# Automatic detection and rejection of avocado fruits with internal damage caused by ripeness and of seeds with poor sprout capability

*Low-Energy, High Contrast, High Resolution X-ray Technology*

Fig. 1. HYMCIS low-energy X-ray system

The InnospeXion food inspection system is based on the **newest and most effective X-ray technology**, providing high contrast and high resolution X-ray images.

The high quality X-ray images is a necessity for **the automatic identification and detection of damages** in fruit and similar products.

The unique technology has been **proven in numerous applications** during many years, e.g. for fish bone detection in the fish processing industry, for chicken bone detection, and for quality sorting in food industries.

Hence, the technology satisfies the requirements of the food processing industry, e.g. concerning **hygiene, robustness, cleaning, detection performance, and false reject rate**.

**We offer an integrated technology**, including tailoring towards individual sorting, reject, and other automation requirements.



## THE AVOCADO INSPECTION PROBLEM

The quality, price, and overall sales parameters for Avocado and other fruits is related to their ripeness and damages that they may have suffered upon transport. Avocado is especially vulnerable to become overripe, a condition which may be difficult to distinguish from ripe fruits, and a condition which makes the fruit worthless.

## THE SEED SPROUT INSPECTION PROBLEM

Expenses on care-taking of seeds with bad sprout capabilities, and the cost of farm surfaces or forest land without crops, are significant. Therefore, for some crops and types of seeds, the sprout capability assessment has a large value.

In both cases, low-energy X-ray scanning can be applied cost-effectively to perform the sorting to ensure that the product has the highest possible value.

*The food quality sorting system is a variety of the "HYMCIS" products, which have been on the market since 2006. The technology has received innovation awards due to the high quality X-ray images acquired and analyzed in real time. The technology is robust, reliable, and very well proven for demanding 24/7 applications worldwide. Developed, Engineered, and Made in Denmark*

## X-RAY IMAGES OF NON-RIPE, RIPE, AND DAMAGED/OVERRIPE AVOCADO SAMPLES

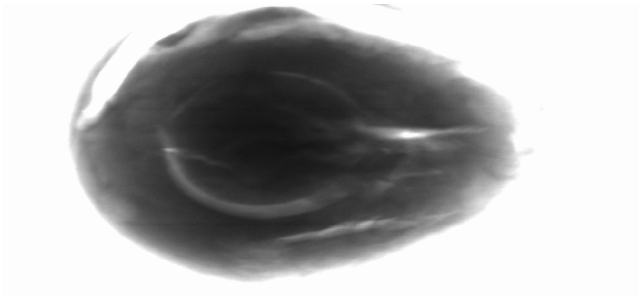

Fig. 2. Low-energy X-ray image showing two avocado with obvious internal structural deterioration (white areas and uneven structure).

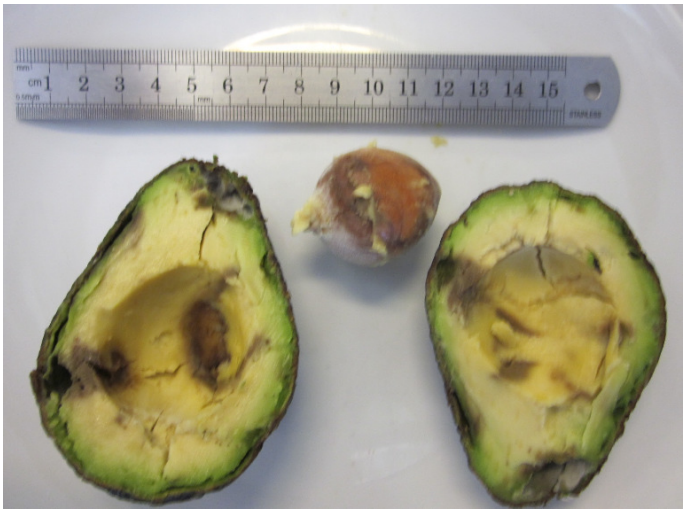


Fig. 3. Partly decomposed avocado (X-ray image in Fig. 2)

Low-energy X-ray scanning of e.g. avocado fruits can be accomplished with the fruit travelling past an X-ray scanner on a conveyor belt. A sorting mechanism based on the ripe condition and possible damages can be positioned immediately after the X-ray scanner. This sorting mechanism reacts on the basis of the real-time image processing and image quantification of the X-ray scanner.
The ripe condition is readily discerned from the X-ray image. Fig. 2 shows two avocado fruits which externally look similar to others. The X-ray image shows a distinct gap between its core and the surrounding fruit. Upon sectioning (Fig. 3) the avocado is soft, starting decomposition and is locally mis-colored.

