Packaging

After sorting the dried tomatoes, the quality pieces are packed. The packaging is done in food quality vacuum bags with a maximum weight of 5 KG.

The bags are labeled, the following information must appear on the label:
- Name of the product : Natural dried tomato
- Composition: 100% Dried Tomatoes.
- Date of production : DD/MM/YYYY
- Best before date: 6 months from the date of production
- Condition of preservation : To be kept in a cool place, once opened, to be kept at a temperature < 10 °C.
- Produced by : Name of the company
- Net weight : 5 Kg

V.9. Storage

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The use of a refrigerated room is essential for the storage of dried tomatoes in controlled conditions (temperature and humidity). The packaged product is stored at a temperature of 4°C.

VI. Layout of the production room:

VI.1. Production room

The room planned for this drying activity will have two separate spaces;

The first space is dedicated to the reception and sorting of fresh tomatoes, their washing, rinsing, and grading and their cutting and exposure on the hoppers of the dryer.

The second space is dedicated to the following operations:

- The drying of the tomato slices

- Sorting, grading, filling and packaging of dried tomatoes in vacuum packages and labeling of the final product.

- Storage of the final product.

VI.2. Recommendation for the design of the production room:

- Make a plan of the unit, which clearly indicates the different types of flows (raw materials, finished products, packaging, waste...)
- The storage areas for raw materials and finished products must be clearly separated,
- Arrange the room in order to avoid any type of crossing between clean operations or products on the one hand and contaminated products on the other hand,
- Respect the principle of forward movement, the products must always follow a unidirectional advance, from the dirty area to the clean area,
- The design of the room must allow for easy application of the cleaning and disinfection plan
- Make the right choice of construction materials to avoid any type of toxicity,

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- Cover floors, walls, ceilings and doors with materials that are easy to clean and disinfect,
- Construct floors in such a way as to allow adequate drainage,
- Ensure that the premises are well ventilated, to avoid the condensation of steam and the appearance of undesirable moulds,
- Provide corner rounding between walls, floors and ceilings,
- Designing windows to provide good light and prevent dirt accumulation (window sills should be designed to prevent objects from being placed in them)
- Equip windows with mosquito screens to prevent insects from entering,
- A drinking water supply with appropriate facilities is mandatory for the various cleaning operations or water requirements for the manufacturing process at the packaging unit
- Drainage pipes must guarantee a good flow of waste water,
- Floor drains must be screened and equipped with traps
- Provide adequate sanitary facilities to ensure an appropriate level of hygiene, and to allow the application of GHP; personal entrance and a sanitary block consisting of at least two toilets with non-manual hand washing stations and equipped with paper and liquid soap dispensers.
- Sinks in work areas must be non-hand operated and equipped with potable water
- Provide a soap dispenser or disposable paper to wash and dry hands.
- Provide non-hand operated trash cans
- Post pictograms with hand-washing instructions, especially after exiting the restroom.

VI.3. Materials and equipment needed for the dried tomato processing room:

- To have a weighing device stamped by the competent services with a valid stamp
- That the equipment or the washing, rinsing and sorting chain are made of materials that do not damage the tomatoes. They must be installed in an

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independent space where they can be easily controlled and maintained. They must be equipped with the necessary means to drain off waste water.

- Have equipment for tomato cutting operations,
- That the air is free of particles and odors that affect the quality of tomatoes in the drying chamber,
- That the air is free of particles and smells that affect the quality of the tomatoes in the drying chamber.
- That the cold rooms have a sufficient capacity, adapted to the production capacity and are equipped with effective tools for the control, the security and a system of follow-up of the temperature.
- Tables for sorting, cutting of fresh tomatoes and packaging of the final product, made of non-oxidizable material,
- Ergonomic stools according to the nature of the work and the number of workers in the sorting, sizing and packaging rooms,
- Raw material washing stations consisting of two tanks with a minimum capacity of 50 liters each in non-oxidizable material.
- A tomato cutting machine in quarters of 04 or 06 according to the size of the tomatoes.

VII. Solar Dryer:

The solar dryer is made of food-grade stainless steel. It is removable and washable, internally illuminated and with thermal insulation. It has a drying capacity of 6.5 m^2. The drier is composed of two chambers with removable partitions.

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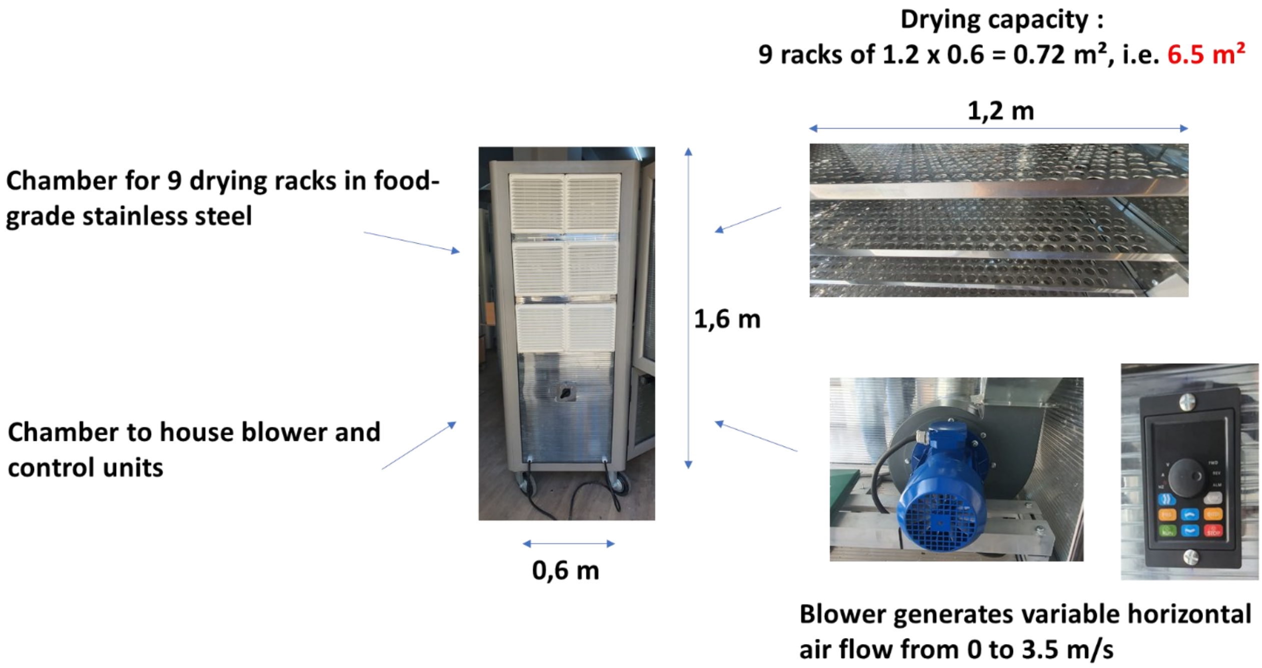

Fig.2. Illustration of the solar dryer

The drying chamber house nine drying racks. nine trays of dimension (0.6 x 1.2 m) are installed for fruits, vegetables and fish.

