

**Technical study of the constraints
associated with long distance
transport to high value markets**

R2371(S)

Project: ZB0101 (A0714)

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August 1997**



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ACKNOWLEDGEMENT

The authors wish to express their thanks to the Department for International Development (DFID) for funding this project. The authors also wish to thank Mr Prasada Rao and his staff at the Vijaya Association of Fruit and Vegetable Growers' Co-op Societies of Andhra Pradesh for their assistance with this research and their hospitality. Thanks are also due to Mr A.S. Rawat (APEDA), Hamish Robbie and Philip Pailes (Marine Management Services Ltd.,) and Erling Moesgaard (Maersk Singapore Pte. Ltd.) for their technical inputs.

GLOSSARY OF TERMS AND ABBREVIATIONS

APEDA	Agricultural and Processed Food Export Development Authority
CO ₂	Carbon dioxide
CA	Controlled Atmosphere
CFTRI	Central Food Technological Research Institute
CPH	Crop Post-Harvest
DFID	Department for International Development
HACCP	Hazards analysis critical control points
IIHR	Indian Institute of Horticultural Research
NDDB	National Dairy Development Board
NRI	Natural Resources Institute
ODA	Overseas Development Administration
RNRRS	Renewable Natural Resources Research Strategy
UK	United Kingdom

This document is a output from a project funded by the UK Department for International Development (DFID) for the benefit of developing countries. The views are not necessarily those of DFID.

EXECUTIVE SUMMARY AND RECOMMENDATIONS

- i) This report presents the findings of a study to identify the main technical constraints associated with long distance transport of Indian horticultural produce to high value markets. The work was undertaken as part of the project 'Development of a strategy for CPHP research to support small farmer access to high value markets for horticultural products (India)', (ZB0101), funded by DFID's (formerly the UK Government's Overseas Development Administration) RNRRS Crop Post-harvest Programme development funding.
- ii) The post-harvest and marketing system of mangoes produced by smallholders in the Vijayawada region of Andhra Pradesh, south India, was selected as a case study. The study consisted of a Hazard Analysis Critical Control Point (HACCP)-type analysis of farm and marketing practices for local and distant markets and included physical analyses in field and laboratory at key points.
- iii) Farm size appears to have a direct impact on the type of market the producer can aspire to. Small farmers are limited in their access to high value markets unless they can organise themselves into some form of farmer association. There are a number of different marketing channels either for the local market or for the domestic 'export' markets or the international export markets.
- iv) Traditionally, mangoes may move through as many as eight, intermediaries between farmer and consumer. New marketing mechanisms, for example, the Fruit & Vegetable Project (NDDB) and the Vijaya Association of fruit and vegetable growers' co-operative societies are sourcing directly from farmers and are cutting down the trading steps to three or four. These types of marketing initiatives with more direct sourcing are increasing in number in several areas of India.
- v) Handling methods have evolved to provide for the rapid disposal of fresh mangoes on the domestic market and are a reasonable compromise between the need to limit costs, avoid excessive losses and cope with the demanding requirements of a fruit which is harder than an apple at harvest and softer than a peach when consumed (New 1982). The need for novel and appropriate handling techniques to enable exploitation of the growing export markets (either domestic or international) through the new marketing mechanisms is identified in this report. The current handling systems are a major constraint to the continued development of these sectors.
- vi) Technical advice currently available, particularly at the pre-harvest level, is often in the form of blanket recommendations which do not take into account the circumstances of smaller farmers. Improvements in technology generation and delivery for small farmers are required to enable them to meet the requirements of high value markets.
- vii) The need for improved criteria for selecting material for the sophisticated 'export' markets (international and domestic) are required both in the field and at the packhouse or assembly point. Current maturity indices and grading criteria do not adequately address the requirements of these markets.

viii) The potential for fruit damage during harvesting operations was identified. In order to reduce losses to the farmer as a result of damaged fruit being graded out, improved methods for harvesting and handling of fruit in the field are required. One of the major constraints facing farmers was quoted as a shortage of skilled labour for harvesting. Procedures which simplify the harvesting operation are of increasing relevance.

ix) Due to the dispersed nature of the farmer holdings and the small size of individual holdings there are inevitable delays before processing and pre-cooling of fruit is completed, which can adversely affect storage life of export fruit. Techniques need to be investigated to overcome this constraint e.g. conditioning of fruit through hot water treatments; or simple techniques for removal of field heat e.g. use of field water tanks (this would also have the benefit of reducing latex damage - another constraint identified in the report).

x) Control of post-harvest diseases was identified as a major constraint to long distance transport. It was noted that over 30% of a trial controlled atmosphere (CA) shipment was lost to anthracnose and stem end rot infections. The introduction of a post-harvest treatment, preferably not involving agrochemicals needs to be investigated e.g. hot water treatment.

xi) Development of volume exports of mangoes requires effective sea transport conditions. Refrigerated sea containers have been found to be inadequate for conserving fruit life for the European market. For this reason a trial CA shipment for the UK market was undertaken in 1997. The conditions for trial shipment were arrived at through discussions between the shipping container provider (Maersk), who had practical commercial experience of shipping mangoes from other regions, and CFTRI who had some laboratory based experience. The result was only 30% of the consignment was saleable as Class 1 fruit. The use of CA technology has not been sufficiently researched for the export mango variety in question to provide practical recommendations. Further research is required not only to define gas mixes for CA but also safe shipping temperature.

xii) Assessment of fruit on arrival in the UK market indicated further areas related to CA shipment required closer investigation, including shelf-life and ripening after removal from the container and flavour development.

