
Working Paper Series

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Improving smallholder farmer incomes through strategic market development in mango supply chains in Southern Vietnam

Activity: A2.4 Mango productivity and quality improvements in processed supply chain

Study focus - Mango processing

Partial freezing trial

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Summary

This activity examines one strategy to improve smallholder farmer incomes by providing an outlet for a portion of the very high volumes of fresh mangoes at season glut when chains and facilities cannot accommodate such large influxes. The technique of bulk freezing with minimal prior processing is an established technique used throughout the horticulture industry.

The aim of this study was to establish a partial trial as a methodology for mango season extension and productivity improvement.

The approach adopted was to engage with major mango processors in the Mekong delta to ensure commercial relevance where possible. Through structured interviews, priorities and protocols were developed. Preliminary freezing trials were undertaken to ascertain the appropriate method to be used for freezing. Commercially realistic techniques were formalised and then applied to a commercial model. Full production expenditures including input materials, handling, ripening treatment, cleaning materials, sterilisation, packaging, and energy costs were defined. The study revealed the average profit ranges from AUD38,289 to AUD46,441 per 100 tonnes of product. Although many intangible factors remain, that can only be defined from a full-scale commercial production run, there is sufficient data to support the attractiveness of the system to extant manufacturers and to aspiring processors for adoption.

Supporting this study, a Code of Practice for the mango freezing technique has been developed. A guide to support the Recommended Procedure has been prepared to assist processors to engage in the freezing process as a commercially viable method for mango season extension and productivity improvement.

1 Introduction

Improving mango productivity and competitiveness offers a significant opportunity to improve incomes and livelihoods of thousands of farming households in Southern Vietnam. Currently, processed, and frozen fruit accounts for only a small proportion of the total mango production in Vietnam. Most fruit is consumed as fresh fruit supplied through traditional markets and retailers, including supermarkets, convenience stores, and high-end fruit shops. A large majority of mango production quality is sub-standard. Much of this production does not reach the domestic supermarket retailers and is wasted because of the current lack of processing facilities.

Engagement with manufacturers confirmed that mango supply is inadequate both in quality and quantity with seasonality confounding productivity outcomes. Freezing highly seasonal fruit volumes at season glut is a common and well-practiced procedure that reduces waste and optimises use of expensive equipment at times when it would be under-utilised as supplies wane. In some cases, processing provides an opportunity to mitigate quality dissimilarities and defects (Class I and Class II fruits). Mangoes in Class I and II must be of superior quality. They must be characteristic of the variety. They must be free of defects, with the exception of very slight superficial defects, provided these do not affect the general appearance of the produce, the quality, the keeping quality and presentation in the package. In addition, attainable prices possible by seasonal crops tends to increase after harvests as supplies decline.

The processors in Southern Vietnam have diversified their product range using other fruits to make optimum use of, otherwise idle, equipment throughout the year. However, prices obtained by such products as frozen pineapples, papaya, banana, and longan do not match returns for mango equivalents. Hence bulk freezing is a possible means of maximising the use of the available mango resource with the promise of utilising reducing waste, optimising the use of factory facilities thereby increasing profitability. This situation has prompted the study as a partial trial as a methodology for mango season extension and productivity improvement.

2 Methodology

Two major strategies were used to undertake the study:

Phase 1: A mango freezing trial was undertaken at the commercial processing facility at Long Uyen Co. In so doing, the research team gained access to industrial production procedures and protocols. Commercially acceptable quality features of incoming mangoes were established, in collaboration with the company's quality management team.

Using the practical procedures established mango freezing trials were repeated. So that commercial relevance was maintained these trials were conducted both using the research team facilities and at selected, convenient processing facilities. These facilities were situated at one company in Cu Chi in Ho Chi Minh City and two companies in Dong Thap - Lai Vung and Cao Lanh. Throughout the design of these trials, consideration was consistently directed towards a system that demanded minimum input at the season height thereby not disrupting normal processing schedules. In particular the effect of stone removal after peeling and before freezing was considered pertinent to verify that the simpler technique of peeling and freezing without stone removal was the preferred technique.

