FOOD & BIOBASED RESEARCH
WAGENINGEN UR

Reducing Food Losses in India

Postharvest strategies

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Report 1523

Colophon

Abstract

This project is launched by the Dutch ministries of Economic Affairs and of Foreign Affairs and executed by Wageningen UR, Yesbank and Blue infinity. The underlying report is the final deliverable of Wageningen UR, Food and Biobased Research.

The project goal is to link significant inhibitors with existing or custom build solutions, adapted to local circumstances, to improve efficiency in Indian postharvest fresh food chains.

Within this project 2 approaches are chosen. The reason for these two specific approaches is to challenge the goal from two different perspectives to obtain the most value from it:
1. From a point of view of expertise field (route 1)
2. From a point of view of specific product or chain link (route 2)

Each approach is considered to be a route in which respectively first the focus is set, secondly analyses are executed and finally improvement or implementation suggestions are offered

In Route 1, the following steps can be distinguished, respectively
* a quick scan is performed to list the high-level inhibitors for improvement,
* choices are made considering which fields of expertise will be further analysed (Information Management),
* a benchmark is created by interviewing three experts,
* the benchmark is compared with the situation in India and
* finally the implementation suggestions offered by the experts are related to existing western and non-western initiatives hereby providing practical implementation solutions.

In Route 2, the following steps can be distinguished, respectively
* a quick scan is performed to understand in which part of which particular fresh chain the highest losses occur,
* the output of Yesbank and the quick scan are used to set the scope (Fresh Mango Chain),
* the concept of ripening is explained,
* the potential is further illustrated by visualizing in which parts of the ripening process opportunities occur and
* finally opportunities are combined with knowledge gaps and technology developments within other food supply chains to define solutions and next steps.

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1   Introduction

Postharvest Technology and its huge potential within the Fresh Food Chain of India is not a new subject. A lot of research is available for anyone with a particular interest in India's Fresh Food Chain aspects. Whether an individual is looking for technology possibilities, climate consequences, governmental policies or business opportunities, it is likely that detailed information is easily found concerning the requested topic.

Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life[1]. Some 805 million people in the world do not have enough food to lead a healthy active life. That's about one in nine people on earth[2]. The vast majority of the world's hungry people live in developing countries, where 13.5 percent of the population is undernourished[2].

The Food and Agricultural Organization of the United Nations (FAO) expects that the world population will grow by 50 percent and reach 9 billion by 2050[3]. Sufficiently feeding this population to secure active and healthy life is challenging. To improve efficiency, reduce food losses and raise profits many economic barriers will need to be broken, Food Supply Chains need to be optimized and scientific breakthroughs need to be implemented properly and in-time.

Optimizing Food Supply Chains will contribute most in developing countries and emerging economies. Food losses (excluding losses at the consumer) are relatively higher than food losses in western economies[4]. For example, the total average waste percentages concerning fruits and vegetables in handling and storage, processing and packaging, and distribution is 33% in South and Southeast Asia and 13,8% in Europe including Russia[4].

In 2014, a group of postharvest professionals have started to setup a "Postharvest Network" to create impact on global food losses within Food Supply Chains worldwide. The Postharvest Network is an initiative of the Dutch Ministries of Economic Affairs and of Foreign Affairs. The aim is to reduce food losses in emerging and developing countries and improve food security. This by means of stimulating local companies, Universities and governments in connection with Dutch experience on a basis of mutual benefit. The network consists of a variety of stakeholders from the agribusiness community, Research centres, Universities, public sector, NGO's and alike organisations that are active in food production, logistics and international development.

This report focuses on postharvest losses in India. Inhibitors are elucidated, opportunities are clarified and solutions are offered. It is a pilot to provide a prove of concept of the Postharvest Network itself. The report can be considered as input for business professionals to focus on significant postharvest opportunities to extend business to India and to improve food security at the same time.

This reports starts with elucidating on the project goal and scope in chapter 2. Chapter 3 will explain definitions of supply chain concepts, food losses and food waste. In chapter 4 the authors will introduce two project routes as the followed approach. Route 1 is worked out in chapter 0 and route 2 in chapter 6. Finally, the project conclusions are summed up in chapter 7.

2 Project goal and scope

This chapter describes the goal and scope of this project.

2.1 Project goal

The goal of this project is to: *Link significant inhibitors with existing or custom build solutions, adapted to local circumstances, of efficient Indian postharvest fresh food chains.*

Offered solutions need to be relative inexpensive to implement (low cost / low tech). If not, the effects need to be significant and someone within the particular supply chain should be willing to invest in the offered solution (high cost / high effect).

2.2 Project scope

Product quality within the postharvest chain is influenced by both pre-harvest and harvest conditions and decisions. Efficient postharvest chains cannot be obtained from poor quality raw materials as a result of pre-harvest conditions. This project is scoped to postharvest chains only.

As the goal suggests, this project relates to fresh food chains. Nevertheless, solutions for local improvements within Fresh Food Chains might also be found within e.g. Processed Food Supply Chains. Definitions of these concepts will be further elucidated in the next chapter.
The report can be considered as input for business professionals to focus on significant opportunities to expand business to India. The actual linking of a particular (Dutch) business with a particular Indian partner is not part of the project and is left for Infinity Blue which is contracted by the client.

A quick scan within available literature and data concerning the inhibitors of efficient Indian postharvest fresh chains is part of this project. Detailed mapping of the Indian inhibitors is out of scope and will, prior to the start of this project, be performed by a local Indian Bank. The effect of this project is influenced by their deliverable.

Figure 2.1 shows all stakeholders involved including their mutual dependencies:
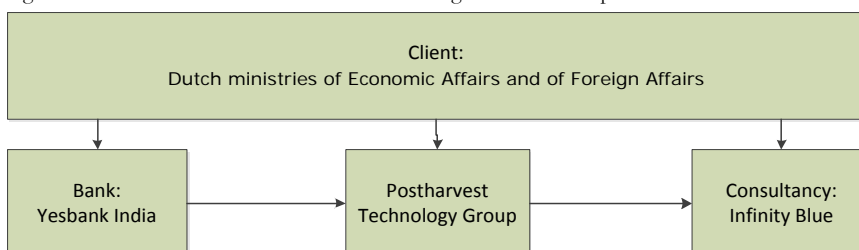
Figure 2.1: Stakeholders involved and mutual dependencies.

3 Definitions

This chapter explains definitions used throughout the report.

3.1 Definitions of Supply Chain concepts

In literature, non-supply chain professionals can easily be lost in between definitions of "chains". Differences between keywords like "Supply Chain", "Food Supply Chain", "Fresh Food Supply Chain", "Processed Food Supply Chain" and "Cold Chain" are important to understand the focus of the particular author.

In Figure 3.1, a simplification of chain magnitudes is shown.
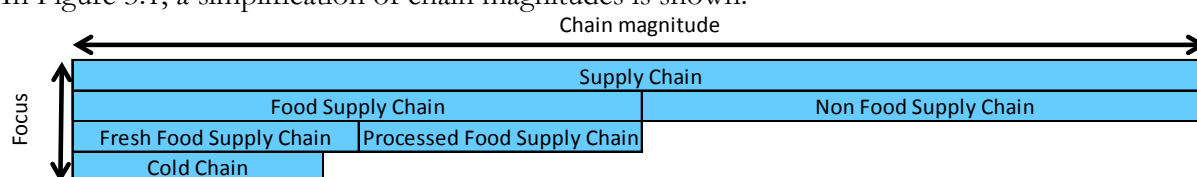
Figure 3.1: a simplification of chain magnitudes

A lot of research focuses on the most comprehensive concept: "Supply Chain". It can be defined as "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer"[5].

Other research emphasises more on a particular part of a Supply Chain. "Cold Chain", for example, can be limited to "a temperature-controlled supply chain network, with storage and distribution activities carried out in such a manner that the temperature of a product is maintained in a specified range, required to keep it fresh and edible for a much longer period than in normal ambient conditions"[6].

"Food" can be considered as all products suitable for human consumption, "Non Food" as products that have other applications like cosmetics, furniture, office supplies, etc. "Processed Food" is food that is treated (processed) to change product properties. Examples are "heating to destroy bacteria" and "canning", both in order to improve shelf lives of the products. In the case of "Fresh Food" the product is not is not treated to change product properties but is kept in its original state as from harvest. Both processed and fresh foods can be under the regime of temperature controlled cooling in the supply chain from harvest to store.

One could argue whether the concept "Cold Chain" is synonym for the concept "Fresh Food Supply Chain". There might be valuable knowledge available of Fresh Food products that, under particular conditions, do not require a Cold Chain. Also, Cold Chain benefits could also be applicable on Processed Food Supply Chains

In this project the term 'Fresh Food Supply Chain' is leading as focus is on fresh food only.

3.2 Definitions of Food Losses and Food Waste

Within this report, definitions of FAO are used considering 'Food Loss' and 'Food Waste '.

FAO[4] states that: "Food losses refer to the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption. Food losses take place at production, postharvest and processing stages in the food supply chain. Food losses occurring at the end of the food chain (retail and final consumption) are rather called "food waste", which relates to retailers' and consumers' behaviour".

FAO[4]: "Food waste or loss is measured only for products that are directed to human consumption, excluding feed and parts of products which are not edible. Per definition, food losses or waste are the masses of food lost or wasted in the part of food chains leading to edible products going to human consumption. Therefore, food that was originally meant to human consumption but which fortuity gets out the human food chain is considered as food loss or waste even if it is then directed to a non-food use (feed, bioenergy…). This approach distinguishes "planned" non-food uses to "unplanned" non-food uses, which are hereby accounted under losses".

3.3 Types of Food Losses and Food Waste

FAO[4] distinguishes 5 systems boundaries within the Food Supply Chain. Definitions differ partly between vegetable and animal commodities & products.

Table 3.1: 5 systems boundaries within the Food Supply Chain

System boundary	Definition for vegetable commodities & products	Definition for animal commodities & products
Agricultural production	Losses due to mechanical damage and/or spillage during harvest operation (e.g. threshing or fruit picking), crops sorted out post-harvest, etc.	For bovine, pork and poultry meat, losses refer to animal death during breeding. For fish, losses refer to discards during fishing. For milk, losses refer to decreased milk production due to dairy cow sickness (mastitis).
Post-harvest handling and storage	Including losses due to spillage and degradation during handling, storage and transportation between farm and distribution.	For bovine, pork and poultry meat, losses refer to death during transport to slaughter and condemnation at slaughterhouse. For fish, losses refer to spillage and degradation during icing, packaging, storage and transportation after landing. For milk, losses refer to spillage and degradation during transportation between farm and distribution.
Processing	Including losses due to spillage and degradation during industrial or domestic processing, e.g. juice production, canning and bread baking. Losses may occur when crops are sorted out if not suitable to process or during washing, peeling, slicing and boiling or during process interruptions and accidental spillage.	For bovine, pork and poultry meat, losses refer to trimming spillage during slaughtering and additional industrial processing, e.g. sausage production. For fish, losses refer to industrial processing such as canning or smoking. For milk, losses refer to spillage during industrial milk treatment (e.g. pasteurization) and milk processing to, e.g., cheese and yoghurt.
Distribution	Including losses and waste in the market system, at e.g. wholesale markets, supermarkets, retailers and wet markets.	Includes losses and waste in the market system, at e.g. wholesale markets, supermarkets, retailers and wet markets.
Consumption	Including losses and waste during consumption at the household level.	Includes losses and waste at the household level.

