THE FRUITS AND VEGETABLES INDUSTRY SERIES

OECD-COLEACP Fruits and Vegetables Industry Series

Session 3 - Technology innovations for fruit and vegetables quality control

23 May 2022 – 10h00-11h30 CET
Online (Zoom)

1. Background

Delivering high quality and freshness of fruits and vegetables (F&V) is of paramount importance for the consumers and determines the selling price of the produces. Quality control is key in fresh-food retailing as quality often prevails over price and reducing food waste is critical..
Significant capital investments have been made to meet the changing consumers' demand for safer and better-quality foods. The food industry has also to contribute to deliver food that is better produced, distributed, stored and retailed and meets social and environmental standards and is constantly innovating to respond with efficiency to the increasing consumers' expectations.

Food preservation techniques can be classified as traditional or as emerging. Traditional techniques are based on the effects of temperature, reduction of water activity or pH, or addition of preservatives. Emerging or novel food preservation technologies are based on other processes.[1]
Four areas in which significant advances in quality maintenance have been made over the past decade include: (i) inhibition of ethylene action with 1-methylcyclopropene; (ii) postharvest treatments to maintain the quality of fresh cut produce; (iii) modified atmosphere, active, and intelligent packaging technologies; and (iv) increasing selection for postharvest quality traits and quality stability in fruit and vegetable breeding programmes.[2]
The main advantages of traditional food preservation techniques are lower operational costs, safety and the fact that they are well established and widely used. Emerging or novel preservation technologies may be an important complement to existing traditional processes

[1] Application of science and technology by the South African food and beverage industry. Lisa-Claire Ronquest-Ross; Nick Vink; Gunnar O. Sigge.
[2] https://www.ishs.org/ishs-article/875_1

for certain foods, but their use is associated with certain risks which need to be evaluated by industries and regulatory authorities prior to their commercialisation. Before successful development, implementation and adoption of a novel technology can take place, consumers' acceptance, product quality, preservation efficacy and final product safety need to be assessed.[3]
As the pressure in extending shelf life products, especially for fresh produce, new products are constantly being developed by the industry.

2. Defining quality control in fruits and vegetables

Quality control is an exploration carried out at different levels and scales to F&V to determine if they adequately comply with the expected characteristics to reach a final consumer. A good treatment in the quality control allows the products to always arrive fresh and with good flavor to the consumer, avoiding wastes in the way.

External characteristics taken into account in a quality control are:

- Firmness: This feature helps to determine the degree of ripeness of a fruit, is done regularly with a penetrometer directly from the fruit in the field.
- Color: This may be one of the most important characteristics, given it allows the consumer to have the feeling that a product is in good condition.
- Morphology: It is everything that involves the physical form of the fruit or vegetable, such as size, weight or curvature. Instruments such as scales, sizing machines and tape measures are used to make this measurement.
- Smell: Especially in fruits such as citrus, a factor that can be decisive is the aroma that the fruit gives off. This smell comes from aromatic substances present in both the skin and the pulp. Currently, one way to measure it through technology is with a gas chromatography combined with mass spectrometry.

Internal characteristics include:

- Soluble solids: This measurement is made with a refractometer and allows to know the amount of sugar present in a sample, normally known as the brix scale. This number allows not only to know the amount of sugars, but also indicates the maturity of the fruit and indicates the best time to harvest it.
- Acidity: It is obtained through the juice of the fruit with a pH electrode. In addition to the level of acidity present in the product being known, it allows to know what possibility exists of proliferation of microbes, since this factor directly affects the ease with which external agents can enter.[4]

Quality losses of fresh F&V are frequently attributable to an inappropriate use of postharvest technologies, bad handling of transport or improper postharvest preservation technologies. For each step of supply chain (packing house, cold storage rooms, precooling centre, refrigerate transport and distribution), innovative preservation technologies allow fresh products to their quality and nutritional characteristics.[5]

