
Post-harvest technology of mango fruits, its development, physiology, pathology and marketing in Pakistan

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Introduction.

- Mangoes are climacteric, harvested at a mature green stage. Post harvest changes are principally concerned with events associated with ripening and senescence and with effects of post-harvest handling techniques devised to control the occurrence and rate of these events. **(1)**
- Mangoes are highly perishable some times due to over-ripening they increased susceptibility of mature mango develop anthracnose and other bacterial, viral and fungus diseases. Some time internal breakdown, premature ripening of the mesocarp around the seed in unripe fruit that results in to un-marketable fruit. Control of mango fruit ripening by transformation using the antigens strategy either with ethylene controlling or polygalactouronase gene, could control jelly seed. **(2)**

Pre and post –harvest of mangoes fruits.

- Disease caused by virus, fungi, bacteria, algae and lichens, physiological disorders, nutrition deficiencies, parasites, injuries occurs due to environment, diseases of post harvest due to pre-harvest treatment transit, storage. All these have to be controlled by proper treatment and management of pre and post-harvest, to give mangoes long shelf-life and without any loss of nutrients, shape, colour, size and other things.
- Post-harvest disease occurs due to high moisture content, vital heat produced due to accelerated rate of respiration, high temperature in transport containers and storage place.

The methods used to prolong shelf-life of mangoes.

Several treatments for cleaning and culling to dipping in various chemicals, antibiotics, oils, hot air treatment, hot water treatment, refrigerated storage and gas storage, copper fungicides, borax, aminoathiozol, aminopyridine, thiourea, dithiocarbamates, agrimycin, aureofungin, nystain, grisofulvin heated benomyl, oil and wax emulsion have been suggest as pre-harvest spray or post-harvest dip. **(3)**

Role of ethylene gas on mangoes fruits.

The use of ethylene gas a post-harvest treatment to enhance the colour and promote uniform ripening of mature mango fruits. **(4)**

- Mangoes are climacteric, fruit exhibit typical responses of exogenous ethylene, the role of endogenous ethylene in mango ripening is little understood. The rate of ripening in mangoes can be substantially slowed by reducing fruit temperature, but below 10-12 °C fruit suffer chillig injury. While the modified atmosphere storage result in to unfavourable atmosphere storage result in to unfavourable fruit responses **(5)**

The advantages of post-harvest of mangoes.

- Pathogenic decay is an important factor affecting the post-harvest quality of mangoes. Post-harvest handling and storage technologies needed to control quality of fruit, and to avoid post-harvest losses. The future post-harvest research should aim to provide methods to control ripening, avoid or minimise physiological disorders and to provide maximum fruit quality to the consumer. **(6)**

Pre-harvest activities to increase post-harvest life of mangoes.

- Analysis of anthocyanins of mango peel identified paenoidin-3-galactoside. Anthocyanin content had been found to remain constant or decrease slightly during ripening in association with decreasing chlorophyll and increasing carotenoid contents. **(7)**
- The colour of the peel and pulp are important determinants of fruit quality.
- Pre-harvest calcium spray only delayed peel colour development. Pulp temperature of 46 °C for 10 minutes induced internal breakdown in the inner mesocarp of fruit. **(8)**

Extraction and analysis of mango peel wax.

Wax was extracted from mango peel with n-hexane and gave a yield of 3% .The mango peel contains variable contents of wax to render the fruit water-proof.

Characteristics of mango peel wax characteristic.

Melting point (C°)	-----	62
Acid value	-----	39
Saponification value	-----	197
Ester value	-----	158
Iodine value (Wijs)	-----	44
Unsaponifiable matter (%)	-----	17.7

The work done at the Babha Atomic Research center Bombay, they also found mango peel is a good source of pectin- a polysaccharide of high commercial and industrial importance. **(9)**

Edible fat from mango stones.

Mango kernel contains 10% fat on an average. This fat closely resembling cocoa butter in physical and chemical characteristics. It contains 24-49% stearic acid, 6-18% palmitic acid. The major component glycerides in mango fat are the diunsaturated glycerides steardiolein-54% triunsaturated glyceride –14% and oleopalmitostearin-16%.

Characteristic of mango kernel fat.

Characteristics	Mango kernel fat	Reference.
Melting points (C°)	34-43	B.L NaraSimha Char and G.
Slip point (C°)	30	Azeemoddin
Acid value	2-6	Oil technological
Saponification value	193-195	Research Institute
Iodine value (Wijs)	32-57	Anantapur-
Fatty acid composition.	Pale yellow	51500, India.
16:0	6-8	
18:0	24-49	
18:1	33.5	
18:2	1-13	
20:0	1-2.6	
Glyceride composition		
Trisaturated	STSTST-5	
Oleodipalmitin	STSTST-9	
Oleopalmitostearn	8	
Oleoppalmitosterarin	16	
Palmitodiodiotein.	7	
Stearodiolein.	54	

Defatted mango Kernel powder can be used as a good plant manure.

Characteristics of mango Kernel fat (refined) (10)

Melting point (C°)	38
Refractive Index (40C°)	1.46
Acid value	0.3
Saponification value	190
Iodine value (wijs)	50
Unsaponifiable matter (%)	0.7
FFA of crude fat (5)	5
Refining loss (%)	18
FFA of refined and bleached fat (%)	0.09

Fatty acid composition of mango kernel fat by GLC. (10)

Methyl ester	Weight (%)
Palmitate	8.6
Stearate	42.2
Oleate	45.8
Linoleate	3.4

Mango Processing.

Mango jam.

Mango pulp	40kgs
Sugar	40kgs
Pectin 150 grade	500g
Citric acid	400g
Mango essence	70ml

Mango squash

Juicy varieties of mangoes are preferred for making mango squash. Fully ripe fruit is taken and washed well. The stem portion is cut off and four vertical slits given to each fruit to facilitate pulping. The fruits are then passed through a pulping machine to separate to skin and the stones. The fine smooth pulp is used for making the squash.