4   Approach

India's magnitude is nearly intangible big in both food production and inhabitants. India has produced 181.000.000 tons of food in 2011. The population of India counts 1.236 million people, 19% of all the people in the world[7].

To actually be able to offer solutions in this vastness of the Indian postharvest fresh chains one needs to focus. The challenge is to focus on a specific field of expertise or part of the fresh chain such that the highest effect is expected without getting lost in the magnitude.

Within this project 2 approaches are chosen. The reason for these two specific approaches is to scope and challenge the goal from two different perspectives to obtain the most value:
1. From a point of view of expertise field (route 1)
2. From a point of view of specific product or chain part (route 2).

Each approach is considered to be a route in which respectively first the focus is set, secondly analyses are executed and finally improvement or implementation suggestions are offered. In both cases the choices that are made are supported by arguments.

4.1   Route 1: Focus on a significant field of expertise

Route 1 is considered as the high level approach in which the following steps can be distinguished.

First, a quick scan (literature review) is setup to understand the current inhibitors to a more efficient Indian Fresh Chain on a general level. One needs to understand which high-level key inhibitors India is facing before the actual scoping is done and decision making to zoom in, can take place.

Secondly, choices are made considering which field of expertise will be further analysed. In other words: what kind of expert knowledge is needed or which pair of expert glasses are needed? The most ideal situation would be a field of expertise that affects all inhibitors derived from literature.

Once the scope is set, three experts of related fields of expertise will be consulted to create a benchmark. Which countries or which part of the world is performing best? And why? In other words: the result of this project step is to build a high-level benchmark of the ideal situation.

Next, the benchmark is compared with the situation in India. Again, three experts are consulted: Is it possible to implement the benchmark in India? If not, why? If yes, how?

Then, the implementation suggestions offered by the experts are related to existing western and non-western initiatives to provide the reader with practical implementation solutions.

Finally, improvement suggestions are offered

4.2   Route 2: Focus on a significant product and/or postharvest chain part

Route 2 is considered the focused approach in which the following steps can be distinguished.

First a quick scan is performed to analyse in which link of a particular fresh chain the highest losses occur.

In parallel with this project, Yesbank has performed a local market study. To set the scope (focus) of route 2, both the quick scan and the results of Yesbank will be used. The scope will be a certain part of the Fresh Food Chain, a specific product or product group, or a combination of both.

By interviewing Indian and Dutch Experts, the potential is further illustrated by visualizing in which parts of the fresh chain opportunities occur. In order to do so, the concept of a ripening is clarified.

Finally, opportunities are combined with knowledge gaps and technology developments within other food supply chains to define solutions and next steps.

Chapter 5 will elaborate on the above mentioned steps for route 1, chapter 6 will elaborate on route 2 and chapter 7 will describe the main conclusions derived from chapter 5 and 6.

5   Route 1: the high level approach

5.1   Quick scan: Inhibitors to efficient Fresh Food Chain India

Most available research performed by experts, concerning the Indian Fresh Food or Cold Chain, focusses on one or two aspects of the chain, not on the entire chain. Fortunately, Rohit et al.[8] have performed a literature study in which a lot of expert research is analysed. Below the observed inhibitors to an efficient Fresh Food Chain in India are listed and a brief description for non-supply-chain-professionals is added.

5.1.1   Lack of awareness about the use of information technology (IT)

Information Technology (IT) systems within any Supply Chain usually, not exclusively, involve inventory levels, demand forecasting, production planning tools, supplier & customer figures, product losses, quality monitoring, etc. IT is considered as prerequisite regarding opportunity insights and therefore concerning structural improvements programmes. It is also considered as opportunity to dominate an entire chain (as the 4-5 retail organisations in The Netherlands do at this moment).

In India, major information technology systems are only implemented within the professional retail chains. This gives this sector a competitive advantage towards less organised players in India.

Yesbank concluded[9] that 10-15% of market share consists out of organised players, meaning 80-85% out of unorganised players with a lack of awareness of the opportunities of information technology. It is considered a great opportunity loss if there were any delays in adopting Information Systems.

5.1.2   Improper collaboration planning

Any Supply Chain consists out of multiple players. Optimization of the entire chain requires collaboration among these players. Improper collaboration results in efficiency losses like: overproduction due to improper or absent forecasts, high stocks to reduce the chance of out-of-stocks, too much or too less scheduled labour, etc. India lacks a developed system to bring together the numerous loosely integrated players like seed companies, farmers, cooperatives, third party logistic providers (3pls), educational institutions, value-added producers and customers.

One should note that this inhibitor is discussed in detail in many University study books. It's the ultimate supply chain dream to overcome this inhibitor. India is, like many countries, in the beginning of this process and can substantially benefit from lessons learned in Western Countries. No country or supply chain is already at the end. It's common practice that companies are not willing to fully share stock figures, forecast figures, potential business cases, overcapacity, etc.

5.1.3   Incompetent professional skills

In India, relatively poor working conditions and unattractive wages within the cold chain are the result of the unorganised industry. Poor image and lack of attractiveness does not attract new,

well educated, recruits. Recruits tend to focus on other career paths outside the food supply chain.

5.1.4   *High cost for installation and operation*

It is considered relatively expensive to install and operate cold storage units in India. Different causes are related: Equipment is imported and energy is relatively expensive (28 percent of total expenses, 10% in the West[8]).

5.1.5   *Lack of quality and safety measures*

One of the main targets of any (cold) chain is to realize sufficient product quality at the final consumer. One of the tools to realise this in food supply chains is to implement cold storage units.

To optimize product quality at the final consumer, information through the entire chain is required. One needs to be able know and use freshness figures to decide what the next process step will be (e.g. cooling at 3 or at 10 degrees depending on the ripening stage of a product. One should also be able to predict expected quality after a certain process (e.g. cooling at 6 degrees for 50 days), to know next supply chain preconditions (e.g. process or sell to consumer after 8 days but before 23 days).

This requires knowledge, information systems (again) and technology investments (equipment).

5.1.6   *Inadequate education of growers/farmers*

Farming is subject to rapid changes. Production processes are constantly developed to gain higher yields and profits. To manage farms effectively and efficiently farmers need to get acquainted with new technology and management skills. Especially unorganised players (85-90% market share[9]) lacks education of these skills. Therefore, opportunities are missed. In India very few training centres for farmers are present to overcome this inhibitor.

5.1.7   *Too many intermediaries*

Every farmer, trader, processor, distributor, logistical provider, warehouse provider, wholesaler and seller wants to make a profit. In India, the food chain from farmer to consumer involves many intermediaries with multiple-point handling and long transit periods resulting in loss of product quality and ultimately food waste. The middlemen and poor supply chain facilities have increased agricultural prices up to 60% without actually adding any value[8].

5.1.8   *Lack of standardization*

A proven concept to improve efficiency within chains is standardization of business processes. For example: loading a truck always in a predefined method, reduces loading time, reduces the change of product breakdown, improves truck capacity utilization, improves truck driver safety etc. Moreover, tackling and improving by standardization make processes easier to perform which gives staff the opportunity to tackle the next process (continuous improvements).

5.1.9 Government regulation

Rohit et al.[8] state that the cold chain industry is miserably insufficient to meet the growing production of perishable items. Yesbank[9] confirms this statement by showing that cold storage capacity is only 49% of the cold storage requirement in India.

This fact is party caused by governmental regulations. Governmental policies are handled by a large number of departments, either in central and state governmental agencies. In processed foods, India is amongst the highest taxed in the world. Also, the cold chain industry is not given any priority during peak hours of electricity consumption. Power plants sometimes fail to provide during these hours.

5.1.10 Improper tracing

In some of the previous inhibitors the lack of information systems regarding planning & quality is already discussed. Improper tracing relates to the ability to know inventory levels at all stages in the Supply Chain. Spending extra money on stocking products in cooled warehouses to maintain its quality can be considered as a sound idea, but if you don't need this product it can be an economic disaster and ecological burden at the same moment. So, final goal of proper tracing is, again, optimizing the chain. Think of examples like reducing inventory, reducing quality losses, reducing labour costs, reducing transport, etc.

5.1.11 Poor infrastructure

In contrast to the West, 70% of India's residents live in rural areas. Reaching customers is relatively difficult and costly. Especially when a cold chain is involved. Bad roads, corrupt officials an innumerable toll gates cause inefficient transport. This is a strong inhibitor that is directly or indirectly related to most other inhibitors.

5.1.12 Lack of top level commitment

Strategic programmes often fail due to a lack of top level commitment. Especially within partnerships it is extremely important that the top management of all partners are committed.

5.1.13 Customer ignorance towards quality

The most important variable to effectively change a food supply chain is the consumer him- or herself. If customers expect better quality (and are willing to pay for it), producers and other Food Supply Chain partners will try to meet these requirements. Simply because they will benefit financially more from their activities. Unfortunately this concept also works the other way around. If consumers do not care about product quality, no changes in the Food Supply Chain will be boosted.

5.2   Scoping decisions

Before further reading, one needs to realize one important note considering scoping decisions: The quick scan of the inhibitors is meant to be a small part of this project only. The quick scan is used to read in between the lines to create a basic understanding of India's Fresh Food Chain, its potential and its gaps-to-fill. Output is the possibility to scope towards a field of expertise in which efforts performed will significantly improve India's Fresh Food Chain. Even though the author believes that the chosen field of expertise is most significant, the process towards the actual choice is not scientifically grounded.

After reading the quick scan, one could, most likely, mention many fields of expertise that might influence India's Fresh Food Chain. No research has been found that lists effects of different fields of expertise considering improving a fresh food chain in any developing country. Therefore, four fields of expertise have been giving special attention as effectiveness to weaken multiple inhibitors is expected: governmental regulation, (technical) asset development, knowledge management within companies and information management (IM).