[3] Rodrigo, Dolores & Sampedro, Fernando & Silva, A. & Palop, Alfredo & Martínez, Antonio. (2010). New food processing technologies as a paradigm of safety and quality. British Food Journal - BR FOOD J. 112. 467-475. 10.1108/00070701080001384.
[4] Consentio. May 2021.
[5] Pace, B., & Cefola, M. (2021). Innovative Preservation Technology for the Fresh Fruit and Vegetables. *Foods (Basel, Switzerland), 10*(4), 719. https://doi.org/10.3390/foods10040719

3. Some examples of technological solutions to quality control

The majority of techniques applied to evaluate horticultural crops and cereal quality are invasive as they measure both their internal and external characteristic. Currently, diverse optical, electrical, aerodynamic, and mechanical non-invasive techniques are attaining significance owing to ease in functioning, rapidity, reliability, and their robust nature. However, a few of these emerging methods are presently being applied in research organisations, laboratories, and food processing units, while a few techniques are yet to reach an advanced phase.
Studies on the use of non-destructive techniques, including nuclear magnetic resonance, near-infrared (NIR) spectroscopy, Fourier transform infrared spectroscopy, hyperspectral imaging, computerized X-Ray tomography, electronic nose, and computer vision system, for fruit, vegetable, and cereal processing industries are summarized by Rifna et al.[6]
Various emerging, unconventional technologies (e.g., pulsed electric field, pulsed light, ultrasound, high pressure, and microwave drying) enable the processing of F&V, increasing their stability while preserving their thermolabile nutrients, flavour, texture, and overall quality. Some of these technologies can also be used for waste and by-product valorisation.[7]
There are many ongoing technological innovations led by the private sector companies or research programmes and we couldn't list them all.

Researchers are working on new **digital solution** to track changes in the quality of fresh F&V in real-time. This solution can reduce food waste by informing companies digitally about quality changes and potential later losses.
Delayed effect of the storage conditions has an impact on the quality of fresh F&V, which creates food waste. Consumers cannot always see the effect of inappropriate storage conditions, just that they will not be able to keep them as long as planned after buying them (i.e. 1-2 days instead of 5-6 days for strawberries).[8]
Predicting product quality and residual shelf life through monitoring the storage conditions in the supply chain, installing sensors in the trucks or on boxes with products are well-known useful practices.

Packaging plays an important role in the food manufacturing process by making packaged foods more convenient, extending shelf life, allowing distribution across wide geographies while maintaining quality and food safety as well as providing containment, marketing and information and traceability. To meet the huge demand for processed food with a longer shelf life, various new methods of packaging are being used in the food-processing industry. Packaging can manage oxygen in the package through gas flushes, controlling internal atmosphere or modified atmosphere packaging and vacuum, and enabling clean-label products without preservatives. **'Smart packaging'** is a term used to describe packaging that is either active or intelligent and provides information to the user through absorption or

[6] Rifna E.J., Madhuresh Dwivedi, Chapter 7 - Emerging nondestructive technologies for quality assessment of fruits, vegetables, and cereals, Editor(s): Charis M. Galanakis, Food Losses, Sustainable Postharvest and Food Technologies, Academic Press, 2021, Pages 219-253.
[7] Safety, Quality, and Processing of Fruits and Vegetables Urszula Tylewicz, Silvia Tappi, Malgorzata Nowacka and Artur Wiktor. MDPI. 2019.
[8] Let us take the example of strawberries. If the fruit are transported optimally at 1 °C and under high relative humidity; they can be stored in the fridge at the consumer for 5-6 days. This is on the condition that the consumer buys them immediately after arrival at the supermarket, Alexandru Luca explains. However, if the transport cooling system is out of order or not adequately controlled, the strawberries might look good when they arrive at the retailer, but the consumer, who buys them, may only be able to store them for 1-2 days at home. If the fruit are not purchased immediately, they might turn directly into food waste at the retailer or soon after purchase. It is challenging to react in a timely way if the retailers and consumers do not receive information about non-optimal storage conditions during the supply chain and their effects on the residual shelf life.
Alexandru Luca from the Department of Food Science at Aarhus University is the activity leader of the DigiFresh project, which is funded by the European Institute of Innovation and Technology (EIT Food).

