DETERMINING INTERNAL QUALITY OF MANGO FRUIT

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Why Determine Internal Quality of Mango Fruit?

Mango (*Manifera indica* L.) is a tropical fruit originating in the Indo-Burma region (Mukherjee 1972) and currently grown in many tropical countries and frost-free regions in the subtropics. It has been cultivated for more than 4,000 years and is said to be as important to the tropics as apples to temperate America and Europe. The fruit has a unique taste, pleasant aroma and flavor, and contains more vitamin A than most fruits. It is mostly consumed raw as a dessert fruit, and small quantities are also processed into mango juice, jams, jellies, nectars, and preserves. Eastern and Asian cultures use unripe mangos for pickles and in chutney, relishes, and sauces (Wanitprapha et al. 1991; Jain 1961).

Considered an exotic fruit, a good quality mango fruit is highly desired and fetches a good price in the world market. Thus, for Hawaii, which aims for the competitive but lucrative export markets and also its local/tourist market, it is of significant importance to develop a viable mango industry based on high quality fruit.

In Hawaii, the commercial production of mango is still rather limited due to production techniques and practices. Shipment to the U.S. mainland is presently prohibited due to the presence of the mango weevil (*Cryptorhynchus mangiferae*), which is not found in other mango-growing areas of the United States. This problem can be thwarted, either by controlled atmospheric (CA) storage, irradiation, or through development of an effective treatment to disinfest mangos of the mango weevil. Currently, mango fruits from Hawaii can be exported to Canada and some European countries without any difficulty.

The potential of the mango industry in Hawaii is good due to recent interest in commercial production. The large number of tourists makes it possible to develop a local market in Hawaii. The major potential is envisioned in the export of mango fruit. While the future opening of the U.S. market to mango fruit shipped from Hawaii would improve the viability for increased commercial production, the major potential is visualized in the Far East markets. In 1989, Hong Kong imported 14.6 million lb of fresh mangos at a value of $6.1 million, Singapore imported 24.3 million lb of fresh and dried mango, avocados, mangosteens, and guavas, Japan imported 11.6 million lb of fresh mangos (Wanitprapha et al. 1991). Japan, in particular, is considered a preferred target for future export of mangos from Hawaii because of the high prices, which exceed $15,000/t, obtained for high quality mango fruits and gift fruit packages even sell for $110 per package of four fruits. Since demand for fresh mango fruits is constantly increasing, and mango imports in Europe and North American markets have increased ten-fold since 1975 (Wanitprapha et al. 1991), a major potential exists for developing the mango industry in Hawaii based on high quality fruit destined for export.

An ensured supply of high quality fruit is the key to a successful export. This can be guaranteed only from productive commercial orchards with selected varieties, proper control of the harvesting of fruits with a proper degree of maturation, and selection of high quality postharvested fruits for packaging and export. With technology available to ensure high quality fruit, there will be sufficient incentive to solve the quarantine problems. In fact, ensuring high quality fruit may solve the quarantine problem. Quality of fruit consists of various attributes and is defined differently by various researchers. One of the major quality characteristics, however, which is directly related to consumer acceptance, is the fruit maturity at harvest. While in general usage, "mature" is a term that is synonymous with "ripe," most postharvest technologists consider "mature" to the stage at which a commodity has reached sufficient development that after harvesting and postharvest handling (including ripening, where required), its external and internal quality will be at least the minimal acceptable (Kader 1991). It is generally considered that the fruit ripens after it is physiologically mature.

Today, there are no known external or visible changes in mango fruit which could be used for the accurate determination of internal quality. External fruit maturity indices such as color, size, and shape provide only approximate information on the internal quality characteristics (Thangaraj and Irulappan 1989). If an immature mango fruit is harvested, it will not ripen at all, or will ripen improperly. On the other hand, an over-ripe mango fruit will decay rapidly after harvest. In addition, mangos on the same tree mature at different times, making harvesting at the right time a handicap for marketing. An optimal index of maturity for harvest is especially crucial for fruit destined for export because of the long shelf-life required. Consumers generally prefer to buy ripe fruits, and it is important to maintain a consistent quality of fruit on the shelves. Thus, preharvest detection of maturity indices will aid management of harvest, handling, and marketing of the fruits. Subsequent on-line postharvest sorting for maturity uniformity will assist in obtaining high quality fruit with long shelf-life, mandatory for the competitive export market.

Maturity of mango fruit is not defined explicitly in the literature; hence, different scientists have viewed it in different perspectives (Peacock 1984). Many studies have been reported on maturity measurement of mango, but with marginal success. Most of these studies applied destructive measurements of the internal quality. Only very limited work has been done on the relationship of the external and internal quality attributes to support the development of a reliable, objective, nondestructive technique to accurately estimate the internal fruit quality. It is well known that mango fruits become soft after they mature. Thus, emulating the manual judgement of maturity which involves pressing the fruit with fingers by measuring the fruit response to some loading, together with the odor and appearance of the fruit as related to the internal quality of mango fruit, may provide a reliable method closely related to the consumer practice of estimating the internal fruit quality.

