GENERAL GUIDELINES
FOR
GOOD AGRICULTURAL PRACTICES FOR SPICES

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The growing and harvesting of spices is a complex matter and is dependent upon the local conditions, whether they are differing climatic conditions, soil conditions, varieties available and the agricultural practices followed. There are a number of spice specific guides that give advice on the growing and harvesting of spices.

The guide was updated in 2016 by ASTA to take into consideration the new science available to date, to incorporate the principles of Hazard Analysis Risk based Preventative Controls (HARPC) and to incorporate the requirements of the new Food Safety Modernization Act (FSMA), thus making this version more focused on compliance with U.S. law.

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INTRODUCTION

Spices are dried seeds, fruits, berries, leaves, roots or bark of plants grown as herbs, shrubs, climbers and trees, used to enhance the flavor of foods. Examples include cumin, chilli, black pepper, oregano, ginger and cinnamon.

Like any other agricultural product, spices may be contaminated by pathogens, naturally occurring toxins such as mycotoxins, agrochemicals such as fertilizers and pesticides, heavy metals and accidental contaminants. Food safety is of considerable significance in this globalized era and the safety of spices depends on maintaining good agricultural and hygienic practices along the food chain during primary production, post-harvest, packing, processing, retail and at the point of consumption.

Reconditioning is carried out throughout the supply chain to remove both foreign and extraneous matter, to improve the microbiological status or to improve the quality. However, it is extremely difficult to recondition spices for contaminants such as heavy metals, mycotoxins and pesticide residues. In such a scenario, the only option is to prevent these potential contaminants from either getting into the product or being formed during post harvest handling.

Purpose of the guide

This guide is intended to aid producers of spices in the prevention of the occurrence of contaminants or to ensure that if present, the levels are acceptable according to food safety and regulatory standards. The purpose of this guide is not to duplicate existing resources, but to produce a document specific to the growing and post harvest handling of spices to ensure that the parameters that cannot be reconditioned are adequately addressed in the countries growing and handling spices. The guide extends a little beyond agricultural practices in recognition that the control of these non-reconditionable aspects does not just stop at the point of harvesting. In addition, allergenic materials, environmental colors and processing aids can also be issues associated with primary processing in an agricultural environment and thus these too are addressed in this guide. This guide is not intended to be used as a reference point for good manufacturing practice (GMP), as this is the subject of a separate and complimentary guide. ASTA has developed a GMP Guide and HACCP Guide which are both available on the ASTA website, and should be used in conjunction with this GAP guide.

Importance of GAP

Good Agricultural Practices or GAP are "practices that need to be applied on farms to ensure food safety during pre-production, production, harvest and post-harvest. In many cases such practices also help protect the environment and safety of workers." They are a collection of principles to apply to farm production and post-production processes, taking into account economic, social and environmental sustainability. The purpose of this guide varies from fulfillment of trade and government regulatory requirements, in particular with regard to food safety and quality, to more specific requirements such as practices to be adopted during post harvest operations.

MYCOTOXINS

Introduction

Contaminants caused by mold formation can impact the safety of spices as some molds produce toxins that can be harmful to human health. Collectively these are known as mycotoxins. For spices, the two mycotoxins of concern are ochratoxin A (OTA) and aflatoxins as they are potentially carcinogenic. Aflatoxins are produced by molds/fungi of the genus Aspergillus and ochratoxin A is produced by both Aspergillus and Penicillum - hence one of the reasons why OTA can be produced in temperate storage. At present the toxin cannot be removed by further processing nor inhibited by heat treatment.

Ochratoxin A and aflatoxins are found in a variety of food commodities, predominantly fruit and cereals but also sometimes found in spices. Globally, aflatoxin appears to be of most concern.

These molds will typically grow on foods that have been subjected to high temperatures and elevated humidity levels, although OTA can be formed at lower temperatures. Similarly it has been shown that while the initial contamination normally occurs during farm and drying activities, the actual mycotoxin formation may happen throughout the entire supply chain, including transportation, storage and production.

