



Bamboo baskets (*doko*) used to transport apples to nearby markets (Source: Padam Bahadur Subedi, Nepal).

## FEED THE FUTURE BUSINESS DRIVERS FOR FOOD SAFETY

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### IDENTIFYING FOOD SAFETY RISKS IN HORTICULTURE VALUE CHAINS IN ETHIOPIA, RWANDA, SENEGAL, AND NEPAL

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*Mangoes knocked down to the ground (Source: GerefeSefu, Ethiopia).*

## Introduction

Food safety losses are related to both physical and quality losses, since the damage caused by unsafe handling practices can lead to both sorting out for physical losses, and to quality losses with associated loss of market value. Postharvest and food safety assessments were carried out using Commodity Systems Assessment Methodology (CSAM), which includes literature reviews, interviews and observations (LaGra et al 2016). Key informant interviews with experts, farmers, traders and extension workers in Ethiopia, Senegal, Rwanda and Nepal have revealed a wide range of food safety issues and associated SME business opportunities.

Four horticultural crops were the focus of these CSAM studies. Tomato value chains were assessed in all four countries. The mango value chain was assessed in Ethiopia and Senegal. Green banana (cooking banana) value chain was assessed in Rwanda, and the value chain for apples was assessed in Nepal. The four crops included fruits eaten as staple foods (starchy green bananas), fresh fruits (tomatoes, mangoes and apples) and processed products (all four crops).

## Sources of Contaminants

In the eight crop value chains we assessed during October- December 2020, for the BD4FS Project led by MarGen and supported by The Postharvest Education Foundation, a variety of sources of contaminants were identified. These are also commonly found for many other horticultural crops and in all developing countries.

Fresh or processed produce can be contaminated by physical items such as wood, metal or plastic debris; chemical substances due to incorrect sanitation solutions or pesticide residues; biological matter such as foodborne pathogens including bacteria or viruses, or by toxins produced by biological contaminants. The crop assessments found evidence of food safety issues all along the value chains, from harvesting where produce was exposed to soil; damaged by rough handling, packing in rough baskets or wooden crates; exposure to inappropriate chemical treatments during ripening, and the use of unsanitary water for washing or pre-cooling. There are no toilets available near the farms and orchards, so workers typically defecate in the fields, and handwashing stations are usually not available. These exposures to food safety problems are increased when the produce is handled or stored at ambient temperatures or when produce is damaged and allowed to heat up in the sun or left in piles during delays in shipping.

In Ethiopia, mangoes are knocked from the trees with sticks and drop to the ground below. The large wooden or bamboo crates used for post-harvest handling of mangoes and tomatoes can cause damage and leave splinters in the fruits. The bruises and injuries caused by mishandling will enhance the damage of produce quality by fungal or bacterial pathogens. In the marketplaces, mangoes are sometimes cooled using ambient temperature water, but the water is not clean, not cold enough to cool the fruits, and is not sanitized before use.

In Senegal, mangoes harvested for local markets are piled on the ground in the orchard, after being knocked from the trees or when whole branches are cut and dropped to the ground. The fruits are cut, bruised and highly susceptible to pathogens when the fruits gain in heat during delays in packing and shipping. Retailers use calcium carbide ( $\text{CaC}_2$ ) to ripen their mangoes sold in local markets. Calcium carbide is placed in a lot of fruits and when the chemical comes in contact with moisture, acetylene gas is produced. It is very difficult to manage this ripening method and residues are carcinogenic. For tomatoes in Senegal, the use of unregistered pesticides or the improper use of pesticides was a concern. Access to food safety certification is possible in the local context but certification is not compulsory, and traders do not use certification as it is often seen only as an extra cost. For both crops, there is a lack of access to good quality containers such as plastic crates, and delays can occur when harvesters are waiting for crates or traditional containers (baskets, sacks) to be provided on the farm.