1. INTRODUCTION

1. This report presents the findings of a study to identify the main technical constraints associated with long distance transport of Indian horticultural produce to high value markets. The work was undertaken as part of the project 'Development of a strategy for CPHP research to support small farmer access to high value markets for horticultural products (India)', (ZB0101), funded by DFID's (formerly the UK Government's Overseas Development Administration) RNRRS Crop Post-harvest Programme development funding.
2. The study was undertaken in Andhra Pradesh (A.P.), the main mango producing state in India, where mango production is largely in the hands of the small farmer. One third of mango production in A.P. is reported to grow around Vijayawada. This is where the Vijaya^a Association of Fruit and Vegetables Growers' Co-op Societies of A.P. is based, an organisation which supplies mangoes to both the export and high value domestic markets. In addition, one of the growers associations which supplies Banganpalli mangoes to the retail outlets of the Fruit and Vegetable Project^b (a National Dairy Development Board pilot project) in New Delhi, is located here. Production from the area is directed to export markets, for example through Vijaya, and high value domestic markets, for example through the Fruit and Vegetable Project (F&V) and local markets. [Both organisations were selected as case studies in the wider study ('Horticulture Strategy for India' Project, A0714) to examine the extent to which the institutional forms facilitate the participation of small farmers in high value horticulture markets.]
3. The study focuses on small farmer production of mangoes in this region and describes the post-harvest system and critical points involved in supplying distant markets (within India and export) utilising an assessment of product quality at point of production and in local and distant markets.
4. The report outlines key researchable needs to support small farmer access to the more lucrative distant markets for horticultural products.

^a The Vijaya Association of Fruit and Vegetable Growers' Co-operative Societies of Andhra Pradesh (Vijaya) was established in Vijayawada in 1992. The association is made up of 16 fruit and vegetable co-operatives (primary societies) spread over three districts around Vijayawada. The primary society membership consists of approximately 500 farmers who between them cultivate almost 3000 acres of mangoes. Vijaya acts as an apex organisation to undertake and co-ordinate and assist in the marketing of mangoes to export and high value domestic markets. Vijaya uses a specialist facility for market preparation which has a 40 tonne capacity pre-cooler and a 50 tonne capacity cold store.

^b The Fruit and Vegetable Project (F&V Project) was set up in 1986 as a NDDB pilot project to supply high quality fresh and frozen fruit and vegetables to the New Delhi consumer market. The project now operates independently as a fully fledged organisation under the overall umbrella of NDDB. It remains based in Delhi with over 250 high class retail outlets in the city operating under the 'Safal' brand name. These outlets reportedly retail 7-8% of the fruit and vegetables traded in Delhi. The project sources supplies directly from farmers and encourages farmers to organise themselves as societies or associations. Procurement for vegetables is mainly from Northern Indian states in and around India. The Project provides technical support and inputs to the farmers including hire of cultivation equipment.

2. MARKET STRUCTURE

2.1 Background

5. India is the world's largest producer of mangoes with a current annual production estimated at 9-10 million tonnes. A large number of mango orchards are thought to be in the hands of absentee landlords and fruit reaches the markets through a system of orchard contractors, commission agents, primary and secondary wholesalers (New, 1982). However, in many growing areas, production of mangoes is primarily undertaken by small farmers, whose holdings vary from one or two mature trees up to 10 acres and, who are often entirely dependent on cash income from these fruits.

6. Over 95% of production is marketed, primarily because mango is grown as a cash crop. The rest of the harvest is used for home consumption, gifts, wages in kind or is lost.

7. More than 95% of the mango crop is consumed as fresh ripe fruit. Most of the remainder is processed in either the green or ripe state both for local consumption and for export, and less than 0.1% is exported as fresh fruit although this figure is set to increase over the next few years (source: APEDA). For the small farmer the domestic export markets (which in the Indian context means export to other States), are more significant than the international export markets.

8. A large proportion of fresh mangoes are sold on the local market and have a relatively low unit value and may be more important as a food source for some low income groups; technical interventions at this level are unlikely to have a significant impact on the returns to the small farmer.

9. One growing sector of the market is the supply of horticultural produce to the major urban centres in India, namely Delhi, Bombay, Hyderabad and Madras where there is an increasing demand by middle class consumers for high quality fruit that is ripe. Small farmers can access these markets, through a range of institutional types (e.g. growers associations and co-operatives) and could benefit from technical inputs which ensure that production meets the requirements of these high value domestic markets. This dynamic and fast growing market is competing with the development of international exports. As mentioned earlier, it is regarded as an export activity, although it means export to other states.

10. A small but growing sector of the market is the supply of mangoes to export markets in the Middle and Far East and Europe. High quality, well packaged fruit are essential for these markets and these markets require a different approach to the domestic export market.

11. A brief description of the marketing systems for small farmer production of mangoes is reported here. A more detailed account of some of the marketing mechanisms for smallholder production of horticultural crops for high value markets

are presented in the reports by Hall, Taylor and Malins (1997), Somayajulu and Mukherji (1997) and Sivamohan (1997).

2.2 Marketing channels for small farmer production

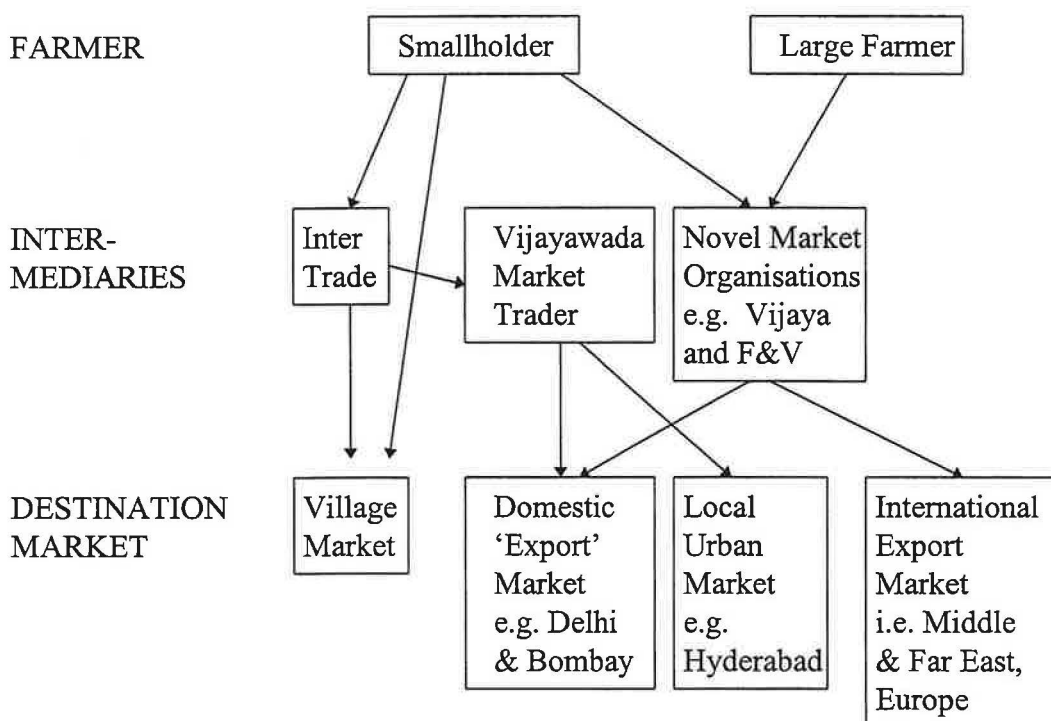
12. The structure of the system through which small growers market their produce in A.P. is presented in Figure 1. In summary, the majority of growers sell their produce at local markets either directly or through a system of brokers. In some cases, fruit is purchased off the trees during the growing season, this can be a speculative form of trading in which the crop changes hand several times before harvest.