Preventative measures taken by all stakeholders in the supply chain from field to fork are the best way to prevent mold formation and thus enhance spice safety. Authorities in many consuming countries have already set maximum permitted levels for aflatoxins in spices and are currently discussing limits for OTA. The presence of these toxins above the permitted levels will result in the rejection of shipments and subsequent destruction of the contaminated product.

This guide is intended to assist operators throughout the chain to apply Good Agricultural Practices, Good Practices in Transport and Storage and Good Primary Processing Practices to prevent mycotoxin formation.

Growing

In general terms spices will have few mycotoxins problems if the spice is healthy and undamaged. Nevertheless, contact with any obvious sources of fungal contamination (soil, poor quality water and moldy spices) should be minimized to help the spices natural defenses.

Harvesting

The soil under the plant should be covered with a clean sheet of plastic during picking to avoid fruits getting contaminated by dirt or mixed up with moldy fruits that have fallen prior to harvesting. Fallen fruit and leaves should be removed from the area as they provide growing conditions suitable for molds.

Alternatively, the raw spice that has fallen to the ground should be collected separately, washed, cleaned, dried and evaluated prior to possible inclusion with the main lot.

Process fresh spices as quickly as possible. Avoid storage of fruits, especially ripe and over-ripe ones, as any period of storage (in a bag or in a pile) increases the likelihood of mold growth. When possible, start drying on the day of harvesting.

Wherever possible, a system for differential harvesting should be applied, so that once products are ripe they are harvested. This ensures good quality and helps prevent mold growth and mycotoxins generating from overripe fruits. This also helps by not overloading the drying operation, and thus fruits can be dried correctly with minimal storage.

Wet processing (if applicable)
Some spices, such as white pepper, ginger and turmeric, often have a wet processing step before the product is dried. Particular attention should be paid to spices once they have been removed from the wash tanks to ensure that the additional water added for processing does not become a vector that encourages microbial growth.

To minimize microbial contamination and the introduction of other contaminants it is essential that any wet processing is done using potable water.

Once the product has been removed from the water, any excess water should be removed as quickly as possible using a clean strainer or other suitable tool. Washed product should not be placed on a drying platform or floor without first draining off the excess water.

If spices are processed in water for several days it is important that the water is changed at suitable intervals to ensure that it remains in good condition.

Sun Drying
Do not dry on bare soil. Use trays, tarpaulins, bamboo mats or drying yards and make sure that these are clean prior to use, as it is known that mold spores from previous use or from the atmosphere could re-contaminate product during drying.

Techniques for cleaning and drying of drying areas should be taught to the farmers by the local authorities.

It is important to ensure that the drying surface allows for water to run away from the product so that spices do not sit in small puddles of water during drying. For example, if a clean tarpaulin is used farmers should make sure that it is placed on a slightly sloping surface without any indentations on the surface.

The layer of drying fruits or leaves should not be more than 4 cm thick, otherwise the material in the center of the layer gets too warm and wet and has little ventilation. This can create ideal growing conditions for molds.

Drying fruits or leaves must be raked regularly (5-10 times per day).

Protect fruits during drying from rain and night dew and make sure that fruit does not get wet again during storage periods.

Drying areas should be raised from the ground to prevent pest ingress and the potential effect this could have on mycotoxins generation and other issues.

The drying area should be constructed of a material that will not contaminate the spices in question and is easy to clean.

Pathways should be made in the drying area to prevent anyone from walking on the crop, as this can damage the fruits and allows mold growth to occur.

Controlled drying
To give better quality, reduced bacterial loads and ensure less risk of mycotoxin growth, a system of controlled drying can be employed.

Solar drying is one method, where crops are protected in polythene tunnels and the temperature is controlled through the use of air movement. Such tunnels should be designed so that the risk of condensation falling onto the drying crop is eliminated.

Hot air drying can also be employed and care should be taken to ensure that there is no risk of fumes from the fuel coming into contact with the product. This is best achieved through the use of a heat exchanger so that only clean air comes into contact with the product.

A solar heat exchanger can also be used where hot air generated from the sun's rays on a heat exchanger are fed into a unit which contains the spice spread on a fine wire mesh.

As with sun drying the crop should be in thin layers and turned to ensure even drying throughout the lot.