Table 5.1: Potential of field of expertise to significantly tackle this inhibitor

	Inhibitor	Governmental policy making	(Technical) asset development	Knowledge management within companies	Information Management
1	Lack of awareness about the use of information technology (IT)	x		x	x
2	Improper collaboration planning			x	x
3	Incompetent professional skills	x		x	
4	High cost for installation and operation		x		
5	Lack of quality and safety measures				x
6	Inadequate education of growers/farmers	x		x	x
7	Too many intermediaries				x
8	Lack of standardization				x
9	Government regulation	x			
10	Improper tracing				x
11	Poor infrastructure	x	x		
12	Lack of top level commitment	x			x
13	Customer ignorance towards quality	x			

Governmental policy making

Governmental regulation can be an inhibitor on its own. Governmental policy making can be considered as a field of expertise that could influence the effect of many inhibitors. The way and the amount of regulation and education can significantly change the vision of a region or country towards a topic. Simply look at the consequences of policy making of your own government. In Table 5.1: Potential of field of expertise to significantly tackle this inhibitorTable 5.1, seven inhibitors are marked as significant affect by governmental policy making.

Unfortunately, Governmental Policy Making requires prioritization. Every stakeholder is lobbying to enlarge its piece of the pie. Developing countries have many great challenges to face. Improving the fresh food chain and reducing food waste and losses is just one of them.

(Technical) asset development

A lot of research can be found considering cold chain assets and infrastructure assets. Improving roads, rail transport, investing in reefers, and investing in cold storage warehouses or other facilities like pack houses are solutions offered to improve India's Fresh Food Chain. (Technical) asset development is believed to directly affect two inhibitors.

Knowledge management within companies

The amount of knowledge available within stakeholders of the Food Supply Chain directly affects its efficiency and long-term business results. A lack of knowledge is a direct cause of four inhibitors and therefore an interesting field of expertise to look into.

Knowledge is key to improvement. India is not to be underestimated considering the developments already made during the last 10 years. Universities educate many talented young people and ambitions are high.

Information Management

There's no field of expertise that is growing as fast as Information Management. The information revolution is providing mankind with valuable tools to improve almost everything. Available information at the right moment at the right place is very valuable for emerging economies. Question is: how well does India take advantage of these tools?

Compared to the other three fields of expertise, Information Management is affecting most inhibitors. Its potential is considered large. Furthermore, the field of expertise is relatively new and relatively little research can be found considering the possibilities of Information Management towards India's Fresh Food Chain. Practical improvement suggestions are therefore relatively easier to expect. Governmental Policy Making and (Technical) asset development do affect as well, but are regarded as relatively traditional. India might be an emerging market, but should not be underestimated with regard to its governmental agencies and potential. The same can be said about Knowledge management within companies. Some battles still need to be conquered, but India has already passed the starting point. Simply look at the amount of software

programmers in India. Many Western countries make use of Indian expertise to develop new software platforms.

From the above reasoning, information management is considered as the field of expertise that can add the most value towards India's Fresh Food chain. From this point on route 1 is scoped to the field of expertise Information Management only (paragraph 5.3). Final solutions might relate to other fields of expertise as well, but they will be offered thanks to an Information Management perspective.

5.3 Benchmarking the Fresh Food Chain from a IM perspective
5.3.1 Definitions and framework and interviewees

The particular benchmark performed in this project is defined as: the comparison of India's Information Management performance in relation to (industry) best practices.

The goal of Information Management can be described as: *"to harness the organization's information resources and information capabilities to enable it to learn and adapt to its changing environment[10]"*. Important to realize is that *"to become strategic, information must be galvanised into knowledge that can guide action[10]"*.

Choo[10] classifies Information management into 4 "management of Information" systems:
1. Resources, records and archives;
2. Technology;
3. Policies and Standards;
4. Processes.
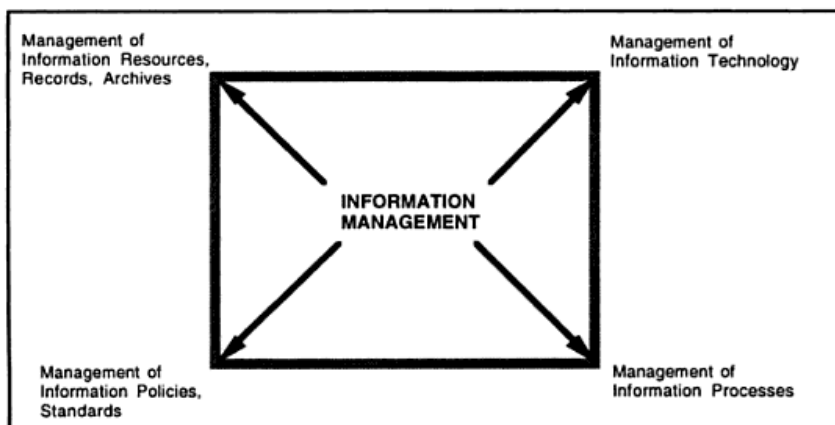
Figure 5.1: Choo's four "management of Information" systems
Choo's[10] classification is used as framework to set up interviews and list the benchmark

5.3.2 Setting the Fresh Food Chain Benchmark

The interviews are performed with three senior experts of Wageningen UR on the following fields of expertise:
- Supply Chain retail
- Supply Chain expert with specific India Experience
- Information Management

The interviews have resulted in 10 conditions to peer with the world-wide benchmark. They have been classified within Choo's framework[10] as shown in Table 5.2. Conditions are kept high-level as the results need to be on strategic level. A detailed zoom-in might in a later phase be relevant if there's a large gap-to-fill in India (next paragraph) or expected effects of offered solutions turn out to be promising.

Table 5.2: conditions to peer with the world-wide benchmark

Conditions to peer with the world-wide benchmark
A.   Resources, records and archives;
A1. Availability of information
A2. Knowledge gathered through IM
B.   Technology;
B1. Availability of Technology
B2. Dominant retail partner investing in Information Management
B3. Cooperations made possible by IM
C.   Policies and Standards;
C1. Use of IT standards
C2. General Food Law that requires IM
D.   Processes.
D1. Access to information
D2. Market-oriented Fresh Food Chain made possible by IM
D3. Relatively small number of large Chain Partners with the possibility to invest in IM

A1. Availability of information
One of the core conditions to effective Information management is the availability of information itself. Appropriate action can only be executed once adequate information is available. Information is leading in chain optimization processes. Demand, supply, quality standards, market prices, amount of losses in the chain, import, export, governmental policies are examples of information that could, once applied correctly, lead to efficient Fresh Food Chains with less losses.

A2. Knowledge gathered through IM

Within Western Economies, Information Management is frequently used to as tool to gather knowledge. Without information systems it is complex to gather information. It is an accelerator to effectively gather and use knowledge. An example is software that is able to show in which parts of a process losses are relatively high.

B1. Availability of Technology

Hardware is an obvious condition to effectively utilize Information Management to improve any fresh food chain. Obvious examples are computers, data networks, smartphones, and mobile networks. In the ideal benchmark hardware is abundantly available.

B2. Dominant retail partner investing in Information Management

Information Management requires investments. In Western Economies, considered the benchmark regarding this condition, investment are frequently realised by a dominant retail player. One example is the national rollout of barcodes in the Netherlands by Albert Heijn (part of Ahold). Other example is the implementation of automatic ordering within Supermarkets. An Information System tracks sales and inventory of a certain product and orders automatically once stocks reach a certain predefined level.

A more intercompany example is the implementation of Electronic Data Interchange (EDI).

B3. Cooperations made possible by IM

Cooperations can share ideas, skills and knowledge with one another. Within a cooperation, participants produce more effectively as individuals. Practice within many cooperations, like groups of united farmers, is that participants are usually physically located far away from each other. Information management can facilitate in setting up and operationally run cooperations. Dutch examples of big successful cooperations are Friesland Campina and AVEBE.

Extra note concerning cooperations is their capacity to jointly invest in Information Management (or knowledge or anything else that collectively leads to process improvements and therefore profits).

C1. Use of IT standards

Information Management has been developing significantly during the last 10 to 15 years. Many individuals and organizations have been working on improving the field of expertise itself. Founders realized that development projects are more effective once standards were available. One developer can use the output of another due to standards. Two examples are Electronic Data Interchange (EDI) and, more practical, the Wordpress platform. The first is a standard to more efficiently link one system with the second. Often intercompany, like linking a customer ordering system of a seller to the production system of a producer. The second is a software platform in which co-developers can, according to a predefined standard, develop plugins or templates.

C2. Laws and regulations that requires IM

In many countries, laws and regulations have contributed to the improvement of Fresh Food Chains.

At EU level, the General Food Law Regulation has been implemented. The aim of the General Food Law Regulation is to provide a framework to ensure a coherent approach in the development of food legislation[11].

An example of regulation within the General Food Law regulation is:

"Regulation EC/178/2002 defines traceability as the ability to trace and follow food, feed, and ingredients through all stages of production, processing and distribution [11].

Without information management this would not be possible.

D1. Access to information

Information might be available on state-of-the-art hardware facilities, but if an end-user is not able to access it, there's no effect. Information will not be guided into action. Improving towards the benchmark would mean: finding ways to access available information effectively. Software to access information is developing rapidly. Businesses that equal the benchmark are effectively using (or even developing) methods to access information. Successful examples are Google Search and different Smartphone apps like "buienradar". "Buienradar" is a Dutch app (and website) that gives detailed predictions of expected showers, very useful for farmers for example.

D2. Market-oriented Fresh Food Chain made possible by IM

Fresh Food Chains that (closely) equal the benchmark have in common that they have implemented market-oriented concepts throughout the chain. More traditional Fresh Food Chains tend to have implemented product-oriented concepts only. As the term suggests, market-oriented chains translate customer demand into actual production of this demand earlier in the chain. No production is performed without an actual customer order. Market-oriented chains are in literature also described as "pull" chains. In product-oriented chains, companies push product to the next part of the chain. In "push" chains, the information flow is in the same direction as the goods flow, in "pull" chain, information flow is in the opposite direction as the goods flow. Therefore, the creation of a market-oriented chain is not possible without information management.

Note: situations exist in which push methods are preferred above pull methods. Also combinations of pull and push exist. Nevertheless, concepts of pull chains are implemented by organisations that equal the benchmark.
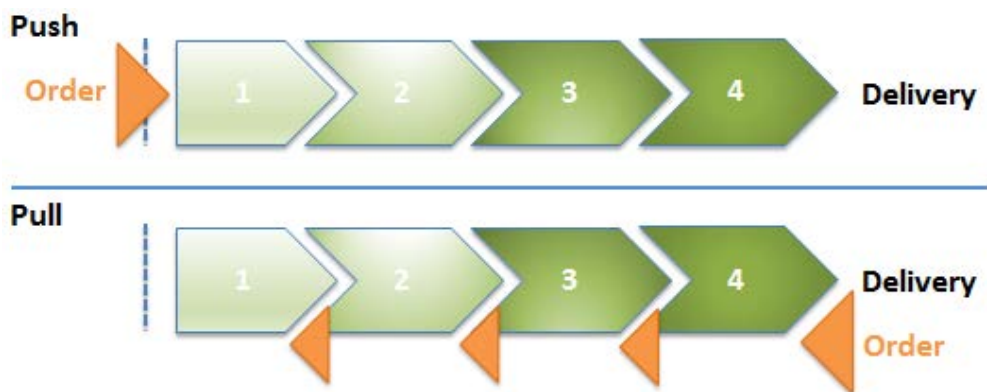
Figure 5.2: Push vs Pull

The Worldbank[12] has set up a table to explain the difference between product-oriented and market-oriented enterprises in more detail.