Mango squash recipe

Ingredient	25% juice 45% Brix 0.8% acidity	33% juice 40% Brix 0.8% acidity	25% juice 50% Brix 1.0 % acidity	33% juice 50% Brix 1.0% acidity

	lb(kg)	Oz(g)	lb(kg)	Oz(g)	lb(kg)	Oz(g)	lb(kg)	Oz(g)
Mangopulp	100	0	100	0	100	0	100	0
18°Brix	(45.4)	0	(45,4)	0	(45.4)	0	(45.4)	0
0.5%acidity								
Sugar	139	1	99	15	178	4	129	5
	(63)	(30)	(45)	(425)	(80)	(113)	(58)	(141)

	lb(kg)	Oz(g)	lb(kg)	Oz(g)	lb(kg)	Oz(g)	lb(kg)	Oz(g)
Citric acid	2	11	1	14	3	8	2	8
	(1)	(311)	(0)	(396)	(1)	(126)	(1)	(226)
Water	158	0	98	0	118	0	68	0
	(72)	(0)	(40)	(0)	(53)	(0)	(26)	(0)
Preservatives	0	4	0	3	0	4	0	3
(Potassium meta bisulphite)	(0)	(113)	(0)	(85)	(0)	(113)	(0)	(85)

Sugar is added in the form of syrup. The squash may be strained through cloth before bottling.

Frozen sliced mangoes in syrup

Add 0.1% ascorbic acid to the sucrose or glucose syrup (40° Brix) to inhibit polyphenoloxidase activity and 0.07% CaCl₂ to improve the texture. The mangoes are peeled, sliced washed with water spray and hold in a receiving tank with solution containing 0.05% ascorbic acid to avoid browning. Slices are kept in polyethylene plastic bag. Ratio between fruit and syrup was 3:1 on weight basis. The plastic bags are vacuum closed and frozen in Dole freeze cell model 2735-8 with double contact. The frozen product was kept in cold room at – 20C° up to 120 days. The CaCl₂ treatment provide firmer texture in the product. **(11)**

Peeled and dried green mangoes.

Mangoes can be air dried to low moisture content after sulfuring and “Osmotic “ treatment in sugar or salt brine solution. These dehydrated mangoes used by chutney manufactures. **(12)**

- Mangoes product such as nectar, juice, pulp, slices were packed in container of template, Tinplate-tin free sheet and flexible plastic pouches and behavior during storage is incorporated. Factors responsible for corrosion of mango products in tinplate cans and possible remedial measures to reduce corrosion have been suggested. **(13)**
- Canning time table for mangoes.
- Type of can used in Plain.
- Strength of syrup (Degree Brix) 40.
- Exhaust can at 180 to 212 F° to 212F°(82C° to 100C°) for 7-10 minutes or unit the temperature in the center of the can reaches at least 165F°(74C°)
- Processing time 25 minutes in boiling water at 100C°.

Introduction

- In Pakistan out of total geographical area of 80 million hectares, which is about 22 million hectare is cropped. Of this about 1.0 million hectare is under high value horticulture crops.
- In the year 1990-00 , the total area in Pakistan under mango crop was 92100 hectare, the area in Sindh was 41700 hectare. For the same year the total mango production in Pakistan was 918600 tones, while in Sindh 306500 tones.

- In the year 1999-00, the total cropped area was 22.76000 million hectares, out of which 6.58 000 million hectares were under fruit crops.
- In 1990 the World production of mangoes were 15 million tones , mango show climacteric pattern of respiration.

Pre-harvest activities of mangoes.

- Pre-harvest rapping of mangoes, a 10-minute dip in hot water 53C° resulted in the least disease. Anthracnose was reduced 83%, stem-end-rot, 100% fruit fly damage 80% and no effect on total soluble solids at ripen stage. **(14)**
- Pre-harvest foliar sprays of 1% aqueous solution of Zinc sulfate (Zn 0.23%) at 20 days interval in May increase fruit storage condition for 8-10 days. The ZnSO₄ spray increase sugar, total soluble acids, lower acidity and ascorbic acid, continuously increase Vitamin A level. **(15)**

Effect of growth regulators on mangoes

- When mangoes fruit treated with NAA (200ppm) or BA(15ppm) and packing them in polythene bags of 100 gauge with 0.2% vents, help in controlling weight loss, maintaining fruit quality and prolong shelf-life by 4-8 days. **(16)**

Post-Harvest life of mangoes

- The post-harvest life of mangoes can be divided in to three phases.
- Storage life (or transport life), which encompasses the period from harvest during which the fruit remains un-ripe and in a condition resistant to physical damage during normal handling (this phase occupy 4 days).
- Ripening period, which designates the period from harvest until the fruit attains the stage of maximum consumer acceptability. This period encompasses the storage life period plus the final stages of ripening (this phase occupy 6 days).
- Shelf life, which start when fruit is full ripe and is the period in which fruit remain in an edible condition (this phase occupy 6 days). **(17)**
- Mangoes required 10-15C° with 3-5% O₂ and 5-10% CO₂ but O₂ and CO₂ may vary among cultivars and according to storage temperature and duration.

Effect of ethylene on Biodegradation and Biosynthesis of mango fruit.

Mango at 29-31C° ethylene concentration is 10uL/L for 24 hours mango fruit become ripening.

Processes associated with fruit ripening (18)

Biodegradation	Biosynthesis
Depolymerization	Amino acid incorporation in to proteins.
Substrate utilization	Nucleic acid metabolism
Loss of chloroplast structure	Maintenance of mitochondrial integrity.

Pigment destruction.	Oxidative phosphorylation.
Action of hydrolytic enzymes, esterase, dehydrogenase, oxidase, phosphatase, ribonuclease.	Phosphate ester formation Synthesis linked to metabolic pathways; EMP, HMP, TCA.
Ethylene production	Ethylene production.

In vivo production of enzymes by post-harvest pathogens of perishables (18)

Organism	Host	Enzymes make-up	Role in pathogens
<i>Aspergillus Flavus</i> .	Mango	Invertase and amylase	Activity decline not associated with rotting. (Ref: Majumdar and Modi 1980)
<i>Botrydipodia theobremac</i>	Mango	Macerating enzymes	PG=polhygalactouranase. PME=Polymethyl-Galacturonase Ref: (Pathak and Srivastava 1969)
<i>Dothiorella dominicana</i>	Mango	PG= polygalactouranase. PME=Pectinmethyl-transeliminase. Ci= Fracgion of cellulase converting native cellulase to shorter linear polyanhydroglucose chain Cx= Carboxy methyl-cellulase.	(Ref: Narania and Reddy 1983)
Protein enzyme	Mango	Protease=causing rotting in mango.	(Ref: Raghavan-et-al 1979)
<i>Phomopsis mangiferae</i>	Mango	Extracellular pectic enzyme.	Associated with rotting (Ref: Reddy and Laxminarayana 1979)
<i>Rhizoetonia Solani</i>	Mango	PG, PMG, PME, Cx.	(Ref: Narania and Reddy 1983)
<i>Bacillus sp.</i>	Mango	Invertase and ascorbic acid oxidase.	Activity enhance during pathogenesis. (Ref: Chaotpar et.al. 1968-69)

Enzymes activities on post-harvest life of mangoes.