Dry Processing
The site processing plant should be in a dry area, as moist, humid conditions such as those found on swampy land encourage the growth of mold.

There should be separation between raw material receipt, cleaning, washing, processing and storage to prevent any cross-contamination.

Dispose of waste from wet processing, such as the washing and peeling of ginger, away from clean dry spices. Ensure that the area where this waste material is taken is controlled through the regular removal and washing of the area to ensure that there is no risk from mold generation.

Keep equipment and facilities clean. Remove any debris prior to using and make sure the equipment is dry before use.

Use clean dry bags for storing and transporting dry, cleaned spices and keep dried spices away from any damp material or areas.

Processing should achieve a uniform moisture content that is as low as feasible and certainly not higher than 12.0% using ISO 6673 as the measuring method or using

equipment calibrated to the same standard. Other comparable methods, such as AOAC, may also be used for this analysis.

Storage and Transportation
Temperature and humidity are key factors to control during storage and transportation to prevent formation of molds and hence the possible development of mycotoxins.

Product should be stored in good, well-maintained warehouses that do not allow the ingress of water through leaks in the roof, walls, under doors, or through open windows.

It is also important to ensure that product is stored off the floor and away from the walls so that any potential condensation does not rewet the product. In addition there should be good air movement through the warehouse to prevent sweating and mold formation.

Temperatures within large warehouses can achieve levels ideal for mold growth, particularly towards the roof, thus suitable ventilation should be provided to ensure that both temperature and humidity are correctly managed.

When product is moved into or out of the warehouse, ensure it is protected from rain during transportation.

Make regular checks to ensure that the truck is covered and that there are no rips in the covers and no leaks on the undersides of trucks which would allow water from the road to get into the truck. A simple check from the inside can be done by closing all doors and looking for holes where daylight is visible.

Trucks must be clean, dry and odor-free. This also prevents cross-contamination from previously transported products (see allergens).

Do not load and unload trucks when the product may be exposed to rain. Provide shelter so that the spice does not get wet during this operation.

Containers
Do not use damaged containers. Ensure there are no water leaks. Rust spots on the roof and sides of containers can be an indication of leakage. Check from the inside during daylight hours by closing all doors and looking for holes and undesirable smells.

Ensure that the containers have not been previously used for dangerous and hazardous cargos according to the criteria set by International Maritime Organization (IMCO). These are cargos such as solid or liquid chemicals and other materials, gases and products for and of the oil refinery industry, and waste chemicals and other cargos which have a damaging effect on foodstuffs.

Make transit times as short as possible and avoid long stops to ensure that excessive heat does not build up within the container. In particular do not load any container too soon as it could get very warm awaiting shipment.

It is preferable to use a shaded area or put another container on top to help to minimize the temperature increase within the container. The roof of an unprotected container can reach temperatures of over 80°C. The subsequent cooling off during the night results in condensation on the internal walls.

Stuffing and shipping

Make sure that pallets or wooden floors of containers are dry. Spices absorb moisture quickly if the bags get wet and as a result the moisture content increases considerably.

Lining a container using cardboard, (single-side corrugated and waxed on the inside) has proven to be the best protection against condensation for bags in containers. Kraft paper has also been used successfully. Control that the lining is properly fastened, particularly in the ceiling so that the lining will not fall down and settle on the top bags.

When stuffing the container with bags or bulk, keep spices away from the roof. Bags should preferably be placed on a layer of pallets to avoid contact with the floor where condensation from the ceiling and walls could be a risk.

If available, fully ventilated containers are preferable for spices in bags, especially if shipped from a high humidity origin. Alternatively the standard dry container with added paper/cardboard protection (top, sides and doors) is acceptable.

Ventilation holes in the container are to be kept clear. Do not cover with tape.

Absorbent ‘poles’ or boxes filled with calcium chloride absorb around 100% of their own weight in moisture and may be used for added protection if parties so agree. The number of bags used should be recorded on the documentation so that when unloaded, they can all be accounted for. It is important that care be taken not to damage these dry-bags and any spillages should be cleaned up immediately.

Enough top space between bags and the roof is important. Use the saddle stow method, which minimizes side contact and maximizes airflow between the bags.