13. The options available to farmers in terms of selling their crop are:

- to sell the crop in advance of harvest to assist cash flow;
- to sell the whole of the fruit at bulk rate to the traders and;
- to sell part of the crop to specialised markets.

The specialised markets such as international exports can only accept a portion of the crop, often as low as 6%. This can be a problem to the farmer not only in grading out their crop to meet the requirements of the export markets but also in disposing of the remaining lower quality portion of the crop. Organisations like Vijaya recognise this, and plan to purchase the whole crop in the future.

Figure 1. Flow diagram of the marketing channels for smallholder production of mangoes.



14. All three options are influenced by both the quality and volume of the crop, and very small farmers may be excluded. In some villages, farmers have organised themselves informally or into registered mango grower's associations e.g. Gayatri Mango Association, or co-operatives e.g. primary societies of the 'Vijaya Association of Fruit and Vegetable Grower's Co-operative Societies of Andhra Pradesh'. These mechanisms by which fruit are sourced directly from the farmers are cutting down the trading steps between the farmer and consumer from as many as eight intermediaries (traditional trading) to three or four. These types of initiative allows for joint marketing including transport and may offer farmers better access to the more lucrative domestic export markets and international export markets (Hall, Taylor and Malins, 1997).

2.3 Market activities

15. The markets in Vijayawada, Hyderabad and New Delhi were visited during the field study and an assessment of product quality and price was made. The information is reported here. Photographs of marketing practices are included in Appendix 1. See Appendix 2 for a map of the localities.

Local markets (village level)

16. Mangoes are generally sold under a tree or at an assembly point in the village. The fruit is generally supplied directly by the farmer or, in some cases, a trader who purchases fruit at the farm-gate. This is typically third grade material which is ripe and either undersized and/or has blemishes (e.g. scarring/ abrasions/ disease).

Vijayawada

17. For eight weeks of the year, during the mango season, the town of Vijayawada becomes a teaming hub of mango trading activity. Fruit arrives daily by truck (as many as 2-3,000 trucks per day) and rail from all over Andhra Pradesh, covering distances of up to 600kms. The market is attended daily by as many as 300-400 farmers and has a throughput of 200 tonnes per day. The main market area at Kedareswarapet is very congested and has very basic facilities. The traders find the facilities unsatisfactory and are well advanced in establishing a new market area close to Vijayawada which will have paved roads and good facilities.

18. The fruit is delivered to the market at Kedareswarapet, either in bulk (Plate 1, Appendix 1) or unitised, by farmers and traders, where it is then graded (Plate 2, Appendix 1), if this has not already been done so. Non-graded fruit are sorted into three grades according to size and appearance (see Appendix 3). The domestic export trade requires ripe fruit on arrival at the destination market. To achieve this, fruit are tightly packed in closed containers (Plates 3 and 4, Appendix 1) usually with calcium carbide (Plate 5, Appendix 1) to 'cook' the fruit and encourage ripening before arrival in the domestic market. This is completely contrary to the requirements of the international export market where the fruit storage life must be prolonged.

19. The current system has evolved to provide for relatively careful handling and rapid disposal of fresh mangoes on the home market and is a reasonable compromise between the need to limit handling costs, avoid excessive losses and cope with the demanding requirements of fruit which is harder than an apple at harvest and softer than a peach when they reach the retail outlet (New 1982).

20. The fruit is sold through the auction by traders who typically receive 4-10% commission on the final price. The auction houses offer a grading service, the price of which is covered by charging a higher commission on non-graded fruit (Plate 6, Appendix 1). The fruit is primarily purchased by buyers from Delhi and Bombay, but the auction traders themselves may also be directly involved in long distance marketing. A small percentage of fruit is exported, primarily by air, to the Middle and Far East.

21. Three popular varieties are sold through the market; in order of importance they are Banganpalli, Totapuri and Suvarnarekha. The market accepts a range of fruit qualities [see Table 1 (page 6) and Plate 7 (Appendix 1)]. This year the average market price was between Rs1500-3000 per tonne, much lower than the average market price in previous years which was put at Rs6000 per tonne. Heavy rain had led to a high level of disease, mainly sooty moulds and anthracnose (Plate 9, Appendix 1). Fruit free of disease and damage were fetching Rs6500-7000 per tonne.

22. Table 2 shows some spot prices for mangoes sold through the Vijayawada market.

Table 2. Price of fruit sold by auction in the Vijayawada market

Variety	Price	Origin
Totapuri	Rs 60 per 20kg (Rs 3000 per tonne)	500-600km by truck
Mulgoba	Rs 6 per fruit	Rayalaseema (300km)
Dasehari	Rs 100-150 per 10kg	Nirmal (distance unknown)

Hyderabad

23. Hyderabad, the fifth largest city in India is an important market for mangoes serving as a gateway to the rest of India. Over 90% of the fruit it handles is re-exported to Bombay and Delhi. The city is approximately 150km from Vijayawada to which it has good rail and road links.

