



Trends in post-harvesting technology

Post-harvest technologies are converging around automation, energy efficiency, and digital integration. From threshing crops to tubers, the future lies in intelligent systems that preserve quality while meeting rising demands for sustainability and traceability.

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Farmers cultivate their crops over an entire vegetation period, and invest in sowing, fertilisation, care and harvesting measures. Their objective is to produce high-quality products – usually food, feed or energy. Losses, mechanical damage or spoilage after harvesting reduce their sales revenues or use on their own farms. Downstream customers' expectations of high-quality products with the most homogeneous characteristics possible (consistent product quality) are increasing at the same time. Added to these are consumer demands concerning sustainable (energy efficiency) and ethically justifiable production (reduced use of farm inputs, traceability).

Maintenance of harvested product quantity and quality

This is where post-harvesting technology comes into play. It encompasses all processes, equipment and methods that maintain the quantity and quality of harvested products, often relying on automation and improving work ergonomics at the same time. After harvesting on the field, the objective is to minimise damage or losses on the farm, during storage or during processing, often by means of cooling, drying or gentle conveying. Even during placement into storage, the products are sorted according to their planned use (e.g. according to size, weight, ingredients, colour or other quality characteristics) and unwanted foreign objects (e.g. soil, stones, damaged or diseased harvested products and other plant parts) are removed. Post-harvesting technologies improve storage stability and protect against spoilage or the degradation of internal and external quality characteristics.

Accordingly, post-harvesting technology is a broad field involving diverse machines, implements and processes and is concerned with a variety of crops and harvested products. The following will therefore initially address some general trends while the second part will focus above all on threshing crops and

potato technologies, whereby potatoes can also be regarded as representative of an entire range of vegetable varieties.

The explanations will focus on technologies that can be used on (specialised) farms. Downstream customers' technologies may include similar methods, but are not the main subject of this analysis. If companies and products are mentioned in the following explanations, these mentions are not comprehensive or exhaustive, but are instead exemplary.

General trends in post-harvesting technologies

- Full automation of machines and technologies with intelligent systems and self-learning units (self-regulation) with continuous process improvement
- In this case, integration into cloud-based farm management systems (FMS) with data-driven process monitoring using AI
- IoT connection for remote diagnosis and remote maintenance, combined with fewer and, above all, fewer unscheduled downtimes and consequently high efficiency of the high-tech processes (performance optimisation)
- Precise and effective cleaning through online sensor technology with high cleaning levels and avoidance of quality losses (breakage, diseased or damaged products)
- Increasingly, optical sorting by means of cameras, lasers, infrared and hyperspectral imaging, partly combined with NIR analytics and artificial intelligence for precise and fully autonomous separation into different quality grades or waste
- High, sustainable energy efficiency thanks to the use of waste heat, solar energy, biomass or heat pumps (key term: low emissions)
- Continuous documentation of processes

Threshing crops

Cleaning and sorting of threshing crops often go hand in hand. During cleaning, foreign bodies (stones, metal parts such as screws, etc.), dust, husks, weed seeds and damaged or diseased (mouldy) grains have to be removed. Proven physical techniques such as sieves are used, supported by targeted air flows and cyclones, which are combined with modern humidity and air flow sensors for automatic and intelligent self-regulation; these carry out adjustments depending on the degree of contamination, for

example (Bühler, Petkus, Cimbria). These are joined by infrared and camera systems for precise and effective foreign body detection. At the same time, they can be used to undertake sorting. In addition to sieves, new optical sorters, some of which also operate hyperspectrally, are also on the advance, often in combination with air technology (e.g. Petkus FTS, Bühler Sortex J, Cimbria SEA.CX). The 'optical sorters' also include technologies that operate with NIR spectroscopy (e.g. Cimbria, Bintec); some of these are able to analyse each individual grain (BoMill InSight) and sort them according to quality, e.g. protein content.

Threshing crops with an excessively high moisture content have to be cooled or dried after harvesting. In the case of cooling, the choice of pumps and cooling agents is particularly important as regards efficiency and the energy or environmental balance. In this segment, FrigorTec will be presenting the latest evolution of its proven cooling units with improved cooling agents (with a very low GWP value of almost zero) and a new refrigeration circuit (Granifor Europe green) at Agritechnica. This significantly reduces the cooling agent's environmental impacts and undershoots the statutory requirements within the EU (GWP <150).

Ventilation is improved by optimum, consistent filling of the silo, which prevents the formation of zones with different ventilation behaviour. To achieve this, Bintec has optimised a non-casting distributor. Frigor Tec also offers high-temperature heat pump dryers that combine gentle drying (quality maintenance) with heat recovery and energy savings. Stela will once again be presenting heat recovery from the entire drying air with a continuous dryer (AgroDry Recu). Almost all manufacturers of drying systems use at least part of the exhaust air for heat recovery (i.e. Skiold, Neuero, Horstkötter, Cimbria, Petkus). All modern drying systems are equipped with sensors for the real-time monitoring and intelligent control of moisture, temperature and humidity, and are connected to a management system. Precise settings therefore also enable a reduction in energy (gas, electricity) and losses (broken grains). The trend is currently shifting towards sustainable systems that are able to directly or indirectly use alternative energy sources (waste heat, solar thermal, biomass, heat pumps) and maintain product quality by means of low-temperature drying at the same time.

