
Working Paper Series

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Resource: A2.4 Mango productivity and quality improvements in processed supply chains
Study focus - Processed mango
Recommended procedure for bulk freezing mangoes

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Summary

Processing of mangoes is well established in Vietnam particularly in the Mekong Delta and increasingly in the north of the country. The purpose of this document is to assist extant processors to accommodate large influxes of mangoes at the height of the season to maximise utilisation of the resource. In addition, it will serve as a guide to intending processors of mangoes yet to invest in sophisticated free-flow equipment. Adoption of bulk partial processing will enable enterprises to make greater use of the mango resource, reduce waste and ultimately improve return for effort for all participants, especially small-scale farmers.

Recommendations for freezing:

- Broader and timely communication with chain partners maintained so ensure impediments to efficiency can be mitigated
- Records of fruit rejections must be kept.
- Traceability is required for HACCP to ensure records include the origin of the fruit
- Chemical treatments to which the mangoes have been subjected in the field or during transport to the processing facility must be recorded and available for the processor
- Fruit is washed with a de-contaminating solution before entry into the HACCP (or ISO-) compliant processing area
- Batch sizes should be correlated to the batch for which the frozen thawed pulp is required by the market or for batches of value-added product
- It is a Codex requirement that all frozen food products are stored at, or below minus 18°C
- It is recommended that the barrier is polypropylene based either biaxially oriented or laminated with Polyvinylidene chloride (PVDC). Polyvinylidene chloride or PVDC is a clear and flexible synthetic thermoplastic produced by the polymerization of Vinylidene chloride. It is optically clear with a high degree of gloss and has outstanding oxygen and moisture barrier properties comparable to metallized films. This makes PVDC ideal for household wrap and food, medical and pharmaceutical packaging to extend shelf life. PVDC also is highly resistant to many chemicals including grease and oil.

1 Overview

Mangoes are highly seasonal and intervention in the form of season extension increases the opportunity to make greater use, not only of the available mangoes but also optimises use of facilities including equipment. Furthermore, it foreshadows the opportunity for extended employment for all parties who may have limited opportunity for income generation. This CoP has been prepared using the experience of existing mango processors. All procedures are based on best practices that conform to international standards. As a member of the World Trade Organisation (WTO) the Vietnam food processing industry is committed to adopting the international standards mandated by Codex Alimentarius Commission (CAC – or Codex) of which the quality assurance practise Hazard Analysis and Critical Control Points (HACCP) are an integral part (see Appendix 1). Further additional standards are imposed by discerning markets. It is a requirement for the processor to adhere to market and international standards.

Mangoes are an increasingly important crop for Vietnam particularly for small holder farmers in the southeast of the country in the Mekong Delta, and recent surveys would indicate that there is considerable further interest in engaging in mango processing.

Mangoes are highly seasonal there are compelling reasons to develop techniques that are designed to handle large quantities of produce in a short time. In so doing, maximum use can be made of mangoes leading to higher sales for the small-scale farmers. There are precedents throughout the fresh fruit and vegetable industry to partially process fresh items for on processing out of the season. This extends the annual processing window and provides an opportunity for processors to meet annual fixed costs. Several options are available for partial processing. Partial dehydration is expensive if ambient conditions do not permit solar drying, preservatives such as sodium metabisulfite which can be removed by subsequent boiling but must now be declared as an allergen. Favoured among other industries based on seasonal crops is the technique of freezing in bulk with minimum prior-processing and without the use of additives.

There are three elements for successful freezing practices:

- Sufficient raw material (mango) of the appropriate quality
- Technology to affect value adding or preservation
- Market demand

2 The value chain

2.1 Mango supply

Participants in any of these elements include growers, collectors, wholesalers, cooperatives, companies, retailers, and consumers. Key market channels range from farmers straight to consumers through to a range of alliances of collectors, wholesalers, exporters, retailers, and processors. Participants in all these elements are contributors to the value chain.

Farmers are the fountainhead of the mango value chain. Farming practices are subject to the standards and practices directed by VietGAP or Good Agricultural Practices specific to Vietnam (Tan 2014). Embedded in VietGAP are standards pre-determined by Codex – particularly relating to pesticide and herbicide residues. Record-keeping at farm level enables the compulsory requirement for traceability in the event that standards are transgressed, and public safety is at risk both within Vietnam and throughout the international markets in later stages of the chain.

It is therefore recommended that all processors ensure that all supply growers are VietGAP registered.