24. The market is well organised with some cold storage facilities. It operates on similar lines to the Vijayawada market. In the peak season, over 100-150 lorries (6-10t) arrive daily. Again, the quality of the mangoes it handles are variable [Table 1 (page 6) and Plate 8 (Appendix 1)]. The price per ton was significantly higher than in the Vijayawada market, with some mangoes being sold for Rs10,000 per tonne; these mangoes were mixed in terms of stage of ripeness, but had very few blemishes. At the lower end of the scale, one trader was selling mangoes for Rs1000-2000 per tonne. These showed heavy signs of scarring/abrasions and disease.

Table 1. Product quality and prices for Banganpalli mangoes in Vijayawada and Hyderabad.

Trader	Price Rs/Tonne	Mean Peel Colour	Mean Shoulder Maturity	Mean Weight	Mean Length	Mean Width	Breadth	Blemishes	Brix
Vijayawada traders ^b									
1. Gupta	2000	1.5	2.6 (2 to 3)	-	115.8 (102-135)	90.2 (84-101)	74 (69-81)	severe scarring; spotting; blotch and sooty moulds; latex staining and bruising	7.4 & 7.7
2. SVR	3000	1.5 (1.5 to 2.0)	2.0 (1.0 to 3.0)	-	108 (100-122)	84.8 (79-93)	67.8 (62-77)	light scarring, minor sun scorch, latex staining and minor bruising	8.1 & 8.2
3. VFT	2800	1.6 (1 to 2)	1.6 (1 to 3)	-	113.4 (96 - 125)	84.4 (81-96)	69.4 (66-76)	moderate scarring, odd spots of sooty mould; moderate bruising; latex staining	7.2 & 9.0
4. YM	5500	1.4 (1 to 2)	2.0 (2 to 3)	-	113.6 (101 -125)	87.4 (80-95)	70.2 (65-74)	some fruit clear of any blemishes; others showing sign of light sooty moulds	8.2 & 8.0
5. Purus-hottam	3500	1.9 (1.5 to 2)	1.9 (1 to 2)	-	106.2 (92-117)	82.6 (73-94)	67 (63-72)	minor latex staining; small amount of sooty mould, minor scarring/abrasions	7.3 & 9.3
Hyderabad Market ^b									
1	10,000	2.0 (1 to 4)	2.2 (2 to 3)	-	113.8 (110-123)	84.4 (81-90)	65.2 (63-68)	very slight markings	11.4 & 9.0
2	5-7000	2.0 (1 to 4)	2.4 (2 to 3)	-	112 (98-130)	84 (77-92)	64.2 (60-68)	mixed. slight to moderate	14.0 & 9.8
3	1-2000	1.8 (1 to 3)	2.1 (1 to 3)	-	112.4 (109-116)	88.2 (74-100)	69.4 (58-81)	severe	13.0 & 9.0
4	5000	1.4 (1 to 3)	1.6 (1 to 2)	-	111 (108-119)	84.8 (80-90)	67.4 (65-70)	moderate	10.2 & 9.2
5	2000	1.0 (1.0)	2.0 (1 to 3)	-	108.6 (100-117)	83.2 (70-94)	70.2 (62-75)	severe	12.5 & 10.5
Vijaya: Export to UK ^a	Rs 14.00 (Bangan-palli)	1 (green)	2.23 (1 to 3) 2 out of 15 < 2.0	288.6 (276-340)	109.2 (102-117)	84 (78-91)	68.8 (64-76)	Sun scorch: 3 out of 15 fruit. (10% x2 + 35%)	8.56 (6.2- 10) 3 fruit under 8%

a = mean of 15 fruit

b = mean of 5 fruit per trader

25. Problems cited by traders included delays on the road and vehicle accidents, which can lead to a reduced shelf-life or complete loss of cargo. Rail links to Delhi and Bombay are currently unsatisfactory, although organisations, such as Vijaya are looking to ship mangoes to Delhi by this means in the future.

Delhi

26. The Azadpur market in Delhi is one of the largest horticultural markets in Asia. The market has facilities for cold storage and auction floors. The majority of traders have organised market stands. Mangoes from all over India were sold either through an auction system and/or directly through traders stands (Plate 10, Appendix 1). The fruit is at or near full-ripe stage. The trading system is described elsewhere (Gray, 1997). Examples of market prices for mangoes sold through small stands in the market are:

- Rs 75-85 per 5 kg for small yellow mangoes (variety unknown).
- Rs 235/60 pieces and Rs 255/26 pieces for Malsassi mangoes.

3. TECHNICAL DESCRIPTION OF POST-HARVEST SYSTEM AND IDENTIFICATION OF CRITICAL POINTS FOR DIFFERENT MARKETING CHANNELS

3.1 Background

27. An assessment of the harvesting, handling and packaging and transport procedures for the supply of mangoes to the local, high value domestic (Fruit and Vegetable Project) and export (via Vijaya) markets was undertaken and key critical points are described here. A full description of the post-harvest system for Vijaya is reported in 'Technical study of an export shipment of Banganpalli mangoes from India to the United Kingdom' (Taylor and Malins, 1997).

3.2 Pre-harvest management constraints

28. The level of pre-harvest management varied according to the size of the orchard and how the farmers are organised i.e. singularly or in groups. Small growers with one or two mango trees did very little crop management, whereas small farmers organised in growers' associations or co-operatives generally maintained their orchards to a higher standard, although for many farmers this amounted to minimum interventions. Orchards generally comprised of trees of different ages and heights which are irregular in bearing and lack uniformity in fruit development rates all of which have an impact on fruit quality and uniformity and make harvesting difficult. The use of dwarfing rootstocks and soft pruning techniques to restrict tree size and facilitate harvesting have not been widely used in India. However, both Konkan University (Maharashtra) and the Andhra Pradesh Agricultural University have recently initiated a programme of propagating trees which are more evenly bearing and can be used for denser cultivation i.e. up to 100 trees per acre rather than 35.