The following procedure was adopted:

- Samples of 100 mangoes were selected using the quality criteria used by the private sector
- Fruits were ripened by the traditional ethylene method
- Mangoes were selected and damaged fruits removed
- Losses were recorded simultaneously
- Mangoes were soaked in a solution containing 200 ppm free chlorine solution for 10 minutes
- Mangoes were drained and soaked in a solution containing 0.6% ozone for 10 minutes
- After surface sterilisation using these procedures, collected samples were divided into two sub-samples
- One sub-sample was peeled and the stone was removed
- One sub-sample was peeled and the stone was left in-situ
- Samples were frozen to -18°C which is the maximum storage temperature mandated by Codex
- Samples were thawed and subjected to taste panel evaluation for; flavour, aroma, appearance and overall acceptability using the Hedonic scale
- Assessors appointed.
- This procedure was repeated, and the results collated

The data was collected for a compilation of the costs of standard freezing for cheeks and cubes and for bulk freezing.

Subsequent bulk handling of thawed mango pulp for stone removal is uncomplicated. Freezing techniques were documented and form the essence of a guide for extant and prospective mango processors.

Phase 2: Having established and documented prospective techniques an estimate of the commercial viability was necessary. Semi-structured interviews were carried out on the three identified processing companies, to define the demand and quality imperatives of mangoes to meet market standards required in finished products. These interviews conducted in March and April 2021.

Interviews with processors were undertaken to determine the current frozen mango production costs associated with mainstream frozen cube and cheek production. From these costs it was proposed to extrapolate costs of freezing in bulk. Significant detail was obtained from these surveys. They included:

- Quantities of mangoes produced in a season
- Preferred varieties

- Raw material standards
- Prices paid for raw mangoes (if available)
- Market preferences (cubes, cheeks, puree)
- Approximate proportion of each option produced
- Export destinations
- Export quality standards
- Total employment and the gender balance
- Capacity to absorb additional volumes rapidly at the height of the season
- Ancillary cost (ripening costs, processing aids)
- Wastage at each stage of processing
- Chemical input costs
- Pre-treatment costs
- Labour costs
- Power costs
- Handling costs excluding labour
- Packaging costs

Data from these surveys enabled the construction of a financial analysis for regular processing into cubes and cheeks. It was the basis for extrapolation of costs for bulk freezing.

From the experiments undertaken protocols for use in a development programme were prepared.

Code of Practice

As an output of this study, a Code of Practice was developed that incorporated relevant standards including VietGAP, obligatory Codex and Hazard Analysis and Critical Control Points (HACCP), General Principles of Food Hygiene (CAC/RCP 1-1969) and those standards required by the market inter alia BRC, HACCP, ISO 22000.

The Code of Practice is available under a separate cover.

Financial analysis

Information was captured to undertake a rudimentary financial analysis. This activity was limited by commercial sensitivity and reluctance by stakeholder to store information. The following information was captured to inform the analysis:

- Costs of raw materials
- Estimated loss mitigation as a result of adopting the concept
- Estimated requirements for additional freezing capacity
- Costs of processing, including – power and labour
- Marketability of the product resulting from the technique

3 Results and discussion

3.1 Phase 1 – Freezing trials

- After analysis of sensory evaluation returns it was established that there was no significant difference between the sub-samples indicating that mangoes could be frozen stone-in or flesh alone
- The projection for the private sector is that bulk frozen mangoes can be simply peeled and frozen for later stone removal by mechanical means
- This system would make lesser demand on resources when mangoes are at peak supply
- From this protocol for the bulk freezing of mangoes was established and later incorporated into a Code of Practice
- It was possible to produce a draft introductory document – a Recommended Procedure for additional processors that had expressed ambition to introduce the technique

From the experiments undertaken it was possible to devise protocols for use in a development programme.