Recommendations during the drying process of the tomatoes

The drying of tomatoes requires the determination of the temperature and duration of drying,

The speed of drying depends essentially on the quality of the air used, its relative humidity, its temperature and its speed of circulation.

The speed of drying also depends on the thickness of the pieces to be dried and the type of dryer.

Rapid drying is not required for all foods. In the case of tomatoes, drying too quickly can lead to crusting. The food product hardens on the outside while remaining moist on the inside. Further drying is not possible.

- Avoid using high temperatures at the beginning of drying (the first hour), it is recommended to start with a temperature of 40°C (ventilation),

- Increase the temperature to 75°C, for 4 hours,

- Then lower the temperature to 50°C, for 2 hours,

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- It is preferable that the cooling is done properly after the drying.

Generally for 100kg of tomatoes we find 94kg of water and 6kg of dry matter (DM), after drying the elimination of 81kg of water is desired to reach a humidity between 11 and 13%.

VIII. Provisions concerning the quality of dried tomatoes

VIII.1. Minimum features

In all classes, dried tomatoes must be:

- Intact (only for whole tomatoes and halves); however, slightly damaged edges, slight superficial blemishes or slight scratches are not considered a defect,

- Healthy; products affected by rotting or deterioration such as to make them unfit for consumption are excluded,

- Clean; practically free of any visible foreign matter,

- Sufficiently developed,

- Free from living pests, whatever their stage of development,

- Free from damage caused by pests, including the presence of dead insects and/or mites and their debris or excreta,

- Free from superficial defects of discoloration

- free from mould filaments visible to the naked eye

- Free of fermentation

- Free of abnormal external moisture

- Free of foreign smell and/or taste, except for a taste of sodium chloride and a slight smell of preservatives or additives.

- Free of abnormal external moisture

- Free of foreign smell and/or taste, except for a taste of sodium chloride and a slight smell of preservatives or additives.

VIII.2. Water content of dried tomatoes:

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Dried tomatoes have a different water content defined by their designation, and their texture varies according to their water content

Table. Water content of dried tomatoes

Designation of the water content	Min	Max	Texture
High	25%	50%	Flexible and foldable
Usual	18%	25%	Firm but foldable
Reduced	12%	18%	Very firm
Low	6%	12%	Hard and breakable

Dried tomatoes treated with preservatives or by other means (such as pasteurization) may have a moisture content between 25 and 50 percent.

VIII.3. Microbiological quality of dried foods:

The growth of microorganisms is dependent on the activity of water, there is an optimum value of Aw for growth, located between 0.92 and 0.99. Below this optimum, growth is slowed or inhibited.

To evaluate the microbiological quality of dehydrated products, the microorganisms to be counted are

- The total aerobic mesophilic flora: gives an idea on the safety and quality of food in industrial control.

- Indicator flora of fecal contamination: coliforms at 30°C and 40°C, the presence of which indicates an alteration in the sanitary quality of the food. They are considered as an indication of the application or not of good hygienic practices.

- Thermophilic spores thermo-resistant: They have no significance from a hygienic point of view but they are important from a technological point of view.

- *Clostridium* sulfuto-reductor at 46°C: The enumeration of this microorganism is considered as an indicator of the efficiency of the washing.

- *Bacillus cereus*: Gives an idea on the efficiency of the cleaning, but also capable of causing food toxin infections with high doses of 105/g to 109/g.

- *Escherichia coli*: It is the most significant species of human fecal contamination. Its enumeration has as objective to control the hygiene of manipulation as well as the efficiency of the used process.

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Physico-chemical characteristics	**pH : 4,2 à 4,3** **Aw : 0,98 à 0,985**				
Risks	Moulds, pesticide residues				
Requirements	**Micro-organisms**	**n**	**c**	**m**	**M**
	Mesophilic aerobic germs	5	2	10^{4}	
	Staphylococcus coagulase +/g	5	2	100	1000
	Total coliforms	5	2	10	
	Fecal coliforms	5	2	10	
	Listeria monocytogenes	5	0	Abs /25gr	
	ASR/Clostridium	5	2	10	
	Coliforms 44°C	5	2	10	100
	Yeasts	5	2	1000	
	Salmonella	5	0	Abs 25g	
	Mould	5	2	1000	
	Pesticide residues (organochlorines, organophosphates)	absence			

m:fixed criteria (minimum value of germs)/ M = Maximum threshold or limit of acceptability (Maximum tolerated value of germs)/ n= the number of sample units/c= the number of sample units giving results between m and M.

