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SPS Compliance in Fresh Produce Supply Chains: An Integrated Approach for Food Quality and Safety Assurance

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Abstract: In recent years, the concept of food quality and safety has been intensively traded and the consumer's level of conscious towards 'safe' consumption of fresh produce has risen. Accordingly, the sources of supply of fresh produce and the chains through where the high value horticultural commodities are handled and processed have attempted to improve their production, handling and processing systems to match with the demands of their deserving markets and consumers. In this context, capacity building of the fresh produce supply chain stakeholders in the developing countries which are the source of fresh produce for rest of world becomes an area of prime importance. Phytosanitary risk management program is being implemented in Pakistan, since, 2014. The program, among other research and development chapters, include capacity building of the national plant protection organizations alongside improving the capacity of research, academia, development sectors and the fresh produce industry in the area of Sanitary and Phyto-Sanitary (SPS) compliance in fresh produce supply chains. A group of master trainers was developed by organizing a walk the chain learning experience in a well-structured horticultural industry in South Africa. The master trainers developed a training manual and generated learning guides and conducted follow on stakeholder's trainings in whole-of-the-chain context for hundreds of the industry participants. The training program has been acknowledged by the beneficiaries as a complete package for orientation of the fresh produce supply chains, from the point of production to the point of retail, to cater the food compliant of the current food quality and safety requirements. An assessment is being conducted to evaluate the environmental, social and economical impact of the training program for development of future investment priorities in the area.

Key words: Compliance, fresh, produce, quality, safety, value chain, SPS

INTRODUCTION

Though the concept of SPS compliance in food chains is not new, however, the consumers in the developed world have most recently started to focus on the need of this highly desirable for food safety and quality parameter (Collins and Dunne, 2007). Particularly, in recent years, there has been an increased focus on food safety in the united states and europe and the trend is making its way elsewhere (Henson *et al*., 2005). In this context, certain public food safety standards have been enforced through legislation and firms at different levels of the supply chain have developed various private standards. Legislation adopted to improve food safety include standards regarding the characteristics of the final product (e.g., maximum residue levels), production practices in the food supply chain, traceability within the supply chain and the legal liability of the supply chain.

Realising the increasing need of SPS compliance in fresh produce supply chains due to the consumer's demand and based on the lack of awareness and capacity of the food suppliers in developing countries of the world (Misra *et al*., 1991), phytosanitary risk management program is being implemented in Pakistan. The project, among other key research and development areas, include capacity building of the fresh produce industry stakeholders in SPS compliance in fresh produce supply chains.

MATERIALS AND METHODS

A group of master trainers was identified by the project implementing organization and a walk-the-chain activity was organized for hands-on learning of the SPS compliance in fresh produce supply chains by passing through each individual stage of the supply chain. The master trainers developed training manual based on their

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learning and designed a training program for the fresh produce industry spread across the country. The training contents covered all potential aspects of implementing SPS compliance in fresh produce supply chains.

RESULTS AND DISCUSSION

Policy making for SPS compliance: Policy making is the collective responsibility of all the stakeholders involved in a business, albeit, it is finally approved and implemented by the government. For an SPS compliance policy making process for example, an issue is identified by the relevant industry and is brought in to the attention of the allied stakeholders and government agencies. If the issue is supported by enough evidence, government prioritise it and asks for possible options for remedy of the issue. Possible options are then discussed at various forums for validation and deliberation of the argument. Once all stakeholders are convinced or consented by majority, the policy is implemented by the relevant stakeholders. Post-implementation, the policy is evaluated if this is delivering in an appropriate manner and if need be it is passed through revision process.

A dedicated or more than one ministry can be responsible for formulation and implementation of a policy. Accordingly, more than 1 government institute and several public and private sector organizations might have role in development of a policy.

Once a policy is in place, uniformity in action and implementation can be assured by the relevant government and private sector organizations.

SPS compliance at farm level: Major SPS compliance practices are adopted at farm level because it is relatively easy and cost and labour efficient to control pests of major quarantine concern for instance fruit fly, codling moth, black spot and canker, etc., at source.

