Disorders of Fibreless Mangos Grown in South Africa for Export

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ABSTRACT

Physiological disorders characterized by mesocarp breakdown, disorders relating to fruit development abnormalities, disorders relating to the stage of maturity at harvest and extended cold-storage, as well as other disorders of mango that are of concern to the South African Mango Industry, are described and discussed.

UITTREKSEL

Fisiologiese afwykings wat gekarakteriseer word deur pulp-afbreking, afwykings wat verband hou met vrugontwikkelingsabnormaliteite, afwykings wat verband hou met die stadium van rypheid by oes en verlengde koelopberging, sowel as ander afwykings van mango wat van belang is vir die Suid Afrikaanse Mango Industrie, word beskryf en bespreek.

Introduction

The occurrence of disorders can seriously affect the potential for marketing mango fruit, and in particular, the marketing of cultivars that are especially prone to such disorders. Physiological disorders that are commonly observed can be broadly classified into two groups; firstly, disorders characterized by internal breakdown, and secondly, disorders relating to fruit development abnormalities. Unlike chill related disorders or disorders like sapburn and bruising, physiological disorders cannot be easily remedied in view of their causes not being as obvious.

In the present paper, commonly observed physiological disorders, disorders relating to stage of the maturity at harvest and extended cold-storage, and other frequently observed disorders are briefly described and discussed. Symptoms of postharvest diseases are not considered.

Physiological Disorders

Disorders Characterized by Internal Breakdown - Jelly-seed and Soft-nose

Jelly-seed was first described by Van Lelyveld and Smith (1979) **[1]**. This disorder commonly occurs in Tommy Atkins and Sensation, but is sometimes observed in Zill and Kent. The development of jelly-seed is associated with the ripening process, being typified by mesocarp (pulp) breakdown in the vicinity of the seed. When in an advanced state, affected tissue may become discoloured **[2]**. The seed is sometimes completely enveloped by affected tissue, or the fruit almost entirely affected **[3]**. Affected tissue may become sponge-like due to moisture loss and the formation of oblong cavities or hollows in it **[4]**. Jelly-seed is most noticeable in fruit that ripens early whilst attached to the tree.

Soft-nose is similar to jelly-seed in that it is characterized by tissue breakdown and its development is associated with ripening. However, tissue breakdown is initiated at the distal or nose-end of the fruit **[5]**. This disorder was first described by Young (1957), who stated that Indian cultivars and their progeny developed in Florida were particularly susceptible. In South Africa, soft-nose is most noticeable in Sensation.

Affected tissue may become a spongy grey mass extending through much of the fruit. Closely spaced oblong cavities may also develop, particularly at the nose-end **[6]**. Failure of the skin to develop colour (loss of green colour accompanied by yellow colour development) at the distal-end of the fruit may indicate the presence of soft-nose.

The cause of jelly-seed and soft-nose probably relates a nutrient imbalance in the fruit, specifically in relation to a deficiency of calcium (Wainwright and Burbage, 1989). Burdon *et al.* (1991) in fact observed that mesocarp tissue at the nose-end of fruit susceptible to soft-nose contained the lowest concentration of calcium. It is well known that calcium is important in maintaining cell-wall and membrane integrity during fruit softening.

Enhanced nitrogen fertilization has been found to increase the incidence of soft-nose (Young, 1957; Young and Miner, 1961; Young *et al.*, 1962). Clear evidence to indicate a direct or indirect effect of nitrogen has not been elucidated, however.

Disorders Relating to Fruit Development Abnormalities

Developing or ripening mesocarp is inclined to develop hollows or cavities due to the pulp rupturing. Furthermore, the seed coat (endocarp) may split during the later stages of fruit development, which in turn may cause cracking of the adjacent mesocarp **[7 - left]**. If cavities or cracks develop during the period of ripening, there is usually no detraction in quality **[8]**. However, if cavities develop whilst the fruit are actively growing, atypical tissue development occurs to internally line the cavities **[9 & 10]**.