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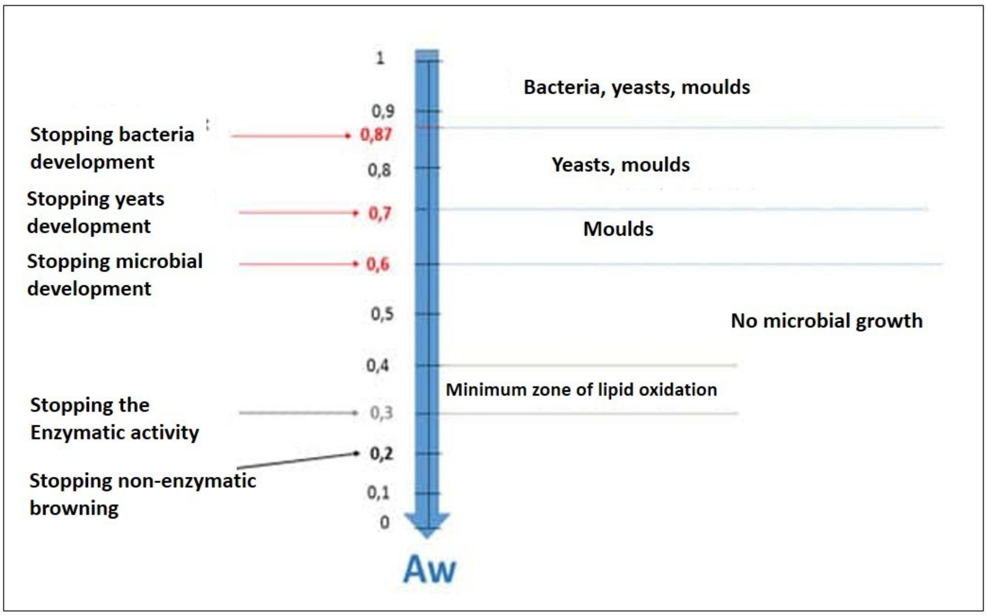

Fig.3. An overview on the phenomena that can occur at different stages of water activity (AW)

A quick reminder:

- 0 <aw<1

- aw of pure water = 1

- Wet product aw>0.9

- Intermediate moisture product 0.65<aw<0.9

- Dry product aw<0.65

- Optimal preservation aw<0.35

VIII.4. Classification

In accordance with the defects allowed (see below "Provisions concerning tolerances"),

Dried tomatoes are classified into the following classes: "Extra" Class, Class I and Class II.

The defects allowed must not affect the general appearance of the produce, the quality, the keeping quality and presentation in the package.

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IX. PROVISIONS CONCERNING TOLERANCES

Tolerances in respect of quality and size shall be allowed in each lot for produce not satisfying the minimum requirements of the class indicated.

Admissible defects	**Permitted tolerances** (weight of defective dried tomatoes tolerated as a percentage of total weight of dried tomatoes)		
	Extra Class	**Class I**	**Class II**
a/ Tolerances allowed for dried tomatoes not satisfying the minimum requirements	5	10	15
Fermentation, rot, mold, pest attack	1	2	3
Mouldy products	0.5	1	1
Fermented products	0.5	1	1
Mechanical injuries, rips, calluses and scars (for whole tomatoes and halves)	2	3	5
Superficial defects and color alterations (for whole tomatoes and halves)	4	6	9
Dirty fruit	0	0.5	1
Soft tomatoes (low moisture content product), scars, blisters and other superficial defects (except on the abscissa of the tomato)	1	2	3
B/ Size tolerances			
For products not conforming to the size indicated, in case of sizing	10	10	10
C/ Tolerances for other defects			
Foreign matter and excess plant material (leaves, wood, stems and tails)	0.5	1	1
Living parasites	0	0	0

X. Provisions concerning the presentation

X.1. Homogeneity:

The contents of each package must be uniform and contain only dried tomatoes of the same origin, quality and size (if sized).

- For "Extra" Class, the dried tomatoes must be similar in shape and appearance, and have a distinct uniform color.

- For Class I, the dried tomatoes must be relatively uniform in color.

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- The visible part of the contents of the package must be representative of the entire contents.

X.2. Packaging:

Dried tomatoes must be packed in such a way as to protect the produce properly.

The materials used inside the package must be clean and of a quality such as to avoid causing any external or internal damage to the produce. The use of materials, particularly of paper or stamps bearing trade specifications, is allowed provided the printing or labelling has been done with non-toxic ink or glue.

Packages must be free of all foreign matter.

X.3. Presentation:

Dried tomatoes after sorting and grading may be presented in rigid or flexible packages. All the packages intended for sale contained in the same package must have the same weight.

The empty packages are stored, in separate, non-humid places on pallets and protected from rodents and pests.

1.B. Solar drying

Food Hubs Mukurweini (KE), Kilombero (TZ), Nakaseke, Kajjansi / Masaka (UG)

Objectives and description of the innovation

The overall objective is to produce and characterize tree tomato powder through solar drying.

The specific objectives are to:

i. Design and fabricate an innovative solar cabinet drier with solar powered fan and air heater.

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ii. Determine the drying kinetics and quality characteristics of tree tomato powder produced by the innovative solar drier and the existing solar tunnel drier.

Innovative solar cabinet drier:

The prototype is a hybrid solar drier with a solar collector at the top through which air at ambient temperature circulated by a solar fan passes as it is forced through the drying cabinet containing stacked drying trays loaded with the food material before it comes out as exhaust air. Convex lenses fixed on the glass cover of the solar collector concentrate the solar radiation thus increasing the intensity of the radiation reaching the black absorber surface. In addition, the drier has a battery that is charged by solar energy and is used to heat the drying air and to power the air fan when there is inadequate or no solar radiation. This changeover from direct solar air heating to battery powered DC air heating is accomplished by a programmable logic controller. There is therefore extended drying period beyond that for a typical solar drier to achieve fast drying before the onset of microbial or chemical spoilage especially for drying fruits and vegetables with high moisture content. The prototype is simple to operate and scalable.

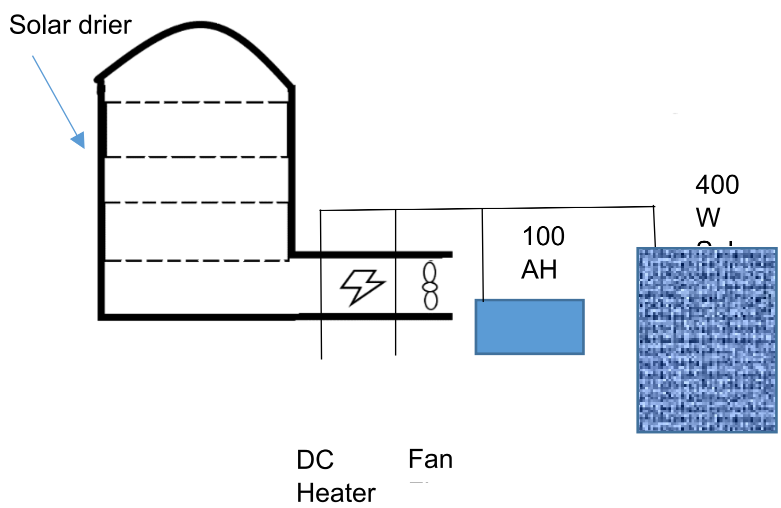

Figure 1: Innovative solar cabinet drier

First results from lab-small-scale tests and expected results

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The solar cabinet drier has been designed and will be constructed. The solar drier and the existing solar tunnel drier will be compared in terms of drying characteristics and tree tomato powder quality as above. Variation of moisture content with time will be determined under different conditions and drying models will be developed and the best model identified.

