Demonstrated Value of Improving Postharvest Practices

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New Use Agriculture & Natural Plant Products Program
Rutgers, The State University of New Jersey. Purdue University, and Agri-Business in Sustainable Natural African Plant Products (ASNAPP)

USAID FROM THE AMERICAN PEOPLE HORTICULTURE INNOVATION LAB UCDAVIS UNIVERSITY OF CALIFORNIA

RUTGERS PURDUE UNIVERSITY ASNAPP

Applying our market-first science driven models to fresh Vegetables

Value Chains are the Model Used. Mitengo Women in Zambia Produce High Qualit Vegetables for supermarkets

Public-Private Partnerships for economic development using technologies to reduce poverty

Partnership between ASNAPP and Sun International hotel served as a driver for the supply of high quality vegetables by farmer groups.

Our farmer groups (including disabled heads of households) now meet quality, time of delivery, *and have earned >$3 million by providing as much as >85% fresh produce and culinary herbs. And, had no prior commercial horticultural experience.*

Greenhouse Specialty Vegetables Livingstone, Zambia

Open field vegetables
Disabled community
Livingstone, Zambia

From Seeds and Plants to Nursery

Good Crop Management

- Success in horticultural production builds upon good management;
- Horticultural production relative to agronomic production is knowledge intensive, requires significant management input from selection of crop enterprises, production, crop rotations, scheduling all inputs from seeds- final products sold.

Many projects focus on the production/supply side of value chain w/out a focus on Postharvest Handling of F&Vs and AIVS

Why is it relevant?

- Access to new markets- more formal ones such as supermarkets, distribution centers, buyers and traders for longer distance shipping
- Increase sales
- Reduce waste and spoilage
- Increase shelf-life to market
- Most of the investment already made; yields often a limiting factor due to low inputs by smaller holder, PH can often make a real difference between profit or loss.

Washing, Cleaning, Sorting, Bundling (clean water is important)

A Fresh Market in Eldoret, Western Kenya

Water: Used to cool and keep produce looking fresh

Basics of Postharvest Handling & Storage

- Keeping F&Vs cool after harvest can more than double their postharvest life for each 10° C decrease in handling temperature.
- Keeping F&Vs cool **will reduce the rate of water loss** (and reduce the related wilting, shriveling, yellowing)
- Keeping F&Vs cool **will reduce the rate of decay** (and reduce related rotting, oozing, mushiness, browning)
- Keeping F&Vs cool and minimally developing practical systems to keep produce as intact, fresh, turgid, and free/clean from pests increases your marketable product.
- Your agricultural inputs in production remain the same- the risks are minimized when you now focus on post-harvest as much as you focus on production.
- There are many steps you can do even without coolers and fancy equipment.

Cool Chain: Step 1

Harvest during the cooler times of day (in the early morning or even at night-time if possible)

- Leafy greens will stay fresh for about only one day at 30˚ C
- 'General' effect of temperature on postharvest life of F&Vs:

The harvested crops are alive, breathing and the growers task is to keep it as fresh as possible

Temperature	Postharvest Life
40˚ C	½ day
30˚ C	1 day
20˚ C	2 days
10˚ C	4 days
0˚ C	8 days

Cool Chain: Step 2

Product Protection At Harvest:

- **Keep harvested produce out of direct sunlight**.

- Use shade immediately after harvest. Shade keeps produce (estimated) 10 to 15˚ C cooler than air temperature at very low cost. Plan this at or even before production time!

- **Shade** can be expensive or inexpensive when using local materials.

- From moving produce into shade under live trees, or introducing open sheds, building overhangs, and even rigging up shade cloth on an open pickup truck or wagon. Shade cloth or grass, palm as thatched materials all can serve as cover on poles, **market umbrellas**, etc.

Cool Chain: Step 3- if possible

Next step forward is to introduce cooling into your production system and use it for those products which would gain most and generate highest earnings.

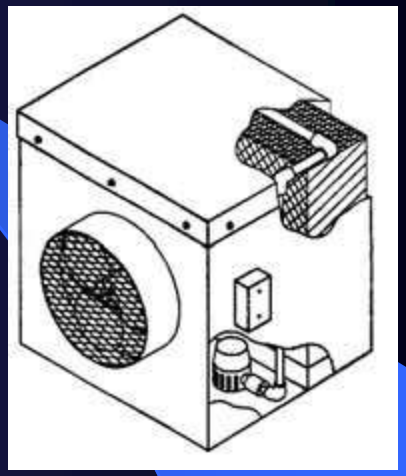
- Evaporative forced air cooling (uses moist air to cool to within 2° C above dew point temperature)– works best in dry regions or during the dry season

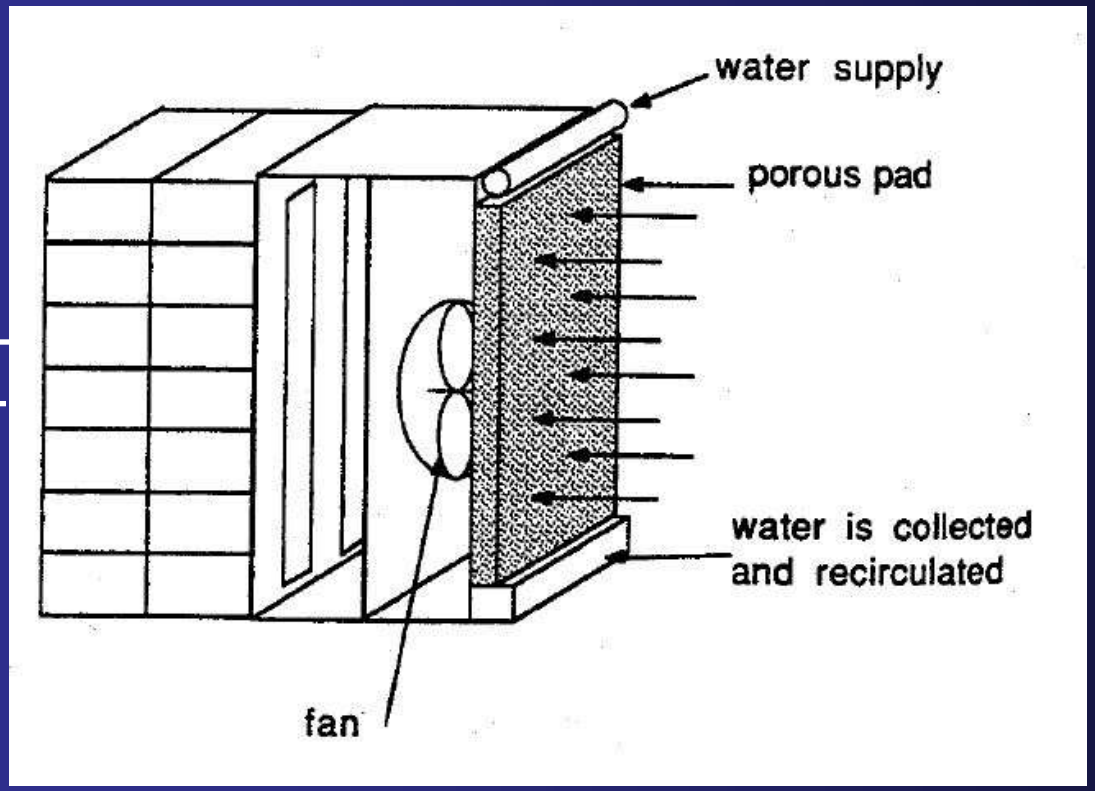
- Use of ice – crushed ice can be used to cool some vegetables to low temperatures (but may be very expensive to purchase or make)

- Refrigerated cold room – low cost systems such as the CoolBot™ can be used to cool small insulated storage rooms if electricity is available. (We will focus here)

Evaporative forced air cooling

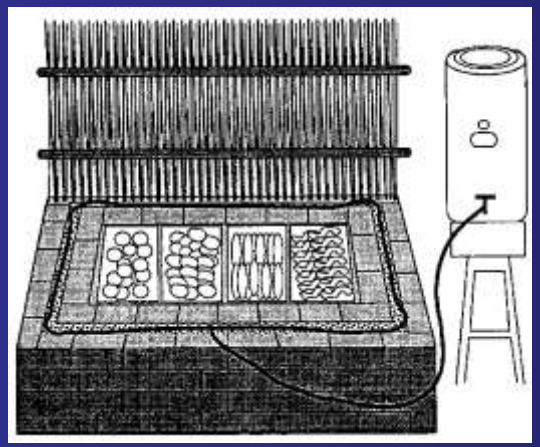
- Cut-away view of an evaporative cooler





Evaporative Cool Storage- is it really helpful for larger growers?

- Zero Energy Cool Chamber (ZECC)
- Developed in India in the 1980s by Dr. S K Roy
- Bricks and sand storage boxes, kept moist with a gravity fed drip system
- Passive system (no power needed)
- Low cost



Similar systems in use:
Charcoal walls (Kenya)
Fabric tents (Cambodia)
Clay in clay jars (Nigeria)

Cool Chain: Step 4

Short term cold storage

- May extend F&Vs when kept at 5 to 10˚ C their postharvest life for up to one week.