3.2 Phase 2 – Processor interviews

Processor feedback

- Mango varieties: Main use - Cat Chu mango and Keo for freezing
- For cheeks and free-flow cubes Special class (if available) and Class I are utilised
- Cat Chu - must exceed 230 g (Brix 14 +/-1%)
- Keo - mango must exceed 300 g (Brix 17 +/- 1%)
- Reject and Class II fruits - used for puree production
- Mango puree - represents 5 - 10% of production all puree is exported
- Remaining fruit is used for - dried mango with all products exported
- Mango is processed for nine months of the year – factory facilities are used for processing other products

Standards for frozen mango

- Major markets: Russia, Korea, Japan, China, Singapore, Hong Kong, Europe
- Export criteria - Japan, China, and Korea – IQF frozen cheeks and cubes vacuum packed
- Quality standards required
 - Europe - VietGAP/GlobalGAP, BRC, HACCP, ISO 22000 certification
 - Korea - VietGAP/GlobalGAP, HACCP, ISO 22000 certification
 - USA - require HACCP, ISO 22000 certification
 - Codex MRLs certified
 - Japan and South Korea irradiation required

Processing strategies

- Companies aspire to produce high quality cheeks and cubes
- Production is confined to a three-month period, where production is at maximum productivity
- Complementary frozen products include jackfruit, banana, sweet potato, taro, durian, and papaya
- Approximately 10% of fruit received for processing does not meet the standards required
- One company receives raw material, with high quality non-blemished fruit (Class I) for free-flow products, other products for frozen puree, and the remainder for dried mango slices

- Another company is constrained by labour shortages at the height of the season. A technique for extending production would be a possible solution. This has been exacerbated by COVID19 restrictions.
- Another company situated in Cao Lanh district has supply and transport issues related to raw mango. They require assistance with transport and shipping containers to mitigate what they perceive as undue waste.
- Conformance to VietGAP and GlobalGAP was essential for traceability for export. Additional standards including HACCP are an accepted norm.

3.3 Phase 2 – Financial analysis

Financial analysis – Frozen mango cheeks and cubes

The costs and pricing during processing phases used for freezing cubes and cheeks was collected. Costs incurred during the production of standard cheeks and cubes but excluding bulk freezing costs were established (see Table 1).

Table 1. Input cost - freezing mangoes for cheeks and cubes

Processor / Input cost	Sao Khue Co. (1) Cost		Hung Hau Co. (2) Cost		Western Farm Co. (3) Cost	
	VND	AUD	VND	AUD	VND	AUD
Average cost of 1 tonne mango	6 000 000	372.8	8 000 000	497.1	12 000 000	745.7
Ripening cost	40 000	2.5	200 000	12.4	120 000	7.5
Handling cost (chemical or irradiation)	3 600 000	223.7	4 350 000	270.3	1 500 000	93.2
Packaging	3 500 000	217.5	3 500 000	217.5	3 000 000	186.4
Labour	1 500 000	93.2	1 600 000	99.4	1 450 000	90.1
Energy	1 000 000	62.1	1 090 000	67.7	1 125 000	69.9
Total cost of processing / 1000 kg	9 640 000	599.0	10 740 000	667.4	7 195 000	447.1

Source: Author's analysis

There is a significant difference in input costs between the three companies interviewed. This difference is due to the cost of mangoes, reflecting the tolerance to fruits of lower cost (quality), the ripening cost and the handling cost. The ripening costs of company 1 are lowest due to the use of mangoes simply harvested on the tree. Company 3's input mango price is the highest because they require mango material that is wrapped (covered) fruits on the tree before harvesting to ensure pesticide residue safety. The processing costs of company 1 and company 3 are high because the final product must be irradiated according to the requirements of the export market.

Where market values were given the profit from production of these high-quality cheeks and cubes, it was possible to estimate the profit that can be obtained from current cubes and cheeks production (see Table 2). This process relies on the availability and acceptable price of the mangoes fitting for the process and the market.