Good agricultural practices and orchard management according to the guidelines developed by the relevant government organizations can mitigate the incidence of pests of quarantine concern. Orchard management includes but is not limited to, site selection, selection of true to type seedlings orchard layout, planting, soil and nutrition management, irrigation, pruning, fruit bagging, pest management and ground covers. General good orchard management practices must carefully consider the following:

- The orchard is planned on a well-drained piece of land, irrigation water in abundant quantity and of good quality is available and the prior planting history is available
- Nursery plants are purchased from a certified source and all the plants are true to type
- The orchard is planted following an appropriate layout for easy to do orchard management practices
- Soil and leaves are consistently tested for nutrient management
- Water quality is regularly tested and a water efficient method of irrigation is adopted
- Pruning of trees is judiciously done, keeping in view that the canopy is maintained and fruit bearing is not compromised
- Fruit bagging is practiced to make sure that best quality fruit is prepared for harvest
- Pests (weeds, insects and disease causing organisms) are regularly monitored and adequate control measures are taken to manage the pests below a threshold level
- Ground covers, mulching and ploughing are considered according to the plant growth cycle

Following the volunteer standard of global GAP itself enables orchards to fulfil most of the SPS compliance requirements by incorporating good agricultural practices as per standardized recommendations of orchard management. All the commercial orchards in South Africa are global GAP certified.

Weeds compete with the plant for their nutritional requirements and insects, disease causing organisms (fungi, bacteria, viruses) and soil borne worms feed on plant parts and not only affect the plant health but also reduce the plant vigour and yield.

Weeds are of major concern for orchards during the early planting stages. Once the plants have developed and established their root systems, then weeds cannot compete with plant for its nutritional needs. However, weed eradication is still important to control insects and other biological pests because weeds can act as alternate hosts for these organisms. A spray program may be implemented for weed eradication in orchards.

Insects can directly affect the quality of the plants and fruit they feed on. For example, leaf miners can reduce the photosynthetic ability of leaves and mealy bugs feed directly on plant stems. Similarly, citrus peel miner and thrips can cause skin blemishes in growing fruits. Some insects like fruit fly and codling moth are of quarantine concern and they must not be present in fruit shipped to the export markets. Regular monitoring and surveillance can help mitigate the pests of quarantine concern. Insects also act as carriers of disease-causing viruses and fungal spores. Some insects are also beneficial. Understanding the nature of insects, their life cycle and the range of alternate hosts of plants is crucial in the control or

management of insects. Diseases cause immense economic losses in horticulture. The most significant diseases of quarantine concern include citrus canker, citrus greening (also known as Huanglongbing) and black spot. Citrus canker is caused by a bacterium, *Xanthomons campestris* pv. citri. Citrus greening is also caused by a bacterium, *Candidatus Liberibacter asiaticus*. Black spot in citrus is caused by fungus *Phyllosticta citricarpa* McAlpine and *Guignardia citricarpa* Kiely.

Citrus canker in countries including United States of America and South Africa was eradicated only by cutting down all the citrus trees in areas where the disease was reported and burning and burying the plants under ground. Citrus greening can be controlled by monitoring and controlling the vectors of the bacterium, species of citrus psyllid. Black spot of citrus can be controlled by including a regular fungicide spray program in the regular orchard management calendar. Other field diseases can also be controlled below the threshold levels by adopting a recommended field spray program which may vary between production areas.

Different types of traps are used for the scouting and monitoring of insect pest population. Sensus traps are most commonly used for fruit fly, moths and some other insects. These traps are based on the principle that female insects naturally produce pheromones to attract male insects. Pheromone chemicals are forced into a rubber 'septa' or 'lure' and are placed in a sticky trap to attract and cage the male insects. Careful storage of chemicals, monitoring of the expiry dates, regular monitoring and replacement of the traps and maintaining a record for pest scouting and monitoring is very important for proper use of the sensus traps.

Fruit fly control program: Fruit fly is a pest of quarantine concern. It completes its life cycle on a range of host plants. A well-structured surveillance and control strategy is warranted for eradication of fruit fly from the fruit crops of commercial importance.

Identification of the invading species of fruit fly is important for application of control measures. Even the threshold levels for the two species are different. Mediterranean fruit fly and oriental fruit fly are the two most important species. For the mediterranean fruit fly, capilure pheromones are used to attract male flies and questlure pheromones are used to attract female flies. Dichlorvos is used as insecticide inside the trap to kill the flies. One of each type of trap is placed in a block of 5 ha. For oriental fruit flies, methyl eugenol is used to attract male flies. The threshold for the control of Mediterranean fruit flies is 4 flies per trap per week and that for oriental fruit flies is two flies per trap per week.

Fruit flies can disperse to short distances via the following routes: by flying, being moved with the natural vegetation, pupae in soil, eggs and larvae with fruit consignments in commercial cargo and through domestic trade by travellers. Informal trade of fruit like mango, guava and citrus is also a major route of dispersal.