In some instances, cavity formation is not associated with mesocarp breakdown, in which case a fruit will ripen to become an attractive, edible product **[11]**. However, tissue breakdown may occur around and spread from the region of cavity formation, rendering the fruit unacceptable **[12]**. An association may exist between the stage of fruit development during which cavity formation occurs and the occurrence of mesocarp breakdown. It

would appear that cavity formation during the later stages of fruit development is more likely to be accompanied by tissue breakdown.

Small cavities are often lined with tissue that is white and leathery **[13]**. The term "papery cavity" is used to indicate the presence of these cavities, which are seldom associated with tissue breakdown. Cavities lined with darkened tissue are usually accompanied by mesocarp breakdown.

Cavities may form at the stem-end **[14]** or nose-end **[15]** of the fruit. Cavity formation at the stem-end is often accompanied by localized skin darkening around the point of pedicel (fruit-stalk) attachment. A discolored and indented region on the skin may indicate the location of a cavity having come into contact with the skin (exocarp) **[16]**.

The name "vark hart" (pig heart) is given when cavity formation occurs adjacent to the seed **[17]** (the name "vark hart" might be considered to be appropriate if one visualizes a pig's heart comprising of cavities located at the heart of the fruit). Such cavity formation can often be found to have occurred adjacent to a split in the seed coat.

Cavity formation and associated mesocarp breakdown commonly occurs in Tommy Atkins **[18]**. Fruit with large cavities, or cavities that result in disruption of major vascular connections, often *spontaneously* ripen early on the tree. Ripening is initially localized to the region of cavity formation. Such fruit often do not exude sap when picked, and have a poor taste due to the stage of maturity at which spontaneous ripening was initiated.

Winston (1986) and Mead and Winston (1991) described a physiological disorder called "stem-end cavity" occurring in a number of cultivars grown in Australia. Kensington Pride, Tommy Atkins, and Van Dyke were indicated to be particularly susceptible. Absence of sap exudation on picking and premature ripening were associated with this disorder. Furthermore, increased incidence was ascribed to windy conditions.

Mesocarp rupture and subsequent cavity formation during the period of fruit growth, development, and maturation could be attributed to tugor pressure variation of mesocarp cells brought about by transient, water deficient conditions. This inference is supported by the observation that fruit grown under dry-land conditions show a greater tendency to exhibit cavity-related disorders. It is noteworthy, however, that canopy and fruit moisture deficits may arise despite adequate irrigation when conditions are windy or hot. Cultivars that typically produce large fruit are more prone to this type of disorder. Large fruit would be expected to be more susceptible to water deficient conditions and, therefore, to tugor variation. Enhanced susceptibility to an internal disorder ("spongy tissue" in Alphonso) in relation to an increase in fruit size has been observed elsewhere (Subramanyam *et al.*, 1971; Joshi and Limaye, 1986). Mesocarp breakdown in association with cavity formation may relate to a depletion of calcium in the surrounding pulp, caused by the tissue developing in response to cavity formation. Directed research is required to clarify these issues, however.

Other disorders that might be related to cavity formation in the mesocarp are "spongy cavity" **[19]**, "spongy tissue" **[20]**, and "grey yolk" (cavity filled with a homogeneous grey tissue) **[21 & 22]**. The difference here may relate to the nature of cavity formation, and the growth reaction at the site of cavities in response to their formation. Spongy cavity and spongy tissue, for example, might arise when many small cavities form adjacent to one another. Each of these disorders may or may not be associated with tissue breakdown.

Disorders Relating to the Stage of Maturity at Harvest and Extended Cold-storage

Refrigerated storage for three to four weeks, especially at temperatures that are effective in suppressing many of the processes associated with ripening, can adversely affect the quality of mangos, particularly if the picking operation is performed when mesocarp colouration has not commenced or is little advanced.

Surface Scald

Fruit may develop surface scald evident as skin discolouration or browning **[23]**. The non-blush regions of the skin appear to be more susceptible **[24]**, and the likelihood of this disorder occurring increases as the cold-storage temperature is lowered. A relationship with stage of maturity at harvest is not clear. However, fruit showing enhanced ground skin colouration at harvest appear to be more susceptible **[25]**. Surface scald may arise either during or after cold-storage.