- The amino acids which are identified are aspartic acid, glutamic acid, alanin, glycine, serine and alpha-aminobutyric acid.
- The problem of canning slices to prevent softening which can be achieved such as calcium chloride and calcium lactate.
- Mano is a climacteric produced 0.04 to 30uL/L Ethylene, its storage life is 2-3 days at 5-9C°. (19)
- The two key enzymes in the pathway are those catalyzing conversion of s-adenosylmethionine (SAM) to 1-aminocyclopropane-1-Carboxylic acid (ACC) and ACC to ethylene called ACC synthase and ethylene forming enzyme (EFE), show increase in activities during ripening. (20)

Changes in enzyme activity during mango ripening enzyme activity (units/mg of protein) (21)

Enzyme	Unripe	Midripe	Ripe
Catalase ^a	0-18	-	30-64.8
Peroxidase ^a	6-18	-	30-90
Alpha amylase (x10 ²) ^a	0.12	0.18	0.46
Cellulase(x10 ²) ^a	0.55	1.3	0.41
Pectinesterase ^a	31	-	42
Sucrose sinthase ^a	0.14	1.05	1.25
Phosphofructokinase (x10 ²) ^a	0.2	0.32	0.36
Polygalacturonase ^b	0.51	10.8	24.3
Aldolase ^a	0.85	-	4.8
Glucose-6-phosphate dehydrogenase ^a	0.28	0.7	1.13
Malic enzyme ^a	0	0.21	0.1
Geranyl kinase ^a	0.36	2.44	1.85
Sucrose phosphate synthase ^c	7	40	110
Acid invertase ^c	0.4	0.5	1.5
Neutral invertase ^c	0.2	0.1	0.1
Sucrose sinthase ^c	35	30	28

Enzymes activities in post-harvest technology of mangoes.

- During ripening period pectic enzyme activity increase.
- Enzyme Amylase phosphates and invertase level increase with the process of ripening. **(22)**
- In vitro study suggest low pH, high level of citrate malate and responsible for low spoilage. High level of glucose, fructose, sucrose give ripe fruit spoilage. The activities of invertase, cellulase, pectinesterase and polyphenol oxidase and higher in infected fruit . The dose of 50Krad needed to bring about one log cycle reduction in the viable count of the organisms. **(23)**
- The activity of invertase polyphenol oxidase, cellulase, and pectinesterase high in infected fruits. This also indicate softening of tissues in the infected portion, The enzyme polyphenol oxidase cause browning reaction and invertase are lower while cellulase and protease becomes higher in infected tissue. **(24)**
- Alpha and beta amylase found high concentration. **(25)**
- Malate enzymje activity increase during ripening. **(26)**

Enzymatic activity in postharvest technology of mango fruits.

- The number of enzymes at mature stage of mangoes include catalase, peroxidase, phosphofructokinase, aldolase, glucose-6-phosphate, dehydrogenase, phosphogluconate dehydrogenase, fructose-1,6-diphosphatase, malate dehydrogenase citrate cleavage enzyme, germyl kinase, pyruvate decarboxylase and acid phosphatase. **(27)**

Ethylene action retardation to increase mangoes post-harvest life.

Post –harvest life its aims to inhibition of ethylene action or retarding ripening process, which have already been initiated before harvest.

The enzyme Polygalacturonase (PG) enzyme involved in mango softening.

Soluble solids increase, while titratable acid decrease in ripening of mangoes. (28)

Effect of micro-nutrients on shelf-life of mangoes.

- Zn is an essential micronutrients for plant growth it prolong the storage life. Zinc it increases the photosynthetic efficiency by increase carbon dioxide fixing enzymes like : Carbonic anhydrase. (29)

Effect of protein on mango ripening.

During ripening period protein content increased it may be due to mRNA activities. (30)

Effect of lipid content on mango fruit.

The lipid content of the pulp has also been correlated with aroma. (31)

Effect of carbohydrate content of mangoes.**Changes in carbohydrates content of mango during pathogenesis. (32)**

Organism	Host	Carbohydrate	Observation	Reference
Aspergillus flavus	Mango	Sugar	Reducing sugar decrease and sucrose increased	Majumdar and Modi (1980)
Botryodiplodia theobromae	Mango	Sucrose, fructose, glucose, monosaccharides	Hexose sugar exhausted, oligosaccharides newly formed	Gupta et al (1978)
Curvularia lunata	Mango	Glucose, fructose, sucrose.	Contents decreased	Singh and Tandon (1978)
Dothiorella Dominicana	Mango	Sugar and other carbohydrates	Content decrease	Singh and Tandon (1978)
Bacillus spp.	Mango	Glucose, sucrose, pectin	Content decrease	Chattpar et.al (1968)

Effect of post-harvest of mango on total solid.

- The increase in total soluble solids (TSS) and sugars might be due to transformation of polysaccharides (starch) to simple sugar. **(33)**

Effect of specific gravity on mango

- Specific gravity in Dashehari mangoes appears to be a loss of pulp moisture accompanied by and increase in total sugars at latter stages of maturation (Tandon and Kalra, 1983). **(34)**

Effect of total sugar content on post-harvest life of mangoes.

Total sugar contents of samples of various fruits at the edible stage. **(35)**

Mango, flesh only contain 15.3 fresh wt. Of sugar (g/100g) and dry wt.90. **(36)**

Changes in organic acids in mangoes during pathogenesis. (37)

Organism	Host	Results	Reference
Aspergillus flavus	Mango	Citric acid enhanced	Majumdar and Modi 1980
spp.	Mango	Citric acid (and carotenoids) reduced	Chattparetal (1968-69)
Curvularia lunata	Mango	Content changed	Singh and Tandon 1978

- The organic acid found in ripen mangoes are citric acid , tartaric, oxalic, glycolic , succinic, pyruvic, oxaloacetic and alpha keloglutaric acid. **(38)**

Physico-chemical changes during ripening, softening of mango fruit.