- CoolBot™ can be used with a regular window style air conditioning unit to cool storage air down to 2˚ C.

- Need to use containers that allow good air circulation within the cold room for best results. (Example: plastic crates; properly placed to facilitate airflow)

CoolBot ™

- Cost of A/C with CoolBot™ refrigeration installation is about 1/10 that of the cost of commercial systems designed for a traditional small cold room. Designed and commercialized by Ron and Kathryn Khosla, truck farmers in New Paltz, NY.
- Refrigerated cold rooms are most useful for storing higher value crops.
- Requires a cold room with excellent quality insulation, no air leaks.
- Power use estimation:
- 35 kWh/MT for 12˚ C
- 50 kWh/MT for 2˚ C
- http://storeitcold.com

CoolBot™ Cold Rooms

Size of storage room

Approximately 60% of the floor space is usable for storage, as the rest is taken up by doorways, aisles and open space left along the walls- all needed to ensure proper airflow.

- Typically window style air conditioners (A/Cs) are sold in two sizes

	Recommended Size of storage room
12,000 BTU A/C	8 x 8 ft
18,000 BTU A/C	8 x 12 ft
Two 18,000 BTU A/Cs , two Coolbots	10 x 20 ft

- 12,000 BTU = 3.5 kW =1 ton of refrigeration

CoolBot™ Cold Rooms

Design recommendations

- Locate the entire cold room under shade
- Keep the A/C unit out of direct sun
- Sealing for vapor barriers to the outside (the hotter side) of the constructed walls
- Single door located in a short wall
- Door that closes tightly
- No windows; ensure AC vent is closed, no leaks
- Plastic strip curtains to keep the cool inside when the door is opened
- Floor with easy to clean surface (ex: cement)
- 8 to 9 feet tall inside

CoolBot™ Cold Rooms

Construction materials

- Locally available materials must conform to the needed specifications
- R20 minimum for walls and door
- R30 for floor and roof

R value = insulation value, higher is better

- 8 inch cement block = R1
- One inch of wood shavings, sawdust, straw bale= R2
- Example materials and price list:

http://www.bae.uky.edu/ext/Specialty_Crops/PDFs/Material_and_Price_List_for_Low-Cost_Cold_Storage_Room_for_Market_Growers.pdf

Uganda


HortCRSP
Horticulture Collaborative Research Support Program
USAID
FROM THE AMERICAN PEOPLE
Coolrooms and Cool Transport for Small - Scale Farmers
Partners :
University of California Davis, USA
Reach Your Destiny Consult Ltd.Uganda
Eco Mungusi Farmers' Group, Arua

CoolBot™ in Uganda

Cavity wall will be filled with dried grass stuffed into plastic sacks

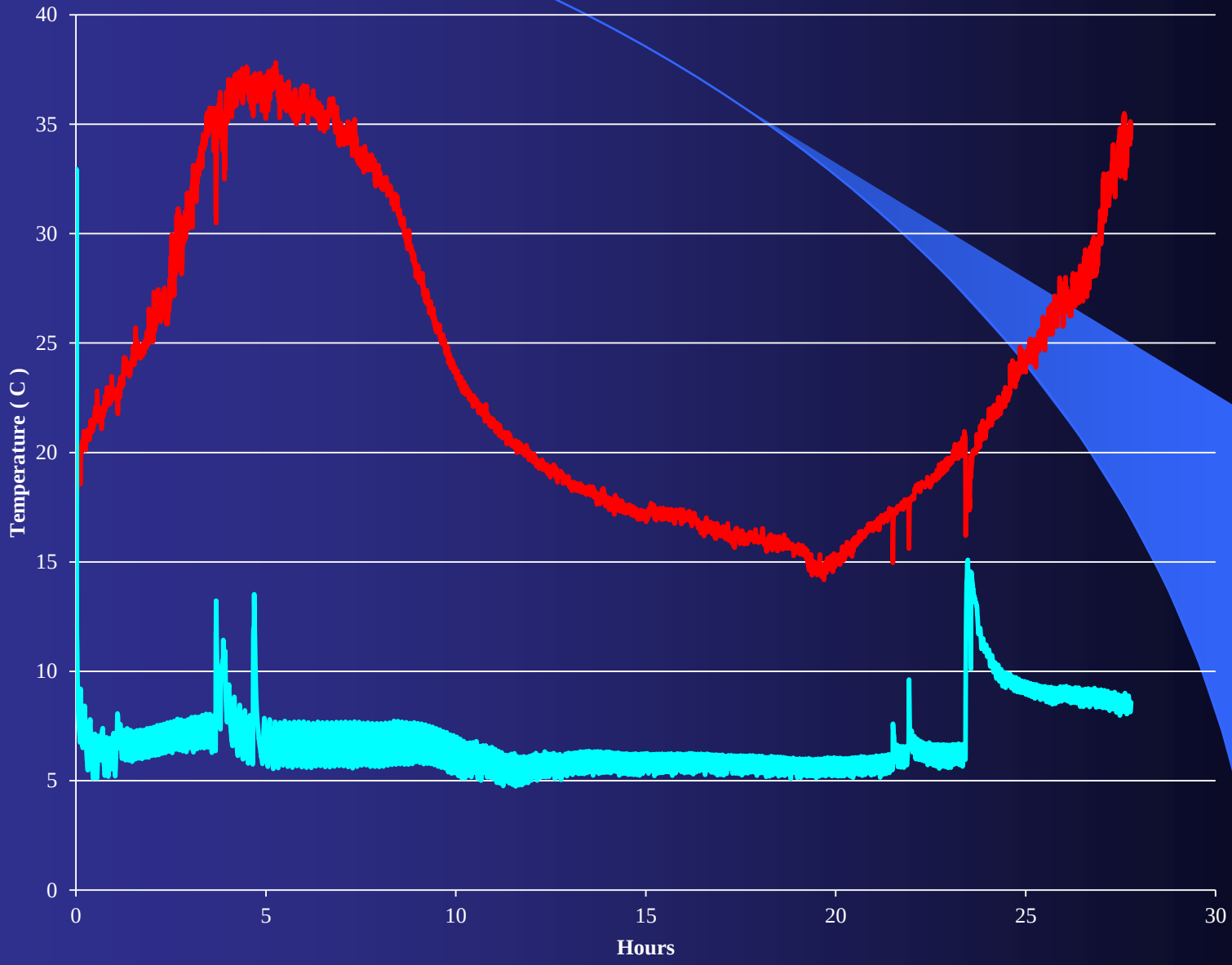

USAID

CoolBot™ at UC-Davis

(Int. Hort CRSP research Gloria Androa,Uganda)

CoolBot™ Controller showing frost on coils, the heater that defeats thermostat (surrounded by foil) and sensor in the coils detect formation of frost.

Coolbot room temperatures, Davis



CoolBot™ Cold Rooms

Electricity

- Requires a power source of 120 or 220 volts
- Back-up generator needed to provide temporary electric power if the power goes down.
- Solar electric power is a possibility in some locations (being used in Uganda under a Hort CRSP Exploratory Project, M. Reid)

CoolBot™ Cold Rooms

Installation

- Simple installation and set-up
- Video of the installation process
- http://storeitcold.com/install.php

CoolBot™ Cold Rooms

Management and Logistics- or a single family or grower cooperative/associations

- Inventory control and labels (who owns what inside the cold room? How is produce organized, stacked so it can be found quickly and easily?)
- First in- first out
- Inspections (Grading, sorting, maintenance)
- Sanitation
- Keep containers off the floor and away from the walls
- Recordkeeping;