Pitting

Indentations or pits may develop in the skin of the fruit. This disorder may occur in the absence of surface scald **[26]**, or arise when portions of scalded skin tissue become sunken and necrotic **[27 - left]**. Pitting normally becomes evident after the fruit have been removed from cold-storage. The incidence of surface scald is found to be much higher than that of pitting. (see Wardlaw and Leonard, 1936, and Hatton *et al.*, 1965)

"Lenticel Damage"

Lenticel damage is characterized by localized darkening of the skin tissue surrounding lenticels **[28]**. Increased incidence has been observed when the cold-storage temperature is reduced. Its occurrence has also been linked by growers and shippers to other factors, such as picking at an advanced stage of maturity, picking when conditions are wet, the adoption of pre-packing detergent washes, and a high humidity of the storage atmosphere. Sap-flow over regions of the skin often cause or enhance lenticel damage **[29]**. This disorder is generally not serious. However, a discernible detraction in the appearance of the fruit may result when more than 25% of the skin surface shows affected lenticels.

Sap Pitting or Pitted Spot

This disorder occurs during cold-storage and on regions of the skin having been exposed to sap-flow at the time of picking, or sap that oozes from the cut pedicel at some stage afterwards. The lenticels become slightly sunken, and the tissue around them becomes darkened **[30]**. Regions of concentrated, small necrotic indentations consequently arise.

Contact Scald

Contact scald arises during cold-storage when fruit come into contact with one another or with one of the sides of the container in which they are held. The area of the skin making contact becomes discoloured or darkened **[31]**.

Mottling

Mottling arises when regions of the skin fail to degreen and develop yellow colour **[32]**. High nitrogen availability to fruit during their growth and development, particularly if accompanied by low potassium availability, seems of promote the occurrence of this disorder. Mottling occurs frequently in Sensation. (see Thompson, 1971, Veloz *et al.*, 197l, Medlicott *et al.*, 1986, Medlicott and Jeger, 1987)

Black Sap Exudation

Fruit showing chilling injury, made visible by surface scald, pitting or both of these disorders, often exude darkened sap after, or during and after cold-storage **[33]**. Black sap exudation is a clear sign of the mesocarp tissue having suffered chilling injury.

Peripheral Blanching or Peripheral Browning

Peripheral blanching or browning refers to whitening and subsequent browning of pulp tissue beneath the skin **[34 & 35]**. This disorder is usually initiated in mesocarp tissue close to the stem-end, and fruit picked when mesocarp colouration has not commenced or is little advanced are especially susceptible. Affected tissue may remain firm and assume a spongy consistency.

Internal Browning

Internal browning is typified by browning of mesocarp tissue in the vicinity of the seed **[36]**. Most or all of the mesocarp tissue may become affected, and in severe cases, browning may extend as far as the skin. Fruit that are picked immature and left at room temperature for a number of days prior to their placement in cold-storage are particularly prone to this disorder, which develops during or after cold-storage. Heat treatment may predispose fruit to internal browning. Affected tissue tends to remain firm. (see Chaplin 1987, and Lizada, 1991)

Impaired Ripening

This disorder is characterized by the suppression of skin colouration, softening, pulp colouration, and the rise in total soluble solids content and fall in organic acid levels associated with ripening **[37 & 38]**. Impaired ripening becomes evident on fruit removal from cold-storage. Normal development of aroma and flavour are also impaired, and the fruit may exhibit a marked increase in susceptibility to decay. Fruit that are picked when mesocarp colouration has not been initiated or is little advanced, and are stored at 8^0C or less, are particularly prone to this disorder. (see Kapse *et al.*, 1975, Veloz *et al.*, 1977, Medlicott and Jeger, 1987, and Chaplin *et al.*, 1991)

Shriveling

This disorder is characterized by complete or partial shriveling of the skin **[39]**. The direct cause is moisture loss by the fruit. Increased incidence has been associated with a reduction of the cold-storage temperature, despite the maintenance of a high humidity in the storage atmosphere.