- Softening is accompanied by an increase in water-soluble ethanol-insoluble pectins. The polygalacturonase (PG), might be one of the enzymes involved in mango softening. Some time PG activity correlated with textural changes.

Changes in peel and pulp colour. (39)

Both water and alkali-soluble pectin decline whilst oxolate soluble pectin increase during ripening.

- All controlled atmospherers (CA) or ethylene adsorbents charcoal/vandium oxide are used to remove ethylen and increase shelf life. **(40)**

Effect of growth regulators on post-harvest of mangoes fruit.

- The effect of GA₃, NAA, BA post-harvest dip with above chemical inhibited respiration and ethylene production during storage at 10°C little effect was observed on soluble solids and titratable acidity.
- Gibberellic acid 2000 ppm gave a highly effective treatment for retarding rate. **(41)**
- If mangoes are treated with gibberlic acid 150ppm +Bavistin 1000 ppm, both the treatment slow down the process of ripening by retarding preclimacteric activities of catalase, peroxidase. **(42)**
- Carbide treatment could be enhanced by increasing the rate of application from 5 to 15g/15 fruit.
- Propylene enhance ripening and increase fruit acidity. **(43)**

Effect of temperature and relative humidity as separate factors of post-harvest disease. **(44)**

Host	Pathogens	Temperature °C	Relative humidity (percent)	Observation.
Mango	Botryodiplodia Theobromae Macrophoma Mangiferae (Causes stem end rot in mangoes)	10-35	Low-100	No rot at 10 °C Complete rotting at 35 °C No rot at low RH. Maximum at 100% RH.

Optimum storage and gaseous diffusion for post-harvest technology of mangofruit.

- Estimated rate of gaseous diffusion through the integuments of number of plant organs. Rate of diffusion 8.3 CM³ Kg⁻¹h⁻¹per 1% gradient. **(45)**
- Rates of CO₂ output (mg Kg⁻¹ h⁻¹) by fruit harvested and store unripe, the temperature will be 40°C. **(46)**
- Temperature which have been recommended as optimal for the storage of commodities in mango , 6-7°C. **(47)**

Various factors affect on post-harvest of mango fruit.

- The peak respiration rates reported for the mango are high, exceeding 175mg CO₂ Kg⁻² h⁻¹ at 25°C in some cultivars. **(48)**
- 1.02-1.04 best for cold storage and ISS, sugars and carotenoid pigments showing direct correlation with specific gravity. **(49)**
- Low pressure increased the storage life of mangoes in Florida study. The lowest storage pressure (76mmHg) caused an abnormal response in the proportion of green, red and yellow in the peel after the fruit softened.
- The moisture, acidity, ascorbic acid and tannins are inversely proportional to the specific gravity of fruits. **(50)**
- At the level of 10⁻⁶ M concentration of growth regulator decreased, sugar:acid ratio become maximum. The level of hydrolytic enzymes, amylase, invertase, and cellulase become higher due to presence of abscisic acid. The cyclohexamide treatment blocked the increase in the level of hydrolytic and gluconeogenic enzymes in ripening of mangoes. **(51)**
- Terpenes as monoterpene hydrocarbons contributing 50-63%, w/w of total volatiles and sesquiterpene hydrocarbons 14-19%. **(52)**

- Indole, acetic acid, gibberellic acid and cytokinins delay chlorophyll degreening and appearance of carotenoids in mangoes. **(53)**
- Fruit treated with cycloheximide and Combination of cycloheximide and ABA exhibited a lower sucrose and fructose content but the amount of glucose was increased.
- The treatment thiobendazole at 100ppm with 6% wax emulsion recorded the least spoilage during 20 days of alphonso storage. **(54)**

Postharvest infections and diseases in mangoes fruit.

The following are the months in which maximum post-harvest losses takes place in Sindh. **(55)**

Crop	Pathogen	Peak month of losses	Minimum intensity (%)
Mango	B.theobromae R.arrhizus A.Niger	May and June	5.5 to 6.5

Effect of temperature on development of post-harvest diseases of mangoes. **(55)**

Crop	Pathogen	Temperature Tested (C°)	Maximum rating at (C°)	Minimum or no rotting at (C°)
Mango	Aspergillus niger	10-35	35	10
	Botryodiplodia	10-33	33	10
	Colletetrichum gloeosporioides	10-33	33	10
	Rhizopus arrhizus.	10-33	33	15

Chilling injury in mangoes.

- Chilling injury symptoms are: dark scald like discolorations in the peel and pitting or Sunken lesions. **(56)**
- Ripening of fruits at control temperature (22-25 C°) significantly reduced the physiological loss in weight, increase the time require for ripening.

Stem end rot infection on mangoes

- Stem end rot caused by Dothiorella spp., the most heat resist of the species phomopsis sp. The least heat resistant. **(57)**

Pathogens causing minor post-harvest disease in mangoes

- Absidia Corymbifera.
- Botryosphaeria Buteae.
- Dothiorella doninicana.
- Fusarium decemcellulare (Calonectria rigdiuscula.)
- Gibertella persicaria
- Guigordia mangiferae.
- Myrothecum rotidum.
- Sclerotium rolfsii.
- Trichothelium sp.
- Erwina mangiferae.

Major postharvest pests:

- Major postharvest pests are fruit flies genus Dacus, mango seed weevil (Sternochetus mangifera F) and mango weevil (Sternochetus gravis F.) and mango seed borer, Noorda albizonalis.
- In order to control fruit flies is control by synthetic male lure, methyl eugenol plus insecticides malathion.
- Fumigation done by ethylene dibromide its dosage are 16g/m³ for 2 hours at temperature of 26C°

Major post-harvest pest. (58)

- Fruit flies (Dacusa dorsalis)
- Mango weevils (Sternochetus mangifera F)
- Mango seed borer (Noorda albizonalis)
- Major postharvest diseases of fresh mango are anthracnose caused by pathogens colletotrichum gloeosporides.