The following quality parameters will be obtained

- Nutrient content (vitamin A and C) – AOAC methods;
- Colour – tristimulus colour meter;
- Microbiological quality (TVC, E-coli) – ISO methods;
- Organoleptic quality (colour, taste, overall acceptability) – 5-point Hedonic scale
- Functional properties of the powder – standard methods.
- Pilot validation of the drying technologies have been done in both Mukurweini and Kitui Food Hubs.

Procedure and required actions

The innovative hybrid solar cabinet drier should be constructed/installed in a place where there are no objects such as trees or walls that can obstruct the solar radiation by their shadows. The transparent cover of the solar drier should be cleaned regularly to maintain high efficiency of transmission of solar radiation to the black surface absorber that comes into contact with the incoming air and heats it since the black surface becomes hot due to absorption of solar radiation. Drying is continued at night or whenever solar radiation is insufficient by automatically switching on the battery operated heater. The battery is charged whenever there is solar radiation by a dedicated photovoltaic system.

Tomato pulp or other prepared fruits and vegetables are loaded on drying trays as a thin layer and the trays are placed on the drying cabinet shelves.. Vegetables should be blanched before drying. For tree tomato powder production, the dried product is milled using a disc attrition mill or a hammer mill.

Technology and production key performance indicators to be gathered

- Drying kinetics;
- Physicochemical properties of the dried food product;
- Technology acceptance during validation in the SME and food hub; and
- Profitability of the food business operation..

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Work plan

Activity No.	Activity	2023				2024				Comment (If any)
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
1	Construction & Testing of solar drier									
2	Comparison tests on solar tunnel drier									
3	Validation activities									SMEs and food hubs' communities
4	Tests on laboratory cabinet drier									Drier exists

Risks and mitigation measures

The major risk is availability of sunshine. Its mitigation measure is to only carry out solar drying tests when there is adequate sunshine.

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2. Milling

2.1. Introduction

Milling is defined as the process of grinding cereal grains or legumes into flour or meal. It is an important and intermediate step in the post-production of cereals. The primary objective of the milling process is to remove the outer layer (husks) and produce an edible portion that is free of impurities and in the form of a powder with different particle sizes (Oghbaei and Prakash, 2016). The milling process can be of two kinds: first, wherein the whole grain is converted into flour without abstracting any parts; and second, it could undergo differential milling to separate the grain into different parts (Oghbaei and Prakash, 2016). Cereal grains are the major source of energy for the majority of the population in developing countries. However, cereal-based foods are a poor source of dietary protein and subsequently have poor nutritional quality (Abdel-Gawad et al., 2016). Thus, supplementing cereal-based foods with legumes such as pulses and oil seeds provide high-quality foods because legumes are an excellent source of proteins, complex carbohydrates, low saturated fat, dietary fiber, a variety of micronutrients, and phytochemicals (Chiweshe et al., 2012).

2.1.1 Objectives

The overall objective is to produce blended flours with improved nutritional and functional properties.

Specific objectives of Subtask 4.4.4 are:

i. Develop cereals- legumes composite flours with improved nutritional and functional properties

ii. Develop composite flours based on quinoa flour

iii. Develop fish bones powder

iv. Determine the nutritional, sensory and physico-chemical properties of the developed food products

2.1.2 Description of the innovation

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The innovation of the subtask is to develop different milled products from locally available materials into acceptable and nutritious products.

2.1.3. Protocol of milling processes: specific procedures for products

Composite flour cereal-legumes based (maize flour)

Locally grown cereals (maize and millet), legumes (bio-fortified common beans and soya beans), and oil seeds (sesame seeds) were used as the main ingredients for the formulation of composite flour. Soybean and sesame seeds were used to increase the protein and fat contents, respectively. Maize, millet, soybeans, and sesame seeds were purchased at the local market in Morogoro, Tanzania, while bio-fortified common beans were obtained from one of the FoodLand bean projects at Mvomero Food Hubs. These materials provided optimum proportions of ingredients according to the desired amino acid profile requirements. Proportions of food ingredients were obtained through a computer program by blending essential amino acid compositions similar to those recommended by FAO, WHO, and UNICEF for children. The goal is to produce composite flour with 360 kcal of energy, a 65 amino acid score (AAS), 15 g of protein, and 10-20% protein energy. The proportion of the four formulations selected for study is shown in Table 1. Except for sugar, all raw materials were cleaned and washed to remove any dust, stones, or damaged seeds before drying for 12 hours at 60 °C and milling into flour using a locally fabricated hammer mill.

Table 1. Ingredients used for formulations of composite flour

Ingredients	1	2	3	4
Maize (%)	60	50	52	53
Millet (%)	10	15	10	5
Soybean (%)	10	10	10	7
Biofortified common beans (%)	15	20	25	30
Sesame seeds (%)	5	5	3	5
Sugar for taste	3	3	3	3

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Composite flour cereal-legumes based (wheat flour)

Raw materials and formulation of composite flours

The raw materials used in composite flour formulations are wheat flour, pea flour, chickpea flour, and faba bean flour. The raw materials were collected from the Food hubs of Chebika and Enfidha based on the results of a farmer survey and the nutritional and functional properties of the legumes (proteins, phenolic compounds, rheological characteristics, etc.). Thus, wheat flour, untreated, microwave heated, germinated pea flour, chickpea flour, untreated, microwave heated, germinated chickpea flour, and untreated, microwave heated, germinated faba bean flour are the ingredients used in the formulation of composite flours. Three percentages of wheat flour substitution are chosen (10%, 15%, and 20%), and each percentage is formulated by a mixing plan, 14 of which are generated by the Design Expert 13 software (Table 2).