Once the fruit flies cross their threshold level as measured by the surveillance program, a regular spray program is implemented to minimize the population of the relevant species. Weekly spraying is sometimes needed to control the fruit flies.

Most fruit fly control measures in South Africa for example are undertaken in the pre-harvest stage of the supply chain. A well-structured program of fruit fly surveillance and control is implemented by the Department of Agriculture, Forestry and Fisheries. This is called the 'National Exotic Fruit Fly Surveillance Program'. Several legislations are made for the control of fruit fly which include surveillance, slowing the spread, delimiting surveys orchard and field sanitation, male annihilation techniques, bait application, removal control and compliance auditing.

Harvesting: Fruit should be harvested at the right stage of maturity. Different methods of fruit maturity determination are practiced. These include degree days, chilling hours, oil content, dry matter content and "Brix. Maturity of, for example, avocado fruit is determined by dry matter content and that of mango and citrus is determined by Brix".

From an SPS point of view, all the harvesting equipment must be cleaned and maintained regularly. Any debris or contamination can be a potential threat to food safety. A record of the cleaning and maintenance of harvesting tools and equipment should be maintained. All the produce units must be numbered by block for traceability and the relevant details should be clearly marked and noted before the start of harvesting. Harvesting should preferably be done during the cooler parts of the day.

All the labour involved in the harvesting operations must be qualified to meet the minimum standards of food safety during fruit harvesting. Personal hygiene, health and safety procedures must be followed in order to harvest a healthy produce. Care should be taken that the harvested fruit does not drop on the ground and stays free of injuries and contamination during harvesting. Global GAP certifications assure that good harvesting practices are followed during the harvesting of a fruit crop.

After harvest, the fruit should be kept at a cooler place under the shade for minimum possible time before

transport to the packing shed. Field bins should be labelled to keep a record for traceability. Harvest, bins should be gently emptied into the field bins.

The field bins should be covered after they are filled and during transportation from the orchard to the pack house to avoid exposure to any debris and direct sunlight.

Orchard sanitation begins right from the harvest of fruit. Plants debris and decomposing fruit can incubate larvae of certain pests. Once a mature commercial crop is harvested, the orchard should be cleaned as follow:

- Collect all the fallen fruit and the fruit left on trees after harvest and destroy or till them under the ground. The fallen fruit can host the larvae of pests of quarantine concern, i.e., fruit fly and codling moth
- Collect the dead leaves and plant debris that may have been damaged during the harvest. Apply protective layers of fungicide to the broken or exposed plant parts
- Organize pruning of the plants to maintain the plant canopy. The canopy should be maintained to allow sufficient passage of light and air through to each plant part

SPS compliance at pack-house level: SPS compliance at the pack-house is of significance because most fruit handling practices take place between the time the fruit arrives at the pack-house and is dispatched for market. Certain international standards like HACCP, BRC and ISO 22000 (Hammoudi *et al*., 2009) regulate the compliance of SPS requirements. Also there are local standards available with variations for facilitation of the traders. The first and foremost requirement of SPS compliance is the cleanliness of the facility and the workers.

In addition to notices on general facility cleaning and personal hygiene, other pack-house signs including moving automobiles, no food or drink, forklift in operation, no smoking wear protective clothing and footwear, emergency exit and stairs, etc., should be clearly posted. Also, particularly from SPS compliance point of view, there needs to be traps for rodents and any others pests like flies.

General cleaning of all parts, equipment and areas of the pack-house is very important. Cleaning avoids the risk of invasion by rodents, flies and any other insects and diseases of quarantine concern. Cleaning should be performed at the end of every shift and regularly as the fruit handling operations continue at the pack-house. Proper lighting and ventilation is also very important plus provision of ample space for the movement of the workers and the operation of machinery.

The very first step in the pack-house operations is fruit receival from the orchard. All the fruit is subjected to random sampling and assessment for several diseases and disorders. A picking/packing monitoring sheet is completed for each lot of fruit received by the pack-house. After the initial assessment, the field bins of fruit lots are stacked on the clean surface of the pack-house. The decision on whether to process the fruit for domestic or export market or to hold the fruit for the juice factory is made before proceeding to induction of fruit in the processing line.