Rwanda is a high altitude country with the lowest point at 950 m above sea level. The water of rivers and marshlands are the main source of irrigation which had the highest prevalence of microbes (Ssemanda, 2018). With the increasing amount of livestock, the use of animal manure is popular in Rwanda. Compost and/or raw manure application was used in 60% of the vegetable farms while recommended storage and treatment of this manure was not yet implemented by over 50% of the farmers (Ssemanda, 2018). At harvest, the prevalence and concentration of microbes can be affected by cross contamination from contact surfaces of harvest containers and harvesters hands, on-farm washing and refreshing of vegetables. Fruits and vegetables are transported by farmers, suppliers or traders using several means, non-specialized vehicles, bicycles, carts and head carrying, and no refrigeration is involved. Produce is transported at temperatures between 14 to 25°C (Ssemanda, 2018).

Transportation time from farms to markets was about 0.5 to 3 h and the same time was assumed to be spent between markets and FSEs. Therefore, the microbial growth due to transportation between farms and markets was assumed to be equal to that growth due to transportation between market and FSEs. Use of chemicals to control diseases. No bagging technology to protect the bunch yet in the country. Machetes used to cut down bananas do not undergo washing/sanitization before or after this activity. Farmers, wholesalers and retailers sell bananas without any treatment after harvest like cleaning, trimming, hot water dips etc. Transporters can reuse mulch but the practice is not sanitary and can spread disease. Workers for packing the produce do not wash/sanitize their hands before or after this activity. Bananas are put under tree shade or covered dry banana leaves or sheeting in the sunny hours. The methods are not appropriate as they do not keep bananas to cool temperature and can spread pests and other unwanted substances to the produce. Ambient temperatures during the postharvest period is between 20-33°C.

In Rwanda, green bananas are handled as heavy full bunches, which often get dropped or stacked directly on the soil, can be crushed in over-packed vehicles and even stepped on during transport. Mechanical damage to the green bananas, when recently measured at the retail level in Rwanda was up to 100% (ABA 2018). The tomato plants in the field are not staked or trellised, so the plants fall over, and the fruits often come in contact with the soil. A pesticide named “Mancozeb” is sprayed on the tomato fruits after the harvest by some growers and traders because it is believed to stimulate uniform ripening (ABA 2018) -- this practice is an inappropriate unregistered usage and a food safety health issue for vendors and consumers.

In Nepal, apples are harvested in a haphazard manner, including shaking the tree and then picking up fruits from the ground, leading to high levels of damage and losses along with food safety issues. Animals graze in the fields and orchards, and water sources are exposed to birds and animal pests. Water is used to clean apples and tomato fruits after the harvest, but the water is not clean or sanitized before use. The very large bamboo baskets (known as *dokos* in Nepal) cause abrasions and additional damage to the tomato and apple fruits during transport via the traditional means of one headload or when stacked in a vehicle.

Overall, there was evidence in all the domestic value chains of produce being contaminated by contact with soil and associated human and animal feces, unsafe use of pesticides, use of unsanitary water for cleaning, washing or cooling, and the lack of temperature and relative humidity management, which allows any pathogens on the produce to grow at accelerated rates. The traditional processing practice of open-air drying exposed the produce to dirt, insects, and animal pests. Value chains for export markets were more likely to provide sanitary working conditions, documented food safety protocols, and use of proper cooling methods, cold storage and/or refrigerated transport.

## **Solving Food Safety Issues**

One of the challenges in the private-sector approach that BD4FS is championing is the perceived high cost of adopting changes in postharvest handling and food safety practices. Unless there is a buyer who is willing to pay for improved practice, sorting or sanitation operation or the documentation of food safety protocol, produce growers and marketers often lack incentives for making investments that will allow them to better maintain food quality and safety.

Following Good Agricultural Practices (GAP) protocols are a good place to begin since these are simple, low-cost practices that include field sanitation, use of clean water for washing, clean containers for packing, use of appropriate pesticides and sanitizing agents, and safe hygiene practices for workers. Gentle handling throughout the value chain will minimize damage and reduce the susceptibility of fresh produce to subsequent food safety issues.