Stem-end Breakdown

Fruit that undergo cold-storage and subsequently ripen without ever having released sap, due to retention of a portion of the fruit-stalk (pedicel and peduncle tissue) at picking, often show signs of mesocarp breakdown or browning at the stem-end **[40 & 41]**. Symptoms may spread towards the seed or extend along mesocarp tissue beneath the skin. Fruit picked prior to the commencement of mesocarp colouration or when mesocarp colouration is little advanced, are more prone to this disorder.

Other Disorders

Vascular Browning

This disorder is typified by discolouration of vascular strands beneath the skin **[42]**. Skin blotching may indicate its presence **[43]**. Vascular browning does not appear to be chill related, nor does it appear to be a manifestation of tissue breakdown. It occurs rarely, and on occasions, may be associated with anthracnose development at the stem-end. Water stress at some stage during the period of fruit growth and development might be considered as a cause.

Solar Injury

Solar injury (sunburn) can occur at any stage prior to picking and during the picking operation, and is most directly related to temperature. It occurs when a temperature-tolerance limit of the skin of the fruit is exceeded due to exposure of the skin to solar radiation. This is made evident by dramatic increases in its incidence following days that are exceptionally hot. The critical ambient temperature above which solar injury will occur might be recognized to depend on the amount of moisture available to the fruit via vascular connections, the moisture status of the fruit themselves, and the relative humidity. Fruit situated on the western side of the tree generally show greatest incidence, the outward shoulder usually developing symptoms **[44]**. The affected region becomes necrotic and sunken, and may serve as an entry point for pathogens.

Fruit or portions thereof that are normally shaded by the tree canopy, are highly sensitive to solar injury. Direct exposure to sunlight can cause injury to previously shaded skin in less than an hour. It is therefore important to place picked fruit in the shade as soon as is practically possible.

Sapburn

Sapburn results from exposure of the skin to sap-flow just after picking. Affected skin assumes a dull colour. Lenticel damage usually occurs as well, indicating where sap-flow took place **[45]**. Immediate washing of fruit with a detergent solution after picking is effective in preventing any serious effect. (see Loveys *et al.*, 1992, Robinson, *et al.*, 1993)

Bruising

Bruising results from mesocarp damage due impact, or pressure from adjacent fruit, or from one of the sides of the container in which the fruit are held. Susceptibility increases as maturation or ripening progress; both of these processes being associated with a reduction in mesocarp firmness. Affected areas are made conspicuous by localized tissue darkening beneath the skin **[46]**. Symptoms only become noticeable when the fruit ripens.

Overripeness

Overripe fruit are fruit that have passed the stage of full-ripeness and progressed somewhat toward the stage of senescence or death. Mesocarp cells in ripe fruit lose their integrity with time due to rupturing and col-

lapse of the membranes and cell walls. Cytoplasmic mixing ensues, which is accompanied by mesocarp discolouration and the development of off-flavours. The fruit eventually become very soft and indented **[47]**.

The shelf-life of ripe fruit is short, and cannot be extended significantly by cold-storage. High temperatures, on the other hand, hasten the transition to over-ripeness. Mangos often do not attain this state due to prior colonization by the fungal pathogens, *Colletotrichum gloeosporioides* and *Nattrassia mangiferae*, which cause the diseases anthracnose and soft-brown rot respectively.

Conclusion

Of the mango cultivars currently exported from South Africa to western Europe, Tommy Atkins is undoubtedly the most susceptible to physiological disorders, both to those characterized by internal breakdown and those resulting from development abnormalities. Irwin, on the other hand, is least susceptible. Sensation and Keitt show moderate susceptibility, and Zill, Kent and Heidi, low susceptibility.

Chill related disorders occur most frequently in Tommy Atkins and Sensation. That these cultivars are often picked too early probably accounts for this observation. Later picking and cold-storage at temperatures of 11^0C or higher, may reduce the incidence of these disorders.

Much of what has been stated here is based on careful observation by the author over a period of four years. The determination of the physiological and biochemical basis for many of the disorders commonly observed, particularly those of a physiological nature, is an important field of research in view of the potential benefit held in the formulation of ways to prevent them. This paper may prove to be useful to researchers in providing them with a platform from which directed research can be performed.