If the fruit quality is found satisfactory for processing for the export market or the high end domestic market, the fruit is entered into the processing line either through wet or dry dumping. Some pack-houses are designed for wet dumping and some are designed to allow dry dumping. Wet dump means entering the fruit in a packing line direct into the water tub. Whereas, the dry dump means entering fruit in packing line on conveyor belt.

The fruit is subjected to manual and visual pre-sorting by experienced staff. The pre-sorting is done to segregate any fruit with a disease, disorder or physiological defect like over or under maturity, etc. The fruit is particularly monitored for the presence of any pest of quarantine concern, e.g., fruit fly, codling moth, canker, black spot or greening, etc. Depending on the nature of the defect in the fruit, the fruit is either sent to the domestic market or for value added production.

The fruit which has passed through the pre-sorting is then subjected to washing with chlorinated water to sanitize the fruit and remove any dirt or fungal spores, etc. The water in the washing tank should be replaced every day. The water tank should be cleaned on regular intervals, ideally once every day. The chlorine level of the water is maintained and it is topped up frequently throughout the day. After washing, the fruit is passed through a dryer. The fruit is dried with forced air at room temperature.

Fruit is then subjected to fungicide to give extra protection against the incidence of postharvest diseases, e.g., stem end rot and anthracnose and to extend its shelf life. Different fruit crops have different recommended fungicides and doses. However, Prochloraz@ 55 mL per 100 L is a general recommendation for mango, avocado and citrus. Some of the fungicides are more effective when applied with hot water treatment. Some others work equally well when applied in water at room temperature. Similarly, some fungicides work better when the fruit is dipped in the fungicidal solution whereas some fungicides work more effectively when applied to the fruit as a mist or spray.

Some fresh produce like plums, strawberries and tomatoes are dipped in a solution of an insecticide, Malathion, to control insects. Malathion has a quick rate of decomposition and it is effective for short term

insect control. Fumigation with Methyl Bromide is another way of postharvest application of insecticide. Fumigation of all the packaging material as well as the pallets is done to control mites and other insect pests. Application of Methyl Bromide fumigation has also been tested for insect control and shelf life extension of stone fruit, e.g., peach and plum.

Appropriate selection of insecticide, knowledge of the rate of product decomposition, rate of application of the insecticide and target pests is of prime importance for the application of insecticides.

Wax is applied on the fruit surface to avoid and minimize the loss of fruit water content and hence to retard fruit shrinkage and spoilage and to enhance fruit appearance. Citrus and apple are the typical examples of fruit where the wax material is applied on the surface. Most waxes are water soluble and are applied in combination with fungicides. Fruits are dried in hot air at about 45°C after application of waxes.

Final sorting of fruit is done before it is packaged manually by experienced staff. At this stage, all the fruit is scanned for its quality in terms of the requirements of the customer. Any fruit below the minimum quality standards which vary from product to product and from market to market are separated and are either packed for an alternative market with lower quality standards or are sent for value added processing.

Careful sorting of fruit at all the stages of the fruit processing in the packing line is important. However, extra attention and more staff are required to conduct this final sorting so that the threat of the presence of any pest of quarantine concern does not pass through the packing line. Any further inspections past the fruit packing can cause rejection of the consignment and can result in enormous economic loss.

Fruit sizing is important for packaging fruit of uniform size in a box. Irregular sizing and mixed packaging can result in mixed ripening and odd cosmetic appearance. Different fresh produce are sized based on either the volume or the weight of the produce unit.

Manual sizing is practiced for domestic and low end export markets. Different methods of sizing including using bars or circles of increasing diameter that are fixed next to the sorting section of the packing line. Fruit from small to large size continue to drop into their respective openings and are gathered for packing.

More precise sizing is warranted for high end markets. Precision sizing tools like optical sensors are used for accurate sizing based on fruit size and fruit weight. The produce passing through a chamber of optical mirror fixed is assigned to individual cups which drop the fruit in their respective tray for packing. Various commercial operators are manufacturing equipment required for optical sizing of fruit and vegetables.

Fruit of different sizes which is ready for packing in separate trays are manually packed in cardboard or plastic trays for further processing. Experienced and trained staff is appointed for packing.

Packaging material needs to be carefully manufactured taking into account the environment and sustainability. Good quality cardboard boxes are considered more appropriate due to the recycling option available for the packaging material. All the packaging material must be fumigated before the produce is packed so that any pests of quarantine concern can be eliminated.