CoolBot™ Cold Rooms

Financing and ownership options

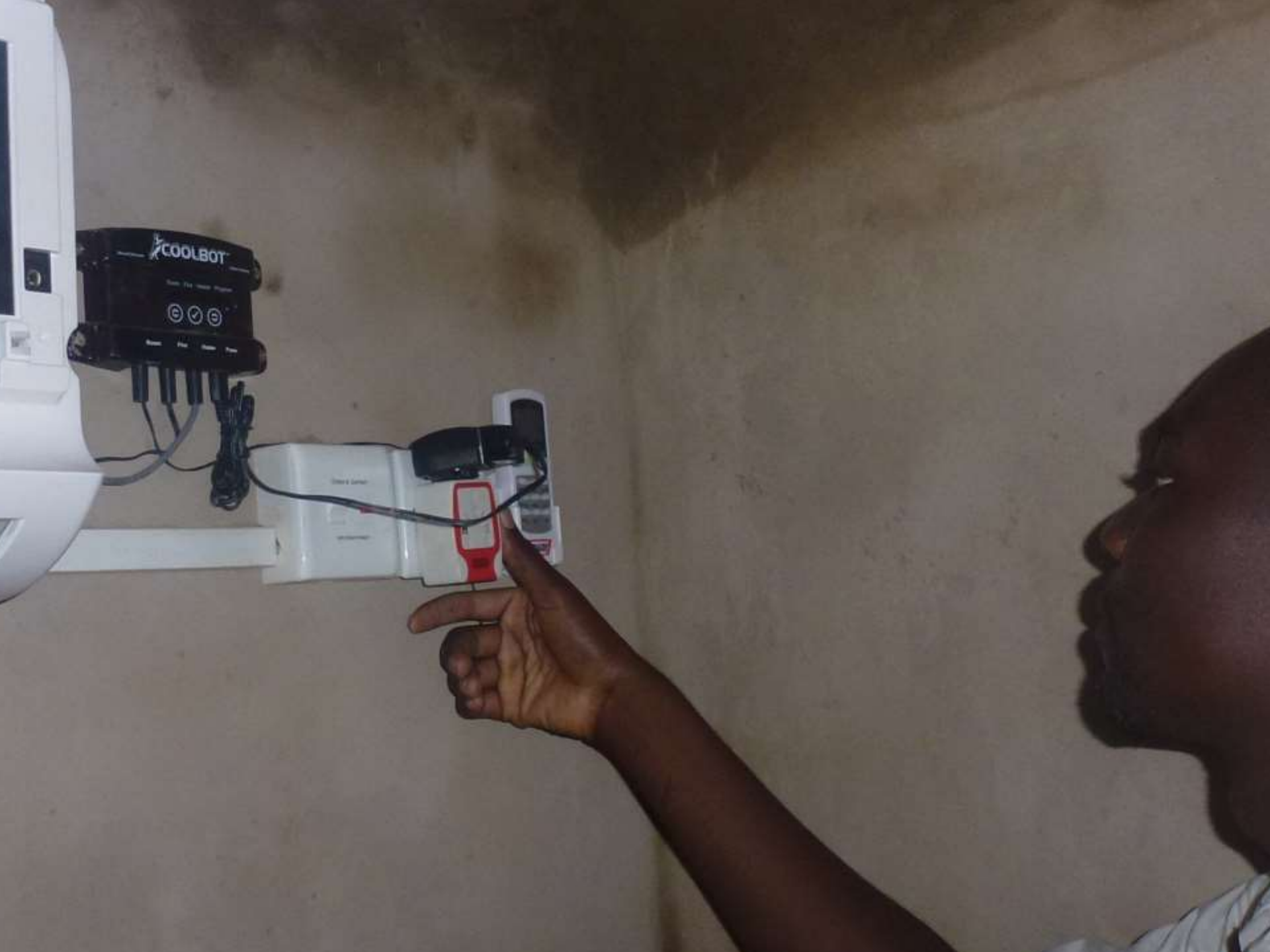
- Estimated costs total approximately US$3,000 for a cold room that will hold 3 to 4 MT of produce.

- Cold room can be owned by a family, an association, even our project, and use can be offered by the project managers on a **fee for service** basis (usually set at a small fee per kg per day).

- Grower groups can be owners of the cold room by taking out a loan for construction and repaying it back over time.

Introduction of the CoolBot into Zambia (Chipata & Livingstone)


DRAGON


COOLBOT


COOLBOT


HOT MUFFLER

ShadeBot ©

ShadeBot and CoolBot Monitoring Experiment

Experiment Overview

Multiple plants were harvested and stored in different environments.

Temperature and relative humidity was monitored.

The purpose of this experiment is determine how efficient the ShadeBot and CoolBot (turned off) were in reducing the temperature and relative humidity.

Plants Harvested:

- Cabbage
- Lettuce
- Green Beans
- Spinach
- Carrots

Experimental Details

Three sensors were used in this experiment to determine the influence of the ShadeBot and the CoolBot (Turned Off) in altering the environment in which the produce will be respiring.

Temperature and relative humidity reading were taken every five minutes for eight days in Nsongwe, Zambia.

This illustration will be for just one time point and also during a colder time period to be more conservative. Readings were taken in the time period from 6/11/2014 through 6/18/2014

Sensor Locations:
-CoolBot
-ShadeBot
-In the field

-CoolBot Sensor

-ShadeBot Sensor

-Field Sensor

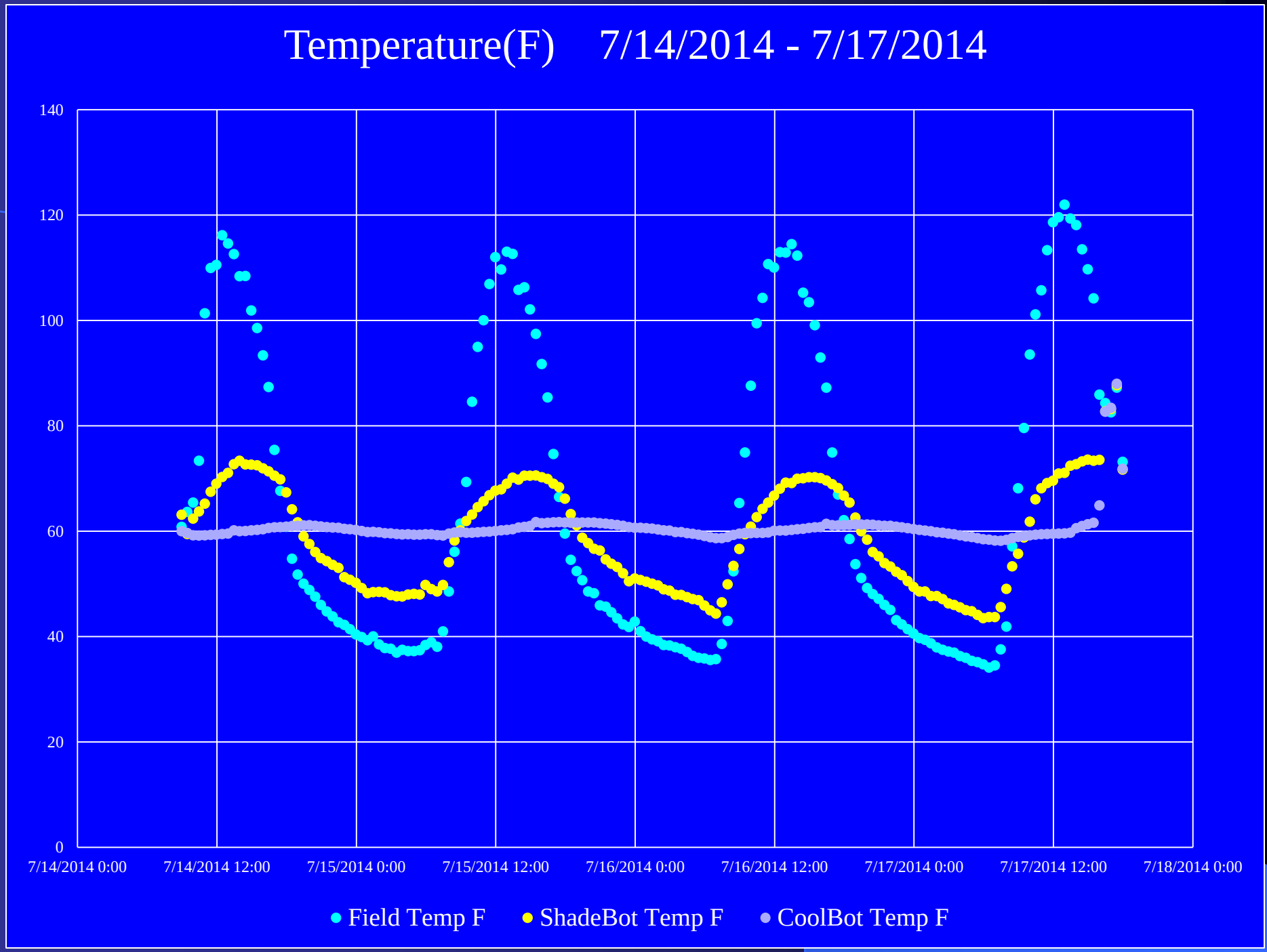
Highlighted Findings on Temperature

Both the ShadeBot and CoolBot were effective in reducing the temperature when compared to the field temperature.

At the hottest points of the day, the CoolBot was more effective than the ShadeBot at reducing the temperatures.

At the hottest point of the day, the ShadeBot reduced the temperature by 35%.

At the hottest point of the day, the CoolBot reduced the temperature by 48%.


Temperature(F) 7/14/2014 - 7/17/2014
140
120
100
80
60
40
20
0
7/14/2014 0:00
7/14/2014 12:00
7/15/2014 0:00
7/15/2014 12:00
7/16/2014 0:00
7/16/2014 12:00
7/17/2014 0:00
7/17/2014 12:00
7/18/2014 0:00
Field Temp F
ShadeBot Temp F
CoolBot Temp F

Quick Glance on Impact of Simply using Shade*

After this first day all of the vegetables were still able to be sold however, the vegetables left in the field were clearly wilted and marginal when harvested in morning- till early afternoon.