Table 5.3: Product-oriented vs market-oriented enterprises

Product-Oriented Enterprises	Market-Oriented Enterprises
• Focus is on product • Strive is towards production maximization • Planning is operational • Information exchange is limited	• Focus is on product-market combinations • Strive is to maximize added value • Planning is strategic • Information is shared along the supply chain

Within market-oriented (pull) chains stocks (inventory) throughout the chain can be reduced. Therefore, these chains are considered more cost-effective. Inventory costs money. It needs to be stocked in warehouses, conditions (like temperature) need to be maintained, there's a risk of quality drop-outs, and so on. A successful example of a market-oriented concept is the concept of "just-in-time". Companies implementing the concept of just-in-time frequently use Information systems to link demand and supply to make sure that raw materials arrive just-in-time, so that (hardly) no inventory exists.

D3. Relatively small number of large Chain Partners with the possibility to invest in IM

Remarkable to notice is that Fresh Food Chains in Western Countries tend to exist out of relatively smaller number of relatively bigger chain partners. These partners tend to develop Information Systems their selves to improve the Fresh Food Chain. Traditional chains, more common in the developing world, exist more often out of relatively bigger number of relatively smaller chain partners. These smaller chain partners usually invest less in Information Systems.

5.3.3   Applicability of Benchmark in India

A1. Availability of information

India is not to be underestimated considering the availability of information. The government has set up different departments that are responsible for collecting and distributing data. Online tools

are available to check fresh food market prices real-time, agro food production figures are up-to-date, national statistics of import and export volumes can easily be found. India does not have a gap-to-fill considering availability of information.

A2. Knowledge gathered through IM
One could perceive al gap-to-fill regarding applied IM considering education. A lot of data is available, but the tools to actually convert this data into knowledge is partly lacking. Especially when it concerns unorganised farmers.

B1. Availability of Technology
India has made major steps last 10-15 years considering the availability of technology. It is helped by the fact that technology develops quickly and gets cheaper every day. India has not experienced the development itself, but has implemented solutions. On interesting example is the implementation of mobile networks. India has partly skipped the "physical cabling" and directly started the "wireless cabling": Cables are not put in the ground, mobile networks are fulfilling their function. Technology revolution instead of evolution. Smartphones are common goods in India, including most farmers, providing people with high tech technology to access information.

B2. Dominant retail partner investing in Information Management
India has not succeeded in letting the retail sector develop towards a more Western approach. Therefore, investments by a dominant retail partner are usually not performed. Question is whether India's culture will accept major Western Retail Partners. India itself is a gigantic food market. Therefore, one could probably conclude that dominant Western Retail organisations would step in any opportunity perceived. This probably won't require any motivation. But, if culture is indeed inhibiting the development of Fresh Food Chains, India should find a way to create dominant chain partners, from national origin, that will improve the entire Fresh Food chain by investing in Information Management systems. This no necessary has to be the retail sector.

B3. Cooperations made possible by IM
India lacks the existence of multiple cooperations, especially in the beginning of the chain. Farmers and processors tend to be individuals operation as individuals, instead of individuals operating as one organisation. Therefore, it is hard to eliminate chain partners and thereby improve the entire chain and product quality will improve and costs will drop.

C1. Use of IT standards
Out of the interviews, it did not become clear whether India is using IT standards. It is expected though. Many software developers originate from India nowadays. These experts will most likely understand the possibilities and already apply them.

C2. General Food Law that requires IM

Out of the interviews, it did not become clear whether the general food law is executed in India and whether it is or is not contributing to an efficient Fresh Food Chain. Other regulations that requires IM was also not found.

D1. Access to information

Technology to access information is available or developments will soon bring the required technology. Information itself is more commonly available. The actual accessing of information is the gap-to-fill. Websites to access do not satisfy needs, free smartphone apps to easily access information lack. Partners within the Food Supply Chain do not possess all available information. The interviews reveal that this will lead to a loss in quality and therefore into food losses and smaller business profits.

D2. Market-oriented Fresh Food Chain made possible by IM

The previous paragraph has explained the benefits of a market-oriented chain. Indian chains are for 85% unorganised and product-oriented [source: Yesbank]. These chains are not efficient and cause food losses and waste. It's, again, part of culture and very hard to transfer into more market-oriented chains. Again, a dominant chain partner would be very welcome.

D3. Relatively small number of large Chain Partners with the possibility to invest in IM

Indian Fresh food chains are the opposite of the benchmark. A relatively big number of small Chain Partners without the possibility to invest in IM are forming the Fresh Food Chain. Relatively few investments to optimize are realised.

5.4   Solutions to improve the Fresh Food Chain

5.4.1   Setting up cooperations

The process of mapping the benchmark and comparing the benchmark with Indian Fresh Food Chains illustrates the potential of cooperations. Especially in the beginning of the chain (production, farming). In Western economies Information Systems have effectively been implemented by cooperations of farmers which has led to a more efficient Fresh Food Chain with relatively less food losses.

For example: Friesland Campina, a merger between Campina and Friesland Foods, the two biggest dairy cooperations of the Netherlands, directly deliver their products to retail organisations in The Netherlands and the rest of the world. Thanks to the vision, investments, information capabilities, internal efficiency and negotiation power of these cooperations, the amount of chain partners has dropped from many too few recent decades. Production of milk and (next chain step) processing of it is now integrated to one powerful company.

Avebe has a comparable history. Around 2500 potato farmers and processors in The Netherlands and Germany are participating in this cooperation. Potato production and processing it into potato starch has become 1 influential chain partner, instead of individual farmers and factories. It has the capacity to effectively use Information Management as tool to improve the entire Starch Chain.

To form and manage cooperations Information Systems are a prerequisite. The benchmark process also teaches us that a dominant Chain Partner will influence the efficiency of Fresh Food Chains. A dominant retail Chain partner might be a complex job to realize in India, but cooperations might also fulfil this task.

The challenge within India is to actually convince farmers to unite. Western knowledge and experiences regarding cooperations are expected to be able to help with this process.

5.4.2 *Joining educational initiatives like "hole-in-the-wall"*

As the benchmarking the Food Fresh chain teaches us: information availability, technology and accessibility will lead to knowledge, of for example farmers, which will result in more efficient Fresh Food Chains with less food losses.

Missing link is an actual educational program. This is an expertise on its own and not part of this project and route 1 as defined earlier in this paper. Nevertheless, looking into successful educational initiatives and brainstorming about possibilities to hitch on and to find a win-win situation, one does not require to be an "educational expert".

A remarkable educational initiative, making use of Information Systems is the "Hole-in-the-wall project"[13]. The hole-in-the-wall is a 'shared Blackboard' which children in underprivileged communities can collectively own and access, to express themselves, to learn, to explore together, and at some stage to even brainstorm and come up with exciting ideas.

Since its inception in 1999, hole-in-the-wall has grown from a single computer at Kalkaji, New Delhi to more than a hundred computers at various locations across India and abroad.

Food Supply is immensely important in India. It's the first priority of many. Food availability is not as certain as it is in Western Economies. Educational initiatives, like the hole-in-the-wall, might embrace the pro-active Western approach to jointly set-up a program to teach the basics of Fresh Food Chains, losses throughout the chain and the possibilities of Information Systems to gather knowledge to finally make food availability less of a problem. Moreover, gaps-to-fill considering the accessibility might become clearer once this idea is executed. Western expertise of both Supply Chain management and educational initiatives should be able to facilitate in this process.

5.4.3 *Fill the information accessibility gap by developing simple Smartphone Apps*

This can be a low cost, low tech, but high effect solution. Smartphone apps are relatively cheap and reach people in remote areas thanks to the availability of relatively cheap technology. Moreover, India owns the expertise to program Apps internally without the help of foreign experts. As stated earlier: many software programmers are present in the country.

New apps should focus on the unorganised parts of the Fresh Food Chains like farmers and small processors. Most comprehensive questions are: What information is needed and how to promote the usage of an app. Both are an expertise of Western Information and Marketing specialists.

5.4.4 *Link the retail sector to smallholder farmers*

As concluded by the Yesbank, around 85% of the Fresh Food Chain is unorganised, leaving 15% organised. The organised Food Fresh chain requires reliable chain partners. Suppliers that deliver on-time and according to quality standards. Western retail organisations that try to conquer market share in India tend to focus on imports once local suppliers do not reach their standards. This does not help India in improving their Fresh Food Chain.

To conquer this dilemma, the retail sector needs to be linked effectively to smallholder farmers. To create a link between the retail sector and smallholder farmers is a complex process

Companies like Reuters Marketlight, Nokia Life Tools, AgriFone, and IFFCO Kissan Sanchar Ltd. have taken the lead in developing several models for reaching farmers with timely agricultural information. Simple Text Messages (SMS) can improve a world! This is a start. The subsidised project "FreshConnect"[14] is trying to setup more even more high tech information systems to provide smallholder farmers with valuable information. Efforts have not resulted in a commercial product. Western experts might be able to consult to face this dilemma.

6   Route 2: the focused approach

As chapter 4 discusses in more detail, this chapter reports on route 2. A quick scan is setup, scoping decisions are defined, the potential is illustrated, the concept of ripening is introduced and opportunities and solutions are discussed.