The storage, transportation and shipping advice in this section is also applicable to all other sections of this document.

HEAVY METALS

Introduction
Heavy metals are chemicals that are known to be toxic to humans and are often impossible for the human body to metabolize. Therefore, their presence needs to be controlled, and should not exceed limits that have been set in regulation, to prevent a build up in the body over a period of time.

Within the spice industry a number of potential heavy metal problems exist and while their presence is not currently considered to be a major problem, this guide offers advice to ensure that their presence in spices is prevented.

Typical heavy metals found in spices are lead, cadmium, zinc, tin, arsenic and copper.

Minimize Exposure to Potential Sources
Spices should not be grown in areas that are known to have the potential risk from heavy metals. Area close to large industrial areas should be avoided.

Consideration must be given to irrigation water and any upstream activity, such as heavy industry or mining operations should be closely monitored.

Irrigation water should be tested annually for heavy metal contamination.

The disposal of batteries, whether car or portable device batteries, should not be done near any spice growing or processing area. Batteries need to be disposed of correctly to ensure that they do not decay and contaminate growing areas.

Any container that is used for transporting or storing spices must be of a suitable food grade material to prevent any risk of heavy metal contamination.

A soil monitoring program should be established to ensure that any naturally occurring heavy metals, for example from natural ores present in the soil, do not become a potential problem for the spices. This is particularly important for spices where ore is processed locally and has the potential to contaminate the local water supply.

PESTICIDE RESIDUES

Introduction
The use of pesticides and other plant protection chemicals is often a key requirement in ensuring that products are produced in an economic manner and are supplied to the market free from pest damage. As our understanding about the effect of pesticide residues on the human population increases it is now key that any potential residues present are controlled, to both demonstrate good agricultural practices and protect the well being of the consumer.

Integrated Pest Management (IPM)
The principle of integrated pest management is to have a systematic approach to the use of plant protection chemicals so that their residues do not become a problem.

IPM uses methods and disciplines that take care to minimize environmental impact and risks and optimize benefits. It is a systems approach to pest management that utilizes decision-making procedures based on either quantitative or qualitative observations of the pest problem and the related host or habitat.

A key concept in IPM programs is the application of decision-making processes to determine whether a chemical pesticide or other action is needed or not. Such decisions depend on evaluation of the pest problem often in a quantitative manner.

IPM systems, such as insect sticky boards, trap crops, perimeter barriers, deterrent crops, predator pests, and natural or organically approved materials are encouraged and should always be used before any chemical intervention.

In the evaluation of agricultural crop pests, the point at which the economic benefit of pesticide use exceeds the cost of treatment is commonly referred to as the economic threshold. Academic definitions of the threshold concept may vary from discipline to discipline. Another term commonly accepted is action threshold, which is commonly applied to a set of conditions where action is warranted and may be based more on practical experience and judgment than on refined mathematical models relating biological and economic parameters.

Since IPM decision-making depends on field observations, the role of the pest scout, pest management advisor, or field biologist has emerged. Although do-it-yourself field observations may be widely practiced, most IPM programs require a person in the field to collect relevant information on the pest populations in question and related parameters concerning the crop or host habitat.

Restricting the use of plant protection chemicals decreases the chance of pests becoming tolerant to those chemicals and also has the benefit of achieving higher quality products, with less risk of rejection at the port of entry.

If fertilizers are used, it is essential that they are from a reputable supplier. It is best practice to use a small amount of fertilizer regularly. If too much fertilizer is used at one time there is the risk of a growth spurt, which can weaken the wall structure of the plant and make it more susceptible to pest attack.

Growing location
The location of the growing area should be such that there is no additional risk of pest or disease attack of the plant due to the growing environment. This could be by growing materials away from waste disposal areas or ensuring that they are grown away from other plants which are known to attract high levels of pests or disease.

For any growing area it is important to identify which crops are growing adjacent to that area and also pay particular attention to any crops that are non-food that are sited up wind of the growing area. The wind can carry pesticides applied to non-food crops, such as cotton, resulting in detectable levels of pesticide that are not permitted for a food crop.

Weeds within a growing area not only compete for nutrients but also encourage pests. Before using weed killer chemicals, mechanical removal of the weeds should be undertaken wherever possible.