What Do We Know about Determination of Internal Quality of Mango Fruit?

Mango fruit varies considerably in appearance (skin color, shape, size), texture (firmness of the whole fruit), texture of the pulp and amount of fiber, flavor (volatile profile), and taste. The shape varies from round to ovate-oblong and the skin color from green through yellow to red (Hulme 1971). Cultivated fruits weigh from about ¼ lb to 3 lb (Chia et al. 1988). However, not all varieties are cultivated on a commercial scale and most of them are found only in a particular area. The aroma of mango fruit is often spicy and alluring. The flesh is yellow to deep orange, juicy, and in the best varieties almost fiberless and melting in texture. The flavor is rich, luscious, and semi-spicy in the best varieties. The better types are comparable to the best quality peaches. The seed is relatively large and flattened. The tough woody outer coat contains a large kernel (Lynch and Mustard 1955).

Mango fruits are usually harvested at the physiological mature but unripe stage, 15 to 16 weeks after fruit setting (Lynch and Mustard 1955). They will be ripened and/or stored before marketing and consumption, to provide the optimal eating quality (Hulme 1971; Tripathi 1980; Kapse et al. 1988; Khurdiya and Roy 1988; Roe and Bruemmer 1981; Roe and Shrimath 1967; Roe et al. 1970; Satyan et al. 1984; Vazquez-Salinas and Lakshminarayana 1985; Bartley and Schwede 1987; Chaplin 1984; Ashraf et al. 1981). International trade in mangos is currently restricted because of unpredictable quality and often high market losses. Information on the postharvest physiology of mango fruit has been reported by various researchers (Brown et al. 1984; Chaplin et al. 1982, 1990; Medlicott and Thompson 1985; Mukerjee 1959; Medlicott et al. 1986; Pantastico et al. 1984; Popenoe and Leong 1957; Yoneya et al. 1990; Krishnamaurthy et al. 1960; Salunkhe and Desai 1984; Sharaf et al. 1989; Shashirekha and Patwardhan 1976; John et al. 1970; Chowdhury 1950; Lazan et al. 1986a, b, c; Pantastico et al. 1984; Kane et al. 1982; Peacock et al. 1986; Veloz et al. 1977; Medlicott et al. 1990a, b; Matto and Modi 1970; Mann and Singh 1975, 1976; Miller et al. 1991; Rolz et al. 1971; Yanko et al. 1984; Yuniarti 1982). These studies focused mainly on destructive evaluation of physico-chemical parameter of the flesh in the mango fruit. Parameters which have shown some usefulness for determining maturity in mango are the softening of the flesh; a decrease in acidity; an increase in sugars, soluble solids, and total solids; and an increase in carotenoid pigments.

Research on preharvest physiology of mango has also been reported (Anantnarayanan and Pillai 1968; Baker 1984; Harkness 1949; Hussein and Youssef 1972; Krishnamurthy and Subramanyan 1973; Kosiyachinada and Pankasemum 1990; Kosiyachinda et al. 1984; Medlicott et al. 1990a; Mukherjee 1959; Nip et al. 1992; Peacock et al. 1986; Popenoe et al. 1958; Suryaprakasa Rao et al. 1970 1972; Teaotia et al. 1968; Wang and Shieh 1990). Again, most of these studies are focused on the destructive measurements of the physico-chemical parameters of the fruit pulp. Chemical parameters which have demonstrated some usefulness for determining maturity of the fruit before harvest are the solid content, acidity, carbohydrate content, volatile compounds, and phenolic constituents. Physical parameters, such as shape and size, surface and flesh color, lenticels, shoulder growth, pit around the pedicel, specific gravity, heat units, etc., have been used. None of these parameters are foolproof methods for determining internal quality. The situation gets more complicated when different varieties are involved. Evaluating maturity requires a combination of parameters coupled with considerable experience. Therefore, variations in fruit maturity are bound to be inevitable in commercial harvest using these existing practices. This situation must be improved in order to compete in the lucrative export and local market of mango. Development of more reliable, nondestructive quality evaluations of mangos before harvest and at the packing site is critical to the success of a mango industry.