6.1   Quick scan: Quantitative waste analyses Fresh Chain India

The quick scan, shown in Figure 6.1, is used to get a quick insight into significant chain sections (defined below) of the food supply chain (FSC) in India. Input of the quick scan is "production per product group per year" and "loss percentages for each commodity group in each step of the FSC
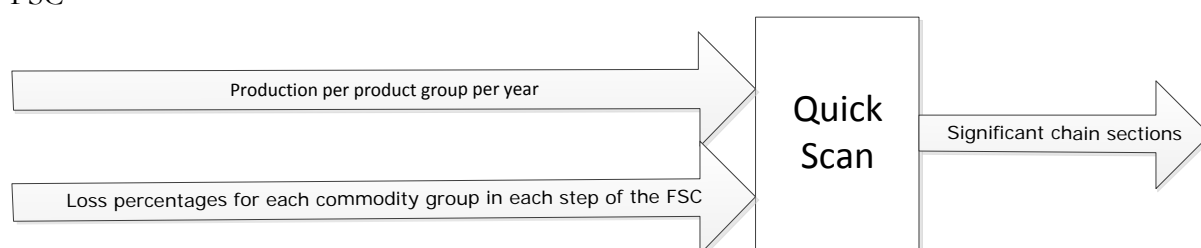
Figure 6.1: Quick scan

Production per product group per year: the Food and Agriculture Organization of the United Nations (FAOSTAT) reports[15] on production volumes worldwide. The latest available figures, 2011, are used as input for the quick scan

Loss percentages for each commodity group in each step of the FSC: No research was found in which Indian loss figures are concluded on the levels of both commodity (groups) and chain sections of the Fresh Food Supply Chain. Fortunately, FAO[4] does report on these figures on South East Asia level: Vietnam, Thailand, Sri Lanka, Philippines, Pakistan, Nepal, Myanmar, Malaysia, Laos, Iran, Indonesia, India, Cambodia, Bhutan, Bangladesh and Afghanistan.
India is, by far, the largest country in this region. During the quick scan, it is assumed that the South East Asian figures are representative for the Indian situation.

Quick scan: The quick scan can be defined as the process of multiplying the input variables: "production per product group per year" with "loss percentages for each commodity group in each step of the FSC".

Significant chain sections: Quantitative figures of chain sections of the Indian fresh food chain in which improvements contribute significantly to the process of reducing total fresh food waste in India. Again, on the levels of both commodity (groups) and steps of the Food Supply Chain. Outcomes are shown in Table 6.1.

Table 6.1: Significant sections

Losses in volume (tonnes) * **	Agricultural production***	PH handling and storage	processing and packaging	Distribution	Consumption
Cereals	out of skope	15.481.378	6.889.426	3.799.026	5.584.569
Roots and tubers	out of skope	11.184.789	4.742.265	4.694.842	1.139.566
Oilseeds and Pulses	out of skope	7.775.685	4.667.888	1.073.614	526.071
Fruits and vegetables	out of skope	13.868.571	34.587.263	10.376.179	6.536.993
Meat	out of skope	1.773.231	171.512	228.111	121.225
Fish and seafood	out of skope	488.526	612.164	928.449	105.224
Milk	out of skope	7.144.860	2.242.692	10.989.191	989.027
Total	**out of skope**	**57.717.040**	**53.913.210**	**32.089.412**	**15.002.675**
* FAOSTAT's figures are corrected from "losses in percentage of what enters each step" to "losses in percentage of the total production volume"					
** Both Import and Export is considered to enter or leave the chain between "PH handling and storage" and "processing and packaging"					
*** AS defined in chapter 3: Losses due to mechanical damage and/or spillage during harvest operation (e.g. threshing or fruit picking), crops sorted out post-harvest, etc. are out of skope					

The quick scan shows us that the volume of losses within the commodity group "fruits and vegetables" is significantly compared to the other commodities within all chain sections. Notable outcome, within the commodity "fruits and vegetables", is the relatively high waste volume of "processing and packaging".

Important to mention is that the term "significant" and not "most significant" is discussed: a kilo of fruit might economically be less valuable than, for example, meat or fish and seafood. Therefore, one cannot conclude that a commodity group is most significant. Within this project, time efforts are spend on linking significant inhibitors with existing or custom build solutions of efficient Indian postharvest fresh food chains, not on finding the most significant section of it.

The quick scan clearly shows that absolute losses in India are substantial in any commodity and chain step. It is very likely that effective efforts anywhere in the fresh food chain will result in reducing food waste. This makes effectively scoping (next paragraph) towards a commodity, product or chain step a difficult process.

6.2   Scoping decisions
Route 2 is scoped towards the Fresh Food Chain of Mangos. Both for export and domestic markets, all cultivars included.
Scoping is based on five discussion topics that are discussed by the client, executor and consultant of this project (as introduced in chapter 2):
1) Yesbank[16] reports that the mango chain is considered as promising by locals. It is believed that once Indians themselves want to change parts of the mango chain, implementability might be relatively easy.
2) Yesbank[16] identifies two chains in which mango is involved. The regular consumer flow (fresh mango) and the pulp flow (raw material of the industry). Pulp can be considered as alternative for mangos once quality is below certain values. This project wants to focus on the core challenges and is scoped on the regular consumer flow only.
3) Via Yesbank, local mango experts are accessible. Within Wageningen UR – Food and Biobased Research, a Dutch mango expert is available for consultation on short term.
4) The quick scan shows us that the volume of waste within the commodity "fruits and vegetables" is significant. Therefore, focus is on this commodity group.

5) It is likely that final recommendations within the Mango Chain will also be implementable for other chains within the commodity "Fruits and Vegetables" in which production volumes are relatively high. For example: insights in how to enlarge shelf life of Mangos might also help enlarging shelf life of other products like onions, bananas and tomatoes, that are produced in India.

6.3 The potential

The study of Yesbank[16] provides the reader already with some insights into the potential of Mango, specifically considering potential in predefined regions and technical cold chain aspects of mango production. This paragraph wants to amplify on this by summing up the position of India in the world market and the existing export markets.

Table 6.2 originates from a mango study performed in 2013[17] and provides insight into the position of India in the word mango market. India produces 40,1% of all mangos worldwide whereby it is the largest mango producer in the world.

Table 6.2: Area, Production and Productivity of Mango in the World

Sl. No	Name of the Country	Area (1000 Ha)	Production (1000 Tonnes)	Productivity (Tonnes / Ha)	Percentage Share on Production
01	India	2021	12538	6.20	40.10
02	China	434	3676	8.47	11.80
03	Thailand	285	1800	6.32	5.80
04	Mexico	183	1679	9.18	5.40
05	Pakistan	165	1606	9.73	5.10
06	Indonesia	273	1413	5.18	4.50
07	Brazil	84	1348	16.05	4.30
08	Philippines	172	1003	5.83	3.20
09	Nigeria	138	812	5.88	2.60
10	Egypt	35	380	10.86	1.20
11	Others	578	4996	8.86	16.00
	Total	4368	31251	7.15	100.00

The average productivity of mango production worldwide is 7,15 tonnes/ha. India's productivity is 6,2 tonnes/ha. Closing to gap from 6,2 to 7,15 tonnes/ha would imply adding 1.912.000 tonnes annually or adding the production of a country like Thailand (3th biggest producer worldwide!) to the total production figures of India. Not to mention the amount of mouths one could feed.

A critical reader might say that this might not be possible, as production is dependent on variables, like climate, one cannot influence. On the contrary, looking at production of sub regions (Table 6.3) of the province Tamil Nuda which produces 8,5% of all Mangos produced in India shows the reader a high variety in productivity figures. Lowest productivity in 2011-2012 is 2,47 tonnes/ha and highest productivity is 12,98 tonnes/ha. This could imply that significant productivity improvement might be realistic.

Table 6.3: Production and Productivity of Mango in Tamil Nadu

Sl.No	Name of the District	2011 – 12 (P)			2011 – 12 (P)	
		Area in ha	Production in Tonnes	Productivity (Tonnes / Ha)	Area in Percent	Production in Percent
01	Coimbatore	6088	39433	6.48	3.16	3.70
02	Cuddalore	917	5063	5.52	0.48	0.48
03	Dharmapuri	13923	122014	8.76	7.22	11.47
04	Dindigul	22018	120631	5.48	11.42	11.34
05	Erode	1495	8249	5.52	0.78	0.78
06	Kancheepuram	4284	23752	5.54	2.22	2.23
07	Kanyakumari	2556	6302	2.47	1.33	0.59
08	Karur	818	2322	2.84	0.42	0.22
09	Krishnagiri	51485	241235	4.68	26.71	22.68
10	Madurai	9264	33557	3.62	4.82	3.15
11	Nagapattinam	1979	10920	5.52	1.03	1.03
12	Namakkal	2126	11732	5.52	1.10	1.10
13	Perambalur	1078	5950	5.52	0.56	0.56
14	Pudukottai	1069	5900	5.52	0.55	0.55
15	Ramanathapuram	199	1100	5.53	0.10	0.10
16	Salem	3592	18316	5.10	1.86	1.72
17	Sivagangai	2466	13608	5.52	1.28	1.28
18	Thanjavur	1479	8165	5.52	0.77	0.77
19	The Nilgiris	38	211	5.55	0.01	0.02
20	Theni	13499	175214	12.98	7.00	16.47
21	Trichy	3584	9032	2.52	1.86	0.85
22	Tirunelveli	7140	9372	1.31	3.70	0.88
23	Thiruvallur	14720	48895	3.32	7.64	4.60
24	Thiruvannamalai	1011	5578	5.52	0.52	0.52
25	Thiruvarur	286	1581	5.53	0.15	0.15
26	Thoothukudi	974	5376	5.52	0.51	0.51
27	Vellore	19073	103790	5.44	9.89	9.76
28	Villupuram	2054	11335	5.52	1.07	1.07
29	Virudhunagar	3541	15124	4.27	1.84	1.42
	State	192756	1063757	5.25	100.00	100.00

The same could be said about losses in the post-harvest chain. The quick scan of route 2 already showed high losses considering the commodity "fruits and vegetables". Absolute figures of the situation of Mango only were not found in literature, but Indian Mango Experts, related to Yesbank, estimate the total losses, farmer-to-fork, at 20%.

Once productivity inefficiencies or losses in the postharvest chain are tackled, one could wonder whether there is a consumer market for the extra availability. It is expected that the voluminous internal market will welcome the extra availably of mango, because both inhabitants as well as the middle class are growing in numbers.

Malnutrition in India is a serious problem. This might explain the relatively small amount of export (Table 6.4). Export volumes in 2009-2010 divided by production volumes in 2011-2012 shows us that less than 3% of all mangos produced are exported.

Remarkable is the fact that almost all European countries are missing in

Table 6.4. The United Kingdom is the only exception. The reason is unclear, therefore this can be considered as opportunity for EU importing companies as many Indians, or Indian related

people, live in Europe. Also, the Netherlands, as being one of the world's biggest fruit transport hubs, could benefit from a new to setup Mango import food Chain.