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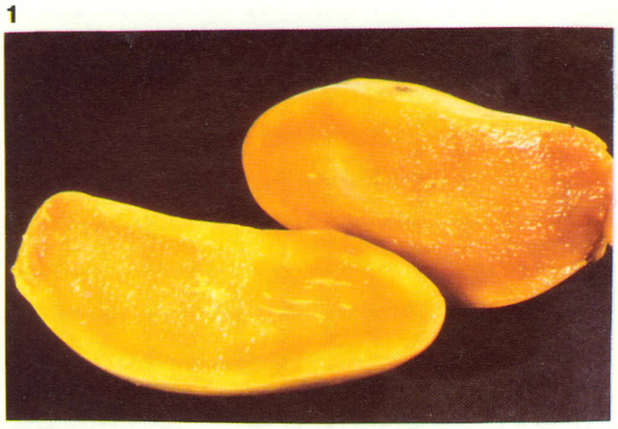

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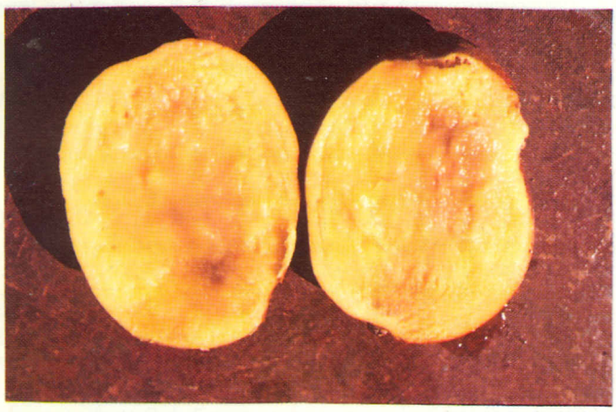

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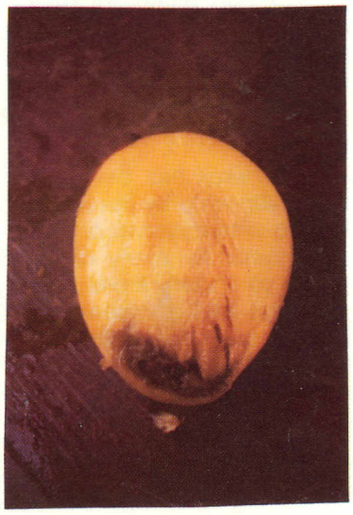

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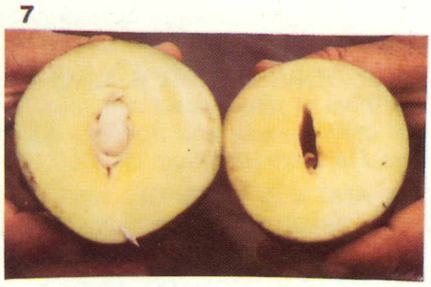

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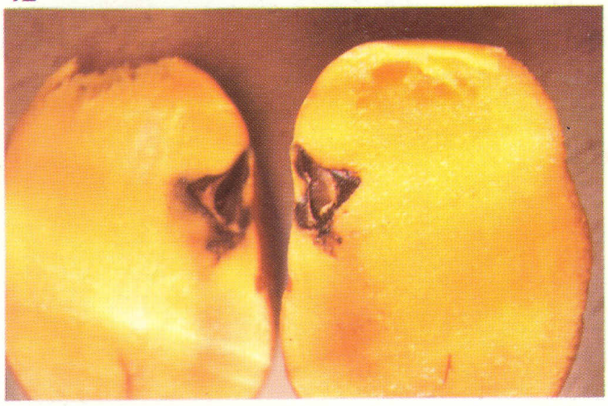