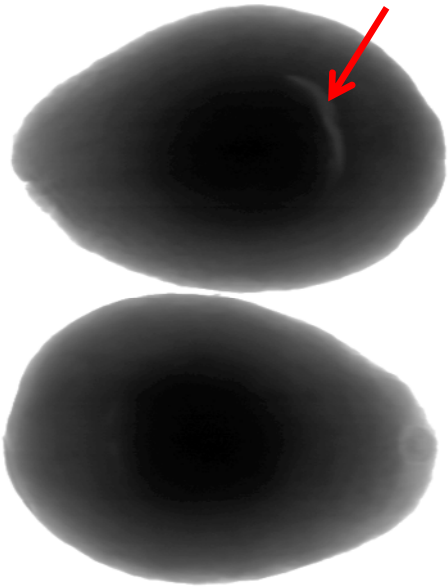

Fig. 4. Low energy X-ray image of two apparently undamaged avocados. Note that the fruit is homogeneous with similar density and very little void around the central kernel.

Fig. 5 and 6. The two avocado above, the one at the right correspond to the upper avocado in Fig. 4. Note the vague void (slightly brighter area, arrowed in Fig. 4 ) near the nucleus/kernel of this avocado. This correlates with this avocado being more ripe than the avocado in fig. 5, cf the X-ray image without internal details of this avocado, Fig. 4.

The X-ray images unveils that the ripe fruits correlates with a void development around the inner core, at the early stages of the ripe. Later, an uneven internal structure with cracks seems to correlate with the further ripe of the fruit, and this can also be correlated to a softer feel of the ripe avocado.

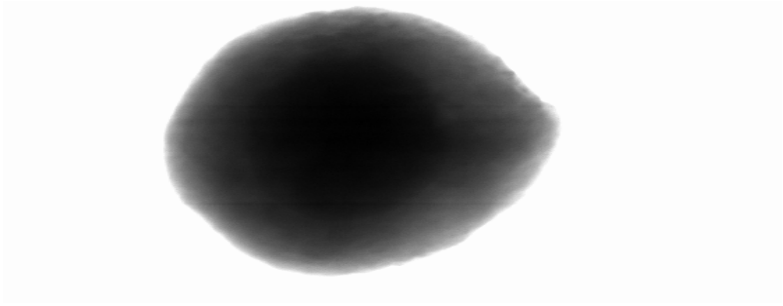

Fig. 7. Low energy X-ray image of two only partly mature (= rather hard on pressing) avocados. Even density and very little structural variation

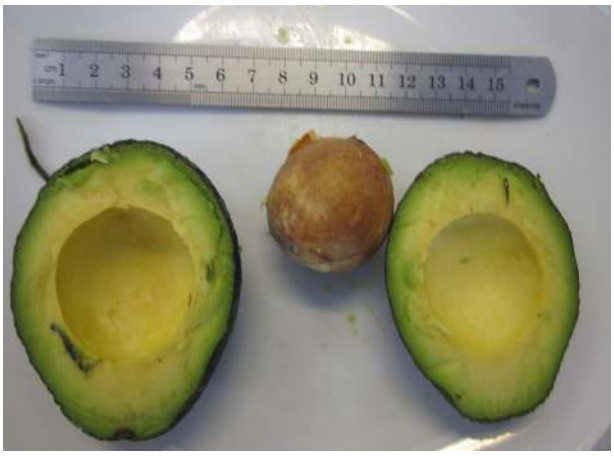

Fig. 8. Corresponding photo of the sectioned fruit. The fruit is hard, and un-ripe and the kernel was difficult to extract.



Figs. 7 and 8 shows the X-ray image and corresponding section image of a hard, un-ripe avocado. No structure can be discerned in the X-ray image. This is confirmed by the hard and homogeneous structure of the fruit.

Fig. 9 and 10. Low energy X-ray image of a “just at the ripe point” avocado. In the image at the right, the grey level range of the picture at the left has been adjusted to allow a study of the region near the central kernel. It can be seen, that the just ripe avocado has developed a small void between the central kernel and the surrounding fruit (see section image Fig. 11).

Fig. 11. At the ripe point avocado from Figs. 9 and 10.

## X-RAY IMAGES OF SEEDS

For seed inspection, they typically are inspected relative to the internal structure, especially the internal density. The inspection may take place with the seeds positioned in a tray. Low density and large internal voids in the seed implies that the seed may not have the sufficient sprout capability, and therefore must be rejected. For some seeds, the proportion of not useful seeds may be substantial. Fig. 12 shows an example where a relatively large proportion of the seeds in the tray have a lower than average density (white spotted seeds in right part of the image).