Table 2. The profit from normal frozen mango production

Processor / Catalog	Sao Khue Co. (1) Cost		Hung Hau Co. (2) Cost		Western Farm Co. (3) Cost		Average Cost	
	VND	AUD	VND	AUD	VND	AUD	VND	AUD
Market Value production of normal frozen mango / kg	40 000	2.5	42 000	2.6	48 000	3.0	43.33	2.7
Turnover production of normal frozen mango / 1 ton	27 600 000	1 715.0	28 560 000	1 774.7	31 680 000	1 968.5	29 280 000	1 819.4
Profit production of normal frozen mango / 1 ton	11 960 000	743.2	9 820 000	610.2	12 485 000	775.8	11 421 667	709.7

Source: Author's analysis

The profit earned per tonne of products of company 1 is the largest due to the cheapest raw material costs and the lowest ripening costs. The above profit calculation results are also consistent with the company's interviews. Company 2 said that the profit is about 18 - 20% of the selling price, company 3 said the profit is about 25 - 30% of the selling price.

Financial analysis - Bulk freezing

The technique for bulk freezing of mangoes was based on initial trials and feedback from processors.

An average of the cost of mangoes was used for the analysis. Labour costs are high at the beginning of the process and small elements are added each month for freezer maintenance. It is noted that at -18°C shelf life can be extended to over 2 years, allowing the processors to achieve price premiums.

Table 3. Profitability of bulk processed frozen mango over extended periods

Catalogue	Processing & maintaining frozen storage in 1 month		Processing & maintaining frozen storage in 2 months		Processing & maintaining frozen storage in 3 months	
	VND	AUD	VND	AUD	VND	AUD
Cost of 100 tonne mangoes	600 000 000	37 282.6	600 000 000	37 282.6	600 000 000	37 282.6
Ripening cost per 100 tonne	12 000 000	745.7	12 000 000	745.7	12 000 000	745.7
Chemical (or irradiation) cost per 100 tonne	315 000 000	19 573.4	315 000 000	19 573.4	315 000 000	19 573.4
Packaging cost per 100 tonne	333 333 333	20 712.5	333 333 333	20 712.5	333 333 333	20 712.5
Labour cost per 100 tonne	162 266 667	10 082.9	172 866 667	10 741.5	183 466 667	11 400.2
Energy cost per 100 tonne	110 000 000	6 835.1	165 000 000	10 252.7	220 000 000	13 670.3
Price of frozen mango pulp / kg	38 000	2.4	38 000	2.4	38 000	2.4
Profit / 100 tonne of raw material	747 400 000	46 441.7	681 800 000	42 365.4	616 200 000	38 289.2

Source: Author's analysis

Additional profits are available to processors by adopting the bulk freezing system (see Table 3). It is likely that the value of the bulk frozen mangoes will increase as time elapses from season peak to season scarcity.

Table 4. Processing and storage costs (added) over extended periods

	Input Fresh Mango	Processing & Storage 30 Days	Processing & Storage 60 Days	Processing & Storage 90 Days
VND	6 000	15 326	15 982	16 638
AUD	0.38	0.97	1.01	1.05
Input Cost Premium (%)		155.4	166.4	177.3

Source: Author's analysis

The longer a frozen mango is stored, the higher the cost due to the increased electricity costs to maintain the freezer (see Table 4). If 1 kg of mango is frozen and stored for 1 month, the cost increases by 155.4 %. If stored for two months, the cost will increase by 166.5%. If storing for 3 months, the cost will increase by 177.3% compared to the price of input materials. However, profits can increase if the right timing and price premium is achieved.