29. Although there are sources of technical advice (e.g. through the Dept of Horticulture, Andhra Pradesh Agricultural University and the Indian Institute of Horticultural Research, Bangalore), these are often blanket recommendations which do not take into account the circumstances of small farmers. For example, certain agrochemicals to control pests and diseases are recommended which small farmers are unable to afford or the chemicals are unobtainable. One field supervisor of Vijaya commented that farmers often substitute recommended fungicide treatments for cheaper ones (pytheroid) which were often less effective. The result is that a high proportion of mangoes in the local markets showed signs of blemish and disease (see Table 1). Inadequate pre-harvest control of diseases can have significant commercial repercussions for example a 30% loss was observed for the CA export shipment (to the UK) due mostly to anthracnose (Taylor and Malins, 1997). These inadequacies in pre-harvest disease control on small farms suggest that post-harvest treatments for disease control may be particularly important.

30. The regulatory requirements of the more sophisticated export markets such as Europe in demonstrating due diligence in pesticide use do not appear to be addressed at any level.

3.3 Harvesting constraints

Fruit Maturity

31. Harvest date is determined by reference to maturity of random fruit samples in the field. However, the fruit are not selectively picked, because fruit are picked at a hard green stage when they are robust enough to withstand handling and marketing. This results in a range of fruit maturities being picked. Criteria for selective harvesting of fruit (see Table 3) are inadequate and the use of picking poles (Plate 11, Appendix 1), recommended by a number of bodies for harvesting fruit from tall branches may be inappropriate for selective picking. Any grading after harvesting is not related to fruit maturity but removal of blemishes. Uniformity of fruit maturity may be less critical for domestic 'export' markets, where there are opportunities for artificial ripening but is of great importance for the international export markets.

Table 3. List of criteria used to select fruit in the field for export (source:Vijaya).

Physical Criteria	Chemical Criteria
Colour of the mangoes: skin should have a pale yellow blush	Total soluble solids (Brix) ~8%
Fruit size (weight) should be greater than 350g but less than 500g	
Firmness of flesh: Pulp pressure 12/13 llb per square inch	
Shape (cheeks should be filling out so there is a dimple around the stem and the shoulders should be either at the height of the stem or above it.)	
Fruit should be absent of insect damage, bacterial or fungal damage, mechanical injury, physiological disorders	
Should be able to feel the stone	

Fruit damage

32. Using present harvesting methods the potential for fruit damage exists. New (1982) reports that in some orchards visited in India, as many as 50-60% of fruit were recorded as falling from a height of more than 4 meters. While, New (1982) commented that after ripening less than 5% of these fruit showed signs of pulp bruising, this was undesirable cosmetically. Ultimately damaged fruit are graded out or the farmer receives a lower price. None of the current improved harvesting techniques introduced by Vijaya answer the problems and prevention of fruit damage requires further investigation.

Delays in transport to packhouse

33. It was observed that mangoes harvested for Vijaya had to wait up to nine hours before being transported in the cool of the evening to the packhouse for processing. The fruit were exposed to relatively high air temperatures (Taylor and Malins, 1997) after harvesting, despite being kept in the shade, which can speed-up the onset of ripening. This is an important issue for fruit destined for the international export market and strategies which reduce the temperature of the fruit in the field and during transport and hence lower the metabolic rate of the fruit would be beneficial.

Labour constraints during harvest

34. One of the main constraints quoted by farmers was the shortage of skilled labour for harvesting. Farmers need 20-25 staff to harvest one ton of mangoes. Procedures for simplifying harvesting operations and which allow inexperienced labour to perform adequately are of increasing relevance.

3.4 Transport of fruit from the field

35. Fruit can be transported in bulk or packaged in rush baskets or wooden or plastic crates. The former method is used only to transport fruit short distances or for transporting low value fruit such as Totapuri which has an unusually hard and durable flesh, even when partially ripe.

36. Temperature recordings of fruit destined for export indicated potential for temperature abuse in transport to the packhouse. Similarly in domestic marketing, New (1982) reported that the average temperature inside a truck or wagon load of mangoes can be as high as 40-50°C. Such high temperatures are likely to impair normal ripening and flavour development. The use of calcium carbide for ripening during transport will increase temperature further. Strategies for ensuring that the fruit are not exposed to high temperatures during transport both to the packhouse and to the domestic 'export' markets require investigation.

3.5 Fruit processing and packaging for export

37. The current practices employed by Vijaya were recommended by CFTRI and are largely based on the 'Quality Assurance Manual for Export of Mangoes', produced by APEDA. An outline of the handling and packaging steps involved in the preparation of a trial CA consignment of mangoes for export is presented in the report on the trial CA shipment (Taylor and Malins, 1997). One of the constraints facing Vijaya is that mangoes are sourced from orchards, typically small in size, which are widely dispersed (2 hour journey or more) over a large area surrounding Vijayawada. Furthermore, fruit are generally transported in the evening when its cooler, which may be 4 to 9 hours after harvest. This inevitably leads to delays before processing and pre-cooling of fruit is completed, and as a result can adversely affect storage life of export fruit. Techniques need to be investigated to overcome this constraint e.g. conditioning of fruit through hot water treatments; or simple techniques for removal of field heat e.g. use of field water tanks.

38. The desapping operation takes a minimum of two hours but typically may last 4 hours or more if the time to load and unload desapping tables is included (Plate 12, Appendix 1). This leads to delays in processing of fruit and it is not entirely successful in avoiding latex staining. Alternative techniques are required and this needs investigating.

39. Post-harvest fungicide treatments do not adequately control anthracnose and stem end rots in sea shipment consignment (Taylor and Malins, 1997). Improved disease control technology, preferably non-chemical are required. Even under CA conditions, contamination by diseases was a problem (Plate 13, Appendix 1). Observations suggested there was a strong correlation between the severity of disease and farm. This may suggest some growing areas may not be suitable for disease free production and this may impact on small farmers in such areas.

40. There was some evidence of labour management problems in packing and this resulted in poor grading of fruit. It was noted that the use of child labour, and current health and safety practices would probably contravene some of the ethical trading criteria which are currently of concern in the European market.