Strength and design of packaging boxes is of high importance. The boxes should be strong enough so that the boxes placed in the bottom layer of a 22 layers pallet can bear the load of all the boxes placed in top layers. It should be resistant to humidity so that the pallet does not collapse after arrival at the destination. The packaging box must be designed to allow proper air flow through the produce. Ideally cross flow of air should be made possible by aligning the holes in the top and bottom portions of the box on opposite sides.

Labelling of the packaging material is important from an SPS compliance point of view as it provides all the relevant details for traceability of the fruit backward from the pack-house to the production unit (relevant block in the orchard) and forward from the pack-house to the respective market. The label also clearly displays the information on the produce packed in the box, e.g., species, variety and size as well as the address of the processing unit.

In South Africa, all the fruit packed for the export market are subjected to random sampling and assessments of fruit quality and safety by PPECB. PPECB draws random samples from the packed boxes and conducts the assessments. If the fruit passes the minimum standard requirements of PPECB, the consignment is issued a clearance certificate and the fruit boxes are allowed for palletizing.

Palletizing is done for easy handling of bulk volume of the fresh produce. Single-layer fruit boxes are stacked in 22 layers and multi-layer fruit boxes are stacked in eight layers. The size of the pallet depends on the size of the container where the fruit pallets are to be loaded for transportation.

Each wooden or recyclable plastic pallet is marked with a unique ID at a corner for identification of the origin of the produce loaded on the pallet and the detail of the farm and pack-house. Also, a unique barcode comprising of all these and other related information is displayed on a fruit box in the middle of the pallet.

Crop and country specific postharvest quarantine treatments have been developed to further ensure that any pest of quarantine concern cannot travel with the fresh produce from its country of origin to the country of

import. Common postharvest quarantine treatments include cold sterilization of citrus, hot water treatment of mangoes and avocados, vapour heat treatment of mangoes and irradiation of mangoes, avocados, apple and papaya.

Most quarantine protocols target the fruit fly and codling moth because there are chances that the larvae of these insects, not visible at the time of fruit packaging, may incubate during long distance sea freight and may become a threat for the industry at the destination country.

Depending on the countries involved in trade and the species of quarantine concern, different intensities and durations of treatment and different dosages of irradiation are recommended for different commodities.

Cold sterilisation of citrus fruit is done during the transit of the fruit in reefer containers. Hot water treatment and vapour heat treatment are done during the fruit processing before packaging and irradiation is done when the fruit is ready for export before going to the terminal for shipping.

Pre-cooling of fresh produce is done for two reasons. First, to remove the heat from the produce which may come with the produce from the field or may have absorbed by the fruit during the processing operations, e.g., hot water treatment, vapour heat treatment, etc., at the pack-house. Secondly, for conditioning of the produce for longer term storage or transit. The produce conditioning keeps produce safe from the temperature shock.

There are several methods of pre-cooling. Field heat can be removed by dipping the fruit in cold water in the field. Forced air cooling or conditioning is done by holding the pallets of a ready consignment in a dedicated room for a specific duration.

Ethylene sensitive, climacteric, fruit are subjected to standard ripening practices for uniform ripening of the fruit lot. The climacteric crops include mango, banana, apple, apricot, id, papaya, avocado and tomato. These fruit are exposed to controlled quantities of ethylene gas that triggers and enhances the natural ripening process. Different doses and different exposure duration are recommended for different crops harvested at different stages of maturity. Usually early maturity fruit are exposed to a higher dose of ethylene for a longer duration and vice versa.

Standard ripening practices are done as part of pack-house operations if the fruit are to be shipped to the export market via air freight or the fruit has to be marketed in the domestic high-end market. For sea freight of climacteric crops to export markets, the fruit is shipped unripe and the standard ripening practices are followed at the destination markets. Fruit storage is required for resource efficient handling of fresh produce. Sometimes extended storage is needed for marketing of produce when higher economic returns are expected by the traders.

In commercial pack-house operations, the fruit pallets are stored until the quantity of a full load container is processed and accumulated for shipment. The pallets of fresh produce are held at a product specific holding and storage temperature after the short term pre-cooling. As soon as a container load is ready for dispatch, the container temperature is maintained at the product specific holding temperature and the pallets are loaded into the reefer (refrigerated) container for shipment to distant markets.

In South Africa, the citrus supply chain catering to the united states market has the final inspection scheduled at a port to confirm that the fruit complies with the SPS requirements of the united states. The fruit packed at the pack-house and cleared by PPECB is transported to the respective port in non-reefer containers during the cooler parts of the day. Fruit arriving at the port is placed in under shade and the sample drawn by PPECB for the final inspection by USDA is drawn. If the consignment clears the final inspection, then the whole lot is shifted to the controlled temperature storage area and the consignment is marked ‘clear’ for shipment. The consignment is stored at the seaport until the vessel is ready for departure.