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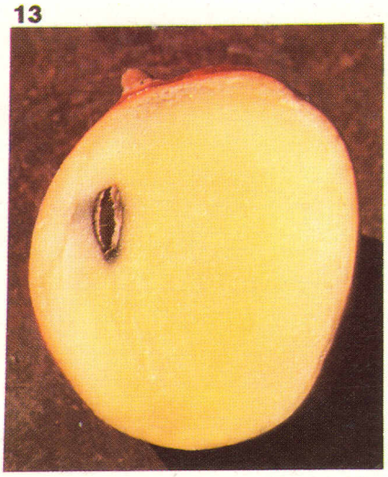

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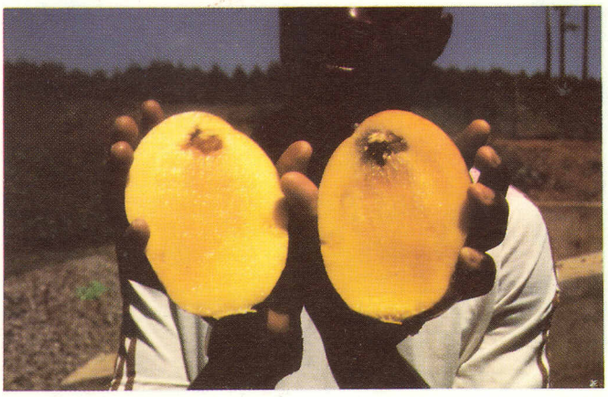

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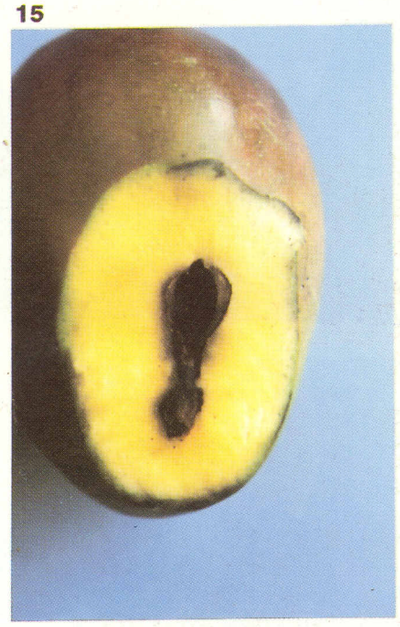

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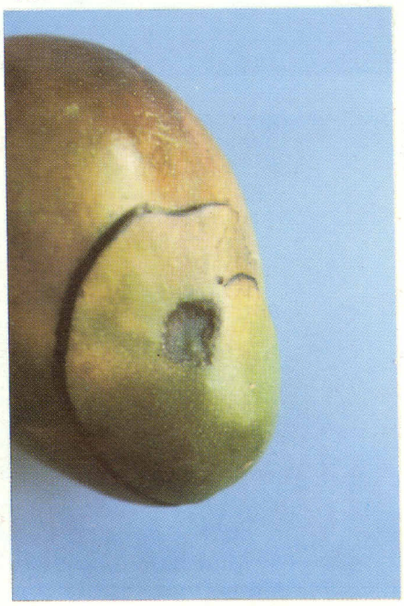

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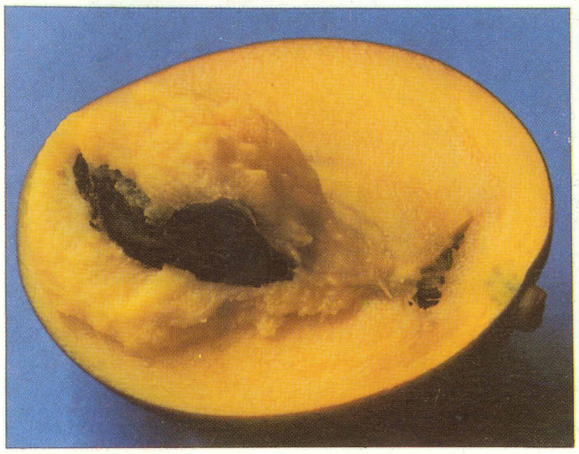