Weeds can have the additional risk that they are non-food crops and thus can produce toxin chemicals that should not be incorporated into the food crop. The manual removal of these weeds is highly encouraged.

Pest monitoring
The use of trap crops, i.e. those crops that are more attractive to a particular pest than the spice being grown, can have a significant effect in identifying any potential pest before the level of pests become unacceptable. For example, a trap crop of castor can be a very good indicator of potential pest activity within a capsicum growing area as the pests that attack capsicums are more attracted to castor than they are to capsicum. In this scenario, regular inspections of the trap crop help to identify any potential pest problems at an early stage in the process and removal of any affected leaves helps reduce the pest population.

The use of pheromone traps within a growing area helps to reduce the target pest by capturing them and also allows close monitoring of the pest so that when plant protection chemicals are applied, it is done in an appropriate manner.

The use of perimeter crops, growing a band of crop around the spice growing area, helps to prevent pests from gaining physical entry to the spice growing area and can also help reduce wind drift effects and insect attacks.

The use of bird perches within a growing area provides a perch for birds to roost, encouraging them to stay in a particular growing area and eat a proportion of any pests that are present on the crop. Wherever possible these bird perches should be located so that they are not directly above any individual plant, thus reducing the risk of bird excreta on the plant. All bird perches should be removed for a period prior to harvesting for the same reason.

Irrigation
To prevent the spread of disease it is better to use trickle irrigation as this ensures that water supplies are used sparingly and also adds benefit by allowing any plant protection chemicals to be delivered directly to the plant.

Flood irrigation techniques use excessive amounts of water and also increase the risk of spreading disease throughout any particular growing area.

Pesticides
If plant protection chemicals are required, natural systems such as neem should be used whenever possible, as these types of plant protection chemicals are more acceptable to the importing countries.

When synthetic plant protection chemicals are used, it is important that these chemicals are permitted for the crop in question, by the country in which the crop is grown and is also permitted in any country to which the crop will be exported.

Plant protection chemical residues are authorized for specific plants, so you should not assume that if a chemical is allowed for one crop that it is automatically approved for other crops. If in doubt seek advice from your local agricultural office.

It is important that when a plant protection chemical is used, that it is purchased from an authorized dealer who can give assurances that the chemical that they are selling is authentic. PPCs should not be purchased from any other source as the active principles in these chemicals may be at the wrong concentration or could even be prohibited.

Once acceptability of the plant protection chemical has been established, the levels of dose for a crop should be set to determine the dilution to be used and also the number of applications that are permitted.

There should be documentation on the use of plant protection chemicals. This should include trade name, active chemical ingredient, product expiration date, application date, the dilution that has been applied, and the target pest.

Plant protection chemical operatives should be provided with suitable equipment to ensure that they can deliver the plant protection chemical correctly, especially when this is done at field level. In this case the use of measuring cylinders, or measuring caps, as some plant protection chemical manufacturers provide, will ensure that the application level is acceptable and thus residue will be within accepted tolerances.

It is important that the equipment being used for pesticide application is washed thoroughly to ensure that there is no cross-contamination from previous use.

A pesticide holiday, typically a period of 10 to 30 days where pesticides are not applied, will help ensure that any plant protection chemicals used have the opportunity to dissipate throughout the plant prior to harvesting. Note: many plant protection chemicals state on their labels the minimum length of time that should be allowed between the last application of the chemical and the harvest and this advice should always be taken into account.

It is important that pesticide containers, whether pouches or bottles, are disposed of correctly and not left within the growing fields where the application was carried out.

It is important that any water used for irrigation is tested to ensure that it is free from pesticide residues from other crop run-off further upstream.

ALLERGENS

Introduction
For reasons that are still to be fully understood it is now clear that in some parts of the world more and more people are becoming sensitive to allergens. This sensitization can, in some instances, result in anaphylactic shock with the smallest amount of food ingredient causing this problem. It is therefore particularly important to ensure that spices are protected from potential allergens if they are destined for use on the world market.

The U.S. has named eight major allergens that require labeling: peanuts, tree nuts, fish, shellfish, eggs, milk, soy, and wheat. Other countries have added additional items to their lists of allergens, including sesame and mustard seed.