Field sanitation includes preventing animals from grazing in the fields, cleaning up any produce that is dropped and not allowing discarded produce to rot in the fields. Tree fruits can be picked using long picking poles or tomatoes can be picked using harvesting bags and then carried to the location where they can be packed directly into crates. There is a potential for SME business opportunities for designing and sale of different low-cost harvesting tools. Harvested produce should not be allowed to touch the soil, and the containers that it will be packed in should not be put directly on the ground or left exposed to direct sunlight. Clean tarpaulins can be used to cover the ground if containers or produce must be left in the field before packing. Field packing (using a mobile station or cart that can be wheeled along the rows of crops while workers pick and immediately pack the produce) can further minimize exposure to soil contaminants.

The water used for cleaning, washing and cooling should be potable (clean enough for drinking) and treated with chlorine (solution concentration of 150 ppm) to manage cross-contamination and minimize exposure to soil pathogens. Wash water in a tank should be changed regularly, or the wash water can be filtered, chlorinated and recirculated in a closed system. Pesticide usage should always follow food safety requirements, including adherence to the correct number of days between

the final application and harvesting (waiting period), and the use of proper safety equipment for workers. Potential SME business opportunities include the sale of bio-safe alternatives to pesticides and chemical treatments.

Ripening methods employing the use of calcium carbide and its toxic residues can be replaced with non-toxic ethylene generation. Simple ripening chambers can be used to control the concentration of the ethylene gas (a natural plant hormone), the time of exposure, the temperature and the resulting rate of ripening.

Temperature management and control of relative humidity can provide the best handling and storage environment for each type of produce, which enables its own biological resistance to pathogens to be optimized. Pre-cooling or hydro-cooling using water dips or sprays requires the use of cold and sanitized water for best results. If ice is used to cool surface water for pre-cooling, it should always be obtained from potable sources.

For tropical and sub-tropical crops such as tomatoes, mangoes and green bananas, handling and storage temperatures between 15 and 18°C are sufficient to reduce postharvest losses and to provide protection from food safety pathogens. Exposure of these crops to lower storage temperatures can increase the likelihood that they will suffer from chilling injury damage and increased decay. With gentle handling, packing in clean, protective containers and low-cost temperature management strategies to limit exposure to heat and sunlight (use of shade during delays, use of evaporative cool storage structures), these crops will remain safe to eat for up to two weeks.

Apples require very cold cooling and storage conditions (0°C) for long term storage and do best under controlled atmosphere storage (low oxygen), so if these conditions cannot be provided it is recommended the fruits be processed to shelf-stable products such as dried fruits, juice, or pulp.

All of the crops assessed for BD4FS can be processed to add value and increase shelf life. Green banana is being dried to make flour, mangoes and apples are being juiced, pulped or dried to make snack foods, and tomatoes can be made into many types of sweet or savory sauces, juice, pulp and powders. Rapid processing and proper packaging under sanitary conditions help to maintain the quality and nutritional value of these processed products.

Processing of horticultural crops requires implementing additional food safety protocols, including HACCP and/or GMPs. There was a lot of interest in SME scale processing expressed during the crop assessments, but the tools, equipment, processing knowledge and skills, along with food safety training will be required to ensure successful investments. Improved solar drying and small-scale processing can be operated using methods that protect the produce from contamination and exposure to pests, dust or soil.

## Conclusions

The critical points for addressing food safety risks for fresh and processed produce in developing regions includes field sanitation, the use of proper harvesting practices, registered pesticides and safe chemicals, clean improved containers, shade during delays, clean water for washing or cooling, protection from contamination, dust and pests during processing, and the use of proper temperature management and relative humidity control during storage.

A summary of food safety protocols for tomatoes can be found in Holcroft and Kitinoja (2020), and similar steps are required for processing all the horticultural crops. Documented safe foods are an SME business opportunity for increasing domestic sales to local hotels, restaurants and foodservice businesses that currently rely on expensive imported produce for hospitals, commercial business centers and the tourist industry.

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