At the end of day 2, the vegetables without PH were unsellable.

Lettuce and Spinach were the only two plants both in the ShadeBot and CoolBot that were still sellable after the second day.

At the end of the third day the lettuce only in the CoolBot (turned off) was still sellable

After the fourth day, no crops were sellable.

**Note- this was during the cold season*

Days Crop is Still Sellable		Sellable(X)	NonSellable(NS)		
Environment	Crop	Day 1	Day 2	Day 3	Day 4
Field	Cabbage	X	NS	NS	NS
Field	Lettuce	X	NS	NS	NS
Field	Green Beans	X	NS	NS	NS
Field	Spinach	X	NS	NS	NS
Field	Carrots	X	NS	NS	NS
ShadeBot	Cabbage	X	NS	NS	NS
ShadeBot	Lettuce	X	X	NS	NS
ShadeBot	Green Beans	X	NS	NS	NS
ShadeBot	Spinach	X	X	NS	NS
ShadeBot	Carrots	X	NS	NS	NS
CoolBot	Cabbage	X	NS	NS	NS
CoolBot	Lettuce	X	X	X	NS
CoolBot	Green Beans	X	NS	NS	NS
CoolBot	Spinach	X	X	NS	NS
CoolBot	Carrots	X	NS	NS	NS

Why not a ShadeChain with ShadeBots ©: A concept we use to educate growers and marketers and can take on many forms

Cleaning, grading and sorting

Drying Rack for cleaning and grading

ASNAPP SENEGAL'S COOPERATIVE PARTNERS

Viviane Badiane
of the Nioro cooperative

ASNAPP's Rural Development strategy relies on collaborations with rural producer cooperatives. These co-ops, primarily made up of women, have proven highly successful at adapting their farming to the agricultural and quality standards promoted by ASNAPP.

Through their relationship with ASNAPP and each other the co-ops have forged **strong** **ties** and fostered economic prosperity for themselves and their families.

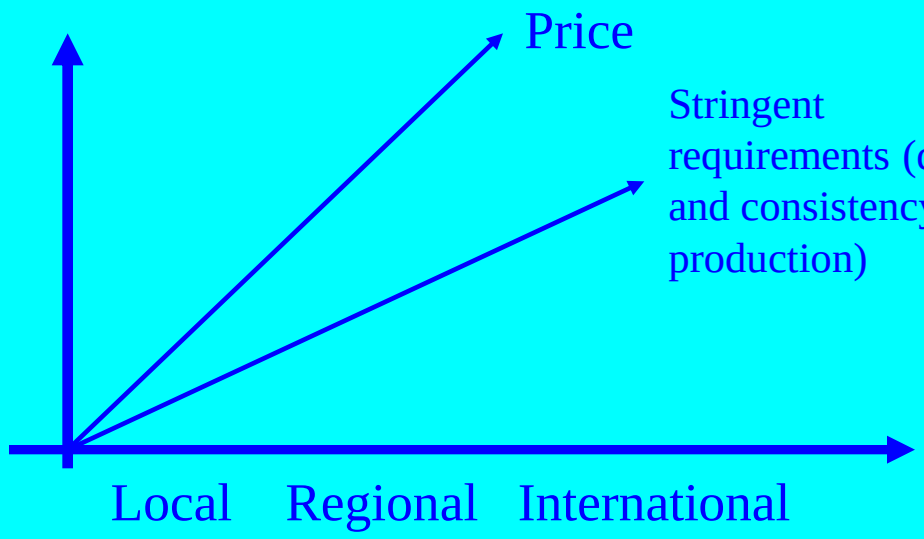
The women of the Latmingue cooperative

Hibiscus in Senegal

Before ASNAPP

After ASNAPP Intervention

What is Quality?



- Quality is a multiple character of products intended to meet consumer needs
- Quality equals conformance to specifications.
- Good Quality adds value to products
- Increase competitiveness helping to obtain higher prices or facilitate market access
- As other value addition activities there is an associated cost

Quality characters and quality control procedures

Characters	Hibiscus	Procedure
Color, aroma	Dark red or medium red (pink low quality)	Organoleptic evaluation
Presence of foreign materials	Lower than 1-2%	Visual observation, sieve analysis and ashes
Moisture content	Lower than 12%	Moisture determination by oven method
Active principle content	Amount of anthocyanins (>1%)	Proximate and HPLC analysis