Table 2. Composite flour formulations

Experience	Pea (%)	Chickpea (%)	Faba bean(%)
1	100	0	0
2	0	100	0
3	0	50	50
4	0	50	50
5	0	100	0
6	0	0	100
7	66.66	16.67	16.67
8	16.67	66.66	16.67
9	50	50	0
10	0	0	100
11	100	0	0
12	16.67	16.67	66 .66
13	50	0	50
14	33.33	33.33	33.33

Preparation of the flours

Elimination of anti-nutritional factors

- **Microwave treatment**

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Seeds of pea, chickpea and faba bean legumes underwent microwave treatment at 950W for 90 s according to Rahate et al. (2020).

- **Germination**
  The legume seeds were germinated according to the method described by Setia et al., 2019. A quantity of 200 g of seeds are washed with tap water for cleaning, then soaked in a 1 L aqueous solution of sodium hypochlorite at 0.07% (w/v) for 30 min for sterilization. After this step, the sterilization solution is removed, and the seeds are washed five times with distilled water, followed by soaking in 1 L of distilled water overnight at room temperature (~25°C). The next day, the batches of soaked seeds were placed on a tray to form a single layer of seeds, which were covered with damp cheesecloth for germination at room temperature in the dark 72 h. Seeds are evenly sprayed with distilled water (~40-50 g) once daily (around 10 a.m.) to maintain adequate hydration. The sprouts are dried in a convective dryer at 30°C for 24 hours and the dried seeds are stored in airtight boxes before grinding. Three independent batches for each type of seed were prepared.
- **Grinding**
  Untreated, microwave heated and germinated legume seeds are ground into flours using a laboratory grinder (Model). Then sift using a 0.5mm porosity sieve to prepare fine flours (Bala et al., 2020). The fine legume flours obtained are used for subsequent analysis.

Composite flours quinoa based

Description of the innovation:

The innovation is to develop quinoa based composite flours to be used in making porridge and “mandazi” snacks.

A major challenge is to remove the bitter taste from bitter varieties of quinoa grains. This is done by washing with running water and drying before milling into flour. Porridge composite flour is made by blending quinoa and maize flours. Mandazi snacks composite flour is made by blending quinoa and wheat flours. Physicochemical and organoleptic properties of mandazi snacks and porridge will be optimized.

Communities in the Kitui Food Hub to adopt and intensify farming of Quinoa crop or purchase of quinoa grains from the market. Farmers to be trained on the best harvesting time for quinoa. The harvested crop must be properly dried before storage to avoid spoilage and mycotoxin accumulation. Proper sorting should be done before processing quinoa seeds. Ideally, plant breeders should produce

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new strains of sweet quinoa with lower levels of saponin that is responsible for the bitter taste. Until this is done, Saponin can be removed from the seeds by rinsing with cold running water. The uncooked quinoa seeds are put in a mesh strainer and rinsed in the running water until the water passing through the strainer is clear in colour. This should be done while sifting the quinoa seeds around with the fingers. Saponin content should be checked by placing the seeds in a tube, adding water and vigorously shaking for 30 seconds. If no foaming occurs, it is assumed that all saponins have been removed. If foaming occurs, the saponin removal procedure is continued.

The washed quinoa seeds should be immediately dried to the moisture content suitable for storage or milling into flour. A suitable solar drier should be used to ensure a quick and hygienic process. A suitable mill such as a disc attrition mill should be used for quinoa flour production.

Quinoa flour should be blended with other flours to make products with enhanced nutrient content and acceptable sensory attributes. The other flours will be wheat for mandazi snacks and maize for porridge. The blending will be optimised.

Figure 1 shows the process for mandazi production, beginning with dry bitter quinoa.

Technology and production key performance indicators

- Nutritious composite flours developed;
- Acceptable sensory quality food products;
- Technology acceptable in Kitui Food Hub; and
- Investment in quinoa based composite flour business is profitable.

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Debittering by washing with water

↓

Drying in dry air oven at 60°C

↓

Milling quinoa –
using a blender (for laboratory scale)
and hammer mills (for pilot scale)

↓ milling

Blending quinoa (70%) and wheat flour (30%)

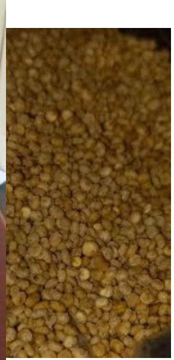
↓

Dough preparation, molding and cutting of mandazi shapes

↓

Deep frying in a shallow pan

Processing flow for making quinoa-based mandazi for malnutrition reduction in school children



Blender

Quinoa flour after milling

Measuring kneaded and matured dough

Cutting of flattened dough to triangle shapes

Ready to eat deep fried mandazi

Figure 1: Composite flour and chapatti production process

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Work plan

Activity No.	Activity	2023				2024				Comment (If any)
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
1	Composite flour formulation & production									Includes characterization of raw materials & products
2	Validation activities									SME and Kitui Food Hub
3	Human intervention studies in Kitui Food Hub									Efficacy trials

Risks and mitigation measures

- Quinoa may not be in the market when it is required; this risk is mitigated by planting the crop in the University of Nairobi land at Upper Kabete.

- This being a relatively new crop, the communities may not adopt the technology; this risk is mitigated by training the consumers on the benefits of the quinoa grains.

<u>Composite flour orange fleshed sweet potatoes based</u>

Raw materials used include biofortified beans (NAROBEAN 3), orange-fleshed sweet potatoes (NASPOT 8), grain amaranth (cream type), and white maize. These crops were selected due to their nutritional value and availability among target farmers. The grains (maize, beans, and grain amaranth) were milled in their natural dry form, while orange-fleshed sweet potatoes were first processed into dry slices before milling, using a locally fabricated hammer mill. The resulting flour was blended into different formulations, as shown in Table 3.