Cross-contamination
Particular attention should be paid to peanuts as they can pose the highest risks for certain consumers and therefore it is imperative that during the growing, processing, storage and transportation periods that spices are protected to prevent contamination from peanuts.

Care should be taken when rotating crops to ensure that a previous allergenic crop has not left any potential cross-contaminants in the growing area.

It is also important that peanut derivatives, such as ground peanut oil, are not used in any way for the processing of spices or for the lubrication of any spice processing equipment.

Care should be taken while harvesting spice and allergen crops which are grown side by side in the same area. If the harvest is more or less during the same period, a suitable harvest gap should be given among these crops to avoid contamination.

Any on-site storage of materials should ensure that spices are stored in a separate location to any allergens to prevent cross-contamination.

It is now clear that certain consumers have allergic reactions to the presence of sulphur dioxide. Traditionally sulphur has been used within the spice industry, either to improve the visual appearance of spices or as a pest prevention method. The risk associated with sulphur dioxide should be carefully considered within any HACCP study and if material is processed in such a way that sulphur dioxide residues are present, then this should be declared on the packaging and paperwork accompanying the lot.

Careful consideration needs to be given to the transportation of spices, especially from farm to exporter or processing. It is recommended that bags not be reused, however, if they are recycled, it is important that these recycled bags have not previously contained an allergen, such as peanuts.

Care and attention should be taken in any common trading yard, where both allergenic materials and spices are handled, to prevent cross-contamination. A suitable cleaning operation needs to be adopted to ensure this risk is eliminated.

ENVIRONMENTAL COLORS

Introduction
It is well-documented in recent years that there has been an occurrence of deliberate adulteration of spices with artificial colors. In some cases these colors were not permitted as food colors and in other case these colors were not declared and thus were deemed to be misleading to the consumer.

The spice industry has developed analytical methods and equipment to ensure these illegal dyes can be detected, even at very low levels which may be due to environmental contamination such as marking inks, colors to assist in applying plant protection products, fuel or dye contaminated water. While it is clear that the intentional use of dyes on spices is not permitted, there are steps that can be taken to prevent the presence of dyes from environmental contamination.

Bag markings
To ensure that spices are not colored when bag markings are used, a food grade dye should be used wherever possible.

Bags that have an open structure, such as jute bags, should not have bag marking made on the jute when the bag is already full of spices. In some cases the liquid dyes can go through the bag and contaminate a small portion of the contents so it is better that the bags are marked prior to filling or are marked using a label or tag.

Plant protection chemicals
When purchasing plant protection chemicals, particular attention should be given to the color of any chemical purchased. Highly colored pesticides have the risk of leaving minor traces of color on the crop, especially if there has been a late application in the growing cycle.

Fuel emissions
The fuel used for transportation and water pump operation is often colored. Consideration should be given to the location of these pumps to ensure that the fuel itself or its exhaust residues do not expose the spices to environmental contamination. In addition, consideration should be given to the location of growing areas to avoid vehicle exhaust emissions becoming a problem if there are high traffic levels next to the growing area.

PROCESSING AIDS

Introduction
A processing aid is a chemical that is used to help improve the processing of spices with no technological function within the finished spice.

For many years bleached spices, such as ginger and cardamom, have been traded commodities. It is important that any bleaching be declared on the packaging and that the residues of any bleaching conform to international guidelines.

The spice industry has historically used a number of processing aids and it is important that the use be fully justifiable, safe and that the buyer is informed.

Any processing aid must be food safe, approved for use within the country of consumption and declared to the buyer.

White pepper
During the manufacture of white pepper, microbial reduction agents such as Chlorine are used to ensure the quality of the processing water. If agents like this are used then their dose should be controlled to prevent a carry over from the process onto the finished products, and the final product levels should be in accordance with International standards.

When this type of process is used it should be declared to the buyer so that he is aware of this and can make any labeling declaration required.

Dressing
The use of mineral oil to coat the surface of black pepper, paprika or other spices is not permitted. The use of vegetable oil should be declared to the buyer. Peanut oil should not be used because of concerns related to allergens.

