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Advances in Fruit and Vegetable Graders

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Introduction

In the fruit and vegetable sector, grading is a crucial step since it guarantees that the produce satisfies consumer needs and quality requirements. Usually, a variety of criteria are used to grade, such as size, shape, colour, texture, and flaws. The procedure is crucial for preserving produce quality, cutting waste, and boosting supply chain effectiveness. One of the most important steps in managing fruits and vegetables after harvest is grading. During storage and transit, it lessens waste and helps to preserve quality. Produce's marketability and value can be greatly impacted by grading according to size, shape, colour, texture, and flaws. Uniform fruits and vegetables, for instance, have a higher market value and are more appealing to consumers.

Grading has traditionally been accomplished by hand sorting and visual inspection. However, computerized grading methods have grown in popularity as a result of technological improvements. Based on predetermined quality criteria, these systems sort produce using computer vision and machine learning algorithms. Enhanced efficiency, accuracy, and consistency are just a few benefits that automated grading systems have over manual techniques.

Fig.: Fully Automatic Fruit and Vegetables Graders

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For grading fruits and vegetables, non-destructive methods including spectroscopy and hyper spectral imaging are also employed. These methods prevent damage to the fruit while evaluating internal quality attributes including sugar content and maturity. When it comes to evaluating fruits and vegetables according to different quality features, hyper spectral imaging has demonstrated encouraging results.

Fruit and vegetable grading has an effect on the marketability and quality of the food, but it also has an impact on the environment and the economy. Growers and retailers may experience higher waste and decreased revenue as a result of ineffective grading procedures. Sustainable grading methods can assist cut waste and raise the produce industry's general sustainability. Examples of these methods include the use of non-destructive quality testing tools and appropriate packaging.

Recent advancement in fruit and vegetables graders:

- **Automation and Robotics:** Automation and robotics have been increasingly integrated into fruit and vegetable grading systems. This includes robotic arms equipped with sensors and cameras capable of sorting fruits and vegetables based on size, colour, shape, and defects.
- **Machine Learning and Artificial Intelligence:** Machine learning and AI algorithms have been employed to enhance the accuracy of grading systems. These systems can learn from vast datasets of images to recognize and classify fruits and vegetables according to various quality parameters.
- **Multi-sensor Integration:** Modern grading systems often utilize multiple sensors such as cameras, near-infrared (NIR) sensors, and hyper spectral imaging to gather comprehensive data about the quality of produce. This multi-sensor approach allows for more precise grading.
- **Non-destructive Testing:** Non-destructive testing methods have gained traction in grading systems, allowing for the assessment of internal quality attributes without damaging the produce. Techniques such as NIR spectroscopy and acoustic resonance are used for this purpose.
- **Data Analytics and Traceability:** Grading systems are increasingly incorporating data analytics capabilities to provide insights into production trends, quality variations, and

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supply chain optimization. Additionally, there's a growing emphasis on traceability, enabling consumers to track the journey of fruits and vegetables from farm to fork.

- **Customization and Flexibility:** Grading systems are becoming more customizable and flexible to accommodate different types of fruits and vegetables as well as varying quality standards. This allows producers to adapt the grading process to their specific requirements.
- **Reducing Food Waste:** One of the primary goals of advancements in grading technology is to reduce food waste by accurately sorting and grading produce. By identifying and separating out defective or substandard fruits and vegetables early in the process, grading systems help minimize waste throughout the supply chain.

Conclusion

There are various methods of grading fruits and vegetables, and each method has its advantages and limitations. Manual grading is the traditional and most widely used method, but it is time-consuming, labour-intensive, and prone to errors. Mechanical grading, on the other hand, is faster, more consistent, and accurate but requires significant capital investment. Machine vision-based grading has gained popularity due to its high accuracy, speed, and automation, but it is limited by the need for high-quality images, the complexity of algorithms, and the requirement for constant calibration. Near-infrared (NIR) spectroscopy-based grading is a promising method for rapid, non-destructive, and objective grading, but it requires extensive calibration, and the cost of the equipment is high.