Pathogen-wise post-harvest of mango losses are as under.

- Aspergillus niger.
- Botryodiplodia theobromae
- Colletotrichum gloeosporioides.
- Macrophoma mangkiferae.
- Penicillium purpurogenum.
- Rhizopus oryzae
- Sterile fungus

Mangoes varieties susceptible to natural infection. (59)

Pathogen	Observation	Reference.
Aspergillus niger	Langra severely affected 22%	Vermn and Kamal (1951)
	Sofeda 255	
	Chausa 16%	Bhargava Singh (1975)
	Alphanso 10%	
	Totapuri 10-20%	Patel (1972)
Botryodiplodia theobromae	Langra 6.2%	Pathak and Srivastava (1967a)
	Totapuri 4.3%	
	Dasheri 7-20%	Srivastava et al (1965)
Colletotrichum gloeosporoides	Safed 8-15%	
	Neelam 9-12%	
	Alphanso 6%	Srivastava et al (1965)

The loss of mango perishable are as under.

Multiple	Infection pathogen	Loss (percent)	Reference.
Multiple	Multiple infection	Avg.17.7%	Chenulu and Thankur (1968) Thakor and Cheulu (1970a) Laxminarayana and Reddy (1977)
Multiple	Multiple infection caused due to colletotrichum gloeosporioides	Avg.10-30%	Sohil (1973)
Aspergillus Niger	Different parts of Pakistan it is different	Avg.4-35%	Tandon (1967) Patel (1972) Laxminarayana and Reddy (1977)
Botryodiplodia Thbromae	Different parts of Pakistan	3-8%	Tandon (1967)
Colletotrichum Gloeosporioides	Different parts of Pakistan	2%	Tandon (1967) Park and Srivastava (1965)
Rizopus Oxyzae	Different parts of Pakistan	5-6%	Laxminarayana and Reddy (1977)
Xanthomonas Mangiferae	Storage in various fruit market	5-100%	Kishun (1982)

Change in protein, protein-bound and free amino acids in perishable during pathogenesis. (60)

Organism	Host	Content	Results	Reference
Aspergillus niger	Mango	Free Amino acids	Alpha-aminobutyric acid, arginine exhausted, leucine/Isoleucine, valine, of alpha-alanine, glutamic acid, aspartic acid, serine/glycine enhanced, beta-alanine, asparagine, glutamine and an un-known amino acid newly formed.	Singh (1968)
Bacillus spp.	Mango	Protein	No change in content	Chattpar et al (1968-69)
Botryodi plodia Theobromae	Mango	Free Amino Acid	Glutamic acid and gama-amino butyric acid exhausted, aspartic acid, serine, glycine, asparagine, alpha alanine, arginine, vlaine, leucines and phenyloalanine reduced	Strivastava (1966-69)
Curvularia lunata	Mango	Free Amino Acids	Changes noted.	Singh and Tandon 1978. Singh B. and Tandon R.N (1978) Proc Nat.Acad.Sct (India)488pp
Dothiorella Dominicana	Mango	Free amino Acid	Changes noted	Narania and Reddy 1983. Narania K.and Reddy.S.M.(1983) Indian Phytopath, 36pp.1983.

Mangoes susceptible to following infection (61)

Organism	Host	Enzyme	Activities
Botryodiplodia Theobromae.	Mango	Macerating enzyme	PG=Polyglacto-Urinase and PMG=Polymethyl-Galacturonase Enzyme.
Rhizopus arrhizus	Mango	7-40C°, Relative humidity 73-90%	Disease intensity 10% at 7-8C°, no Variation at 20-40 C° Incubation period 5 days, 7-8C°4 days at 20-25% R.H.

Mango loss of perishable due to various pathogens (62)

Host	Pathogen	Loss %	References.
Mango	Multiple infection	15-20	Chenulu and Thakur Thakur and Chenulu (1970)
	Multiple infection but mostly due to colletotrichum gloeosporioides	10-30	Sohiletal (1973)
	Aspergillus niger	4-35	Tandon (1967)
	Botryodiplodia Theobromae	8-20	Tandon (1967)
	Colletotrichum Gloeosporioides	6-15	Tandon (1967)
	Rhizopus oxyzae	5-6	Laxminarayana and Reddy (1977)
	Xanthomonas Mangiferae	5-100	Kishun (1982)

Mangoes susceptible to following post-harvest diseases.

- Pseudomonas mangifera indicae, Erwinia mangiferae and various species of Bacilli are the causal organisms for necrotic or black spots and spongy tissues in mangoes. (63)
- Mango products are highly susceptible to spoilage by yeasts, due to their low pH and high sugar content. Hyphopichia is un-washed fruits and kloeckera and Pichia in washed fruits was predominant yeasts. (64)

Post-harvest pathology or perishable mangoes.

- Fungi isolated from mangoes and its affect on human and animal helath. Rhizopus aryzae isolated from mangoes but it cause phycomycosis or zygemycosis of human affecting eyes, sinus, intestine, lungs and brain.
- The fungus attack of Gloeosporium mangiferae Aspergillus flavus, Fusarium species, Rhizopus arrhizus, Rhizoctonia bataticola, Penicillium cycloplum cause fruit rot in mangoes. (65)

Resistance/Tolerance of post-harvest pathogens of perishables to fungicides.

Fungicide	Pahogen	Host	Tolerance, observation	Reference
Benzimi Dazoles	Bryodiplodia Theobromae Colletotrichum Gloeosporioides Phomopsis citri	Mango	Tolerance cross yresistance between any two of bebomyl, TBZ and thiophanate methyl: imazalil and etacanazole most effective against T strains	Spalding (1982)

Organisms effect on mangoes.

Organism	Host	Effect
Diplodia viticola	Mango	It effect on enzymes
PRP- Protopectinase.		
DP-Depolymerase		
PME-Pectin methyl esterase.		
Ci- Fraction of cellulase converting linear Polyanhydroglucose		Native cellulose in to shorter chain
Cs- Carboxymethyl cellulose		
Bacillus sp.		Activity enhanced During pathogenesis
Erwinia corotovora Ssp		
Carotevera (Ecc)		
Erwinia carotovera sp.		Esa has higher depolymerase and cellulase than Ecc reverse with glucosidase.
Atroseptica		
PG		
Cellulase		
Glucosidase		
Dehydrogenase		

Chemicals used to control post-harvest diseases in mangles.