An efficient transport system plays a key role in fresh produce quality management in the supply chain. Ideally, for better product quality and extended shelf life, the fresh produce must be handled in a cool chain immediately after harvest. Reefer vans should be used for transport of produce from the field to the pack-house. Reefer containers should be used for the transport of produce from the pack-house to the export terminal and thereafter to the export destination. However, certain cost cutting amendments may be made in the cool chain management plan without compromising the physiology of fresh produce.

For example, in South Africa, the fruit is transported from the orchard to the pack-house in field bins. From an SPS compliance point of view, the field bins are washed after every delivery from the orchard to the pack-house. Also, the field bins are clearly labelled with the date of harvest, production unit code and the block number of the production unit. This labelling information travels all the way from the orchard to the market with the fruit consignment.

After fruit packaging at the pack-house, the fruit is either transported in the reefer or in controlled atmosphere containers to the export terminals or the fruit is

transported in non-reefer containers to the harbour where the USDA staff conducts the final fruit quality assessment for SPS compliance. The fruit for final assessment by USDA at the export terminal is not transported in reefer containers so that the cool chain is not broken for the purpose of quality assessment at the harbour. Whatever type of vehicle is used for transport of fruit from pack-house to the export terminal, it must be fumigated before the loading of a new lot of fresh produce. The fumigation is an SPS measure that assures that any insect pests of quarantine concern are eliminated and the fresh produce is not contaminated due to the transport.

Long distance sea freight of fresh produce is always done in reefer containers or refrigerated vessels. Refrigerated vessels are washed, cleaned, fumigated and their holding temperature is maintained at the product specific temperature before loading the pallets of fresh produce onto the vessel. Temperature control during the sea freight is not only important to maintain the quality of the fresh produce but also it is important because the SPS compliance of cold sterilization of citrus fruit depends entirely on maintenance of temperature through the transit. Temperature loggers and live GPRS temperature monitoring devices are used for live recording the temperature regime of the consignment. If temperature fluctuations cross the minimum and maximum limits, the fresh produce consignments shipped to a specific market might be refused and sent to an alternate market.

Inspection of the warehouse and even back to the orchards where the fresh produce is produced by the importers is the part of the SPS compliance program. An importer can conduct an inspection itself or can appoint a third party to conduct the inspection on its behalf.

In the South African supply chain engaged in export of fresh produce to united states, a regular inspection of orchards and pack-houses is conducted by PPECB, an independent organization authorized to conduct inspections on behalf of the Department of Agriculture, Forestry and Fisheries. PPECB issues a certificate of currency valid for 2 years to the orchards and pack-houses which pass their criteria.

International certification like HACCP and BRC assure that a pack-house complies with standard SPS requirements. However, in the absence of an international standard certification, a pack-house must comply with the minimum standards of cleanliness and operational flow without potential hazards. Documented evidence should be maintained to support the compliance of the SPS requirements. In general, the following should be observed:

- Maintain a record of the products that a pack-house processes and the respective capacity of volumes processed every year for traceability and referencing
- Maintain a record of suppliers and buyers
- Maintain a record of pack-house staff, any training conducted for capacity building of the staff and any health examinations conducted
- Record of any local or previous international accreditations held must remain available at the pack-house
- Contacts of independent service providers, input suppliers, relevant government agencies and audit firms should be maintained
- Record of previous audit reports must be maintained
- The pack-house should be an enclosed place where insects of quarantine concern and vectors of pathogens of quarantine diseases cannot enter Furthermore, an open entrance can lead to the accumulation of dirt on the packing line
- General cleaning and hygiene of the pack-house, the packing line and the pack-house staff is important for SPS compliance
- Also, the pack-house should have proper storage areas for extra packaging material, chemicals and other spare material and equipment

Quality assurance of a supply chain depends on the frequency and rigidity of the quality assessment points in the chain. Repeated quality inspection by a range of experts assures that the end product shipped to an export market would comply with all the SPS requirements of the import country and there would be minimal chances of consignment rejection and ultimately the loss of a market.

An example of postharvest quality assessment points and procedures followed by the South African supply chains exporting fruit to united states is presented.