3.6 CA Shipping

CA conditions

41. Development of volume exports of mangoes requires effective sea transport conditions. Conventional refrigerated sea containers have been found to be inadequate for conserving fruit life for the European market. For this reason a trial controlled atmosphere (CA) shipment for the UK market was undertaken in 1997. The conditions for trial shipment (6%CO₂ & 6%O₂; 12.5°C) were arrived at through discussions between the commercial container provider (Maersk) who had practical commercial experience of shipping mangoes from other regions and CFTRI who had some laboratory based experience. The result was only 31% of the CA consignment was saleable as Class 1 fruit. This value was significantly lower than for the air

freighted mangoes from the same consignment, see Table 4. A third of the container was lost to disease, mainly anthracnose and a further third showed signs of a peel disorder (Plates 14 and 15, Appendix 1), possibly due to chilling injury; these were re-graded as Class 2 fruit. Further details of the outturn assessment for the CA consignment are reported in Taylor and Malins (1997).

Table 4. Fruit out-turn vs shipping method for fruit originated from the same packhouse consignment.

	1st Class	2nd Class	Discarded
CA shipment (6% CO ₂ & 6%O ₂ , 12.5°C)	31%	36%	33%
Simulated refrigerated shipment (non CA; 12.5°C)	25%	50%	25%
Air freight	73%	18%	9%

42. The study highlighted that use of CA technology has not been sufficiently researched for the export mango variety in question i.e. Banganpalli, to provide practical recommendations. Further research is required not only to define gas mixes for CA but also shipping temperature. Assessment of fruit on arrival in the UK market indicated further areas related to CA shipment required closer investigation, including shelf-life and ripening after removal from the container and flavour development (Taylor and Malins, 1997).

Time constraints

43. Time constraints in the production planning and the processing and packhouse system in use resulted in undue delays in pre-cooling of fruit and container loading. Production planning and management of export consignments requires further attention to ensure that fruit can be harvested, packed and loaded to fill an export container within a specified time.

4. TECHNICAL RESEARCH NEEDS

4.1 Background

44. Significant technical constraints for smallholder participation in high value horticultural markets were identified at both the farm, packhouse and transport level. It is apparent from the mango case study that the requirements for the domestic 'export' market and the international export markets are different and as a result present different technical challenges. In the former case, mangoes arrive in Delhi or Bombay, after a 5-7 day journey, and should be at or near the fully ripened 'ready to eat' stage. If necessary, they are subjected to a ripening treatment before being distributed to retail outlets and wholesalers. For the international markets e.g. Europe, the fruit must have a post-harvest life of 42 days or there about, if it is to be transported by sea freight. The fruit on arrival should be uniform in appearance and size and be at a semi-ripened state, typically importers quote 30-50% colour,

45. There is, however, a certain commonality between the two marketing channels, which means that there are areas where technical research aimed at

improving productivity, quality and shelf-life would benefit both sectors, for example, post-harvest control of diseases.

46. The findings from the field study, highlight the fact that technical research aimed at optimising post-harvest operations should not be tackled in isolation but in conjunction with pre-harvest management. For example, any strategy developed to improve uniform ripening in fruit would need to take into account pre-harvest issues such as age of tree and uniformity in bearing and fruit development.

47. The following areas of research are proposed with a view to addressing the technical constraints identified in this report. Within each area, the technical needs are prioritised in descending order.

4.2 Development of long distance markets: International

Optimisation of sea transport

48. Previous studies (Thompson, Malins, Taylor and Gray, 1996) have indicated that the development of volume exports of horticultural produce relies on effective sea transport conditions. Refrigerated sea containers have been found to be inadequate for conserving fruit life for the European markets. Controlled atmosphere (CA) technology could offer the means to extend post-harvest life, however the use of CA has not been sufficiently researched for the export mango variety in question nor for the length of transit to provide practical recommendations. The trial CA shipment of mangoes (Taylor and Malins 1997) indicated that transport of produce by this means was feasible, however, to be commercially viable further research is required not only to define gas mixes for CA but also shipping temperature. Research would be focused on extending the post-harvest life of fruit (for the UK market the requirement is for 42 days, which is significantly longer than for produce being shipped from South America and Africa to Europe) but also looking at the effects of different storage conditions on quality and consumer acceptability.

49. The identification of appropriate shipping conditions, including the use of controlled atmosphere, would be relevant to other horticultural crops destined for Europe and other long distance markets. Effective use of this technology will require production of sufficient volume of produce per shipment to fill a 40 foot container. This volume requirement in itself presents difficulties for exports of some types of produce, such as Asian vegetables, where market consumption cannot support a 40 foot container a single commodity within a reasonable time span. The ability to ship mixed container loads by sea under CA conditions would allow the development of new markets for speciality vegetables and fruit. This would require novel technologies to be developed.

Improved maturity indices and grading

50. The findings from the CA study also indicated the need for improved harvest maturity indices and/or grading criteria to ensure that fruit arrived in the export markets at a uniform stage of ripeness and size. In order to simplify harvesting

operations, fruit destined for the export market could be sorted out at the packhouse level, rather than investing time and energy selectively harvesting the fruit. Either way, current methods of selecting fruit for export are inadequate and lead to fruit of mixed maturity reaching the market. The need for improved techniques for maturity grading e.g. by using specific gravity, would apply equally to the domestic 'export' market. Indeed it would also be of relevance to a wide range of fruit and vegetable crops. Although the research requirement is partly adaptive in nature, for example in determining suitable harvest criteria for particular varieties or cultivars, there is also scope for the development of entirely innovative technologies which provide a means of maturity grading of fruit after harvest.

Post-harvest control of diseases

51. Control of diseases was identified as a major constraint to long distance transport with over 30% of the CA shipment lost to anthracnose and stem end rot. The severity of contamination was related to farmer, and this might suggest that mangoes grown in certain areas are not suitable for export - this requires investigating. However, since fruit from all farmers showed some signs of disease it is suggested that a post-harvest step, preferably not involving agrochemicals is investigated e.g. hot water treatment.

Improved temperature control: Field and during transit to packhouse

52. Reduction of temperature abuse, both in the field following harvesting and during transit to the packhouse are important in optimising the storage life of export fruit. Simple techniques such as removing field heat e.g. through the use of field tanks may alleviate this problem, plus have the benefit of reducing latex damage - another constraint identified in the report. There is also scope for the development of more novel techniques such as conditioning of fruit through heat treatments which is not only relevant to mangoes but also to other perishable horticultural produce destined for the long distance domestic market, and to fruit and vegetables destined for international markets.