- Benzimidazole, thiabendazole, benomyl, carbendazin, thiophenatemethyl are used to control post harvest pathology. The benzimidazole fungicide is used to control post harvest diseases has been attributed in two factors: (a) a high intrinsic activity of these compound against many fungi responsible for post-harvest diseases. (b) The ability to penetrate, at least, to some degree in to the host to reach the site of infection. **(66)**
- The Sodium benzoate at 500ppm level inhibited all the yeast except Saccharomycodes ludwigii, while potassium sorbate and potassium metabisulphite at 500ppm inhibit all the yeasts. Effect of heat on growth of these yeasts indicated that all the yeasts failed to survive the heat temperature at 60C° for 20 minutes except Pichia membranaefaciens. **(67)**

Post harvest diseases of mangoes

Mango-powdery mildew, caused by *Oidium mangiferae*-doses- 0.2% (wetable sulphur) or sevisulph (Sevin:sulphur, 40:50) .Needed first spray at inflorescence emergence and repeat at 10-15 days. **(68)**

Mango post-harvest diseases. (69)

Diseases	Causes.
Anthraco nose	Colletotrichum gloeosporoides and colletotrichum
Bacterial black spot	Xanthomas campestris pv.mangiferacinidicae (Patel, Moniz and Kalkami) Dye.
Black Mould Rot	Aspergillus niger V. Tieghem
Botryodiplodia Rot	Physalospora rhodina (Berk. And curt) cooke.
Stem end rot fungi (Benomyl used) 0.1kg/100L	Botryodiplodia theobromae Phomopsis Dothiorella Colletotrichum gloeosporides
Alternaria black spot (fungi) Prochloraz 55ml/100L	Alternaria alternata
Bacterial rot	Erwinia
Blue mold rot	Penicillium cyclopium
Charcoal rot	Macrophomina phaseolina
Hendersonia rot	Fungus-Hendersonia creberrima
Macrophoma rot	Macrophoma mangiferae
Mucor rot	Mucor
Pestalotiopsis rot	Pestalotiopsis mangiferae
Phyllosticta rot	Guignardia mangiferae
Phytophthora rot	Phytophthora nictianae
Powdery mildew fungus	Fungus oidium mangiferae
Rhizopus rot	Rhizopus oryzae or Rhizopus stolonifer.
Scab	Elsinoe mangiferae .
Sooty Blotch	Gloeodes pomigena
Stemphylium rot	Stemphylium vesicarium
Verticillium wilt (soil born fungus)	Verticillium albo-atrum.

Effect of ripening regulation on mangoes ripening attractiveness, pathogenic invasion and its losses

Crop	Ripening Regulation	Ripening Enhanced by day	Attractiveness colour and flavour	Pathogens	Loss percent
Mangoes	Calcium carbide	3	Attractive Uniform Colouration	A.niger; B.Theobromne C.glocosporerides	15-34

Organism	Host	Enzyme Makeup
Dothiorella Dominicana	Mango	PG = Polygalacturonase PMG = Polymethycellulase. PME = Pectin methyl esterase Ci and Cx Ci = Fraction of cellulase converting native cellulose in to shorter linear polyanhydroglucose chain Cx= Carboxymethyl cellulase.

Reduction in Ascorbic acid content in various mangoes varieties during pathogenesis (70)

Organisms	Host	Initial content Mg/100g tissue	Period of Incubation (in days)	Observation in losses	References
Aspergillus Niger	Langra	–	10	78.2	Ghosh et.al (1966)
Aspergillus Niger	Dasheri	–	10	85.4	Ghosh et.al (1966)
Botryodi plodia Theobromae	Dasheri	20	10	89.7	Srivastava and Tandon (1966)
Botryodi plodia Theobromae	Langra	110.0	10	100	Srivastava and Tandon (1966)
Colletotrichum Falcatum	Neelam	–	10	73.1	Kaur and Chaudhary (1981)
Colletotrichum Gloeosporides	Dasheri	20	10	100	Ghosh et.al (1966)
Colletotrichum Gloeosporiodies	Langra	110	8	100	Ghosh et al (1966)
Dothiorella Dominicana	Mango	–	–	Considerably Depleted	Naranja and Reddy (1983)
Rhizoetonia solani	Mango	–	–	Considerably Depleted	Narama and Reddy 1983
Bacillus spp.	Mango	–	–	Depleted	Chattpar et al (1969)

Control of post-harvest losses in mangoes

- Injection of 400g/L formulation of potassium phosphonate (15ml/m canopy diameter) significantly reduced post-harvest stem end rot level in fruit after storage at 22C° for 20 days. (71)

Post-harvest of manges.

- Dip fruit within 24 hours of harvest for 5 minutes in hot water not exceeding 52C° to which has been added 100g/100L benomyl (500g/kg) .Temperature must be carefully controlled to prevent fruit damage.
- Anthracnose can be controlled by dipping fruit in hot water alone at 55C° for 5 minutes. Temperature must be carefully controlled.
- Another alternative is to treat fruit with Prochloraz (450ml/litre) at 55mL/100L, applied as a non-recirculated overhead spray for 30 seconds.
- Hot benomyl used when stem-end-rot is also problem
- For long term control of anthracnose during controlled atmosphere storage (5% O₂, CO₂,13C°) apply a dual treatment of hot benomyl, followed by prochloraz. (72)

Control of post-harvest diseases of mango (73)

Pathogens	Time of stage of treatment	Treatments	Results	References
Colletrichum Gloeosporiodes.	Pre-harvest spray	Daconil, dithane M-45, Maneb 9 2.64gm/l)	Effective	Mendoza (1977)
	do	Mycop, fycol, blitox, biltane, dithane	do	Lingaraj (1969)
	do	Cu-oxychloride, bordeaux mixture (3.3:50 and 4.4:50) zineb, captan	Zineb (0.2% or bordeaux mixture (4.4:50) effective if sprayed twice during flowering and subsequently at 14 days interval.	Pordesimo and Borredo (1976)
	do	Four fungicides tried at weekly interval up to 2 weeks before harvest	Difolatan 4 F (0.25%) effective	Widodo (1980)
	Non-inoculation treatment	Storage at 10 C°	Not effective	Cheema et al. (1950)
	do	Do	Effective	Quimio (1974)
Not mentioned	Non- inoculation treatment	Storage at 10C°	Effective	Wardlaw and Leonard (1936): Cheema et al (1939): Karmakar and joshi (1949) Mukherjee (1961) : Tandon et al (1976)
	do	Harvesting at premature stage HWT at 54+!C° for 5 minutes	Effective, no physiological deterioration	Laxminarayan et al (1974)
	do	HWT at 52C°, hot benomyl (0.1%) at 52C°	Hot benomyl better	Spalding and Reeder (1979)

