



## **Fresh-cut Mangos as a Value-added Product**

**The Big Picture:** In today's time-crunched society, the market for fresh-cut mangos shows great potential. Logistically, however, the process of getting great-looking, flavorful fresh-cut fruit into consumers' hands affords many challenges. In an effort to see what the future holds for fresh-cut mangos, the National Mango Board has researched what steps need to be taken to secure the fresh-cut segment of the industry.

According to research by Professor Adel Kader of the University of California-Davis, demand for fresh-cut mango products would increase if processors could provide consistent quality, and especially flavor, to their retail and foodservice customers.

Securing good quality and flavor in such a highly perishable product requires much scrutiny. Most processors are aware of the factors that affect shelf life – proper sanitation and cold chain maintenance. Still, much needs to be studied to determine the best treatments for fresh-cut mangos to ensure maximum shelf life and a tasty product.

- 1. Incoming fruit must be top-notch. To maximize the volume of fresh-cut fruit, processors must work with suppliers to receive large, ready-to-cut (nearly ready-to-eat) mangos and varieties with less fiber for better taste and texture.**
  - Mangos picked at the mature-green stage need to be ripened, at least partially, before cutting to ensure good flavor quality as a fresh-cut product.
  - Regardless of the ripening method, “firm-ripe” (or half-ripe) fresh-cut mango cubes are best able to withstand processing demands, while riper fruit is more likely to show flesh browning and loss of firmness. Finding a middle ground between firmness and superior flavor of fresh-cut product is key.
  - Large mangos (8 or fewer per 4-kg box) are preferred because they give a higher yield. Processors note that yield can vary from 35% to 50% depending on the seed size relative to fruit size and the amount of flesh pieces that are excluded to improve uniformity of packaged product. Comparable yields are obtained by IQF processors of frozen mango products. In contrast, yields in-home or in a foodservice environment could be much higher. For example, a study conducted by Mattson on behalf of the NMB resulted in fresh-cut mango yields ranging from 60-70% in a foodservice setting.
  - With regard to fiber content, research shows that mango processors prefer the Keitt and Kent varieties. The Ataulfo variety is preferred by some consumers for its smooth texture.
- 2. Proper methods of preparation are essential for ensuring high-quality fresh-cut fruit.**
  - Washing whole mangos with some kind of disinfectant before cutting significantly reduces total microbial populations on the skin. (Left untreated, these germs can be spread to the inside of the fruit as it's being cut). Sanitizing the whole mango before it is cut also helps to increase shelf life because such treatment retards the breakdown of mango tissue.
  - Treating the fresh-cut mango cubes with spoilage-reducing chemicals also helps to extend shelf life and reduce browning. Specifically, the effects of sodium chlorite on fresh-cut mangos to control pathogens warrants further evaluation, Kader notes.

- Using very sharp tools to peel and slice mangos is critical in minimizing damage and browning to the cut fruit. Complete removal of the skin with a very sharp knife or peeler helps to avoid brown discoloration of the remaining peel tissues (which appears faster than flesh tissue browning in fresh-cut mangos).
- The industry should work to develop new technologies by automating as many processing steps as possible to help reduce labor costs. While cutting fruit by hand can result in less damage than mechanical peeling, the latter method is more consistent in the types of cuts made. Cost and efficiency of cutting/peeling methods should be evaluated before one method is recommended over another. The goal should be to attain an average yield of 50%.
- The “Best if used by” date should be determined for each lot of mangos when processed, taking into account the ripeness and softness of the fruit as well as the time elapsed between harvest and cutting.

**3. Maintaining proper temperatures and humidity levels for mangos throughout their harvest and processing cycle is the single most important factor in producing high-quality, visually appealing fresh-cut fruit.** Delays between harvesting and cooling or processing can lead to external damage (water loss and decay) and internal damage (losses of flavor and nutritional quality).

- Studies indicate that 2°C to 5°C (36°F to 41°F) is the optimum storage temperature range for fresh-cut mango cubes. Research also shows, however, that fresh-cut mangos may tolerate 0°C to 1°C (32°F to 34°F) storage temperatures for less than 10 days before showing signs of chilling injury.
- For every 10°C (50°F) increase in temperature of the fruit, deterioration and the rate of loss in nutritional quality accelerates two-to three-fold.
- For optimal results, whole mangos in transport to processors should be kept at a relative humidity of 90% to 95%. After being processed, fresh cut mangos should be kept at a relative humidity of 95% to 98%.