2.2 Safety

The HACCP system mandates conformation to all related Codex standards (Appendix 1). Processors may obtain mango supplies directly from growers, from cooperatives, collectives or other middlemen (ACIAR 2019). Current studies are aimed at analysing compliance with international quality standards (Dinh 2020). Hygiene is of critical importance and maintaining freedom from contamination is mandated in Codex General Principles of Food Hygiene (Appendix 2) and each participant has a responsibility to maintain quality. Attention to good handling practices is all chain members' interests since it minimises handling damage and hence losses. Constant reinforcement of chain participants' responsibility to each other is most appropriately achieved by amicable working relationships (PIFON 2019).

In addition, supply fluctuations can be relayed to growers, markets, and processors to ensure that massive fluctuations can be accommodated with minimum loss and wastage.

It is recommended therefore that constant communication with immediate chain partners is maintained so that difficulties and impediments to efficiency can be mitigated.

Packhouses and sorting premises should be subjected to good handling practices but on reaching the processing area Good Manufacturing Practices (GMP) are mandatory. This is particularly relevant in food freezing operations because the freezing process does not guarantee microbial destruction.

2.3 Personal Hygiene

Appropriate facilities and procedures should be in place to ensure that food handlers in any food preparation and handling situation are potential sources of food infection which may pose a threat to public health (Appendix 3). Humans are host to very large numbers and types of bacteria, viruses, and fungi ($\sim 10^{15}$). They are found in highest amounts around the nose and throat, personal toilet areas and hair. Most are not noticed because they do not produce symptoms. However, those same microorganisms may cause sickness in others. Other mild symptoms such as running nose, diarrhoea and boils or lesions on the skin will certainly cause sickness in others. Prevention of infection of disease means that hands must be washed immediately after using the toilet, food workers with cold or flu symptoms or boils must not be permitted near the food preparation area. Smoking and eating in the handling areas are not permitted because microorganisms from the nose and mouth are transferred to hands.

Animals are highly infective and must not be permitted in any food processing area.

Flies, cockroaches, and birds are capable of transferring microorganisms from highly contaminated items such as animal dropping to food equipment and birds perching on pipes are a particular hazard.

Warning signs must be displayed as constant reminders (see Figure 1).



Figure 1. Warning signs

2.4 Quality features

There are a number of advantages of freezing in bulk at season height. Although mangoes require peeling before freezing the food industry has a plethora of devices to remove skins ranging from chemical removal to simple automatic rotating abrasion techniques. Hence this is not an impediment to engaging processing but must be included in any costs associated with setting up.

Unfortunately, freezing damages cellular tissue and is especially significant in soft fruits where cellular integrity affords bite crispness. Hence the use to which frozen thawed mangoes can be used is limited to products that are not texture dependent. These include purees and pulps and in-depth processed products such as juices, jams, chutneys, confections, and leathers. The trade in frozen pulp from Vietnam is significant.

On the other hand, processing is less demanding on fruit quality. Some skin blemishes that are not acceptable in the fresh market can be mitigated during subsequent processing. Mangoes are visually, manually inspected as they arrive at each point in the value chain. Each member of the inspection team must be aware of the standard that is acceptable and that which must be rejected (see Figures 2, 3, 4, 5 and 6), and the quality standards agreed by the grower, the trader or other middle person. Inspection is a Critical Control Point (CCP) for inclusion in the HACCP plan.



Figure 2. Mangoes suitable for processing

Source: Author's image



Figure 3. Mangoes unsuitable for processing – rotten stalk

Source: Author's Image



Figure 4. Mangoes unsuitable for processing – excessively bruised

Source: Author's Image



Figure 5. Mangoes unsuitable for processing – excessive mechanical damage

Source: Author's Image



Figure 6. Mangoes unsuitable for processing – sap-burn damage

Source: Author's Image

Records of rejects must be kept. This enables the purchaser to assess consistency and to identify any variation which may be tied to an unusual event such as weather or change in personnel. Traceability is a requirement for HACCP purposes so the records must include the origin of the mangoes. Chemical treatments to which the mangoes have been subjected in the field or during transport to the processing facility must be recorded and available to the processor on request.

Incoming fruit of any kind will have been exposed to contaminating surfaces. Exposure to the field environment includes wind-blown dust, bird droppings and other adventitious contaminants. It is recommended that the fruit is washed with a de-contaminating solution before entry into the HACCP (or ISO-) compliant processing area. Commonly, soaking for 10 minutes in a solution containing 200 ppm (200 mg per Litre) sodium metabisulfite is used. Residual sulphite is largely removed during peeling. Residues rapidly disseminate during subsequent processing. An additional soak in a solution containing 0.6% ozone ensures surface sterility and is an optional, additional precaution. However, retail labels must include the phrase 'May contain residues of sulphite', which may limit the market.