Simple to complex

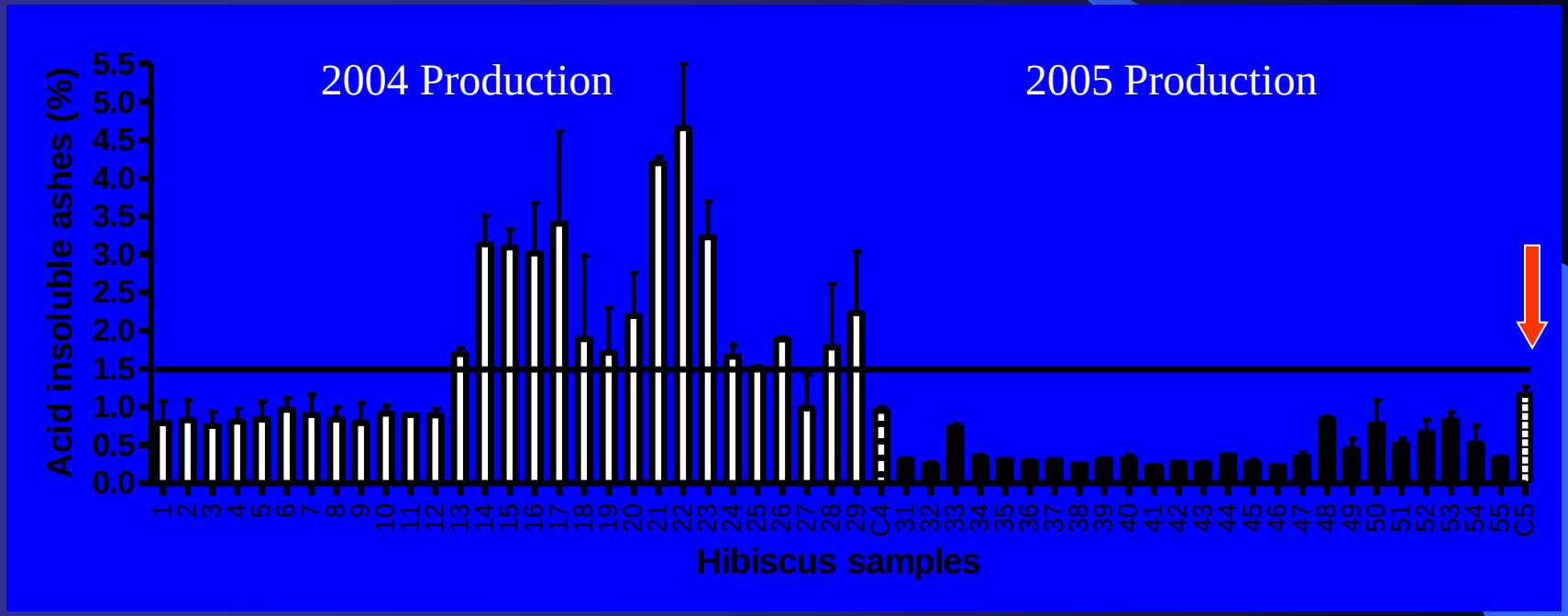
Harvesting of hibiscus calyces

Technologies to obtain clean products

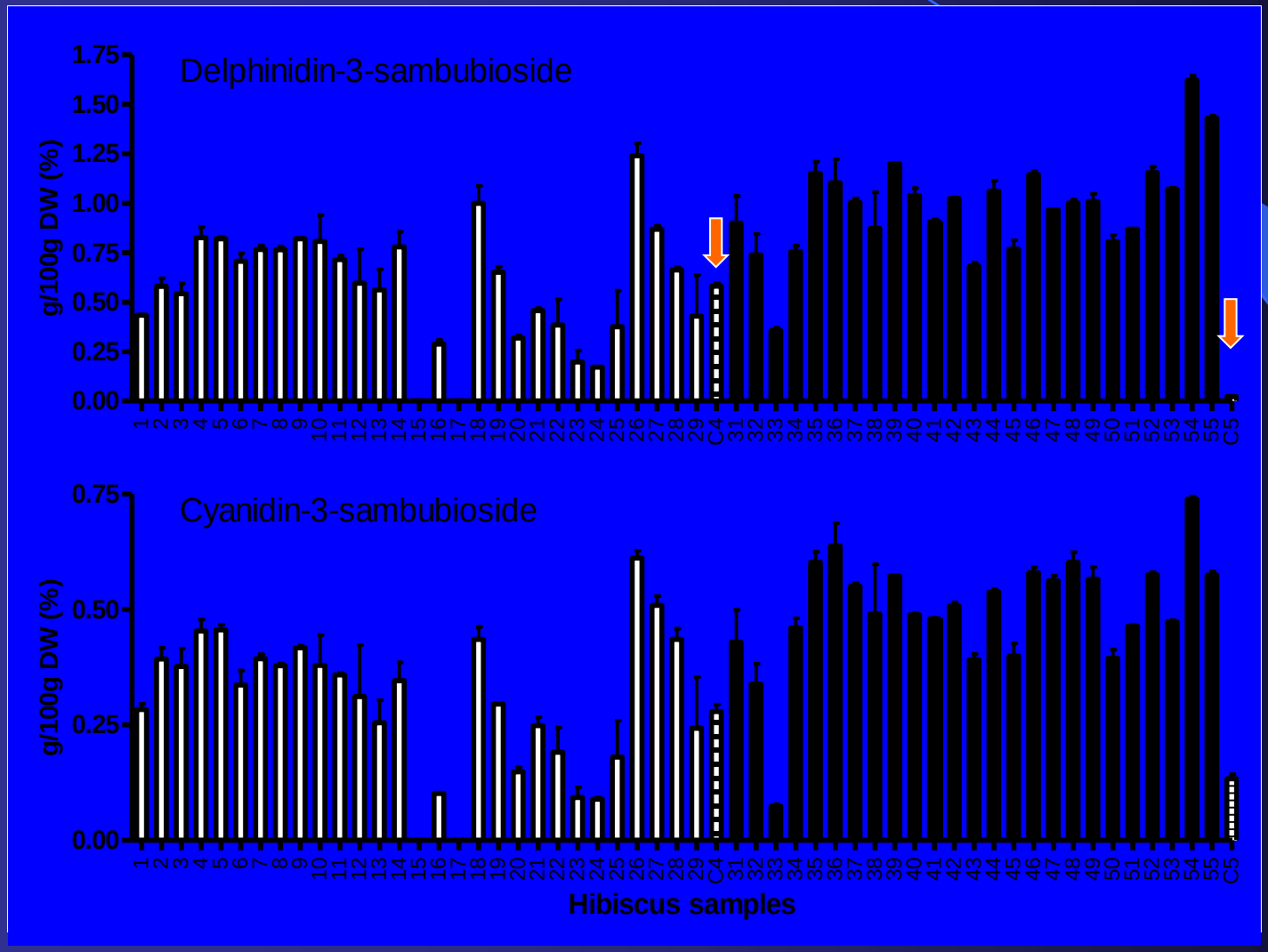
Hibiscus, Senegal: >35 Grower Groups; >4,000 women; Organic certification achieved. FairTrade certification to a few. Future challenge: Yields

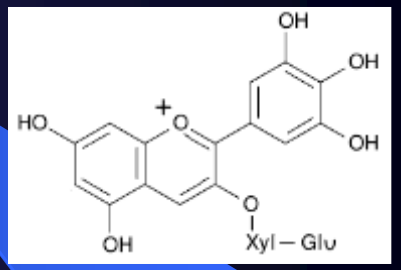
Linking Private Sector Buyers to Communities now organized into grower associations; with improved germplasm and Technology. QC and traceability from field through sales.

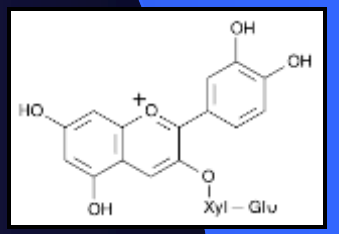
Contamination with sand: Acid Insoluble Ashes



HPLC Analysis of Hibiscus Anthocyanins







Quality Improvement Contributing to Value-Addition

EDUCATION-SANTE
B.P.5603
DAKAR
SENEGAL

LICENCE
ATTESTATION D'ENGAGEMENT
MODE DE PRODUCTION BIOLOGIQUE

PAYS TIERS

Conformément aux dispositions du Règlement (CEE) 2092/91, l'organisme de contrôle ECOCERT Belgium atteste que, en pays-tiers, l'opérateur sus-mentionné :
1°) est soumis aux mesures de contrôle prévues dans le Règlement (CEE) 2092/91.
2°) s'est engagé à respecter les règles de production biologique en vigueur.
Ce document indique que l'opérateur est apte à commercialiser des produits conformes au mode de production biologique. Ces produits figurent sur un ou des certificats délivrés avec indication de la catégorie.

CERTIFICAT DE CONFORMITE
MODE DE PRODUCTION BIOLOGIQUE PRODUITS PAYS TIERS

L'organisme de contrôle ECOCERT Belgium :
- atteste que les produits désignés ci-dessous et commercialisés sous la responsabilité du licencié sus-mentionné, sont conformes au mode de production biologique, suivant le Règlement (CEE) 2092/91 concernant le mode de production biologique.