Table 6.4: Export of Mango to Different Countries from India

S. No	Name of the Country	2007-2008		2009-2010		Percentage Change in the Quantity Exported
		Quantity (Tonnes)	Value (Lakhs)	Quantity (Tonnes)	Value (Lakhs)	
1	Bangladesh	17064	1595.46	33550	3295.82	96.61
2	Bahrain	474	175.70	1238	402.33	161.18
3	Kuwait	461	306.18	804	520.09	74.40
4	Nepal	7551	636.30	4058	378.63	(-) 46.26
5	Oman	39	17.52	270	200.24	592.31
6	Qatar	78	33.24	659	512.78	744.37
7	Saudi Arabia	1489	459.77	3147	1345.40	111.35
8	United Arab Emirates	22470	6320.93	25608	10382.97	13.97
9	United Kingdom	2575	1981.66	2959	1746.88	14.91
10	United States	142	195.77	175	256.58	23.24
	Total	52343	11722.53	72468	19041.71	38.45

6.4   Introduction of the concept: Ripening

The reason why losses occur or export markets are not being served is often related to the quality of fruit once it reaches the consumer. If a fruit is too ripe or rotten, the consumer simply does nog want eat it anymore. Before we can elaborate on causes in the mango chain that result in losses, it is advisable to understand the basis of the process of "ripening" of fruit.

Two types of fruit exist: climacteric and non-climacteric. Climacteric fruits like apples, apricots, avocados, bananas, cantaloupes, figs, guava, kiwis, mangos, nectarines, peaches, pears, plums and tomatoes will continue to ripe after being picked. Non-climacteric fruits only ripe while still attached to the plant. Examples are: cherries, grapes, limes, oranges, pineapples, and berries (blue-, black-, rasp-, straw-, etc.).

After picking of non-climacteric fruits the quality will only get worse. Influencing the ripening process to extend shelve life is not an option (as the fruit is already ripe). Influencing the ripening process of climacteric fruits is an option and is done on a large scale.

Influencing the ripening process of climacteric fruits goes hand in hand with influencing the ethylene levels in and around fruits. Ethylene is a gaseous plant hormone that is responsible for the entire fruit ripening process. A low level of ethylene slows down the ripening process while a high level will speed it up. Plant/fruits are capable of producing it themselves, but it many cases (like in ripening chambers) artificial ethylene is used to start the process[18]. External sources, next to artificial creation in the industry, are emission gasses, cigarette smoke, industrial air pollution, factories in which polyethylene (plastic) is being produced.

In research, many parameters can be found to influence the levels of ethylene. The effectivity of a parameter differs among plants or fruits. Ripening parameters often used in practice to influence ripening are:

- Temperature
- Ethylene levels
- Packaging
- Wounding (or prevention of it)
- Cultivar selection
- Picking Stage
- CO_2, O_2 and H_2O-levels

Considering Asian countries, like India, experts of postharvest technology agree on the fact that influencing temperature (cooling) is the first parameter to use to improve shelf life of all fruits including mango. All other parameters contribute as well, but temperature simply is most significant. Moreover, cooling technology is a relatively old technology which is relatively more accessible and less costly.

6.5   Opportunities of Mangos in India

The previous paragraph has provided the reader with basic knowledge concerning the process of ripening. This paragraph elaborates on the actual fresh chain of Mangos in India. Important note is that the provided results are gained through interviews with Indian and Dutch Mango Experts. It will provide the reader with (business) opportunities, but cannot be considered as totally comprehensive.

Route 1 already concluded that (partly) shifting from a push chain (production driven) towards a pull system (market driven) will result in less losses and higher profits. Customer demand or requirement is a strong motivation for chain partners to change. The interviews confirm that changes in the Mango Chain will be most effective and easier to realize once they are enforced by consumers.

Therefore, this report starts elaborating on opportunities at the end of the fresh mango chain (consumers) first. To visualize the chain of all mango cultivars produced in India, the mango chain of Yesbank[16] is used as basis and extended with export flows. It is shown in Figure 6.2. Opportunities are highlighted with yellow stars, which are further exemplified in the final part of this paragraph.
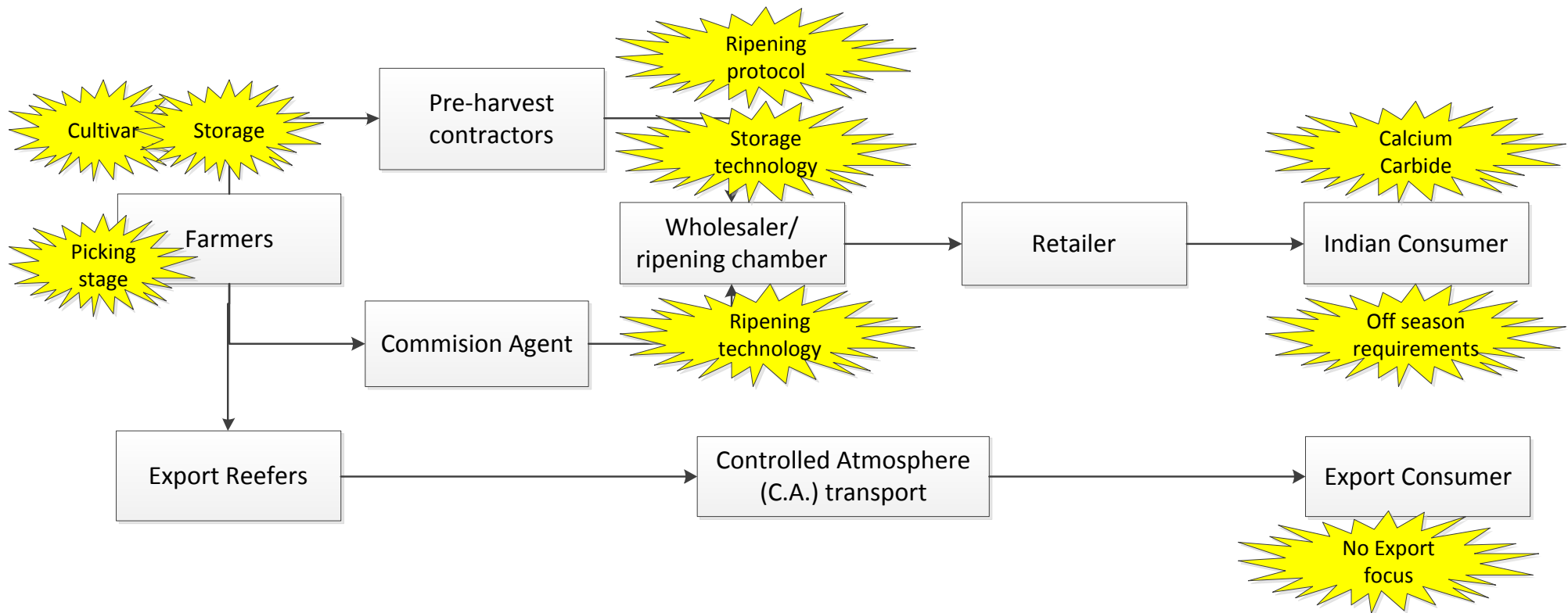
Figure 6.2: Opportunities in the Fresh Food chain of Mangos in India

6.5.1 Calcium carbide

Yesbank[16] elaborates on the potential of the Mango Fresh Chain from a consumer perspective: "Mango ripening is done at 25 ° Celsius with high humidity (100 %). Presently, majority of mango ripening in India is done using chemicals like calcium carbide despite a government ban and very few players are using ripening chambers". In India, Andhra Pradesh horticulture department[19] estimates that "95 percent of the mangos available in the open market today are carbide-ripened".

Fattah and Ali[20] state that "Consumption of carbide ripened fruits is extremely hazardous for health, mainly for the nervous system. Acetylene, generated from carbide reduces oxygen supply to the brain. In acute stage, it causes headache, vertigo, dizziness, delirium, seizure and even coma. In the long term, it may produce mood disturbance and loss of memory. Immediately after consumption, there may be abdominal pain, vomiting and diarrhoea".

Literature[20], [21] concerning the use of calcium carbide seem to agree on the fact that the use of calcium carbide is extremely hazardous for health. Rahman et al[21] claim that "industrial grade calcium carbide contains traces of arsenic and phosphorus hydride, which are hazardous for human health in direct contact". Unfortunately it is not clear whether people who actually use calcium carbide for ripening purposes or consumers of calcium carbide ripened mangos are facing the mentioned risks. One should note that the toxic substances mentioned in research are volatile, meaning that it is doubtful whether mangos contain significant levels of those substances during consumption. Toxic substances might have evaporated before consumption. This could mean that consumptions might be harmless and that it is might not be possible to measure whether a mango is ripened by using calcium carbide (as residues are not present anymore).

Subsequent, literature does not reveal which levels of toxic material are "extremely hazardous for health". If mangos contain "traces of arsenic and phosphorus hydride", what levels are indeed dangerous?

Summing up the text of this paragraph, one can say that the actual problem of using calcium carbide for ripening purposes is unclear. To face/solve the problem one needs to define it first. For example: the use of calcium carbide results in:

> => health risks A, B and C,
> *because*
> => toxic substances D, E and F exist
> *at*
> => supply chain stage G, H and I,
> *relatively on*
> => significant levels J, K, and L.

Afterwards, alternatives like ripening by ethylene (natural ripening hormone), ethephon (used for ripening of pineapples) or changing production methods of calcium carbide (to exclude toxic substances) can be discussed in relation to cost-effectiveness.

6.5.2   Off Season requirements

The second identified, customer driven, optimization chance is mango requirement during off-season periods. One local expert is convinced that when "mangos are available off season there will definitely be a promising market, Indian people just love Mango".

Yesbank[16] concluded that: "Mango ripening has not yet picked up in a big way as mango is a seasonal crop available during 4-5 months and people are not willing to invest in ripening infrastructure". The reason why they are not willing to invest relate to the fact that pilots, using ripening chambers, were not successful: "One of the food parks in Andhra Pradesh, Srini Food Park, Chittor had experimented for storage of mangos for long duration but the results were not very promising due to chill injury of mangos".

These failures might relate to a lack of ripening knowledge and the disability to face this challenge from a chain perspective. This is further exemplified in the sub paragraph "ripening protocol" later in this paragraph.

6.5.3   No Export Focus

As stated earlier in this chapter, less than 3% of all mangos produced in India is exported. Concerning the EU, only the United Kingdom imports a relatively small amount of mangos from India.

Export that does exist usually is directly set-up between Indian farmers and Indian exporters of foreign importers, skipping all other chain partners.

Only a few Mango cultivars are available in the Netherlands. In the Netherlands 1,3% (215.000 Indians[22]/ 16.000.000 inhabitants) of the residents originates from India. 215.000 Indians + other (Dutch) inhabitants that are willing to buy Indian Mangos, like the popular Alphonso, might be considered as an interesting opportunity. Moreover, the harbour of Rotterdam is an ideal hub to distribute Indian Mangos to other destinations in Europe.

Table 6.5 shows the number overseas Indians (>10.000) living in the European Union according to the Indian Government[22].