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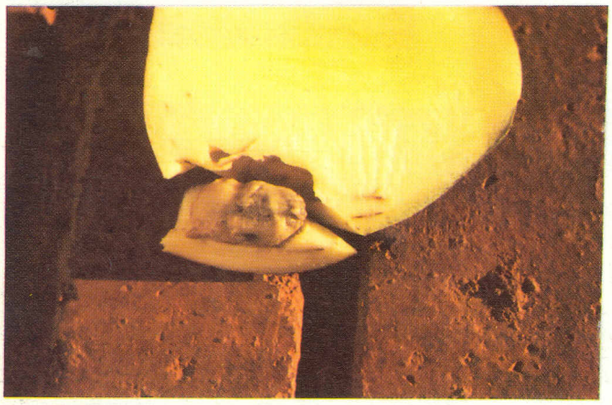

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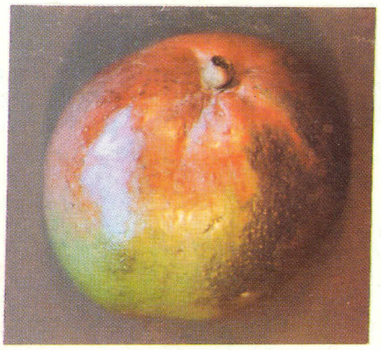

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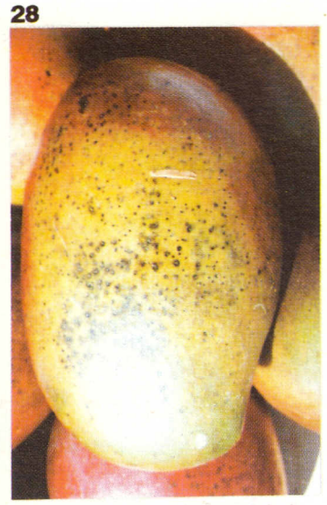

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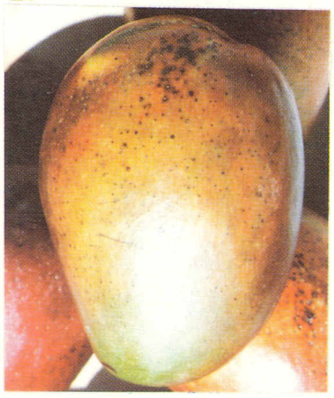

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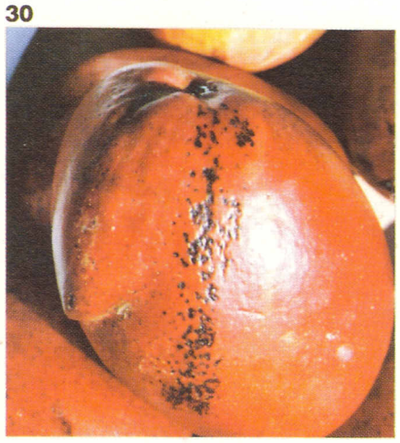

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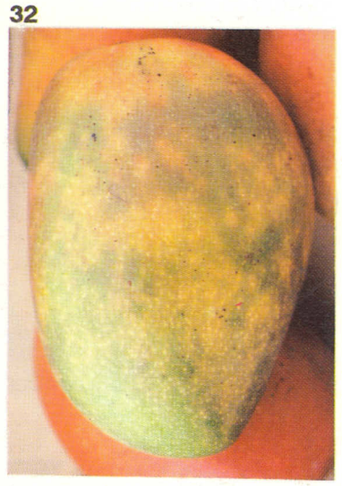

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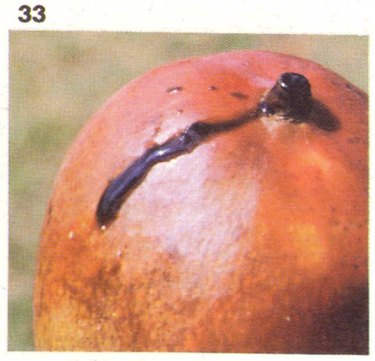

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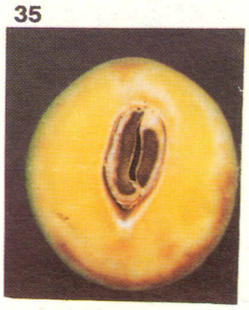

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