Fait le 4/12/2006

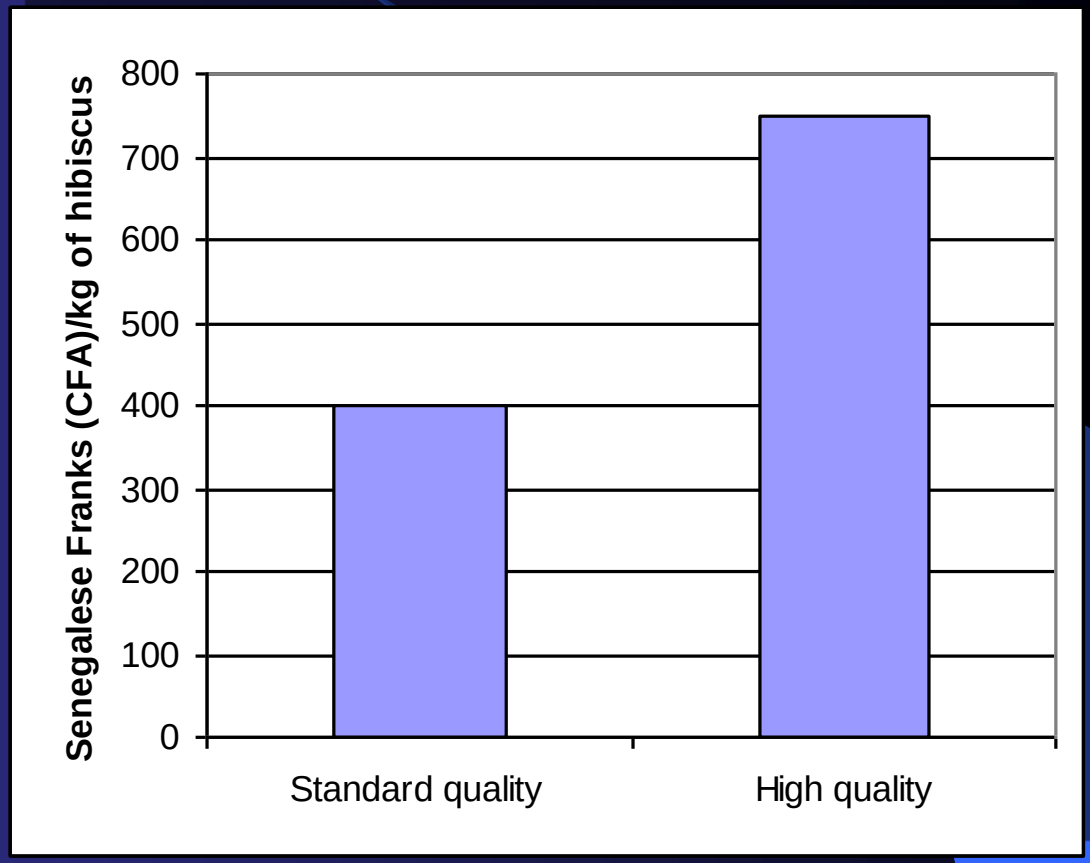
Pour la société ECOCERT SPRL

Tom Nizet
Responsable Certification

ECOCERT and NOP (USDA) Certifications

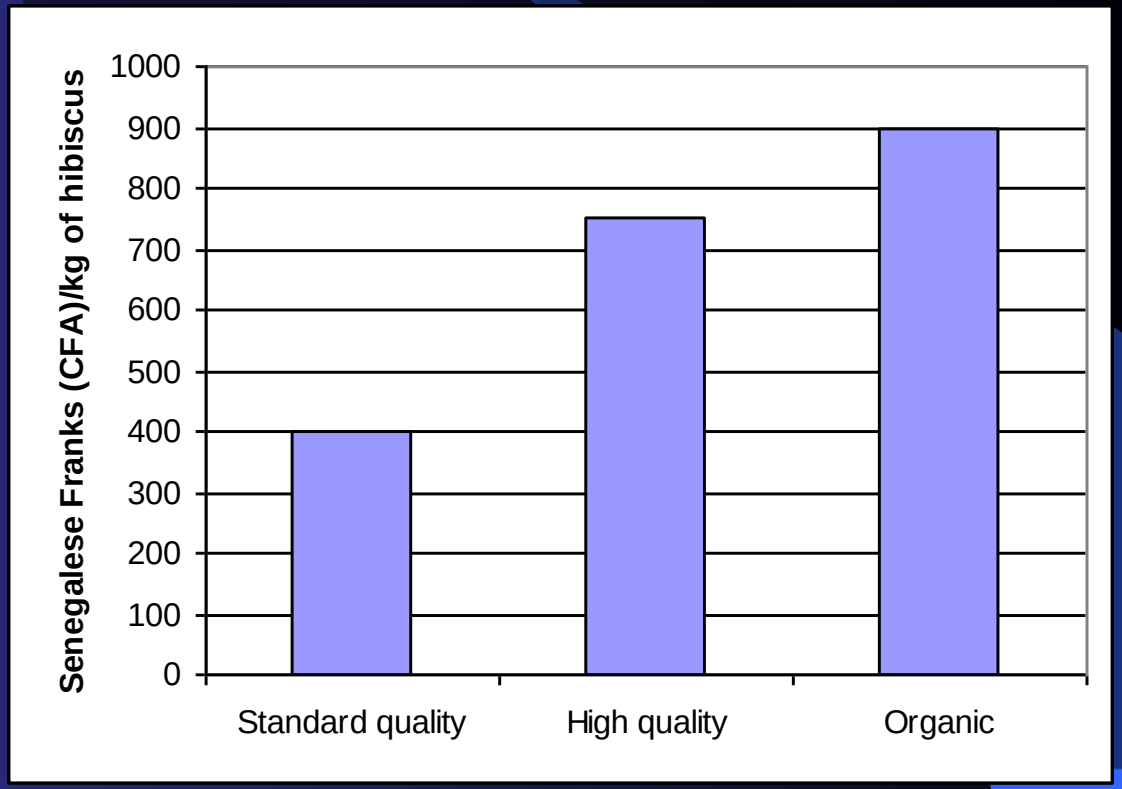
Value addition: quality

- Women producer organizations obtained higher prices for their products
- The production of higher quality hibiscus add value



Value addition: Organic production and certification

- Create new commercial opportunities (organic market is growing faster than the conventional)
- Suitable for Small Scale farmers in Senegal (low input)
- Premium price (CFA150)

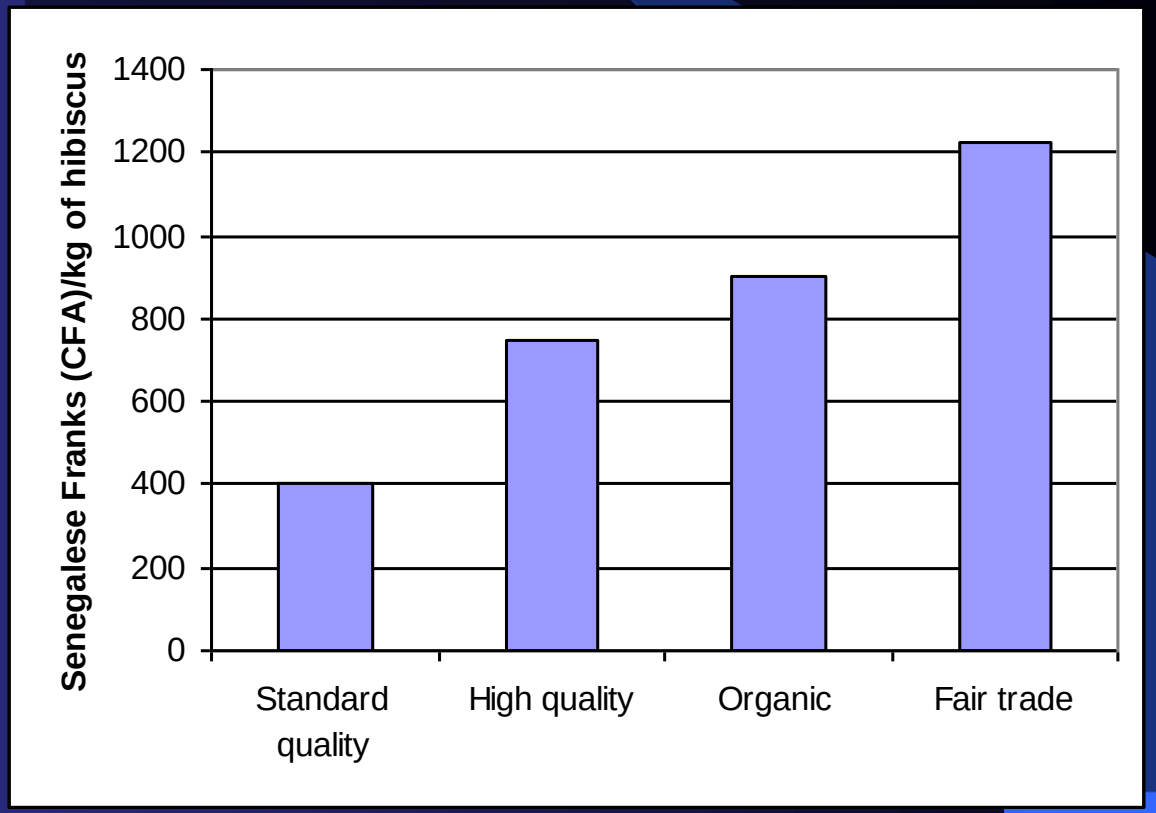


Value addition: Fair Trade certification

- Fair Trade certification bodies guarantee:

-fair price to producers; hibiscus premium price (CFA320)

- Must invest in social, economic and/or Environmental project.



PFID/NP Intervention and Results

Before ASNAPP	ASNAPP Interventions	Results
• Low yields • About $1/kg • Low production volume • • Neglected crop	• Supplied improved seeds and seeding technology • Introduced seed pod removal device • Good agricultural practices • Instituted vigorous quality systems (Rutgers University) • Trained 4,000 women annually • Train 40 Extension Officers annually • Linkage to buyers • Products tested locally for Microbial loads	• 350ha organic certified; 200ha ECOCERT /NOP certified • Quality of products improved • Now selling organic hibiscus to ADINA, USA • Reduced planting time from 14days to 2 days per hectare: Farmer saves $90/ha • Price now stands at $2.2/kg • ASNAPP assisted farmers receive 30% price premium

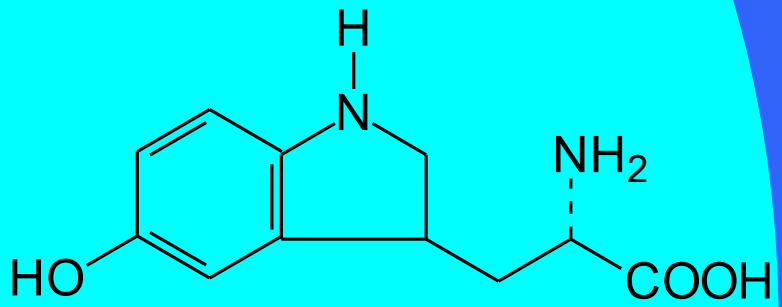
From Gender Divide to Gender Shift: Enterprise Development Success

Following Best Management Practices

- Great improvements in the quantity and quality
- Senegal was a low quality producer now known for high quality and higher value
- Using a science driven, environmentally and socially sound model created new markets with higher profits and greater demand for use fresh and in processing- powdered
- Few activities support enterprise development more than good business and profits!

Griffonia (*Griffonia simplicifolia*)

- **Griffonia (*Griffonia simplicifolia*):**
- **A Source of 5-HTP**
- **Seeds are used as an anti-depressant, to treat serotonin deficiency syndrome, and in the treatment of headaches and weight control.**
- **Can be found in the US dietary supplement market for weight loss, an antidepressant, anxiety, in treating fibromyalgia, insomnia**



GRIFFONIA

MINIMAL QUALITY REQUIREMENTS

THE SEED MUST BE:

- clean, flat, shinny and black/brown in colour;
- dry (max 10% min moisture content) and reasonably uniform in size;
- characteristic taste and odour of variety;
- endosperm skill be yellowish in colour;
- safe and suitable for industrial extracting the oil for medical purpose free from insecticides and pesticides;
- free foreign matter (twigs, leaves, etc.) varied odour ad mould;
- free from insect infestation, mates, insect fragments, excrement and rodent contamination;
- free from adulteration (sand,gravel,etc.).

GRIFFONIA

ILLUSTRATED QUALITY STANDARDS FOR EXPORT

MATURITY

FULLY MATURED
Matured seeds show cracking along the cleavage line of pod.

MATURED
Black spots on the freshly harvested green pod is a sign of maturity.

IMMATURED
The harvested pod is all green.

SHRIVELLED/HOLLOW SEED
Seed is shrivelled/hollow due to immaturity

COLOUR

Seed must be brown to black when dried.

BROWN/BLACK SEEDS

GREEN SEEDS

COLOUR UNIFORMITY
Package must show uniformity in colour

DISEASES

Seeds must be free from decay, insect infestation, excrement and animal contamination.