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Table 3. Different formulations of OFSP composite flour

	Ingredients (%)			
Run	***OFSP**	**Maize**	**Beans**	**Grain amaranth**
1	69.7	0.3	20.0	10.0
2	20.0	30.0	40.0	10.0
3	44.5	16.1	29.1	10.3
4	30.9	10.8	28.3	30.0
5	32.4	24.6	33.0	10.0
6	38.2	3.8	38.9	19.2
7	20.0	24.8	28.3	26.9
8	50.0	0.0	29.2	20.8
9	20.0	24.8	28.3	26.9
10	44.5	16.1	29.1	10.3
11	42.3	9.0	20.0	28.8
12	57.7	12.3	20.0	10.0
13	50.0	0.0	29.2	20.8
14	26.5	14.7	40.0	18.8
15	26.5	14.7	40.0	18.8
16	36.6	18.2	24.8	20.3
17	34.3	30.0	20.0	15.7
18	42.3	9.0	20.0	28.8
19	27.3	3.4	39.3	30.0
20	50.0	0.0	40.0	10.0

*OFSP- Orange fleshed sweet potatoes

Fish bones powder

Fresh, Nile tilapia, and African catfish were purchased from fish farmers in Kakiri, central Uganda. The fish was transported to the food processing plant at the Food Biosciences and Agribusiness Research Program (FBA), National Agricultural

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Research Laboratories, Kawanda, which is one of the NARO institutes with facilities for product development. Upon arrival, the fish was washed, filleted, and washed again before being put on a shallow tray. The fillets were used for other processes. The carcass was washed and deboned using a deboner to separate the bones from the mince. The bones were dried in an electric dryer at 60 °C until brittle (10% moisture content). Then vacuum pack and store in a cool, dark, and dry place. The preparation of fish powder is shown in Figure 2.

Figure 2. Preparation of fish bones powder

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2.1.4 Products analysis and results

Composite flours based on cereals-legumes

The raw materials and the developed composite flours were analyzed for proximate analysis (moisture, crude protein, crude fibers, ash, and carbohydrate), total phenol. As well as for physical properties such as bulk density (BD), water absorption index (WAI), water solubility index (WSI), oil absorption, and angle of repose.

The results of proximate composition, physico-chemical properties and mineral contents of raw materials and composite flour are shown in Table 5, 6 and 7 respectively.

Table 5. Proximate composition of raw materials and cereals-legumes based composite flour

S/N	Materials	Moisture content (%)	Crude protein (%)	Crude fiber (%)	Crude fat (%)	Ash content (%)
1	Soybean flour	6.45	39.45	8.88	7.25	4.73
2	Maize flour	6.91	11.63	2.05	10.96	1.38
3	Biofortified common bean flour	8.99	18.03	5.59	6.40	3.26
4	Sesame seed flour	9.67	20.60	19.74	23.99	4.00
5	Millet flour	12.87	5.60	2.74	3.68	2.42
6	Composite flour	3.99	15.22	3.36	3.43	2.39

Table 6. Physico-chemical properties of raw materials and cereals-legumes based composite flour

S/N	Materials	Water absorption index 'WAI'	Water solubility index 'WSI'	Oil absorption index 'OAI'	Bulk density, g/cm3	Angle of Repose
1	Soybean flour	4.84	84.00	0.65	0.40	69.25

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2	Maize flour	4.77	17.00	0.75	0.56	72.01
3	Biofortified common bean flour	4.87	42.50	1.24	0.57	71.45
4	Sesame seed flour	4.70	19.00	2.18	0.44	62.15
5	Millet flour	4.46	6.00	1.94	0.56	67.55
6	Composite flour	5.20	16.50	2.14	0.66	74.20

Table 7. Mineral contents, vitamin A and Phenols of raw materials and cereals-legumes based composite flour

				Minerals contents mg/kg, except K in %							
S/No		**Vit A (µG/100G)**	**Total phenol (mg/100g)**	**Cu**	**Zn**	**Fe**	**Mn**	**Ca**	**Mg**	**K%**	**Na**
1	Soybean flour	391.70	2.92	9.65	57.02	75.48	40.92	29.49	254.75	0.54	78.25
2	Maize flour	438.36	1.47	2.26	39.08	26.38	8.40	0.86	164.46	0.12	71.88
3	Biofortified common bean flour	113.56	0.96	7.35	48.42	66.10	10.30	16.92	385.19	1.11	75.92
4	Sesame seed flour	258.06	1.34	14.15	70.51	49.49	30.01	102.09	533.10	0.74	43.43
5	Millet flour	60.66	2.31	7.03	35.06	52.41	3.48	41.36	380.18	0.16	116.37
6	Composite flour	77.87	1.18	4.31	41.42	165.99	25.68	13.06	254.64	0.33	125.34

Composite flours based on cereal (wheat)

The individual and composite flours were subjected to different analyses (a detailed description is shared in the Foodland database (characterization and labeling)). The dry matter, protein content, total phenols and flavonoids contents, and the DPPH test scavenging radical capacity were all determined using physiochemical analysis. Color parameter evaluation was done using a Konica Minolta chromameter. The techno-functional properties of the different flours were determined by the determination of different parameters (apparent density, tapped density, compressibility index, Hausner ratio, water absorption capacity, water solubility index, foaming capacity, and foam stability).

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The obtained results revealed significant differences in the studied parameters: the microwave-heated faba bean flour had the highest dry matter (92.43%), while wheat flour had the lowest (87.72%). All the tested flours presented a higher DPPH radical scavenging capacity than that of wheat flour. The different faba bean flours (untreated, microwave-heated, and germinated seeds) presented the highest DPPH radical scavenging capacity, and for the different legume flours, the germinated seeds were more effective than the untreated and microwave-heated seeds. These results suggest that the incorporation of germinated seed flours can be a good issue for the formulation of products with added value.

Furthermore, the obtained results for color parameters (L*, a*, and b*) showed significant differences between the tested flours (p 0.001). The legume flours presented a lower value of L* than that of wheat flour. The chickpea and faba bean flours presented the closest L* values to those of wheat flour. For the parameter a*, all the flours presented negative values, indicating a greenish tint; however, the recorded values of b* were positive, indicating a yellowish tint for all the flours. Wheat flour had the lowest b* value recorded (11.17).

For techno-functional properties, significant differences were observed for apparent density (a), tapped density (t), compressibility index, Hausner ratio, foaming capacity, and foam stability. The highest values of t were observed for the different faba bean flours. The results showed that microwave heating has significantly decreased the foaming capacity of legume flours.

Composite flours quinoa based

The raw results of proximate composition and micronutrient content of four varieties of quinoa grains are shown in Tables 1 and 2 respectively.

The moisture content of the four varieties ranged from 10.27 to 10.59 %, with Titicaca with the lowest percentage. Brilliant Brightest Red variety had the highest level of fiber content and the lowest amount of ash. Cherry vanilla variety had the highest level of crude protein (25.08g/100g) as well as fat content (11.46g/100mg). The carbohydrate level in the four varieties ranged from 42.50 g/100g to 64.15 g/100g. Subject to statistical analysis, Cherry vanilla had the highest energy Kcal of 373.46 kcal compared to the other three varieties (Table 8).

