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FRUIT CRACKING: A MAJOR CHALLENGE IN FRUIT PRODUCTION

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Abstract

Fruit cracking is a widespread functional disorder that affects both the skin and flesh of fruits, leading to reduced quality and quantity. This issue is common in many fruit crops and can also occur after harvest. Cracked fruits lose market value due to their poor quality, making them unsuitable for sale. Several factors contribute to fruit cracking, including orchard management practices for example irrigation and nutrition, environmental conditions like temperature and wind, and the specific fruit cultivar or genotype. To reduce fruit cracking, proper orchard management is essential, focusing on minimizing water stress and addressing nutritional and physiological factors. Hence, this article discusses the effects, mechanism and types and remedies of fruit cracking affects in different fruit crops.

Keywords: Fruit cracking, Physiological disorder, Mechanism, Environment.

Introduction

Fruit production is vital for agriculture, nutrition, and the economy. Fruit production is increasing worldwide due to rising demand caused by population expansion, health awareness, and a shift toward plant-based diets. Countries such as China, India, the United States, and Brazil are among the leading fruit producers. India is the world's second largest producer of fruits. Mango, banana, citrus, guava, papaya, and apples are among the most produced fruits. Fruit cultivation faces several challenges that might affect productivity, quality, profitability, and market value. Fruit cracking is a physiological disorder in which the fruit surface breaks, usually because of intensive irrigation or rain following a lengthy dry spell. Fruit cracking can also happen after harvest in some fruits, mainly due to storage conditions. This disorder is commonly seen in fruits like apples, sweet cherries, plums, apricots, litchis, bananas, pomegranates, avocados, citrus fruits, persimmons, grapes, pistachios, and peaches. While research on fruit cracking has been ongoing since the 18th century and fruit plant breeders have developed crack-resistant cultivars, there has been little more progress in completely understanding the causes and physiology of fruit cracking in fruit crops.

Extent of losses of fruit cracking

Several factors contribute to fruit cracking, including orchard management practices like irrigation and nutrition, environmental conditions such as temperature and wind, and the type of fruit cultivar or genotype (Singh *et al*., 2020). On average, fruit cracking results in a loss of 50-85% of the crop (Li *et al*., 2021). Cracked fruits lose value in the fresh market and are typically only used for processing, like fruit juice production, if they are not affected by fungal infections. These fruits are more vulnerable to storage diseases and have a shorter shelf life (Singh et al., 2020). Economic losses from cracking range from 10% to 40%, but in some cases, they can be as high as 70% (Singh *et al*., 2017). In pomegranate orchards, cracking can reduce fruit market value by 50%. Additionally, inadequate fertilization with calcium and boron increases the percentage of cracked fruits from 5.5% to 13.0% when either nutrient is missing from the solution.

Mechanism of fruit cracking:

The Fruit cracking is a complex physiological disorder influenced by multiple factors, including environmental conditions, orchard management, and genetic factors. The mechanism of fruit

cracking involves physiological, molecular, and biochemical changes within the fruit.

1. Physiological mechanism of cracking:

When plants do not get enough water for a while and then suddenly receive a lot of water, their fruits can start to crack. This happens because the tubes that carry water and nutrients through the plant get stronger when there's not enough water, but they don't grow and expand when the water supply is restored. The tougher tubes then burst, causing the fruit to split. Also, in hot and dry weather, the fruit peel becomes stiff and inflexible, while heavy rain during the wet season makes the inside of the fruit grow faster than the peel. This difference in growth rates can lead to the fruit peel breaking.

2. Molecular mechanism:

At the molecular level, several genes are involved in regulating processes like cell wall synthesis, cell expansion, and cuticle formation. Disruptions or mutations in these genes can make fruits more prone to cracking.

a. Cell wall related genes

Cell wall integrity is involved by several genes which are involved in pectin, cellulose, and hemicellulose biosynthesis etc. when cell integrity get disturbed by genes activity is impaired resulted in fruit cells may not strong enough leads to cell wall breaking ultimately cause fruit cracking. The cell expansion and softening regulated by expansion genes; overexpression of these genes leads to cracking.

b. Cuticle related genes

In cuticle formation the genes **LACS (long-chain acyl-CoA synthetase)** and **CYP86A (cytochrome P450)** are very crucial, reduction of these gene activity led to increasing permeability and allows more moisture resulting in cracking**.** In sweet cherries, the ***WINA*** and ***WINB*** genes code for ***AP2/EREBP*** transcription factors, which control various genes responsible for cutin and wax production. These genes show higher expression during the early stages of fruit development. Similarly, in apples, elevated levels of ***SHN3*** are linked to increased cutin and wax production and reduced russeting. In contrast, lower ***SHN3*** transcript levels lead to decreased cutin and wax content, resulting in microcracks and consequently greater russet formation.

3. Biochemical Mechanisms:

Biochemical factors like enzymes and metabolites also play a significant role in fruit cracking.

a. Cell -wall degrading enzymes

Cell wall membranes and tissue softer was due to pectinase, cellulose and polygalacturonase enzymes break down, increasing enzymatic activity during fruit ripening resulted in damage of structural integrity which resulted in fruit cracking.

b. Sugar Accumulation

During ripening the starch converts into water soluble sugars high level of sugars in ripening casus osmotic imbalance and draining the water rapidly and fruit cracking is promoted by increasing in internal pressure.