DECAY/MOULD
Seeds show mould and visible signs of rotting

INSECT INFESTATION
Insect infestation presence

POST-HARVEST PROCEDURE

Seeds must be free from extraneous/ foreign matter.

CLEAN SEEDS

FOREIGN MATTER
Seeds with foreign matter

Seeds must be clean, whole and of the same colour.

WHOLE SEED

SKINNED SEED

BROKEN SEED

MECHANICALLY DAMAGED SEED

MIXTURE OF SEEDS

By working on grades, standards and QC, quality
Increased, exports have risen, more than

Griffonia

Griffonia pods and Mature griffonia seeds after drying

Griffonia collectors from one of the cooperatives and groups organized in Ghana.

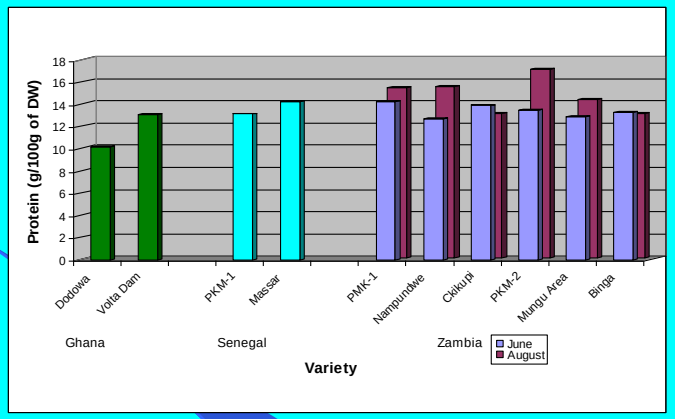
The bag contains dried griffonia seeds (see rack) paid to a collector that will provide enough income to pay for one month of rice for his family (in Liberia, 2/ 2010).

Plants as a Delivery System to Improve Human Nutrition, Health & Reduce Disease: Moringa

- Moringa, an endemic tree found across sub-Sahara Africa with 13 species, *M. oleifera,* the main spp. of interest.

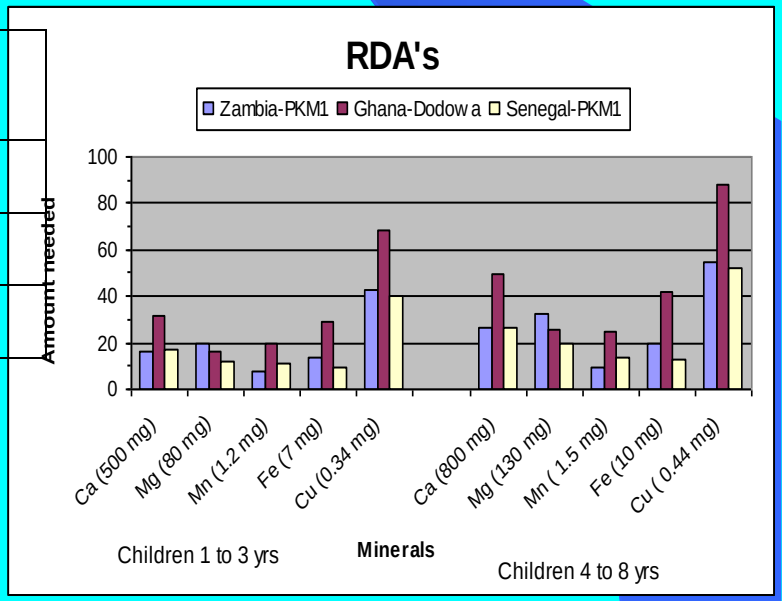
- Very rich in vitamins A and E, iron, zinc, selenium (same vitamins and minerals that have been identified as the major limiting nutritional factors in the same region particularly for vulnerable populations)
- Leaves, pods and seeds rich in glucosinolates and flavonoids

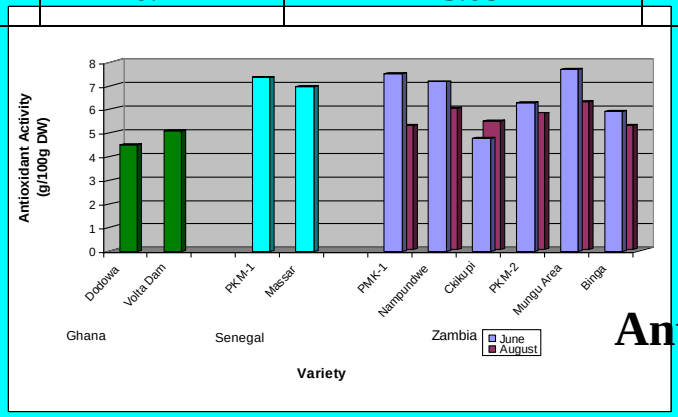
Total Protein



Child between 1 to 3 years old is 13 grams/day
Child between 4 to 8 years old is 19 grams/day

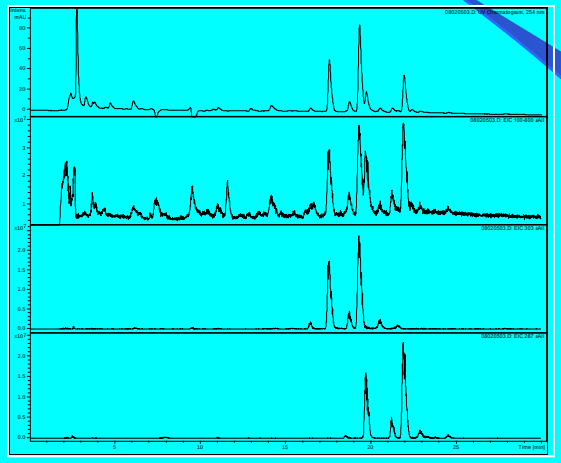
Location	Ascorbic Acid mg/100g	Total tocopherols (mg)	Total Carotenoids (mg/100g)
Gasabo	0.36	36.93	23.02
Kibungo	0.35	49.52	45.94
Kicukiro	0.44	43.08	29.44

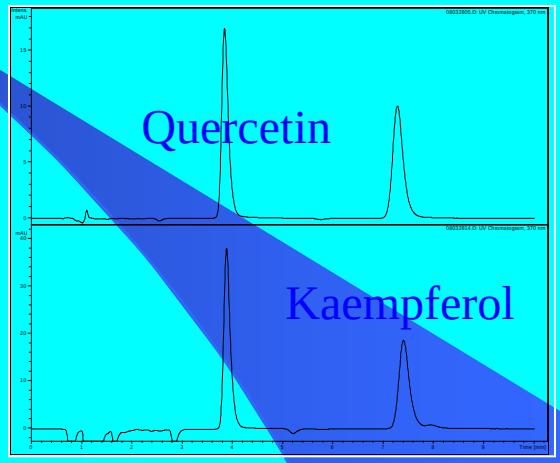




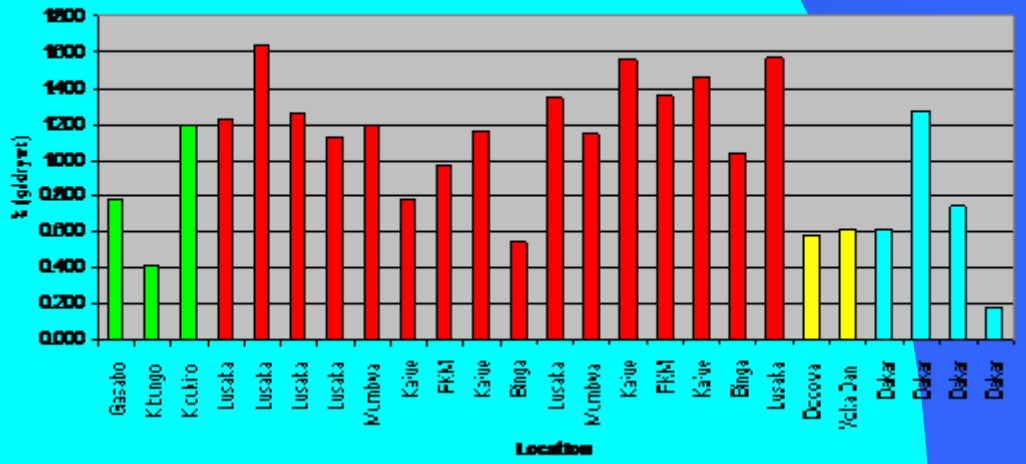
Antioxidant Activity

Moringa: Also a Rich Source of Health-Beneficial Bioactive Flavonoids*





Total Flavonoids (Quercetin and Kaempferol)