Pathogens	Time of stage of treatment	Treatments	Results	References
C.gloeosporiodes	Do	HWT at 52-54C° for 10-30 minutes or 56C° for 5-10 minutes	Effective	Chang (1975)
	do	HWT at 50C°, 54C°,55C°,60C° for 15 minutes followed by drying and storing at 9-10C	55C° best for all varieties tested, for Langra, 50C°	Tandon and Singh (1968)
	do	HWT at 50C° for 30 minutes and 55C° for 10 minutes	Effective in all 6 varieties tested	Sampio et al. (1979a,b)
	do	HWT and hot benomyl at 54+1C with 0.025%, 0.05%,0.1% (a.i)	Hot benomyl effective, efficacy unaffected by interval between harvest and treatment	Sampio et al (1980)
	do	HWT at 52-54C° for 10-39 minutes or 56C° for 5-10 minutes	Effective	Chang (1975)
Not mentioned	do	Gama irradiation (15-30 Krad), Vaporgard, growth regulation	Effective to enhance storage life for 10-2-0 days	Hassabella et al (1984a,b)
	do	HWT (50C for 5 minutes) captan (0.2%) bavistin (0.1%0	Effective	Srivastava (1984)
Rhizoctonia bataticola	Do	Dipping in antifungal antibiotics (100ppm)	Loss reduced from 40% in control to 5%	Asnani et al (1972, cit. Eckert et al (1975)
Botryodplodia Theobromae	Do	Dipping in K-metabisulphite aureofungin dithane M-45, brassicol, captan difolatan, bavistin, benomyl, TBZ, NF-48	TBZ (0.05% a.i) most effective	Mandal (1981a)
	Do	TBZ(0.1%)+ Ethrel (0.25% , 0.5%	Effective	Kalyansundram and Parthasrathy (1977/78)
Diplodia natalensis	Do	Dipping in sodium salicylaniide, borax, SOPP, Flit 406, Waxol.W, Sodium hypochlorite + 2,4 -D in different concn and for different periods	Borad (6%0 at 43C° for 3 minutes most effective	Thomas and Dalal (1968)

Pathogens	Time of stage of treatment	Treatments	Results	References
C. gloeosporioides	Non-inoculation treatment	Dipping in (i) aureofungin, captan, formalin (ii) benomyl, TBZ, instant deip of 10 minutes with different concn	Non effective Both effective but benomyl 500 ppm (a.i) superior	Sohi et al (1973)
Aspergillus spp	Do	Dipping in borax, sodium bicarbonate, aureofungin, sodium hypochlorite	Borax (8-10%) most effective	Garcha and Singh (1980)
Rhizopus arrhizus	Pre-inoculation treatment	Dipping in boric acid-2-aminopyridine, 2-amino thiazole, diphenylamine, and their various combination	2-aminopyridine + 2-aminothiazole both at 5% concn, most effective up to 20 days	Thakur and Chenulu (1970b)
	do	Dipping in 15 treatment of chemicals and their combinations	2-aminopyridine, +2 aminothiazole both at 5% concentration most effective up to 20 days	Chenulu and Thakur (1968)
D.natalensis	Do	Dipping in aureofungin (55ppm) for 20 minutes	Effective	Dharam vir et al (1967), Dharam vir (1970)
Aspergillus niger	Do	Dipping for 5 minutes in ferbam, benomyl, TBZ at different concentration	Benomyl (0.15% and 0.2%) effective	Bhargavca and Singh (1975)
C.gloeosporioides	Do	Dipping in benomyl + tween-40 at 600 or 1000 ppm for 10 minutes	Effective	Quimio and quimio (1974b)
A.niger and C.gloeosporioides	Do	Difolatan, TBZ, benlate, Kitazine, cela W524	Non effective	Pathak and Shekhawat (1976)
A.niger	Post –inoculation treatment	HWT at 55C for 5 minutes	Not effective	Pathak and Shekhawat (1976)
	do	Dipping in K-metabisulphite, borax, aureofungin, TBZ, Benodanil, hot benomyl, bavistin, NF-48, HWT (55C° for 20 minutes)	Hot benomyl (0.2% a.i) at 55C° for 10 minutes most effective	Mandal (1981a)

Pathogens	Time of stage of treatment	Treatments	Results	References
	Do	Mustard oil, groundnut oil, coconut oil, linseed oil, vanaspati (hydrogenated misc. vegetable oils)	Mustard oil most effective	Roof and Prakash (1983)
C.gloeosporiodes	Do	HWT at 53C° for 10 minutes	Effective only if treated within 72 hour of inoculation	Quimio and quimio (1974c)
D.Natalensis	do	HWT at 53C for 10 minutes	Effective for naturally infected fruits	Quimio and Quimio (1974d)
	do	Dipping in aureofungin (500ppm) for 20 minutes	Prolonged shelf life by 18-20 dyas	Dharam Vir et al. (1967, 1968), Dharam Vir (1970)
	Post –inoculation treatment	Triming of infected pedicel	Effective	Srivastava and Durgapal (1965)
	do	Irradiation	Effective but not feasible	Pathak and Khandelwal (1969)
	Do	Wrapping with plain paper, butter paper impregnated with iodine + KI, butter paper impregnatged with diphenyamine	Non effective	Chenulu and Thakur (1968)
	Do	Dipping in 2,4-D, ,4,5-T, alpha NAA, PABA, GA, ascorbic acid	Alpha NAA at 200ppm effective up to 5 days	Thakur et al (1974)
Rhizopus spp.	do	Wrapping with newspaper polythene bag	None effective	Tandon et al (1976)
A.niger, B.theobromae. C.gloeosporioides	Do	HWT at 48C°, 51.7C° and 54.4C° for 5 minutes and 57.7C for 10 minutes	Effective	Tandon et al (1976)
	do	Dipping in mycostain 100-400 ppm and borax 6%	Satisfactory	Do
Diplodia sp. And Rhizopus sp.	do	Dipping in fungicides, antibiotics, oil	Non effective if tested after 48 hours of inoculation	Pathak et al.(1971)
A.niger and C.gloeosporioides	do	Difoltatan , TBZ, nenlate, Kitazin, Cela W-524	Non effective	Pathak and Shekhawat (1976)