After placement into storage, it is crucial to continuously monitor the moisture content and temperature development of the threshing crops. Either wireless sensors or what are called 'grain cables' with real-time functions are used for this; these deliver measured values simultaneously at various locations and at different fill levels (e.g. Bintec). Under the key term 'smart drying', intelligent process control with networked, digital components has therefore also become increasingly important for threshing crops, from acceptance in the gutter to retrieval. At the same time, all of this technology is monitored by means of IoT (and AI), and potential downtimes are avoided thanks to predictive maintenance.

Potatoes and other tubers

When harvesting potatoes, onions or other tubers, initial mechanical cleaning is carried out on the harvester, sometimes in combination with manual sorting of undesired constituents (potato haulm, clods, stones, misshapen produce, etc.). Fundamental sorting is undertaken for placement into storage or retrieval, during which sorting can be carried out according to size, shape, colour (e.g. green discolouration) and surface characteristics. It is also carried out according to damage, anomalies, pressure bruising, wire worm infestation, dry rot, sprouts or shoots. The aim is precise, effective sorting with reduced effort and improved work ergonomics.

First and foremost, mechanical sorting and cleaning using roller, screen and flat screen sorters continue to play an important role in this. They are an essential preliminary stage ahead of downstream optical sorters. This high-tech sensor technology is used primarily in large-scale production facilities on washed potatoes and employs automatic cameras, lasers, infrared and hyperspectral imaging (e.g. CropVision from Downs, Eqrader TM from Ecraft, Raytec Vision's Opportunity, Karevo, Celox P-UHD Newtec, Visar Sortop, Bijlsma Hercules from GeJo Grading). In this process, self-learning systems continuously improve the quality of the sorting work. Systems with 360° image analysis are also used in addition to devices that visually sort unwashed potatoes via a drop step (photo shooters). To do this, the unwashed potatoes first have to be cleaned (roller cleaners, leaf separators, brush devices) and fed to the optical system individually on wide belts or conveyor elements. In combination with laser-based devices and/or hyperspectral image processing, internal defects or characteristics can also be detected (e.g. MAF Roda Sorters, GREEFA, AVEKA/Key Technology, TOMRA 3A from Tomra Food, Buhler Group/Sortex).

Artificial intelligence and machine learning enable adaptive learning with the objective of improving sorting performance in terms of quantity and quality. To achieve this, some devices are linked to the manufacturer, whereas others perform this task on site at the farmer's premises (e.g. AI belt sorter for potatoes, onions and carrots from Photoheyler). The undesired components are sorted out, or sorting into different fractions (size, shape, etc.) is carried out, mechanically (often with 'pinball' fingers), pneumatically (compressed air) or by means of sorting arms (e.g. robots from SiftAI). The trend is shifting towards lightweight mechanical ejection systems with low noise levels and energy consumption. As is the case with all digital machines and devices, focus is being placed on real-time data collection (IoT) for process monitoring and coupling with management systems. This can also be used for predictive maintenance. Future technologies such as 3D volume measurement directly on the harvester are being considered as the next stage of development.

Conclusion and outlook

Irrespective of crop type and harvested product, several technical trends are emerging in post-harvesting technology; these are focused on sensor-controlled automation (increasingly optical systems), efficiency improvements (particularly in terms of energy), digitalisation (IoT, FMS) and AI integration, sustainability (avoidance of losses and reduced use of farm inputs) and flexibility (scalability).

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About DLG

With more than 31,000 members, DLG is a politically independent and non-profit organisation. DLG draws on an international network of some 3,000 food and agricultural experts. DLG operates with subsidiaries in 10 countries and also organizes over 30 regional agricultural and livestock exhibitions worldwide. DLG's leading international exhibitions, EuroTier for livestock farming and Agritechnica for agricultural machinery, which are held every two years in Hanover, Germany, provide international impetus for the local trade fairs. Headquartered in Frankfurt, Germany, DLG conducts practical trials and tests to keep its members informed of the latest developments. DLG's sites include DLG's International Crop Production Centre, a 600-hectare test site in Bernburg-Strenzfeld, Germany and the DLG Test Centre, Europe's largest agricultural machinery test centre for Technology and Farm Inputs, located in Gross-Umstadt, Germany. DLG bridges the gap between theory and practice, as evidenced by more than 40 working groups of farmers, academics, agricultural equipment companies and organisations that continually compare advances in knowledge in specific areas such as irrigation and precision farming.

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