Operation

53. As a general research requirement, there is a need to ensure limits are defined for each post-harvest operation. For example, it is critical that the maximum delay before pre-cooling for international export consignments is established. Such information is essential to production planning for a range of crops and in developing appropriate sourcing strategies for the various markets.

4.3 Development of long distance markets: domestic 'export' markets

Optimisation of transit conditions

54. Again, the priority would be to optimise long distance transport of horticultural produce within India to ensure that fruit arrives at the market, at or near the ripe and ready to eat state. For organisations which have access to fruit ripening

plants, as used by the F&V Project (Delhi), the state of ripeness on arrival at the market is not so critical, but for traders who do not have these facilities the stage of ripeness is key. Traditional transport methods involve packing mangoes with calcium carbide to speed up the ripening process. The effect this has on flavour development and consumer acceptance has not been systematically investigated and may be of importance to the middle class consumer who has more discerning tastes.

55. Fruit when transported in the ripe stage are more susceptible to damage and attack by diseases. So new techniques are required which take into account the market requirement for ripe fruit but at the same time minimising these defects. It is envisaged that to address this particular constraint, research would focus on a number of areas including fruit conditioning, packaging, and transport conditions.

Improved maturity indices and grading

56. The need for improved maturity indices and grading apply equally for fruit destined for the domestic 'export' markets as for the international export markets. However, the criteria may differ; for the domestic market, methods for determining the moment of harvest, particularly for orchards where the fruit is harvested in a single operation, may be key, rather than selecting fruit at the right stage of maturity for long term storage (transport to UK).

Post-harvest control of diseases

57. The research requirement for post-harvest control of diseases applies to both the international export market and the domestic 'export' market. See paragraph 51 above.

4.4 Conclusions

58. Technical requirements in the areas of long distance shipping/transit conditions; improved maturity indices and grading; post-harvest control of diseases; improved temperature control and, operation management and quality assurance were identified in the Vijaya case study. These requirements are relevant not only to mangoes but other horticultural crops destined for high value markets. Addressing these requirements is essential to the central development of small farmer access to high value markets both in India and Europe. Whilst many of the research requirements are adaptive in character, there are opportunities for novel technologies to be developed.

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**Appendix 1: Photographs of post-harvest system
for mangoes, India**



Plate 1. Bulk delivery of mangoes to Kedareswarapet market, Vijayawada.



Plate 2. Sorting of non-graded fruit into three grades according to size and appearance. Kedareshwarapet market, Vijayawada.

Plate 3.



Plate 4.



Plates 3 and 4. Fruit destined for long distance domestic markets are re-packed into wooden crates, lined with newspaper and straw. Kedareshwarapet market, Vijayawada.



Plate 5. Young boys wrapping pieces of calcium carbide in paper.



Plate 6.
Non
graded
fruit
delivered
to an
auction
house,
Kedare-
swarapet
market.

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Plate 7. Banganpalli mangoes collected from 5 traders in Kedareshwarpet market, Vijayawada. From left to right, column 1 = Gupta, 2 = SVR; 3= VFT; 4= YM & 5 = Purus-hottam. Quality and prices for the mangoes sold by each trader are reported in Table 1.



Plate 8. Banganpalli mangoes collected from 5 traders in Hyderabad. From top to bottom, row 1 = trader 1, 2 = trader 2; 3 = trader 3; 4 = trader 4 & 5 = trader 5. Quality and prices for the mangoes sold by each trader are reported in Table 1.



Plate 9. Mango showing signs of insect damage and heavily infected with sooty moulds.



Plate 10. Trader stand in Azadpur market in Delhi. The fruit is at or near full ripe stage.



Plate 11. A harvester showing a picking pole used for harvesting fruit from tall branches.



Plate 12.



Plate 13.

Plate 12. Desapping operation. Stems are removed from the fruit, the fruit are then placed stalk down onto the tables for a minimum of 2 hours.

Plate 13. Box of fruit taken from the top of a pallet in the CA container on arrival in the UK. The fruit show heavy signs of anthracnose and secondary rots.

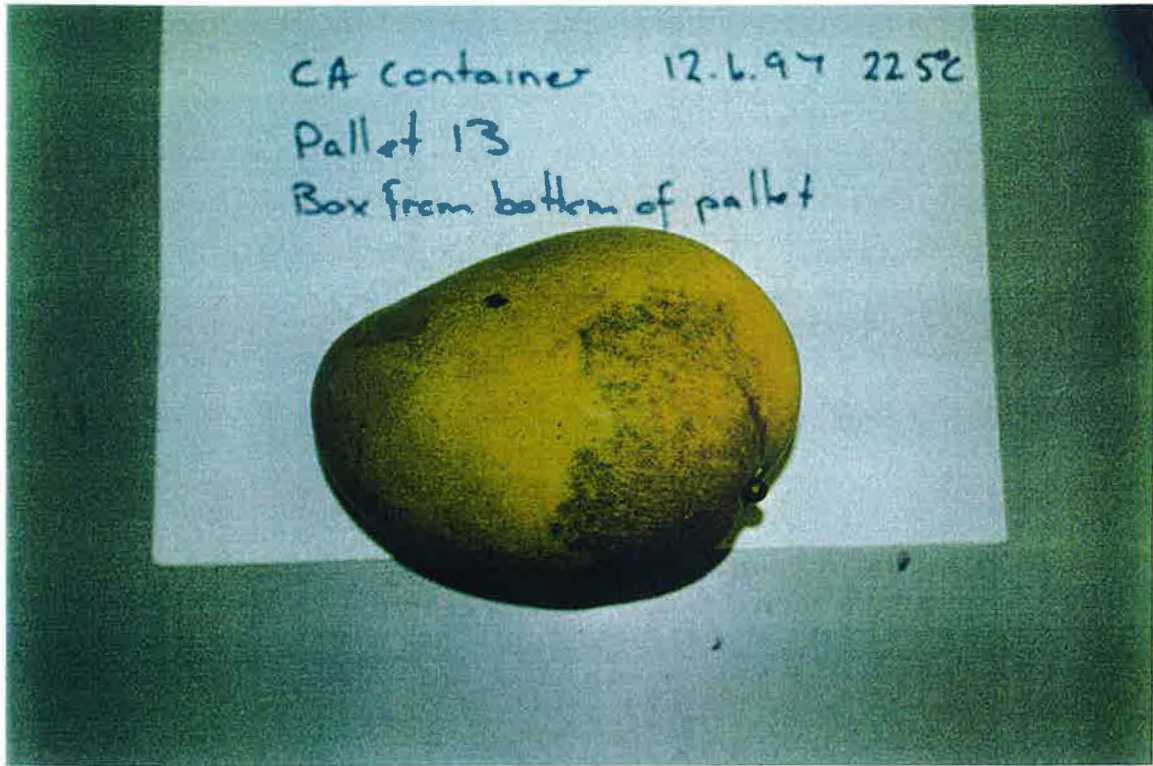


Plate 14.