release of substances to or from the food or environment. Nanotechnology has been hailed as the industrial revolution of the 21st century and has been applied to food packaging to improve barrier properties, and provide active antimicrobial and antifungal surfaces, mechanical and heat-resistance properties, sensing and signalling microbiological and biochemical changes, traceability purposes and monitoring and repairing of tears in packaging.[9]

Fresh produce is more susceptible to disease organisms because of increase in the respiration rate after harvesting. The respiration of fresh F&V can be reduced by many preservation techniques. Modified atmosphere packaging (MAP) technology is largely used for minimally processed F&V including fresh, "ready-to-use" vegetables. Extensive research has been done in this research area for many decades.[10] MAP involves modifying the atmosphere surrounding the product inside the package. This in turn allows chemical, enzymatic, or microbiological reactions to be controlled and therefore reduces or eliminates the main processes of deterioration in the product. The package usually has a low permeability to gas, so that the initial concentrations of the added gases remain unchanged after the package is sealed. MAP can be used to extend the shelf life of many fruit and vegetables. Most F&V age less rapidly when the level of oxygen in the atmosphere surrounding them is reduced.

Packaging technology advances the need to balance food protection with energy and material costs, growing social and environmental concerns, strict regulations on pollutants and disposal of municipal solid waste. Reducing, reusing and recycling are the main initiatives in reducing the environmental impact of packaging. In terms of alternative packaging materials, biodegradable, renewable polymers are being extensively researched, with cellophane being the most common.

Advances in **food safety and quality management** by food manufacturers have been mainly driven by increased public and private standards. The control of food hazards (biological, chemical and physical) by food manufacturers has been undertaken through hazard analysis critical control points (HACCP), which is a science-based approach to identify and establish control measures for specific hazards. Contaminants in products must be inspected and removed and technological advances such as electromagnetic spectrum X-ray or vision systems have enabled a non-destructive method with which to achieve this. Hyperspectral imaging is another inspection method for the analysis of the chemical composition of food products, allowing for examination of disease conditions, ripeness, hardness/tenderness, grading or contamination.[11]
Hygiene control systems should be applied throughout the food chain and, more specifically, to proper product and process design from a food manufacturer perspective. Being able to trace a food product from production to distribution is critical because of the consumer focus on quality with more complex supply chains. This traceability can be achieved through barcodes or radio-frequency identification.
Relating to inventory and distribution, examples such as implementation of warehouse management systems, refrigeration and cold store upgrades and new, larger, more

[9] Sonneveld, Kees. (2000). What drives (food) packaging innovation?. Packaging Technology and Science. 13. 29-35. 10.1002/(SICI)1099-1522(200001/02)13:1<29::AID-PTS489>3.0.CO;2-R.
[10] Sandhya, Modified atmosphere packaging of fresh produce: Current status and future needs, LWT - Food Science and Technology, Volume 43, Issue 3, 2010, Pages 381-392.
https://www.sciencedirect.com/science/article/pii/S0023643809001546
Pinto, Loris & Palma, Amedeo & Cefola, Maria & Pace, Bernardo & d'aquino, Salvatore & Carboni, Cristian & Baruzzi, Federico. (2020). Effect of modified atmosphere packaging (MAP) and gaseous ozone pre-packaging treatment on the physico-chemical, microbiological and sensory quality of small berry fruit. Food Packaging and Shelf Life. 26. 100573. 10.1016/j.fpsl.2020.100573.
[11] http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0038-23532018000500017&lng=pt&nrm=iso

sustainable distribution centres were reported. Examples of material preparation and handling included automation, de-palletising and palletising equipment, conveying and mobile racking.[12]

4. Way forward

Consumers have become more demanding for high-quality and convenient food products with natural flavours and taste, free from additives and preservatives. Therefore, the challenge for the F&V industry is to develop such products, taking into account quality and safety aspects along with consumer acceptance. Emerging, unconventional processing of F&V is more and more studied in order to develop products rich in bioactive compounds, paying attention at the same time to waste and by-product valorisation.[13]
The challenge remains implementation at scale, cost and access by operators from developing countries exporting to international markets. The demands for higher quality control should go hand in hand to affordable technologies allowing the value chain actors to deliver the expected quality. The adoption of relevant skills remain also a challenge.