3 Preparation for freezing

3.1 Peeling

The method selected for skin removal is based on cost. Mechanical peelers are available that abrade the skin. They vary in capacity and efficiency and cost. The ultimate decision is based on the merits of hand peeling which can be combined with inspection relative to the capital cost of mechanical peeling (see Figure 7).



Figure 7. Hand peeled mango

Source: Author's image

Losses during peeling Cat Chu variety (seed 16%; peel 18%; flesh 66%). The sensory characteristics of the mango after freezing are not significantly different if the stone is removed or retained. After freezing and thawing the pulp is homogeneous so that it is likely the stone can be removed from the pulp mechanically thereby reducing the cost of hand removal prior to freezing.

There may however be opportunities to recover value from the peel and the seed.

4 Freezing

Soft mango tissue undergoes significant loss of texture during the freezing process. Very fast freezing is required for free-flow mango pieces or cheeks but for bulk frozen mango the rate of freezing is not important. The rate of freezing will depend on the mass of the portion to be frozen. These peeled mangoes can therefore be frozen in a static container freezer which is much less expensive than continuous belt blast freezers.

Batch sizes should be correlated to the batch for which the frozen thawed pulp is required by the market or for batches of value-added product. It is a Codex requirement that all frozen food products are stored at, or below -18°C. To prevent moisture loss during storage, the packaging material must be an excellent moisture barrier and prevent the distillation of odours from other items in the cold storage facility.

It is recommended that the barrier is polypropylene based either biaxially oriented or laminated with polyvinylidene chloride (PVDC). The temperature of the cold store should remain below -18°C and not fluctuate more than +/-5°C to avoid ice crystal formation. Stones can be removed mechanically either by pressure sieving or centrifugation before further processing. The quality of the frozen fruit pulp and purees is mandated by the Caricom Regional Code of Practice.

5 Value adding

This product can be prepared for export to processors for value adding. The product quality must conform to Codex standards at the point of transaction or further processing.

The thawed product is not suitable as a finished product. However, it is a base for other products such as:

- Jam: In which the product is boiled down with sugar until the soluble solids reach 72% and the pH is below 4.2
- Leather: In which the product is dehydrated on a flatbed until sufficient moisture is removed for it to form a continuous sheet
- Chutney: In which the pulp is boiled down with vinegar, sugar, salt, and spices
- Confections: Such as jellies in which the pulp is boiled down with glucose or fructose syrup, gelatin, and citric acid

6 References

HACCP (1997 Rev 2015) Hazard Analysis and Critical Control Point System and Guidelines for its Application. *Annex to CAC/RCP 1-1969, Rev. 3 (1997)*

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7 Appendices

Appendix 1: Relevant codex standards and codes of practice

CXS 1-1985	General Standard for the Labelling of Pre-packaged Foods	CCFL	2018
193-1995	General Standard for Contaminants and Toxins in Food and Feed	CCCF	2019
234-1999	Recommended Methods of Analysis and Sampling	CCMAS	2019
XS 247-2005	General Standard for Fruit Juices and Nectars	TFFJ	2005
CXC 46-1999	Code of Hygienic Practice for Refrigerated Packaged Foods with Extended Shelf Life	CCFH	1999
C 47-2001	Code of Hygienic Practice for the Transport of Food in Bulk and Semi-Packed Food	CCFH	2001
3-2003	Code of Hygienic Practice for Fresh Fruits and Vegetables	CCFH	2017

Annex to CAC/RCP Hazard Analysis and Critical Control Point (HACCP) System and Guidelines for its Application 1-1069 Rev 2018

Appendix 2: Codex Alimentarius

GENERAL PRINCIPLES OF FOOD HYGIENE CXC 1-1969 Adopted in 1969. Amended in 1999. Revised in 1997, 2003, 2020

ESTABLISHMENT - DESIGN OF FACILITIES AND EQUIPMENT OBJECTIVES:

Depending on the nature of the operations and the associated risks, premises, equipment and facilities should be located, designed and constructed to ensure that:

- Contamination is minimised
- Design and layout permit appropriate maintenance, cleaning and disinfection and minimize airborne contamination
- Surfaces and materials, in particular those in contact with food, are non-toxic for their intended use
- Where appropriate, suitable facilities are available for temperature, humidity and other controls
- There is effective protection against pest access and harbourage
- There are sufficient and appropriate washroom facilities for personnel.

RATIONALE: Attention to good hygienic design and construction, appropriate location, and the provision of adequate facilities is necessary to enable contaminants to be effectively controlled.