Plate 15.

Plate 14. CA fruit showing signs of a peel disorder.

Plate 15. Box of CA fruit taken from the top of a pallet on arrival in the UK. The fruit show signs of a peel disorder, possibly due to chilling injury.

KIRGIZISTAN

TADJIKISTAN

AFGHANISTAN

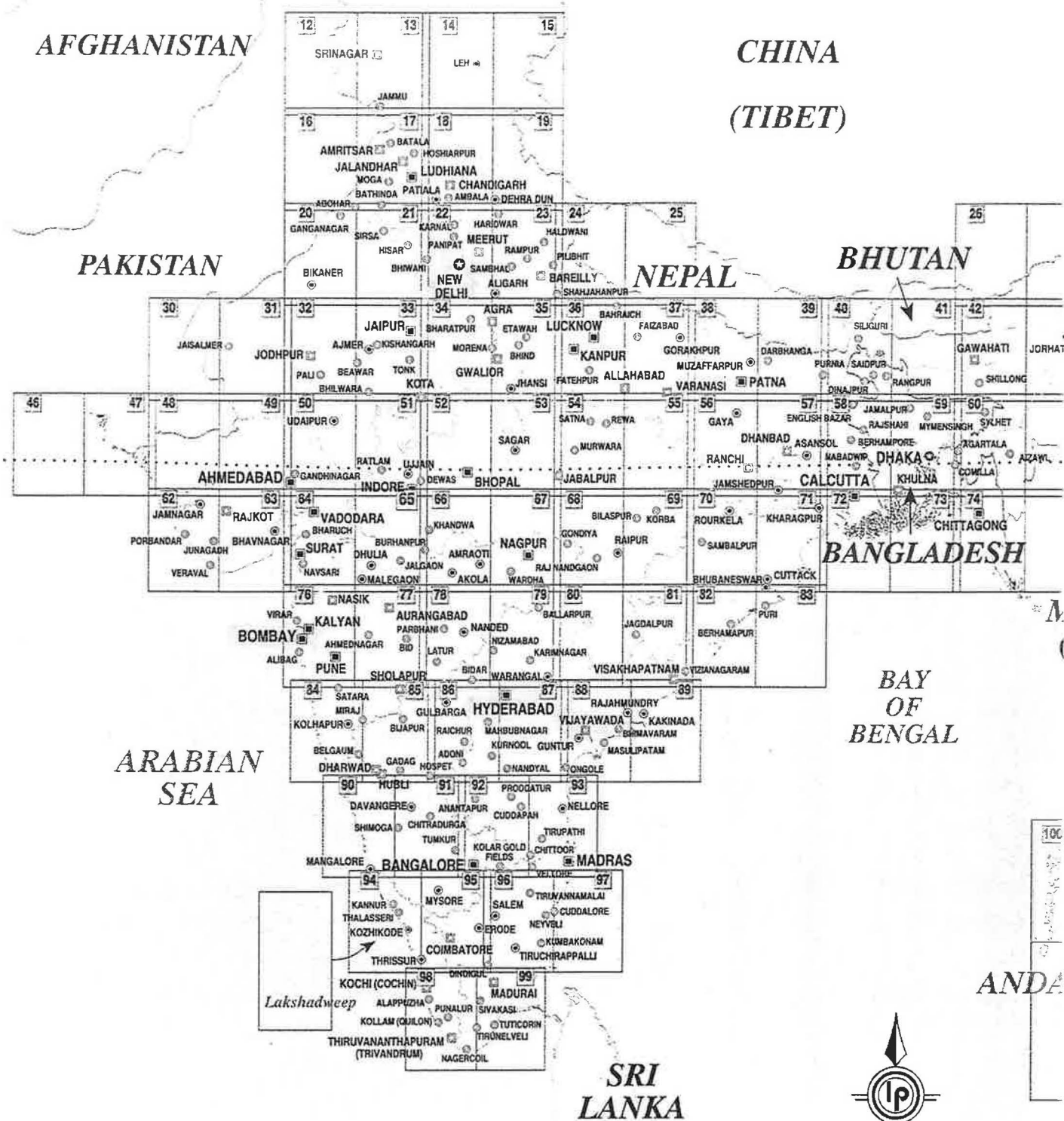
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PAKISTAN

NEPAL

BHUTAN



ARABIAN SEA

BAY OF BENGAL

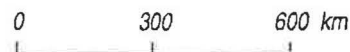
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India & Bangladesh

INDIAN OCEAN



The external boundaries of India in these maps have not been authenticated and may not be correct

Appendix 3: Specifications for mangoes

Vijayawada Market Auctioneer/Trader

Traders at the Vijayawada market were grading mangoes into three classes before auction:

- 1st class : gold colour (and for some varieties a blush) + free from disease and damage
- 2nd class : gold colour, minor blemishes
- 3rd class: small size.

F&V project

When buying fruit, the F&V project works to quality specifications which vary with variety. The general requirements are:

- Colour: 80% ripened
- Size: minimum weight (Banganpalli: 1st grade - 200-500g per fruit
2nd grade - 100-199g per fruit.
Alphonso: 1st grade - 150-200g per fruit
2nd grade - 30-149g per fruit.
- Defects: Black spot (less than 15%)
latex burns (less than 10%)
packing impression
hard pressure mark
bruising mark (lead to a paler colour)
- Misc: shrivelling



*Two essential requirements for successful export shipping:
high quality packaging and quality assurance system.*