5. Promoting increased knowledge about the F&V industry

Launched in the context of the United Nations (UN) 2021 International Year of Fruits and Vegetables, the COLEACP[14] through its FFM SPS and FFM plus programmes (funded by the European Union (EU) and the Organisation of African, Caribbean and Pacific States (OACPS)) and the OECD Fruit and Vegetables Scheme[15] of the Trade and Agriculture Directorate launched an online series highlighting the significance of the F&V sector and its various dimensions.
The main objectives of the series are:

- Sharing knowledge of markets and operators working in local and export F&V markets
- Understanding the F&V sector contribution to sustainable production and consumption
- Promoting F&V contribution to healthy and nutritious diets
- Showcasing successes and innovations of private sector operators across the EU and Southern countries and lessons learned

The third session to be held on 23 May 2022 will discuss the technology innovations for F&V quality control.

[12] http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0038-23532018000500017&lng=pt&nrm=iso
[13] Safety, Quality, and Processing of Fruits and Vegetables Urszula Tylewicz, Silvia Tappi, Malgorzata Nowacka and Artur Wiktor. MDPI. 2019.
[14] As a non-profit association of private sector operators, the COLEACP mission is to develop inclusive, sustainable trade in fruits, vegetables and food products, focusing on the ACP countries' trade with one another and with the EU. https://www.coleacp.org/
[15] OECD Fruit and Vegetables Scheme promotes international trade through the harmonisation of implementation and interpretation of marketing standards. https://www.oecd.org/agriculture/fruit-vegetables/

OECD-COLEACP Fruits and Vegetables Industry Series

Session 3 - Technology innovations for fruit and vegetables quality control

23 May 2022 – 10h00-11h30 CET
Online (Zoom)

PROGRAMME

Moderator: Isolina Boto, Head of Networks and Alliances, COLEACP

10:00-10:10 Welcome and introduction

10:10-10:40 Technologies for quality control

This panel will discuss the challenges and opportunities in quality control of F&V with a focus on standards, barcodes, NIR spectroscopy and aquaphotomics techniques.

- Johan den Engelse, Data Analyst, Fresh Produce Centre and consultant, FRUGICOM, The Netherlands
- Karen Spruijt de Gelder, Policy Officer, Quality Control Bureau (KCB), The Netherlands
- Tiziana Maria Cattaneo, Researcher, Council for Agricultural Research and Economics (CREA), Italy

Q&A session

10:40-11:20 Quality control of fruit and vegetables: insights from operators

This panel will feature experiences from operators in the F&V industry who implement innovations for improved quality control of F&V.

- Rick Schot, Business Developer, Experience Fruit Quality, The Netherlands
- Alexandru Luca, DigiFresh (Digital monitoring of fruit & vegetable freshness) Consortium
- Wycliffe Arodi, Group Technical Manager, Keitt Exporters Limited, Kenya

Q&A session

11:20-11:30 Conclusion and way forward

José Brambila-Macías and Marie Russel, Fruit and Vegetables Scheme (quality and marketing standards), OECD

The OECD-COLEACP Fruits and Vegetables Industry Series focuses on market access conditions and opportunities for the fruit and vegetable sector, especially for fruit and vegetables producers and exporters from ACP-countries. This activity is supported by the Fit For Market SPS programme, implemented by COLEACP within the Framework of Development Cooperation between the Organisation of African, Caribbean and Pacific States (OACPS) and the European Union.