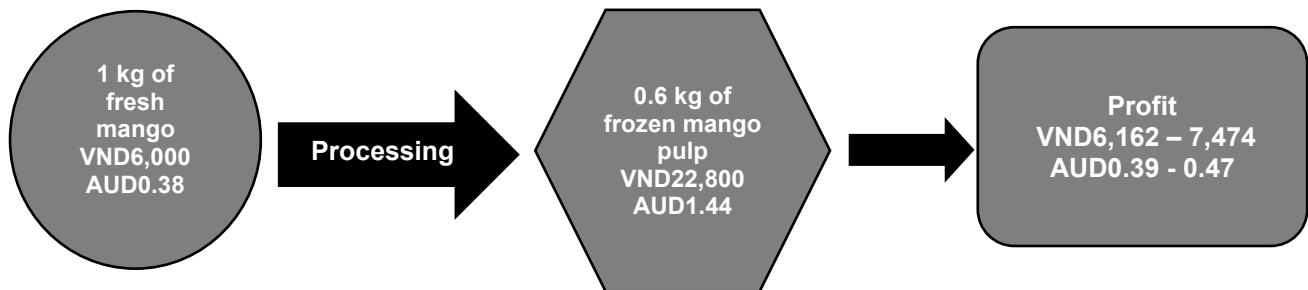


Figure 2. Added value for mangoes after processing

Source: Author's analysis

Figure 2 showed that from 1 kg of fresh mango with purchase price of VND6,000 (AUD0.38) after frozen processing, 0.6 kg of frozen mango pulp was obtained with the price of VND22,800 (AUD1.44). The added value is VND16,800 (AUD1.06) and the profit of the processor per kg of input mango is about VND7,474 (AUD0.39 to AUD0.47).

There is less imperative to purchase high grade mangoes (Class 1 and Class 2) for this procedure and the lowest value accepted by the processors was used. Requisite standards however varied among processors and is reflected in the prices paid. The technique simply involved surface sterilisation, peeling and freezing in bulk. Retaining the stone before bulk freezing is preferred since the object at season height is to process as much of the seasonal volume as possible before spoilage. Stones can be recovered once the bulk mangoes is thawed by pressure filter-press separation or centrifugation.

Costs were established for bulk freezing initiation since there is a greater demand on energy to reduce the temperature through the freezing range (ambient temperature to -18°C) than there is for subsequent storage.

The costs and return for frozen mangoes stored for 1 month, 2 month and 3 months are given in Table 3 for 100 tonnes of mango.

Full benefits of this procedure cannot be defined until the procedure is commissioned in a commercial context. Following this work:

- There is sufficient financial evidence to support the procedure for partner organisations
- A recommended procedure for intending processors is drafted awaits final editing before publication
- All processors using the freezing process include other products to utilise facilities and equipment otherwise lying unused
- Other products include frozen pineapple, papaya, banana, guava and longan
- The value of mango pulp is approximately 10% higher than for these products
- Hence freezing in bulk at the height of the seasons may be a preferred way of recovering fixed costs
- Such a technique would utilise more of the resource which reduce waste and increase returns for farmers

4 Conclusions and recommendations

4.1 Conclusions

Preliminary trials defined freezing techniques for commercial processors. These included:

- Appropriate surface treatment for incoming field mangoes
- Comparative studies of mangoes peeled and stone-in, and with stone removed
- Losses incurred at the freezing stages
- Establishment of sensory evaluation using taste-panels completing Hedonic evaluation

Once freezing protocols were established the engagement with the three processors, initiated:

- Refinement of techniques that could be undertaken in a commercial context
- The programme initiated additional interest among current non-mango processors
- Resource material and proficiency for training of mango processors
- Additional potential profits are possible through adoption of the bulk freezing system
- Additional benefits may be achieved by processors utilising production facilities that would otherwise lie idle

Potential impact

- The project demonstrates that the institutional bulk freezing large volumes of Class 2 fruits is profitable for processors.
- This creates additional demand particularly for mangoes not suitable for the fresh market thereby increasing income for farmers.
- Further tangible benefits additional to the advantages demonstrated such as loss mitigation as a result of exploiting greater use of lower grade fruit.

4.2 Recommendations

- Undertake confirmation of costs on a larger scale for bulk freezing in a full-scale processing context with one processing company to confirm benefits from
 - Increased usage of mangoes
 - Waste mitigation
- Deliver the Recommended Procedure document to the appropriate Vietnam government department
- Disseminate activity resources to provincial processors to undertake fully commercial bulk freezing activities

5 Appendix

CHECK LIST PROCESSOR

Date:

Name of researcher:.....Researcher ID:

Processor name:Processor ID:

Location:

Province:

District:

Ward:

What is your preferred variety?