Table 6.5: Number overseas Indians (>10.000) living in the European Union

Country	Overseas Indians living abroad
Netherlands	215.000
Italy	99.127
Germany	70.500
France	65.000
Austria	23.000
Belgium	18.000
Switzerland	12.354
Greece	12.013

6.5.4 Ripening protocol

Literature research, research of Yesbank[16] and interviews with local and Dutch mango experts do not present any detailed knowledge concerning ripening of mangos produced in India on large scale. It is very likely that this knowledge does not exist. Therefore, parameters to influence ripening are not identified and are not being used. Knowledge and parameters are needed to create a protocol to optimize shelf life anywhere in the chain. Figure 6.3 shows this concept (t=time).
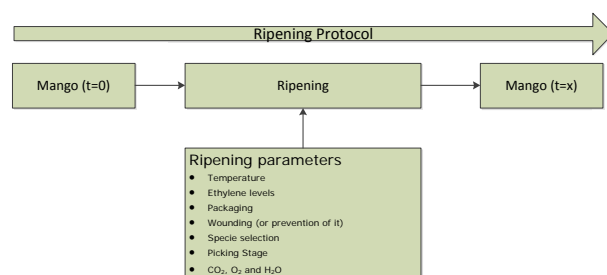
Figure 6.3: Ripening protocol

The mango protocol should be able to advise on using parameters to enlarge shelf life or speed up ripening once consumer demand is pulling it. It should be possible to implement the protocol in every step of the chain, but is preferable integrated in the entire chain to enlarge its effect (as illustrated in Figure 6.4). The last is the ideal state, the first is a starting point, practice is somewhere in between both.

Example: in Western economies, apples are stored and kept dormant for a long period of time. This process is optimized from production to wholesaler to enlarge shelf life. Nowadays apples can technically be stored longer than a year! Once an apple reaches a supermarket or consumer, no advanced ripening protocols are used: an apple is either appropriate to sell or eat or not.

History in the West teaches us that, as route 1 explains, a dominant chain partner setting up the entire chain is needed to accomplish a chain wide ripening protocol. In Western Countries the retail organisations possess these capabilities.
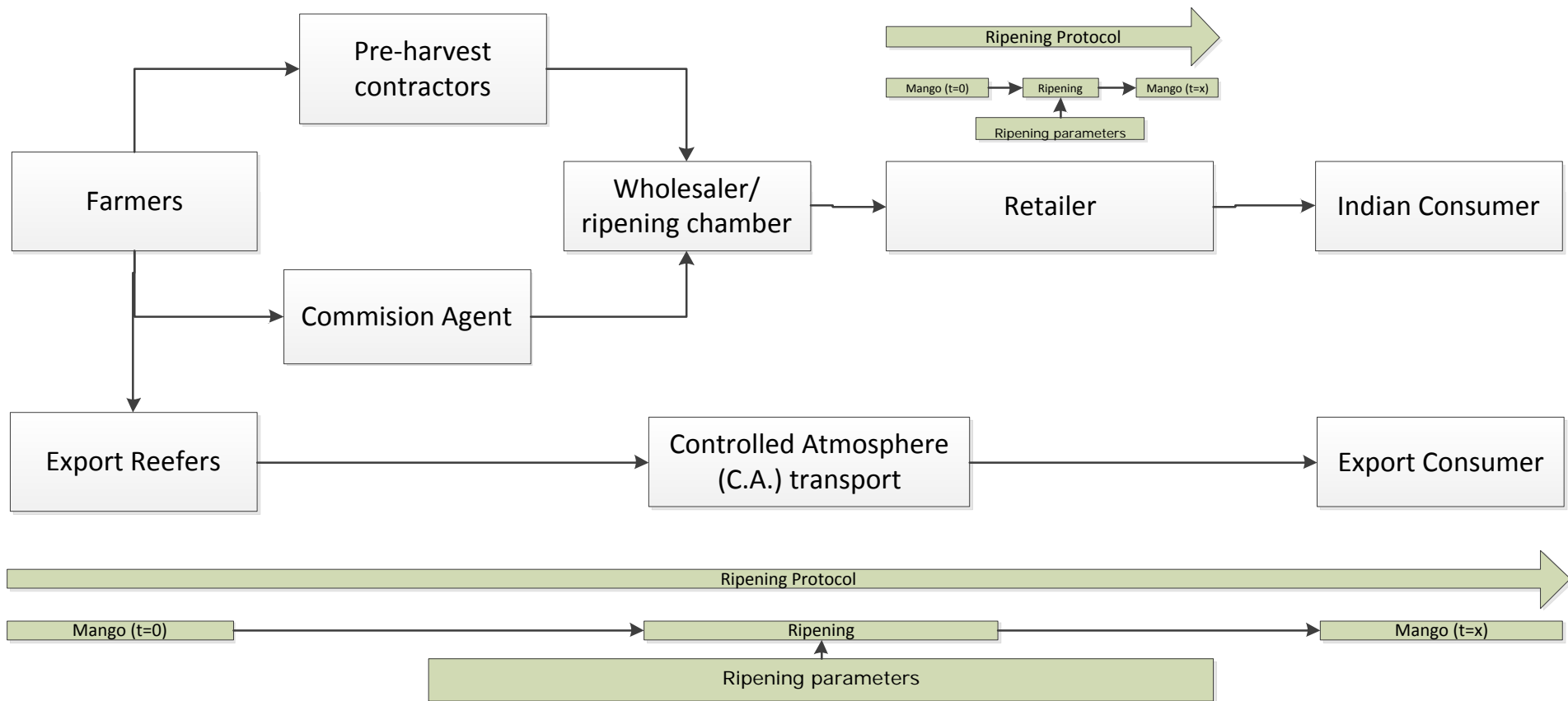
Figure 6.4: Ripening protocol implemented in the entire chain or in a part of the chain

Interesting subject is the reason why ripening protocols are nog being used. No research or document was found to elaborate on this question. Therefore, again, the local and Dutch experts where interviewed.

Experts dedicate the failure of existing pilots to "variation". A mango is not just a mango. Every mango is unique and needs its own protocol. Input quality differs in the beginning of every chain step. Variation exists among:

- Different cultivars
- Different production and harvest seasons
- Orchard variation: tree size, location, age, pruning, water
- Varying age at harvest: blooming period is several months
- Position of the fruit in the tree
- Handling and transport variations

The source of variation is in the orchard.

To conquer this dilemma tools are needed to measure the ripening stage of mangos, decide what needs to be done to influence shelf life and finally execute the protocol in for example storage and ripening chamber.

Also, the concept of ripening itself is a difficult subject. When is a mango ripe? And, what should be implemented in the protocol answer to customer demand? Example: Is the fruit ready to eat (soft) or ready to enjoy (soft and tasty) after ripening.

6.5.5   Repining & Storage Technology

Yesbank[16] concludes that there is a lack of ripening and storage capacity for Mangos. One cause could be the fact that Mangos are only stored periodically, as ripening knowledge and technology only enable mango to be a seasonable product of 4-5 months. Either the remaining months of the year the storage capacity is not utilized or multiproduct warehouses need to be installed. It is likely that those warehouses are more costly or products that need to be stored outside the mangos season do not exist.

6.5.6   Storage after harvest at the farmer

An interesting finding is the observation of local experts that mangos are usually not cooled directly after harvest. Harvested mangos often stay at the farmer for a couple of days before being transported to wholesalers or ripening chambers.
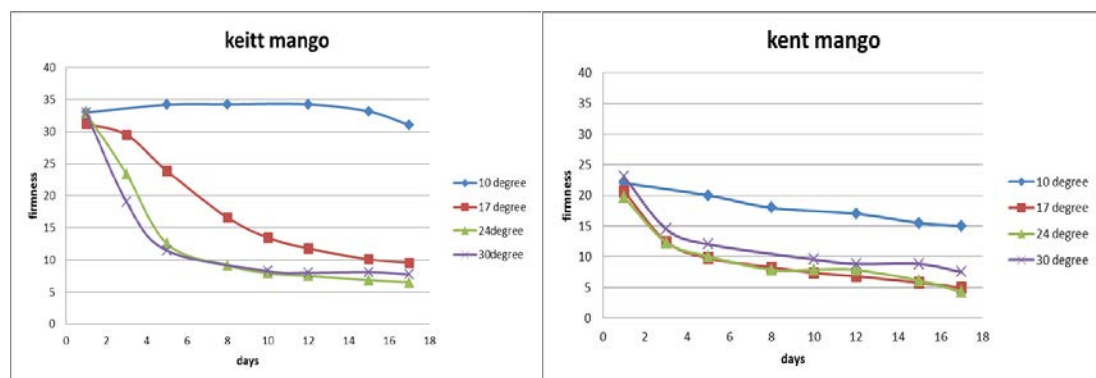
Research considering Keitt and Kent Mangos (Figure 6.5), which unfortunately are not produced on large scale in India, reveals that the period after harvest is extremely important for these cultivars once one wants to improve shelf life throughout the chain. Firmness of mango, which is an important characteristic to estimate ripeness, drops relatively fast after harvest. Cooling at the

wholesaler or retailer does help, but is more effective in the days directly after harvest. Experts expect that cooling at the farmer will also significantly improve shelf life considering other mango cultivars.

Direct cooling after harvest is a relatively high cost solution. The economic benefits (business case) were not revealed by literature research and through the use of the expert interviews. Detailed market research is necessary (as explained in paragraph 6.6.3).
But without a profitable business created by market research once could, as a start, think of eliminating direct sunlight as a low cost solution. Next, isolation to reduce the effect of product warming during hot periods of the day would help.

Figure 6.5: Research considering Keitt and Kent Mangos

It is likely that famers are not motivated to improve this, because they do not own the problem of reduced quality. A farmer is not being paid less for bad quality as the quality is not visible once a wholesaler buys his stocks in India.

6.5.7   Picking stage

As explained in earlier in this paragraph: the source of variation is in the orchard. The picking stage is an important parameter to enlarge shelf life and to ensure quality of a mango. Picking too early can results in mangos that simple do not ripe anymore or will not be tasty after ripening. Picking too late will result in loss of shelf life and therefore losses in the food supply chain of mango.
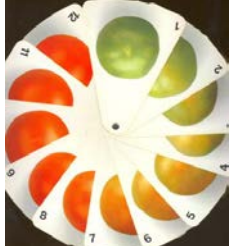
Knowledge of the most ideal picking stage is a competitive advantage and should be considered as an opportunity.

Unfortunately, no literature can be found concerning the ideal picking stage of any mango cultivar. Further research is needed to develop this knowledge. To illustrate the opportunity, an important development of a Dutch Tomato cultivar is presented below:

Ten to twenty years ago, Dutch tomato farmers tended to harvest a Dutch tomato cultivar in a very early stage to enlarge shelf life. This resulted in unsatisfied customers as taste of tomatoes

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was insufficient. After research, farmers understood what the earliest stage of harvest was including the lowest temperatures that were allowed to enlarge shelf life without losing taste.