Table 8: Proximate composition of the four quinoa varieties

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Quinoa Variety	Moisture	Fiber	Ash	Protein	Fat	Carbohydrates	Energy Kcal
CHERRY VANILLA	10.43	6.87	3.66	25.08	11.46	42.50	373.46
BBR	10.59	6.92	2.55	21.06	6.58	52.30	352.66
TITICACA	10.27	6.88	5.18	9.31	4.21	64.15	331.71
BIOBIO	10.38	6.05	3.61	17.30	4.74	57.92	343.54

Subject to statistical analysis, Titicaca variety had the highest amounts of manganese (219.70 ppm), potassium (5120 ppm) ,iron (114.70 ppm) and zinc (141.07 ppm) whereas Biobio had the highest amounts of magnesium (738.56 ppm) and the lowest amount of Calcium (13.42 ppm) (Table 9).

Table 9: Mineral composition of the four quinoa varieties

Quinoa Variety	Manganese (ppm)	Magnesium (ppm)	Potassium (ppm)	Calcium (ppm)	Iron (ppm)	Copper (ppm)	Zinc (ppm)
Cherry vanilla	94.45	334.55	3476.76	108.00	94.87	18.71	116.39
BBR	85.87	291.83	5020.22	79.62	52.04	9.37	88.63
TITICACA	219.70	354.76	5120.25	78.63	114.70	8.32	141.07
BIOBIO	205.62	738.56	3789.34	13.42	86.65	8.60	138.48

Other expected results:

(i) Proximate and mineral composition of chapatti and porridge flours as in Tables 1 and 2.
(ii) Sensory characteristics of chapatti and baby porridge.
(iii) Storage stability parameters for the composite flours: fat acidity, peroxide value, moisture content, total viable count, yeast and moulds count.
(iv) Results of efficacy trials on children.

Composite flour based on orange fleshed sweet potatoes

Raw materials were analysed for protein content (AOAC, 2016), beta carotene (Tiony & Irene, 2021), zinc and iron (Paul et al., 2016) as well as paste final viscosity (RVA 4500, Perten Instruments, Hägersten, Sweden). Data for the aforementioned flour properties are to be analyzed using response surface

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methodology and desirability function approach to determine how response parameters vary with independent variables and for determination of the optimal formulation to be used for up-scaling.

The developed composite flours were analysed for iron and zinc content and gruel made from the flour was subjected to analysis using a Rapid Visco-analyser and the final viscosity recorded. Results of the analyses are shown in Table 10.

Table 10. Selected minerals and Viscosity of raw materials and composite flour

	Ingredients (%)				Composite flour		
Run	**OFSP**	**Maize**	**Beans**	**GA**	**Iron**	**Zinc**	**Viscosity**
1	69.7	0.30	20.0	10.0	0.89	0.46	762
2	20.0	30.0	40.0	10.0	1.26	0.52	827
3	44.5	16.1	29.1	10.3	1.14	0.65	825
4	30.9	10.8	28.3	30.0	1.05	0.51	703
5	32.4	24.6	33.0	10.0	1.13	0.32	827
6	38.2	3.80	38.9	19.2	1.93	0.46	678
7	20.0	24.8	28.3	26.9	1.21	0.48	1113
8	50.0	0.00	29.2	20.8	2.28	0.50	1321
9	20.0	24.8	28.3	26.9	2.31	0.54	635
10	44.5	16.1	29.1	10.3	1.18	0.88	533
11	42.3	9.00	20.0	28.8	0.70	0.28	981
12	57.7	12.3	20.0	10.0	0.73	0.31	494
13	50.0	0.00	29.2	20.8	1.30	0.35	648
14	26.5	14.7	40.0	18.8	0.91	0.31	870
15	26.5	14.7	40.0	18.8	1.09	0.39	943
16	36.6	18.2	24.8	20.3	0.89	0.41	590
17	34.3	30.0	20.0	15.7	0.79	0.34	723
18	42.3	9.00	20.0	28.8	0.92	0.20	908
19	27.3	3.40	39.3	30.0	0.67	0.32	862
20	50.0	0.0	40.0	10.0	0.91	0.42	899

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3. Fisk smoking, salting and fermenting

Introduction: Raw Materials & Formulations

Live fish, Nile tilapia, African Catfish, Labeo and Barbus sp. were purchased from fish farmers in Kakiri, central Uganda. The fish was transported to the food processing plant at Food Biosciences and Agribusiness Research Program (FBA), National Agricultural Research laboratories, Kawanda which is one of the NARO institutes with facilities for product development. Upon arrival, an incision was made at the back of the head to allow for bleeding. Bleeding was done in a white container with water. Keep emptying/refilling the container until the water remains clear, indicating that bleeding has stopped (this took approximately 50 mins). After bleeding, the fish were thoroughly washed, split open in a butterfly way, guts removed and then washed again to remove all the bloodstains and any other form of dirt. In addition, for Tilapia, Labeo and Barbus sp., scales were removed.

Fig 1. Preparation of fish raw material

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Processing Protocols

Smoked Fish

The smoked fish with acceptable levels of Polycyclic Aromatic Hydrocarbons (PAH) was prepared according to Masette *et al*., (2018) using the NARO PAH-Safe Fish Smoking Kiln (Fig. 2).