Fig1: Fruit cracking in Apple

Factors influencing the fruit cracking

Fruit cracking is influenced by various environmental factors, including temperature, fruit characteristics, lack of orchard management, and genetic factors. Temperature in arid and semi-arid zones increases cracking, while factors like humidity and rainfall also play a role. Over maturity in fruits like bananas and grapes, as well as excess water uptake, can also contribute to cracking. Lack of orchard management, moisture imbalance, and deficiency of boron and calcium can also cause cracking. Genetic traits, such as the thickness, flexibility, and cell structure of the fruit's epidermis and cuticle layer, can also affect resistance to breaking.

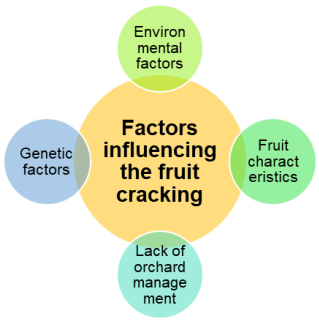

Fig 2: Factors influencing the fruit cracking

Measures to Control fruit cracking

- **Choose resistant cultivars**: Select fruit cultivars that are resistant to rain-induced fruit cracking.
- **Cover fruit plants**: Cover the top of fruit plants while allowing free airflow on the sides to prevent cracking.
- **Regular watering**: Maintain consistent moisture content in fruit by regularly applying water to the orchard.
- **Water sensitivity**: Avoid exposing plants to high or stressful water conditions, as these are very sensitive.
- **Windbreaks**: Plant suitable windbreaks around the orchard boundary at right angles to prevailing winds to reduce fruit cracking.
- **Use organic mulches**: Apply organic mulches like leaves and straw to conserve moisture, reduce evaporation, prevent weed growth, and add humus to the soil upon decay.
- **Maintain soil moisture**: Consistent soil moisture helps reduce the percentage of fruit cracking.
- **Bagging technique**: Use bagging to protect fruit from excessive sunlight, minimizing water loss due to transpiration through stomata.
- **Early fruit picking**: Harvest fruits early to avoid over-maturity or overripening, both of which increase the risk of cracking.
- **Grow resistant cultivars**: The most effective strategy to prevent fruit cracking is to grow highly resistant cultivars.
- **Hormonal spraying**: Use hormone sprays like GA3, NAA, 2,4-D, 2,4,5-T, and Ethephon at recommended levels to reduce fruit cracking.
- **Chemical spraying**: Apply 0.35–10% calcium chloride solution, which is effective in reducing fruit cracking in cherry orchards. Spray Bordeaux mixture containing copper sulfate (CuSO4) at a 0.1% concentration to reduce fruit cracking.
- **Apply anti-transpirants**: Use anti-transparents like glycerine or wax line to reduce water loss through transpiration from the leaf or plant surface

Conclusion

Fruit cracking can be caused by many factors, including the fruit's genetic traits, such as its size, firmness, and ripeness, as well as poor orchard management practices like water stress, nutrient deficiencies, and pest or disease issues. Other causes include environmental factors like temperature and wind. To reduce fruit cracking, it is important to implement proper orchard management that minimizes stress from water, nutrition, and other factors. Additionally, selecting fruit varieties that are more resistant to cracking, while still maintaining good quality, is crucial for successful cultivation. In conclusion, a combination of effective orchard management and the cultivation of crack-resistant fruit varieties is the best approach to minimize fruit cracking and ensure healthier fruit production.

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Table 1. Types of cracking, causes of cracking, incidence in fruit crops and remedial measures of cracking

Types of cracking	Causes	Incidence	Remedy
Radial Cracking	-Rapid fruit growth due to sudden water availability -High humidity after drought	Common in fruits like cherries, and apples	- Maintain consistent soil moisture - Improve water drainage - mulching to reduce soil moisture fluctuation - Regulate irrigation intervals - Use growth regulators like GA (Gibberellic Acid) to reduce cracking risk
Concentric Cracking	-Uneven skin expansion due to rapid water absorption -Rainfall after dry periods	Seen in pomegranates and citrus fruits	- Provide balanced irrigation - Use calcium sprays to strengthen fruit skin - Avoid overhead irrigation
Splitting	- Sudden increase in water after a dry spell - High turgor pressure in the fruit	Common in grapes, litchis, and citrus	- Implement regulated deficit irrigation - Apply potassium to increase skin elasticity - Use shade nets to reduce sun exposure
Internal Cracking	- Nutritional imbalance (high nitrogen, low calcium)	Seen in apples, and mangoes	- Balance nutrient application - Use foliar sprays of calcium chloride or boron
Longitudinal Cracking	- Rapid fruit swelling, high internal pressure - Excessive use of nitrogen fertilizers	Common in stone fruits like peaches and apricots	- Maintain consistent moisture - Use anti-transpirants - Prune trees properly to maintain leaf-to-fruit ratio
Micro-cracking	- Low fruit cuticle thickness - High humidity and temperature fluctuations	Seen in grapes and berries	- Apply calcium and silicon sprays to strengthen the cuticle - Use wax coating or biocontrol agents to prevent pathogen entry
Bursting	- Temperature fluctuation during fruit ripening	Observed in fruits like watermelons	- Maintain uniform irrigation - Avoid late-season fertilizer applications - Harvest fruit at the right maturity stage
Endocarp Cracking	- High water absorption leading to cell expansion	Seen in cherries and litchis	- Use protective sprays - Avoid excessive nitrogen application - Delay harvesting or use plastic wraps to prevent direct rain exposure during critical growth stages