Mango varieties	Average prices (1,000 VND/Kg)			Main sources of supply (Community / Ward / Town)	Estimated % from total purchase
	Grade I	Grade II	Mixed		
1. Cat Hoa Loc					
2. Cat Chu					
3. Taiwanese variety					
4. Cambodian Keo					
5. Australian R2E2					
6. Others (specify:)					

In a season what weight of mango would arrive at your premises?

Do you examine the mango for quality?

What standard do you require for the incoming mangoes (VietGAP or HACCP or USFDA or...?)

.....

.....

What standard is required by their major markets VietGAP HACCP Codex USFDA or other?

.....

.....

How do you grade the mango?

Grade	Quality Characteristics (Weight, Size, Brix, Appearance)	Approximate %

What products do you process from mango?

Products	Local Market	Export
Free flow mango cheeks (Frozen mango cheek)	%	%
Free flow mango cubes (Frozen mango cubes)	%	%
Mango pulp	%	%
Mango puree	%	%
Mango jam	%	%
Mango chutney	%	%
Dried mango	%	%
Other	%	%

Volume of mango material and product in processing

Products	Volume of material (each season or each year)	Volume of product (each season or each year)	Proportion of each product/ total product
Free flow mango cheeks (Frozen mango cheek)			
Free flow mango cubes (Frozen mango cubes)			
Mango pulp			
Mango puree			
Mango jam			
Mango chutney			
Dried mango			
Other			

EXPORT

To which counties do you export?

COUNTRY	PRODUCTS	QUALITY STANDARDS
		VietGAP Codex Alimentarius HACCP USFDA FSANZ Other

Please estimate the average prices of mangoes sold in recent times:

Mango varieties	Average prices (1,000 VND/Kg)			Main sources of supply	Main destinations of this mango	Estimated % from total purchase
	Grade I	Grade II	Mixed			
1. Cat Hoa Loc						
2. Cat Chu						
3. Taiwanese variety						
4. Cambodian Keo						
5. Australian R2E2						
6. Others (specify:)						

Please estimate the average costs of mangoes processing:

Mango products	Ripening cost/1000 kg (VND)	Chemical cost/1000 kg (VND) (washing and handling)	Packaging cost/1000 kg (VND)	Labour cost/1000 kg (VND)	Utility cost/1000 kg (electricity) (VND)

At the height of the season do you have space and equipment to add bulk freezing as an additional task?

.....

At the height of the season do you have spare freezing capacity (this is not the IQF freezing but merely using a static freezer – even a refrigerated container because bulk freezing does not require the IQF technique).

.....

Would it be necessary for you to invest in extra freezing capacity for bulk freezing (not IQF equipment)?

.....

Out of season does your equipment lie idle?

.....

Given that the mangoes that have been bulk frozen and the texture once they are thawed again the product is most suitable for paste or puree – is there an ongoing demand for pastes and purees?

.....

Would you be able to bulk freeze for other processors such as jam, juice and chutney manufacturers?

.....

Can you describe a benefit you might have in greater use of your equipment and from using second grade fruit?

.....

How many extra staff will be required for the bulk freezing (1000kg)?

.....
.....

How long would it take to freeze one tonne of mangoes

.....
.....

Do you estimate the cost of power to maintain a frozen mango container in one month?

.....
.....

Using the information above can you estimate the costs and benefits of the process? Can you summarise the cost-benefits of the technique?

.....
.....

What do you see as working well with your business?

.....
.....

What are the biggest barriers?

- *Efficient processing*
- *Markets (access)*

.....
.....

- *Technology*
- *Other*

.....
.....

Where do you see the future opportunities?

.....
.....

If there was one element you could change in your business, what would it be?

.....
.....

Signature of interviewer

Signature of interviewee

THANK YOU SO MUCH FOR YOUR PRECIOUS TIME AND INFORMATION!