Table 6.6: picking stage and temperatures

Image of stages	Stage	Minimal temperature to ensure proper taste
	<1	No harvest
	1-4	13 – 15°C
	5-8	10 – 13°C
	9-12	7 – 10°C

6.5.8   Mango cultivars

Around 300 mango Cultivars are produced in India. Selecting mangos that meet customer demand best is an opportunity. Both considering the domestic and the Export Market. Which mango cultivars can be stored most easily for a long period without losing quality? These mangos will, most likely, be most suitable for export and off-season requirements.

Keitt and Kent Mangos are frequently exported by other countries than India. Introducing Keitt and Kent Mangos in India or finding existing cultivars that are suitable for export should be considered as business opportunity. This requires research and/or pilots.

To illustrate the influence of the cultivar some conclusions of research on Keitt and Kent Mangos are mentioned:
- Kent is much softer at arrival
- Kent and Keitt have different ripening dynamics
- Keitt is more responsive to temperature
- Kent ripens already at 10°C (during transport already)
- Keitt hardly ripens at 10°C
- Ripening speed: firmness loss/day depends on initial firmness
- To predict ripening: adjust to the batch

Another interesting finding is the fact that some mango cultivars, produced outside of India, do not ripen at the tree. Interesting research question is whether this also counts for Mango cultivars produced in India. Could this new variable improve shelf life by postponing harvest until customer demand is requiring it? Or, from a business point of view, postponing harvest until customer demand is higher than production output, driving up prices?

6.6   Solutions to improve the mango fresh chain

The previous chapter discusses a wide variety of opportunities within the Indian mango chain. This chapter exemplifies on practical solutions that might help to embrace these opportunities

6.6.1 Develop detailed ripening knowledge of Alphonso mango and copy controlled atmosphere export pilots

The Alphonso mango is one of India's premium and most popular mangos. The report shows that a lot of Indians are living in the EU. Therefore, it is very likely that a market exists. Moreover, exploratory meetings with an EU importer (performed by Blue Infinity, introduced in chapter 2) confirm the potential of exporting Alphonso.

Challenge at this moment is to develop knowledge (a ripening protocol) that provides possibilities to enlarge shelf time of Alphonso without losing quality (like taste). Once this knowledge is available one can conclude whether export in controlled atmosphere (C.A.) reefers is an option in regard to the transport time from India to, for example, the harbour of Rotterdam in the Netherlands.

Pilots using C.A. reefers exporting mangos from other countries seem successful. Maersk[23] claims to have finished a successful pilot in which mangos are exported from Kenia to Europe: "A recent test in Ivory Coast shows how West Africa's mango trade can be extended by special containers that place the fruit in hibernation".

Figure 6.2 already shows the possibility to use Controlled Atmosphere (CA) reefers, directly loaded and cooled at farmers. Technology already exists, pilots claim to be successful and export is less than 3% in India. A collaboration between Indian and European entrepreneurs will add value and make mango production more profitable.

The approach can be setup in four phases
1) Develop Alphonso Mango knowledge / ripening protocol
2) Implement this knowledge into C.A. reefers
3) Train all partners in the Mango chain
4) Copy C.A. export pilots (like Maersk)

This would require a team of:
1) Alphonso mango farmers
2) Postharvest knowledge institute
3) Transport company with C.A. reefer technology
4) At least 1 EU importer

6.6.2 Availability of ripening knowledge at wholesaler level

Figure 6.4 explains that a ripening protocol can be implemented in the entire chain or in a part of the chain only. In India, many chain partners are involved from farmer to consumer. Implementing a ripening protocol in the entire chain at once could be considered too challenging.

It is also concluded that influencing ripening directly after harvest will contribute significantly to the shelf life of mangos. Therefore, it will reduce losses in the entire mango chain. But again, making ripening knowledge available among thousands of farmers by developing a ripening protocol only at famer level will also be a challenging job. One might expect that the capacity of farmers to invest is low. Moreover, the benefits of slowing down the process of ripening at farmers will not directly lead to a higher price for farmers that wholesalers are willing to pay.

Making knowledge available at wholesale levels seems more feasible. Fewer wholesalers exist, and more capacity to invest might exist as some wholesalers already own ripening chambers which require investments as well. Moreover, once a wholesaler understands how to measure input quality (ripening state) of mangos, he will force farmers to improve by offering a lower price for low quality and a higher price for high quality mangos.

Therefore, this reports advices to look for entrepreneurs who are willing to help wholesalers to implement a ripening protocol.

This would require a team of:
1) Postharvest knowledge institute
2) At least 1 wholesaler, preferable more
3) Either an entrepreneur (who is funding the project as new business is expected) or a government to fund the project as national reduction of Postharvest losses is expected.

6.6.3 Market research

In the previous paragraphs is extensively discussed that mango chain improvements need to be customer driven to change partly from a push to a pull chain. Customer demand is leading. Two gaps are observed. A lack of available mangos that are non-carbide ripened and off-season availability of mangos.

These gaps seem to be obvious. Still, no change is being executed. One could conclude that either the risk of investment is considered too high or local entrepreneurs question the expected profits of new internal markets.

Both could be tackled by market research that quantifies opportunities. Which off-season customer demand exists (for example: mango/province/month)? And once this demand is realized by entrepreneurs, how much money is a customer willing to spend extra? The same information about non-carbide ripened mangos is required. What is demand and what is, for example the upper segment, willing to pay extra? Once these figures are available, it is believed that entrepreneurs will be able to set up business cases themselves.

This would require a team of:
1) market research experts
2) all mango chain partners (as they are the entrepreneurs who need to be convinced of the potential)
3) a government to fund

6.6.4 Find ideal picking stage of all mangos

This report illustrates that no literature can be found concerning the ideal picking stage of any mango cultivar. Further research is needed to develop this knowledge. From a tomato perspective as provided one can conclude that finding the ideal picking state in combination with temperature possibility (minimal temperature to store) can enlarge shelf life significantly.

Many small mango farmers exist in India. One could conclude that investment possibilities are relatively low. Therefore, it is advised to obtain picking stage knowledge funded by governmental agencies. Motivation of course is to reduce food losses and feed more Indian mouths. An educational program, in which farmers are educated, should be part of this project.

This would require a team of:
1) A selection of mango farmers (50+ in a workshop setting)
2) Postharvest knowledge institute (to advice the ideal picking stage of a particular Mango)
3) Farmers or a government to fund

7   Conclusion

This project is launched by the Dutch ministries of Economic Affairs and of Foreign Affairs and executed by Wageningen UR, Yesbank and Blue infinity. The underlying report is the final deliverable of Wageningen UR, Food and Biobased Research.

The project goal is to link significant inhibitors with existing or custom build solutions, adapted to local circumstances, of efficient Indian postharvest fresh food chains.

Within this project 2 approaches are chosen. The reason for these two specific approaches is to challenge the goal from two different perspectives to obtain the most value:
1.   from a point of view of expertise field (route 1)
2.   from a point of view of specific product or chain link (route 2)

In Route 1, a quick scan to list the high-level inhibitors is performed, choices are made considering which fields of expertise will be further analysed (Information Management), a benchmark is created by interviewing three experts, the benchmark is compared with the situation in India and finally the implementation suggestions offered by the experts are related to existing western and non-western initiatives to provide the reader with practical implementation solutions.

In Route 2, a quick scan is performed to understand in which part of which chain the highest losses occur, the output of Yesbank and the quick scan are used to set the scope (Fresh Mango Chain), the concept of ripening is explained, the potential is further illustrated by visualizing in which parts of the ripening process opportunities occur and finally opportunities are linked to knowledge gaps and technology developments within other food supply chains to define solutions and next steps

This project offers 8 solutions to improve Indian postharvest Fresh Food Chains. The first four are related to the total concept of Fresh Food Chains in India. The last four are related to the Fresh Chain of Indian Mangos.

1.1   Setting up cooperations

In Western economies Information Systems have effectively been implemented by cooperations of farmers which has led to a more efficient Fresh Food Chain with relatively less food losses. Friesland Campina and Avebe are examples of successful cooperations in The Netherlands

1.2   Joining educational initiatives like "hole-in-the-wall"

A remarkable educational initiative, making use of Information Systems is the "Hole-in-the-wall project". The hole-in-the-wall is a 'shared Blackboard' which children in underprivileged communities can collectively own and access. This allows them to express themselves, to learn, to explore together, and at some stage to even brainstorm and come up with exciting ideas. Adding Postharvest knowledge to this initiative, and thereby teaching for example farmers, could improve food availability.

1.3   Fill the information accessibility gap by developing simple Smartphone Apps
Availability of information as well as the availability of technical solutions like smartphones are not the issue in India. However accessibility is. Therefore new smartphone apps need to be developed. New apps should focus on the unorganised parts of the Fresh Food Chains like smallholder farmers and small processors.

1.4   Link the retail sector to smallholder farmers
The retail sector needs to be linked effectively to smallholder farmers. The main challenge to realize this is the fact that the organised Fresh Food Chain requires reliable chain partners. Small farmer are not reliable at the moment. One initiative that tries to conquer this challenge is "FreshConnect".

2.1   Develop detailed ripening knowledge of Alphonso mango and copy controlled atmosphere export pilots
Challenge at this moment is to develop knowledge (a ripening protocol) that provides possibilities to enlarge shelf time of Alphonso without losing quality (like taste). Once this knowledge is available one can conclude whether export in controlled atmosphere (C.A.) reefers is an option in regard to the transport time from India to, for example, the harbour of Rotterdam in the Netherlands.

2.2   Availability of ripening knowledge at wholesaler level
The capacity of farmers to invest is low. The benefits of slowing down the process of ripening at farmers will not directly lead to a higher price for farmers that wholesalers are willing to pay at the moment. Making knowledge available at wholesale levels seems more feasible because investment capacity is bigger and fewer wholesalers exist which makes it easier to cooperate with them. Once wholesalers possess ripening knowledge they will start to reward higher quality mangos from farmers and thereby improve the entire Mango Fresh Chain.

2.3   Market research
As customer demand is leading for the fresh supply chain, two gaps can be observed. A lack of available mangos that are non-carbide ripened and off-season availability of mangos. Although these gaps seem to be obvious, still no change is being implemented. Both gaps could be narrowed by means of market research that quantifies the economic opportunities. Afterwards entrepreneurs will be able to set up business cases themselves.

2.4   Find ideal picking stage of all mangos
Finding the ideal picking state can enlarge shelf life significantly. As the current capacity of farmers to invest is low, it is advised to offer picking stage knowledge to them funded by governmental agencies.

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