**4. The industry needs to explore a variety of chemical treatments aimed to help preserve the quality of fresh-cut mangos. The ultimate goal is to identify the treatments that will preserve flavor in addition to maintaining proper texture and appearance of the fruit.** Research shows that mango cubes with no chemical treatment had significantly lower visual quality scores than those treated with various chemical solutions.

- Adding a 1% calcium chloride solution to fresh-cut mangos is essential for maintaining the firmness of cut fruit, research shows. Such treatment extends the shelf life of fresh-cut mangos by up to four days over treatment with distilled water with fruit stored at 5°C (41°F).

- If the marketing period for fresh-cut product is more than 6 days, additional chemicals are recommended to help delay browning. Chemical dips that show promise for mangos include ascorbic acid, citric acid, L-cysteine and/or N-acetylcysteine. To minimize cost, one research study shows that a mixture of ascorbic acid and L-cysteine in addition to 1% calcium chloride may be a good choice for maintaining the quality of fresh-cut mango cubes. Mango pieces treated with such antioxidants were shown to maintain good visual quality for up to 21 days at 5°C (41°F).
- In addition to the aforementioned chemical treatments, applying ethylene action inhibitors to fresh-cut mangos seems to further help delay softening and browning. Adding 1-methylcyclopropene to mango slices in combination with chemical treatment and/or modified atmosphere packaging has a synergistic effect on maintaining good appearance and textural quality. Its use should be further evaluated for fresh-cut mangos, especially since 1-MCP is now available in liquid form (AgroFresh Inc.).
- A combination of several of the treatments mentioned above, coupled with modified atmosphere packaging, shows the most promise for fresh-cut mangos with regard to delaying browning, softening and deterioration of the cut fruit. Research shows that combination treatments on fresh-cut mangoes have resulted in a shelf life of 9 to 21 days.
- Using irradiation to treat mangos may offer another avenue for cutting down on microbes on the fruit, but it requires further study to determine the positive and negative effects. Preliminary research shows that irradiation at 1 kGy alone or in combination with other treatments may offer health benefits, but the cost/benefit ratio of this treatment must be evaluated before it can be recommended for commercial use.

**5. To further maximize shelf life of fresh-cut mangos, controlled atmosphere packaging treatments should be considered to help slow browning and softening and to prevent nutrient loss.**

- Researchers have experimented with several combinations of gases including oxygen, carbon dioxide and nitrogen as a way of decreasing spoilage microorganisms. A treatment of 2% oxygen, 10% carbon dioxide, and 88% nitrogen has proven effective, as has a combination of 4% oxygen, 10% carbon dioxide and 86% nitrogen.
- The use of polymeric films for packaging fresh-cut mangos also shows promise. Mangos packed in polyethylene terephthalate (PET) clamshell trays had a shelf life of 14 days at 3°C (37°F) versus 11 days for mango cubes in other packages, according to researchers. Packaging fresh-cut mangos in rigid containers is essential to reducing water loss and mechanical damage during distribution.
- Studies show that controlled atmosphere packaging of mango cubes helps to retain nutrient content of the fruit. In fact, low temperatures and modified atmospheres can preserve quality and antioxidant capacity of fresh-cut mangos for up to 10 days. In general, though, fresh-cut mangos visually spoil before any significant nutrient losses occur.

**Looking ahead:**

Members of the National Mango Board believe that the future of the fresh mango industry will depend on the sales of new value-added fresh mango products. For this reason, the Board initiated a fresh-cut mango research program in 2008 as an avenue to increase fresh mangos sales.

Understanding the mechanisms that affect the flavor and texture of fresh-cut mangos (like ripeness when harvested, treatment with chemical dips, adding modified atmosphere, etc.) could lead to new technologies that will help to preserve the fresh flavor of mangos as well as technologies that will help to reduce labor costs. Ensuring good flavor for fresh-cut mangos is important because it will affect how consumers perceive the fruit overall. Driving demand for fresh-cut mangos through retail and foodservice outlets should help to boost overall sales of the fruit as more consumers add mangos to their plates. More research in this area will be funded by the NMB next year.