The first postharvest quality assessment of fresh produce is conducted immediately on arrival at the pack-house. Assessment is conducted primarily to determine the overall quality of fresh produce to decide whether to assign the fruit lot for processing for the export supply chain, the domestic supply chain or for juice production. A random sample of 100 units is drawn from a fruit lot. In addition to assessing the produce for external quality issues, e.g., defects and disorders, the internal fruit quality parameters are also recorded.

The fruit lots that pass the initial quality assessment are processed further for the export market. After dumping the fruit into the packing line, pre-sorting is done to exclude any fruit with disease, defect or a disorder. Once the fruit is passed through all the processes described above in SPS compliance at the pack-house a final sorting

is conducted before packing to make sure that no fruit with any defect of quarantine concern is packed. The inspection is conducted by very experienced and trained staff.

The fruit packed by the pack-house staff is passed through the inspection service of PPECB. PPECB staff appointed at a pack-house draw a two percent random sample from the fruit lot and conduct a quality assessment specific to the pests of quarantine concern and to check for compliance with the importer specific quality requirements. PPECB staff are appointed at a pack-house for the duration of a crop season. Their capacity is adequately built by providing them with field, laboratory and demonstrational trainings by senior staff. A senior area inspector supervises the team of inspectors at each pack-house in a pre-defined area. The inspectors appointed at individual pack-houses are rotated and transferred from one to another pack-house on a need basis.

The PPECB staff randomly collect fruit boxes ready for export before palletizing. The staff conduct quality assessment in consultation with a reference quality assessment guide and develop a quality assessment report for each lot of the fruit.

The PPECB acts with the authority delegated by the Department of Agriculture, Forestry and Fisheries. A phytosanitary certificate is issued to an exporter to any country other than united states only after obtaining a clearance certificate from the PPECB. However, in the case of fruit export from South Africa to united states, a final quality assessment is conducted by USDA staff at the export terminal, e.g., sea port. The PPECB draws random sample from the fruit lot being packed for export to the united states at the pack-house and stacks the sampled fruit boxes on a separate pallet for final inspection by the USDA. The pallet for the USDA inspection is clearly marked 'Sample for USDA Inspection'. The consignment, along with the pallet of sampled fruit boxes, travels from the pack-house to the export terminal. The USDA staff identifies the pallet and takes it to the inspection facility established at the export terminal.

USDA staff at export terminal draw fruit sample based on biometric calculation to give a 95% confidence interval on the quality of the fruit consignment. A random sample of 200 fruit from the sampled lot is assessed for quality and particularly for the compliance to SPS requirements that they are free from pests of quarantine concern.

The peel of the sample fruit is cut on six sides of the fruit at 2 cm thickness and the flesh is observed for the symptoms of presence of larvae of fruit fly or false codling moths. If the assessment staff finds two larvae of a pest of quarantine concern in one box or seven larvae in the whole consignment, the fruit consignment is rejected for export to the united states. However, if the consignment has the pests of quarantine concern below the aforementioned threshold levels, the consignment is passed for cold sterilization and further shipment to the united states. The fruit consignment is accepted at the destination provided the cold sterilization treatment has been adequately completed during the transit of the consignment. Random quality assessment of fruit consignments is sometimes conducted at the destination.

Role of public and private sector in implementation of SPS compliance procedures: SPS compliance procedures require candid efforts of multiple organizations both in the public and private sectors. For example, in South Africa the fruit fly control measures are undertaken at the pre-harvest stage as well as at the postharvest stage of the supply chain. A well-structured program of fruit fly surveillance and control is implemented by the Department of Agriculture, Forestry and Fisheries. This is called the 'National Exotic Fruit Fly Surveillance Program'. Three directorates, the directorate of plant health, the directorate of inspection services and the directorate of food import and export standards, work together for the implementation of the program. Provincial governments also join hands with the federal government organizations to ensure the success of the program. The Department of Agriculture, Forestry and Fisheries has delegated powers to an autonomous body, the Perishable Products export Control Board (PPECB). The private sector organizations, like growers and traders are responsible for cooperating and facilitating the staff of PPECB.

PPECB conducts pre-harvest inspections of the orchards, certification of pack-houses and cold storages for fitness for processing and holding of fruit for export and works on behalf of the USDA on sampling of fruit for final fruit quality assessment by the USDA at export terminals. The Department of Agriculture, Forestry and Fisheries issues export certificates to the exporters only after receiving the clearance certificate issued by PPECB.