Jute sacks
Some suppliers of jute sacks use mineral oil on the jute fibers to make the sewing of the bag easier. This is a practice that should not be used as mineral oil is toxic. Always ensure that you use bags that are free from such processing oils, whether jute or any other material.

Recycled packaging
Care should be taken when using recycled packaging to ensure that any residues of mineral oils and other contaminants, are removed before use.

GENERAL

Worker hygiene

Personnel handling the harvest should not be suffering from any contagious disease that could cause or act as a precursor to foodborne health problems. In the event signs of diseases are observed, a supervisor should take the necessary measures to prevent the person(s) from handling the harvest until they are fully cured from the disease(s).

Basic sanitary practices should be practiced by personnel before and during harvesting and handling of harvest.

Wherever possible, especially in primary sorting centers or drying yards, care should be taken to prevent the potential ingress of glass. This includes the removal of jewelry, the replacement of windows with non-glass material (such as Perspex), and prohibiting the use of any glass container or bottle.

Workers involved in the handling of spices should be aware of the risk of contaminating the crop and thus eating and drinking should be prohibited in these areas.

Field sanitation

The field sanitation standards require the person supervising the harvesting of the crop to provide toilets, potable drinking water and hand-washing facilities to personnel in the field, ensure that each person makes reasonable use of the above and make sure that each person understands the importance of good hygiene practices.

MICROBIAL CONTAMINATION

Introduction
All agricultural commodities carry the risk of being contaminated with pathogenic bacteria. From planting to consumption, there are many opportunities for bacteria, viruses, and parasites to contaminate produce. On the farm, soil, manure, water, animals, equipment, and workers may spread harmful organisms.

There is no way to guarantee that everything we grow and consume is free of harmful microbial contamination. The risk can be reduced if preventative steps are taken before produce leaves the farm. This section of the guide contains detailed suggestions on how you can reduce risks of microbiological contamination on the farm.

Clean Soil
The improper use of manure can be a risk factor contributing to foodborne illness. Pathogens such as *E. coli* 0157:H7*, Salmonella,* and *Campylobacter* can be present in manure slurry and soil for three months or more, depending on temperature and soil conditions.

Composting manure, incorporating it prior to planting, and avoiding top-dressing with fresh manure are important steps that can reduce the risk of contamination while making use of this important source of nutrients. Excluding domestic and wild animals as much as possible from production fields will help reduce the risk of manure (fecal) contamination.

Manure application
Manure should not be applied to the crop area for three months prior to harvesting. If the field is side dressed with manure, only well-composted manure should be used and care must be taken to make sure it does not touch the crop.

Fresh manure and liquid manure should not be used once the crop is in the field.

Irrigation Water
When using surface water for irrigation, test quarterly for fecal coliforms, especially if water passes close to sewage treatment or livestock areas. Water may be filtered or used through a settling pond to improve water quality.

Use potable water for crop protection sprays, such as fertilizer, herbicide or pesticide application.

If overhead irrigation is used, use it early in the day, so that leaves dry quickly, minimizing microbial growth.

Clean Surfaces
Before harvesting or packing and at the end of each day, clean all bins or container that are being used.

As some spices get primary processing at farm level ensure that any equipment used, such as pepper threshers, are thoroughly cleaned before being used. This is

particularly important on equipment that has been sitting unused since the last harvest. Equipment like this should be cleaned to remove product debris before it is put into storage to prevent pest and microbial contamination during the storage period.

Ensure that any vehicle used to transport that crop around the farm is clean and dry. Pay particular attention to the previous use of the vehicle and clean it accordingly.

CONCLUSION

The spice supply chain is complex and product can pass through many hands before it finally reaches the consumer. Everyone along the supply chain shares in the responsibility to ensure that the consumer has access to clean, safe spice. Compliance with Good Agricultural Practices is an important first step in the supply chain to helping everyone achieve the goal of clean, safe spice.

As U.S. companies and their overseas suppliers take steps to comply with the Food Safety Modernization Act (FSMA), expectations will be raised for everyone to understand their responsibility to ensure clean safe spice and use of this GAP Guide can serve as an important resource in meeting that goal.