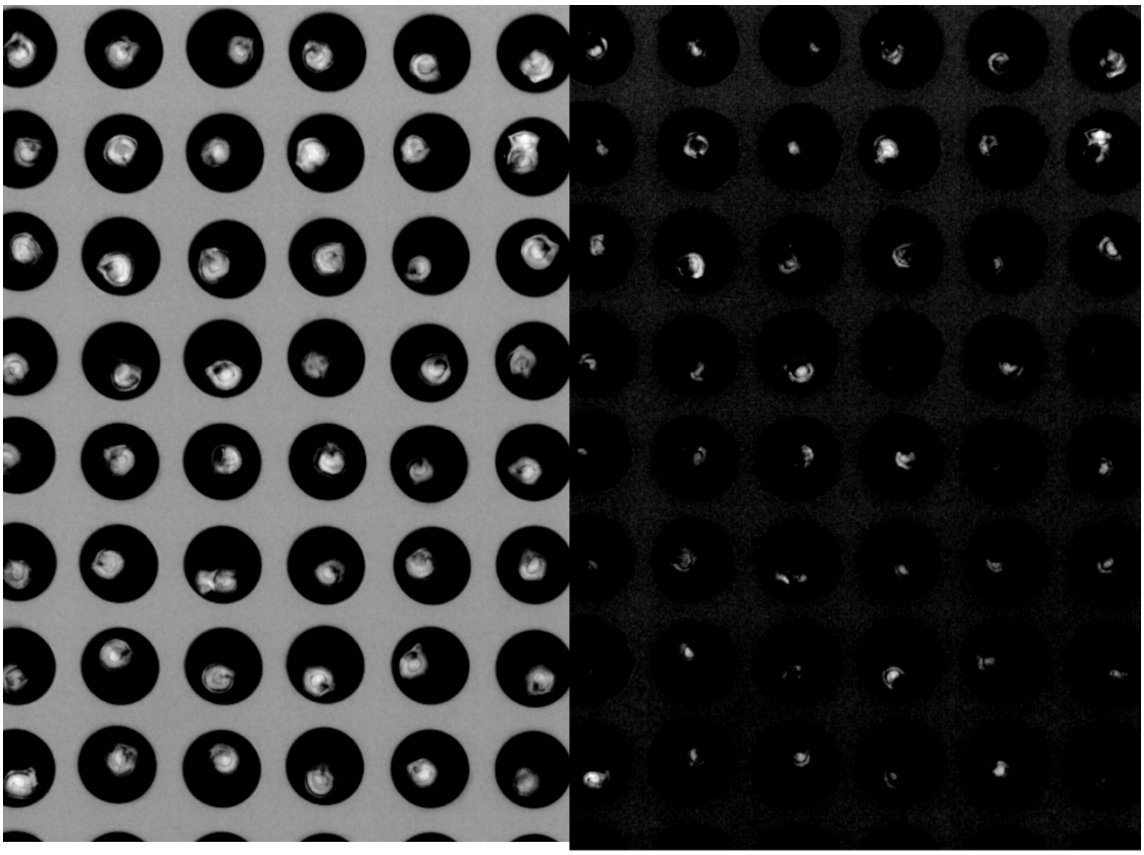

Fig. 12. Low-energy X-ray image of a tray with roe seeds (left part) and image analysed part (right). The latter shows the seeds with lower than average internal density. This is correlated to a smaller sprout capability. Reject of seeds is based on a deviation beyond 20% from the normal density range. Real-time scan at up to 10 m/min.

## THE AVOCADO AND SEED INSPECTION IN PRACTICE

A typical solution involves the scanning of the products being fed into the X-ray system on a conveyor belt, separated into lanes, or, in the case of seeds, presented in a tray. The speed of belt is typically about 12 m/min (limit is 27 m/min), and the inspection speed is around 1 avocado per second for each lane, or about 4 avocados per second at 12 m/min. For seeds, several hundreds of seeds may be inspected per second, depending on system geometrical lay-out.
For fruits, the conveying method involves a special conveyor with side guides, and the sorting method is based on 4 output signals (on PLC to potential free relays for mounting of reject/sorting devices) for each lane, e.g.: Over-ripe, ripe, un-ripe, and not assessed (other damage, movement during imaging, other). Typical operation duty cycle is up to 24/7. Typical error conditions involves: Rolling during imaging, dirt accumulation, wrong orientation, jamming of conveyor, bad conveyor adjustment.

## DISCUSSION & CONCLUSIONS

This study has unveiled that the internal structure of avocado can be traced to its stage of ripe, or damage state. This may have important applications, since the fruit quality can be difficult to evaluate on the exterior. Possible throughput may be 2-4 avocado per second, as a minimum.

For seed inspection, the technology offers a fast and cost effective means of verifying the sprout capability for valuable seeds.

In both cases the inherent high contrast, high resolution, and high sensitivity, achieved by the low energy technology is fundamental for the application.



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