*Samples from Ghana, Rwanda, Senegal, and Zambia, analyzed using our HPLC/UV/MS

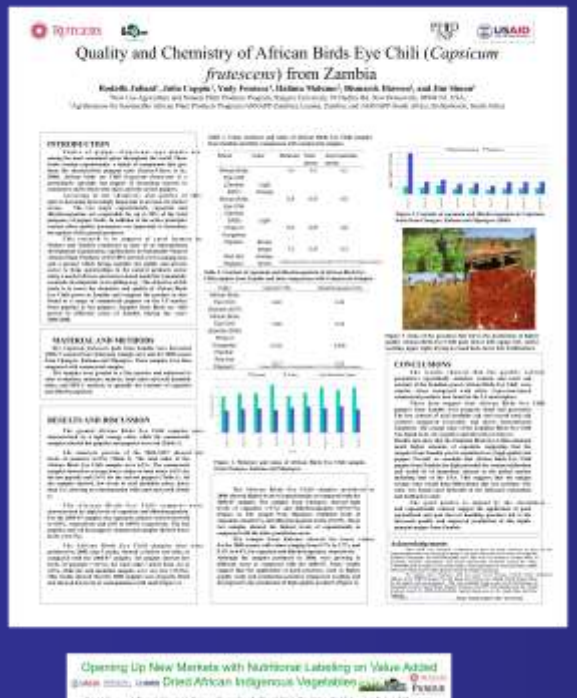
Mitengo Women's Cooperative, Lusaka, Zambia

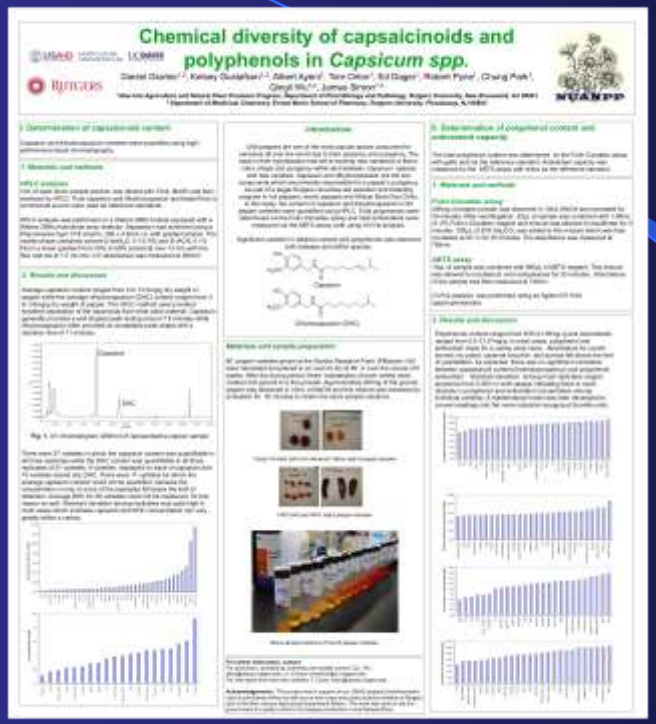
Capacity Building/Trainings And Collective Goals in Chiyanga Triangle (Malawi, Mozambique and Zambia)

Green and Red Pods of African Birds Eye Chilies (BEC)

Drying and Grading of Chilies

2014: Chilli's and PH Zambia


Quality and Chemistry of African Birds Eye Chili (*Capsicum frutescens*) from Zambia

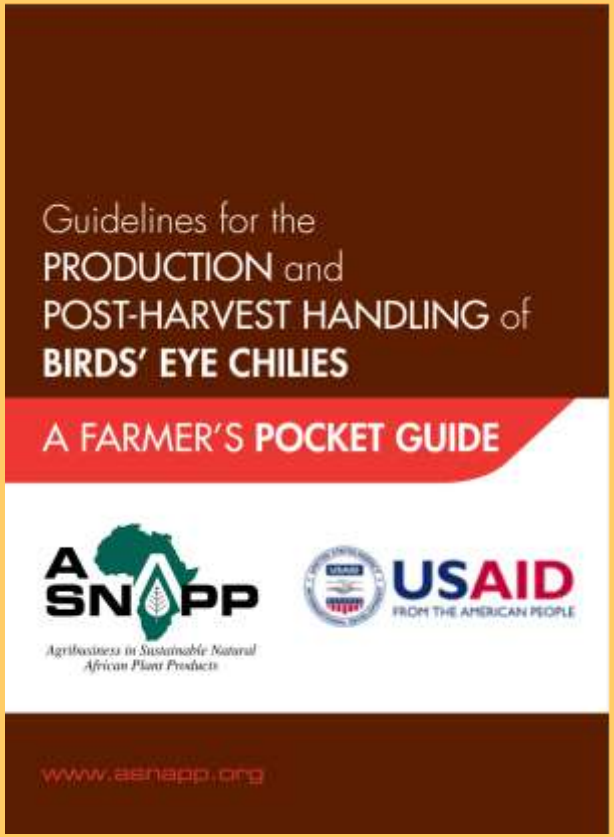

Chemical diversity of capsaicinoids and polyphenols in *Capsicum spp.*

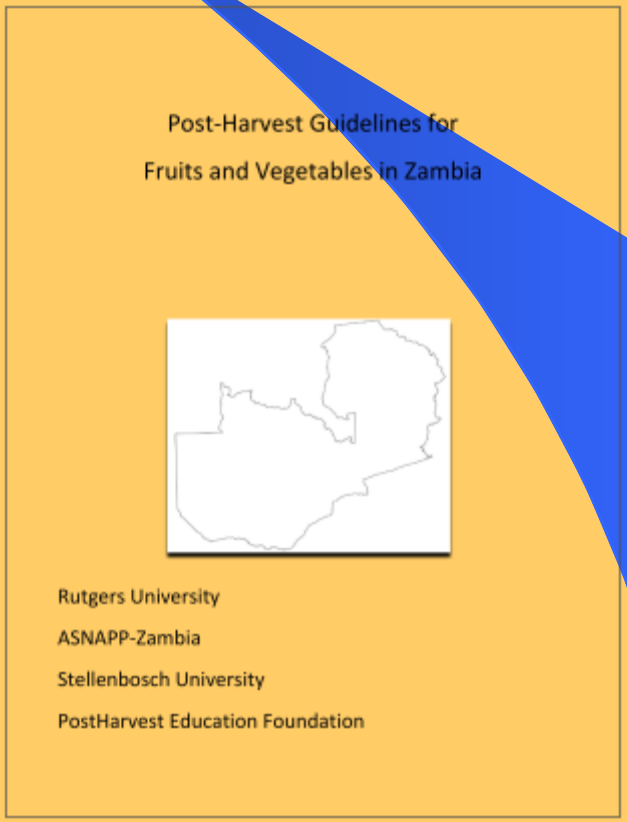

Opening Up New Markets with Nutritional Labeling on Value Added Dried African Indigenous Vegetables

Proper PH with chillis for the fresh market led to a 40% increase over 'street price'.

Using GAP/BP and good PH led to buyer acceptance of dried chillis.

Horticulture Innovation Lab





African Birds Eye Chili

Commercial name	Birds eye chili
Botanical name	*Capsicum frutescens*
Origin	Zambia (Production 2009)
Additives	None
Sensory/macroscopic evaluation[1]	09-BE-FA
Color	Dark Red
Aroma	Spicy, free of foreign odors
Taste	Highly pungent
Lentgh of pods (cm)	2.4
Scoville Heat Units (SHU)[2]	52,000[2]
Physical/Chemical properties[1]	
Moisture content % (m/m)	12
Total ashes % (m/m)	12
Total insoluble ashes % (m/m)	0.8
Active principle[1]	
Total capsaicinoids[3] content % (m/m) (by HPLC)	0.35

Drying Facility- Home Built

- Cold chain involves all steps from farm gate to market
- Includes: Transportation
- Retrofit trucks, pick-up's to have cold insulated chambers
- Keep produce in shade
- Protect produce

How many crates can you stack?

Appropriate Technologies for Post-Harvest

- Shade- umbrellas to netting used in fields and after;
- Low-cost affordable coolers- different types, styles for local conditions and needs
- Buying and rebuilding used larger ones from refrigerated trucks as your stationary coolers
- Maintain quality, be creative

Bringing it together: Farmers selling their fresh produce to Livingstone hotels, and learning entrepreneur skills are leading to significant economics benefits to his family and the community producers.

Comments on the Value of Improving PH:

- Horticulture can provide for increased food security by income generation, community development, empowerment of individuals and communities and providing the means to purchase foods and supplies and improve one's own health and nutrition.
- Horticulture teaches and provides a myriad of skills and expertise that can be later used for other many other enterprises. Thus, can be seen in part as a vehicle to educate, teach and ultimately provide others with hope, confidence and strategies to their livelihoods
- Many models are dynamic, and lend themselves to scale-up
- Horticulture is knowledge intensive. Yields and quality directly related to inputs, management and the profitability of such investment can be lost without proper PH practices.
- **As volumes and # of grower increase, distance to market increases, the need to hold produce under proper conditions becomes a priority.**
- Different approaches and technologies in PH can be applied.
- Success is enhanced by ensuring a market-first, not the traditional production-first approach coupled with appropriate PH systems.

Acknowledgements

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and

The Postharvest Education Foundation, USA

www.postharvest.org