Nondestructive quality evaluation of horticultural crops to guarantee quality have been reported and reviewed by various researchers (Abbott et al. 1992; Armstrong et al. 1989; Ballinger et al. 1978; Bhambare 1991; Brecht et al. 1991; Bower and Rohrbach 1976; Marion et al. 1978; Finney 1970 1978; Finney and Norris 1973; Dull 1978, 1986; Chan and Forbus 1988; Dull et al. 1989; Forbus and Senter 1989; Forbus and Dull 1990; Forbus et al. 1985, 1991a, b; Garrett and Furry 1972; Lee and Rohrbach 1983; Lenker and Adrian 1971; Mahan and Delwiche 1989; Nip et al. 1992; Robertson et al. 1992; Sarig 1989; Sarig and Nahir 1973; Toivonen 1992). Crops investigated include blueberries, grapes, almonds, pecans, seeds, oranges, peaches, cherries, tomatoes, papayas, cantaloupe, persimmons, apples, watermelons, onions, lettuce, melons, etc., as well as mangos. The techniques include x-rays, ultraviolet, visible light, infrared, microwaves, nuclear magnetic resonance, ultrasonic, sonic, deformation/compression, acoustic impulse, dielectric properties, fluorescence, delayed light emission, reflected radiation, and transmitted radiation. Even though these researchers claimed the usefulness of these techniques in the laboratory, the techniques suffered from the drawbacks of using expensive indoor equipment, lack of flexibility of the equipment, reliability of the technique, inefficiency, and unsuitable application for preharvest or postharvest quality evaluation. Electronic and mechanical technology has advanced to the point where development of miniature low-power sensors is possible for properties such as firmness and reflectance.

In order to reduce the reliance on the experience of workers for picking and sorting products for high efficiency and quality uniformity, development and refinements of nondestructive quality evaluation of agricultural crops must be increased. In the case of mango, there is only limited work reported on nondestructive quality evaluation of mango before and after harvest that is applicable in the field and in the packing house (Nip et al. 1992, Peacock 1984). It is generally agreed that the mango fruit will soften when it ripens. Thus, emulating the manual judgement of maturity which involves pressing the fruit with fingers, by measuring the fruit response to some loading, may provide a reliable method closely related to consumer acceptance and that of the experienced worker in the field and in the packing house.

Will Nondestructive Methods Work for the Determination of Internal Quality of Mango Fruit?

As indicated earlier, it is generally accepted that mango fruits soften after they mature and continue to ripen. Consumers also use their judgement on the load response of their fingers when they pick up the fruits. Dull (1978, 1986) summarized published information on the use of deformation/compression as a nondestructive technique on the evaluation of pear, grape, peach, apple, tomato, onion, and melon. However, this approach has not yielded to automation in commercial practice. In the case of preharvested fruits, the same hypothesis will also be applicable since workers in the field rely on their judgement of the load response of their fingers when they pick the fruits.

For 'Haden' mangos, it has been reported that the fruits will show a color break. This is shown as a yellow spot usually toward the blossom end (Lynch and Mustard 1955). However, it is difficult for this sensory evaluation to be accurate. A more objective evaluation is highly desirable. It is also believed that there is a change of the volatile profile of the mango fruits when they mature and ripen. However, this index is also difficult to be practicable, especially in the field. It is our belief that pressure tests on the fruit before they are picked from the tree and before putting them in the box for shipment may be a reliable index, because this will simulate the response of touching or picking up the fruits. If this hypothesis is proven accurate, mechanized processes may be possible to pick the fruits in the field and also sort the fruits before packing. In consequence, quality of mango fruits can be predicted at the wholesale or retail level. Mango fruits of guaranteed quality will be possible. This will have significant impact on the development or expansion of the mango industry.

Preliminary Work at the University of Hawaii.

Research was conducted recently in Hawaii on three cultivars of mango ('Haden', 'Pope', and 'Fairchild') on the relationship of physico-chemical parameters of postharvest ripened mango fruits (Yoneya et al. 1990). Regression analyses of these mango fruits' firmness (as measured by the Instron Universal Texture Tester) and their physico-chemical parameters showed that there is a definite correlation between fruit firmness and some physiological indices such as total soluble solids/titratable acidity ratio, pulp firmness, and color (Nip et al. 1992). Physico-chemical and physiological changes of postharvest mango fruit and its quality control methods are also reviewed (Yoneya and Nip 1991). These research findings showed that there is an urgent need of methodology to predict the internal quality of preharvested and postharvested mangos in order to guarantee the quality of mango fruits most preferred by consumers. Fruit hardness seems to show promise as a reliable index to meet this need. However, considerable refinement on the methodology is needed to perfect this technique in order to be practical.

How Should We Develop the Methodology Needed for the Determination of Internal Quality of Mango Fruits in Hawaii?

The main objective of this conference is to gather all the information related to the development of a viable mango industry in Hawaii. With the information collected in this conference, we should be able to identify the problems and constraints related to the development of a mango industry in Hawaii. We should work together to develop a systematic approach to solve these problems and constraints in order to be successful in this endeavor.

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