Pathogens	Time of stage of treatment	Treatments	Results	References
Pestalotia mangiferae	do	Homeopathic drug-Lycopodium clavatum potency 190	Effective	Khanna and Chandra (1978)
R.arhizus	Do	Fumigation with ammonium chloride, calcium hydroxide +Magnesium hydroxide, sodium meta bisulphite	None effective	Chenulu and Thakur (1968)
	do	HWT at 48C°, 50C°, 52C°, for 10 minutes	Best at 50C°	Chenulu and Thakur (1968)
A.niger	Pre- and post-inoculation treatment	Saprol (1000ppm) and delan (1250ppm)	Both effective	Pandey et al (1980)
Macrophome mangiferae	Not known	Dipping in Captan	Effective	Prasad and Sinha (1980)
Chilling injury	—	Waxing (4-12%), polythene bag and storage at 6C° or 9C°	Waxing (9%) most effective at both temperatures for Mneelam	Sadasivam et al (1971)

HWT = Stand for hot water treatment.

Hot-water treatments to control post-harvest losses of mangoes fruits

- Post-harvest decay can be achieved by hotwater treatment (to inactivate deep-seated infections), incorporating a fungicide. **(74)**
- The use of benomyl at 500ul/l and hotwater 52C° for 2 minutes prior anthracnose caused by colletotrichum glocoporiodes . Ethepon concentration resultting in the highest TSS was between 2000 and 4000 mg/l. But fruit firmness decrease fruit exposed to ethephon for 2 minutes had a higher flavor rating than fruit exposed for 1 minute.
- The main terpenoid compound in the oil fraction of the spur is terpendene. **(75)**
- 48C° and 50C° for 35 and 25 minutes, hotwater treatment to mkangoes made peel colour more attractive, percentage, weight loss, shrivelling, texture, total soluble solids (TSS), acidity, and TSS, acidity ratio were not adversely affected by treatment. **(76)**
- Post harvest treatment of mangoes consisting of 5 minutes hot water dip (50C°)followed by a 20 second ambient temperature prochloraz dip is a conventional mehtod to control post harvest diseases.
- Three minutes exposure to Infra Red radiation is more effective than 5 minute hot water treatment. Infra Red Radiation is cheaper and faster to control anthracnose, soft brown rot and other diseases. **(77)**
- Post harvest treatment that involves hot water spray at temperatures of 50-60C° but when fruit is applied hot water brush, it significantly reduced decay development of Alternaria alternata. **(78)**
- Department of postyharvest science of fresh produce , volcani center; Dept. of Agr. Eng. Tzemaj packing house, Hebel Maon Packing houseAfter hot water treatment, cooling, freezing needed to increase shelf-life of mangoes. Freezing points which has been determined for a number of fruits and vegetables. **(79)**

For mango freezing point is 1.3 to 1.1 C°

- Low temperature is used to control post harvest spoilage of mangles by *Penicillium Cyclopium*. **(80)**
- Below 13 °C Chilling injury occurs. **(81)**

Chilling injury in mangoes fruits.

- Mangoes are susceptible to chilling injury the visible symptoms develop after fruits are exposed to temperature below about 12C°. **(82)**
- Temperature below 10-12C°The fruit are likely to incur chilling injury. **(83)**
- Heating of pulp to 88 to 90C°in steam jacketed kettle completely eliminate all microorganisms present in freshly extracted mango pulp. **(84)**

Irradiation used to control post-harvest decay of mangles. (85)

- Gamma rays at about 0.30 KGY (1KGY=100KRAD) found to delay ripening by inhibiting respiration and ethylene production during storage at 10C°While starch, sugar, titratable acidity ascorbic acid and Carotenes not affected by irradiation.
- Irradiation along with fungicide treatment succeeded lowering the degree of infection of fungus *Penicillium Cyclopium*, low temperature also inhibit the growth of mould .
- Irradiation also been used successfully. **(86)**
- Waxing can delay ripening, but several reports of the development of off-flavours.
- The corrosion of tinplate with mango nectar was inversely proportional to the concentration polyphenol present in mango peel it accelerate corrosion. Thickening against like carboxymethyl cellulose and gelatine help in reducing corrosion. **(87)**

Control of post-harvest losses in mangoes.

- Vegetable oil wipe is slow and laborious, it can cause blotchiness, affect fruit ripening and induce off-flavours in mangoes.
- In order to control post-harvest losses, mangoes should be harvested at optimum maturity, grade treated properly, packed ideally, transported carefully, store at desired temperature.
- Combine wax and fungicide coating of fruit increase shelf life of fruit. **(88)**
- Modern packaging method like wrapping of mango fruit with tissue paper retard ripening and minimized damage in transit. **(89)**

Quality components of fresh mango fruits. (90)

Conclusion

- Appearance (visual) size: dimension, weight, volume,
- Shape and form: diameter/depth
- Ratio: smoothness, compactness,
- Uniformity.
- Colour: uniformity intensity.
- Gloss: nature of surface wx.
- Defects; external, internal,
- Morphological.
- Physical
- Pathological.
- Entomological.
- Texture (feel): Firmness, hardness, softness
- Crispness
- Succulence, Juiciness.
- Mealiness, grittiness.
- Toughness, fibrousness.
- Flavor (Taste and smell)-sweetness.
- Sourness (acidity)
- Astringency.
- Bitterness.
- Aroma (volatile compound)
- Nutritive value.
- Carbohydrates (including dietary fiber)
- Protein.
- Lipid.
- Vitamins.
- Minerals.
- Safety.
- Naturally occurring toxicant.
- Contaminants (chemical residues heavy metals.)
- Mycotoxin.
- Microbial contamination.
- If we considered all above factors during post-harvest life of mangoes , we can earn good money by export and processing of it.

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