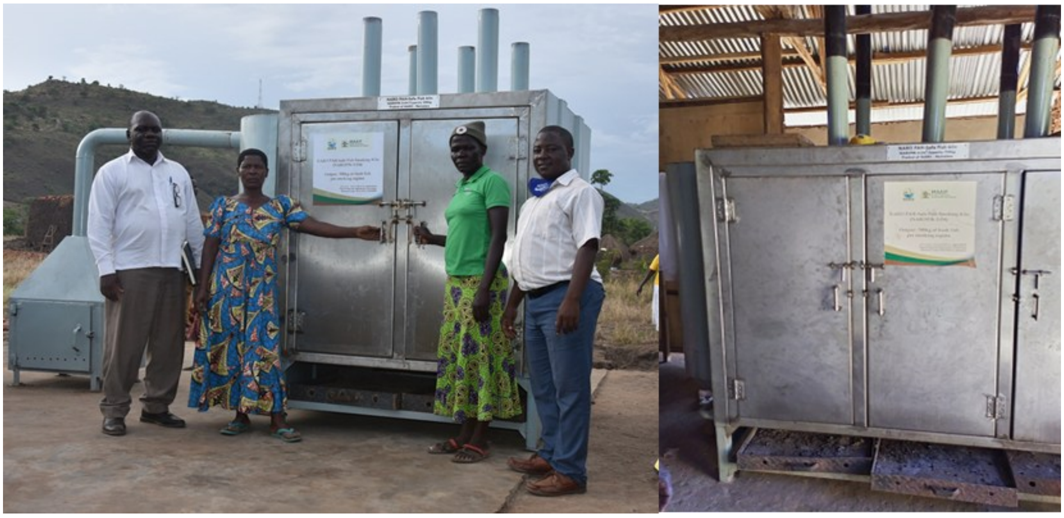

Fig. 2 NARO PAH-Safe Fish kiln

The processing steps are as follows;

a. All the fish were drip dried for 1 hour in the sun and then placed on trays inside the smoking kiln.
b. Different types of fish were placed into different chambers of the smoking kiln without cross contamination
c. Smoke was induced from matooke peelings and guava tree wood for a period of 3-4 hour at 40 °C (depending on the fat content of the fish species).
d. This was gradually increased to 50 and 70 °C over a period of 4 hours.
e. The kiln temperature was gradually increased to 100 °C for a period of 3 hours
f. This was maintained for a further 2 hours after the fish had been turned over so that the side that was up is directly facing the oven bottom
g. Then remove the heat source and allow the fish to cool to room temperature before packaging
h. The smoked products were put on stainless steel trays for inspection

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i. Package in well ventilated waxed boxes and store at ambient temperature ready for market

Fig 3. Smoking of fish using NARO PAH-Safe Fish Smoking Kiln

Salted fish

The salted fish was prepared according to the method described by Masette (2013).

a. The split and washed fish were sliced into thinner portions (10mm thick).
b. The portions were salted in 1:20 ratio (that is 0.25kg salt for 5kg fresh fish) then put on stainless trays overnight slanted at 20 °C.
c. The fish portions were then spread on a raised rack mesh surface at ambient temperatures (26 - 30°C).
d. The racks are slanted at a 20 °C angle to aid drainage of excess water
e. The raised surface was elevated at 1M above the ground.
f. Portions of large fish were also turned regularly (every 1 hour) and dried for 2 - 3 days. (duration depends on the thickness and fat content of the fish as well as ambient temperature and humidity).
g. The resultant salted and dried products were packaged in the ventilated waxed boxes and stored at room temperature ready for market.

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<u>*Sun dried*</u>

The sun drying of fish was done in accordance with Masette (2013).

a. The split and thoroughly washed fish (as in the previous sub-section) fish was sliced into thinner portions (10mm thickness) to facilitate the drying process.
b. Drip dry in the shade for 2-3 hours to avoid case hardening
c. These portions were spreading on a drying rack at ambient temperatures (26 - 30°C).
d. The drying rack was elevated at 1M above the ground.
e. These were turned at regular intervals (1 hour) and dried for approximately 2 - 4 days. (duration depends on the thickness and fat content of the fish as well as ambient temperature and humidity).
f. Dried products were packaged in the ventilated waxed boxes and stored at room temperature ready for market.

<u>*Fermented*</u>

Solid fish hydrolysate feed was produced from the fish offals/guts by lacto-fermentation (using Lactic Acid Bacteria – LAB). A method similar to Arvanitoyannis and Kassaveti (2008) was used as described below;

i. Wash the fish waste and containers to be used under running water
ii. Weigh/determine the volume of the fish waste (5.25L)
iii. Comminute and blend the fish waste using a knife and blender/food processor respectively
iv. Add clean/potable water (ordinary boiled water) to the homogenate in a ratio of 1:1 i.e. 1 part water to 1 part fish waste (5.25+5.25=10.5L Total Volume). If using chlorinated water, leave the water to sit overnight to allow the chlorine to dissipate. Chlorine is an antimicrobial agent.
v. Homogenize the mixture by agitation/stirring
vi. Add lyophilized LAB at an inoculation rate of 0.02%. (2.1g in 10500mL)
vii. Add sugar at a rate of 8.5% of the total volume of mixture (892.5g in 10500mL)
viii. Stir the mixture to homogeneity
ix. Transfer the mixture to the fermentation vessel (jerry can, vat, demijohn etc.) (20L Jerry can)
x. The vessel may be loosely capped however, an airlock should be used to cap the vessel and allow for anaerobic fermentation while containing the

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unpleasant odour from gases produced especially carbondioxide (airlock was used)

xi. Fermentation proceeds at ambient temperature (25-30 °C) for 3-4 week.

xii. The fermentation is complete when a faint vinegar odor replaces the previous putrid odor

xiii. Enhance the carbohydrate/solids content of the fish hydrolysate by adding cassava flour/maize bran in a ratio of 1:1 (10 kg)

xiv. Mix to homogeneity

xv. Sun-dry the mixture on tarpaulin/black polythene sheet for approximately 48 hrs.

Fig. 4 Preparation of fish hydrolysate by Anaerobic Fermentation of Fish Guts using LAB

Fig. 5 Enhancement of carbohydrate/solids content and drying for ease of handling and extended storage of feed

Products Evaluation

Planned analysis yet to be done

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- Composition Analysis - Macro and micronutrient profiling of the primary products
- Smoked fish - PAH analysis
- Salted fish – halophilic bacteria analysis
- Conduct shelf life studies on developed products – Analyses include; moisture/water content, water activity, TVBN, peroxide value, Thiobarbituric acid reactive substances, acid value, total viable counts and yeasts and moulds counts and sensory evaluation
- Performance evaluation of hydrolysate for animal feed e.g. poultry e.g. egg production (quality and quantity)

Plans for Scaling

- Small and medium enterprises (SMEs) in two hubs (Kajjansi and Masaka)
- First training has been conducted to introduce SMEs to the products (primary – smoking, salting and secondary – nuggets, balls, crackers), process layout and preliminary quality assurance
- Second, hands-on training to be conducted after which SOPs will be finalised with input of SMEs

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