The united states is a special market for the exporters of South Africa. Hence, the exporters interested in exporting fruit from South Africa to the united states approach the Department of Agriculture, Forestry and Fisheries for special permits. Once the approval is granted, PPECB conducts special inspections along with the Department of Agriculture, Forestry and Fisheries and USDA representatives of the production units and pack-houses. Furthermore, the fruit undergoes a further and final inspection at the port of export from South Africa.

The USDA conducts the pre-departure inspection itself through a dedicated USDA inspector and a team of local experts appointed for several roles in the inspection team. The team is led by an officer of USDA and also includes a representative from Department of Agriculture, Forestry and Fisheries South Africa.

In addition to the direct regulatory role of government organizations, there are several other commercial partners engaged in the facilitation of SPS compliance in the fresh produce export supply chains. For example, input suppliers make sure that they supply the inputs to the best standard to control the pests of quarantine concern. New ideas for control measures to manage pests of quarantine concern are developed by the corporate companies, e.g., introduction of traps, pheromone chemicals to attract male and/or female insects, formulation of insecticides to kill the insects, etc. Fumigation is done by several commercial businesses. Cleaning and pest control companies play their role in providing the enabling environment for trade.

Some of the commodities are passed through irradiation before being shipped overseas. Food irradiation is a promising food safety technology that has a significant potential for controlling spoilage and eliminating food-borne pathogens. As the market for food becomes increasingly global, food products must meet high standards of quality and quarantine in order to move across international borders. The Food and Agriculture Organization has recommended that member states need to implement irradiation technology for national phytosanitary programs. There is a trend to use food irradiation mainly because of three main factors: the increase in foodborne diseases; high food losses from contamination and spoilage and the increasing global trade in food products. Food irradiation is a safe and effective tool and could be used with other technologies to control pathogenic bacteria in fresh produce. Irradiated foods are generally nutritious, better or the same as food treated by conventional methods such as cooking, drying and freezing. Food irradiation also has other benefits such as delaying ripening and sprouting. Furthermore, food irradiation has a significant potential to enhance produce safety and if combined with other anti-microbial treatments this technology is promising for solving some of the current produce pathogen problems. Although, irradiation is safe and has been approved in 40 countries, food irradiation continues to be a subject of debate and extensive acceptance and use in the food industries is slowed as a result.

Gamma rays use irradiation given off by Cobalt-60, a radioisotope of cobalt. Cobalt-60 is derived from Cobalt-59 which is placed in a nuclear reactor and bombarded with neutrons until an extra neutron is absorbed forming the unstable radioisotope Cobalt-60. For use as a radiation source, the activated cobalt pellets are encapsulated in a stainless steel liner in form of pencil to minimize absorption of the cobalt and to minimize heat build-up. The stainless steel rods are placed on racks which are stored in at least 25 feet of water and raised into a concrete irradiation chamber to irradiate the food. As the food goes through the chamber, the stainless steel liners are raised above the water so that it is exposed to gamma rays (Kilonzo-Nthenge, 2012). The irradiation dose applied to food is measured in terms of kiloGray (kGy) and is usually measured in a unit called the Gray, abbreviated Gy. The practical working range of food irradiation is generally from 50 Gy to as high as 10,000 Gy, depending upon the food in question and the effect desired. The recommended dose for mango fruit for example, is 4 kGy. There are three general application and dose categories that are referred to when foods are treated with ionizing radiation: low dose (radurization)-up to approximately 1 kGy for sprout inhibition, delay of ripening and insect disinfection, medium dose (radicidation) 1-10 kGy for reduction of non-spore forming pathogens, delay of ripening and reduction of spoilage microorganisms and high dose (radappertization) 10-50 kGy for reduction of microorganisms to the point of sterility.

CONCLUSION

Appropriate dosage of intensity of irradiation and duration of exposure of fresh produce to the irradiation needs to be evaluated for the local cultivar of fresh produce before a commercial application is commenced. In addition to the commercial facilitators of trade, the role of research institutes and universities is very important in finding commercially viable solutions to trade challenges. Also, relevant conferences play an important role in learning and exchange of knowledge.

RECOMMENDATIONS

The mass awareness program ran very effectively and the contents described above have been communicated to the fresh produce growers, harvesting staff, processors, transporters, traders, staff of the Department of Agriculture Extension, university teachers and students. The training program was taken very positive and its need has been repeatedly communicated to the project. A second series of mass scale awareness campaign has been launched and attempts are being made to spread the message of SPS compliance in fresh produce supply chains to a maximum possible relevant audience.

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