



One Health
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EVALUATION, MEASUREMENT, AND STABILITY OF FRESH PRODUCT SHELF LIFE: IMPLICATIONS FOR REDUCING FOOD WASTE AND PROMOTING SUSTAINABLE FOOD PRODUCTION

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I. Shelf-life evaluation & measurement

- ✓ **Establishing the shelf-life of foods** = important step in putting safe and quality food on the market and also to assure a good food safety management.
- ✓ An accurate **estimation of shelf-life**
 - analyse the **types of food spoilage**.
 - **ways of measuring and predicting the shelf-life**
 - **ways of communication of shelf-life** in order to raise awareness on food safety and also sustainability and food waste reduction
- ✓ **Predicting of shelf-life**



I. Shelf-life evaluation & measurement

Establishing the shelf-life of foods: types of spoilage

- **Categorization of Spoilage:**
 - **Physical Deterioration:** Observable alterations such as moisture imbalance, crystal growth (e.g., in frozen desserts), and texture modifications due to suboptimal handling during storage or transport.
 - **Chemical Degradation:** Enzymatic and non-enzymatic processes, including lipid peroxidation, browning, and hydrolytic rancidity, significantly impact sensory and nutritional quality.
 - **Microbial Contamination:** Responsible for approximately 25% of global food losses, with bacteria and molds as primary agents.
- **Determinants of Spoilage:**
 - **Intrinsic Factors:** Composition (e.g., sugar, fat, natural antimicrobials like lysozyme and nisin).
 - **Extrinsic Influences:** Water activity, pH, temperature, and storage conditions play pivotal roles.
- **Advancements in Detection:**
 - **Analytical Technologies:** Biosensors and molecular techniques (e.g., DNA-based assays) for spoilage organism identification.
 - **Organoleptic Indicators:** Changes in aroma, texture, and visible microbial proliferation serve as critical quality markers



I. Shelf-life evaluation & measurement

Establishing the shelf-life of foods: evaluation & detection

- Mitigating spoilage = apply knowledge regarding spoilage microorganisms and to utilize diverse systems, techniques, and processes.
- At the industry level, the execution of the Hazard Analysis Critical Control Point (**HACCP**) plan, coupled with effective production processes and subsequent risk assessment, is conducted to manage or identify spoilage.
- Heat, packaging, processing, and storage for food preservation diminish the likelihood of spoiling causes in the environment.
- The **detection** and **identification of spoiling** are critical criteria in contemporary food industries because the health hazards linked to the consumption of damaged or infected foods are microbiologically detrimental and potentially fatal.



I. Shelf-life evaluation & measurement

Establishing the shelf-life of foods: predicting

At the same time a method is also **predicting**.

Prediction = subjecting a product to an unfavorable, predictable environment to see how it responds. Mathematical methods are also used for this.

Accelerated shelf-life testing

- An accelerated test fundamentally posits that altering a storage situation expedites the chemical or physical processes responsible for degradation, hence enabling the establishment of a predictive shelf-life correlation with ambient circumstances.
- It is sometimes (incorrectly) presumed that faster degradation can be attained by increasing the storage temperature, utilizing an Arrhenius model. This model is suitable solely for uncomplicated chemical systems; it frequently falters with intricate meals, such as bread, where elevated temperatures reduce the rate of staling reactions.



I. Shelf-life evaluation & measurement

Establishing the shelf-life of foods: predicting

Predictive models

- As personal computers grow more powerful and accessible, predictive modeling, especially about microbial behavior, has emerged as a significant study domain.
- These models examine **statistical** and **mathematical correlations** among three categories of variables: intrinsic factors related to the product, extrinsic environmental factors, and implicit factors pertaining to the microorganism's characteristics and its behavior in conjunction with intrinsic and extrinsic factors.
- Such models must rely on robust experimental data that delineates rates of change across specific factor combinations. The data from these shelf-life trials are analyzed for statistical patterns and mathematical linkages to construct a model.



I. Shelf-life evaluation & measurement

Establishing the shelf-life of foods: predicting

The design of shelf-life experiment



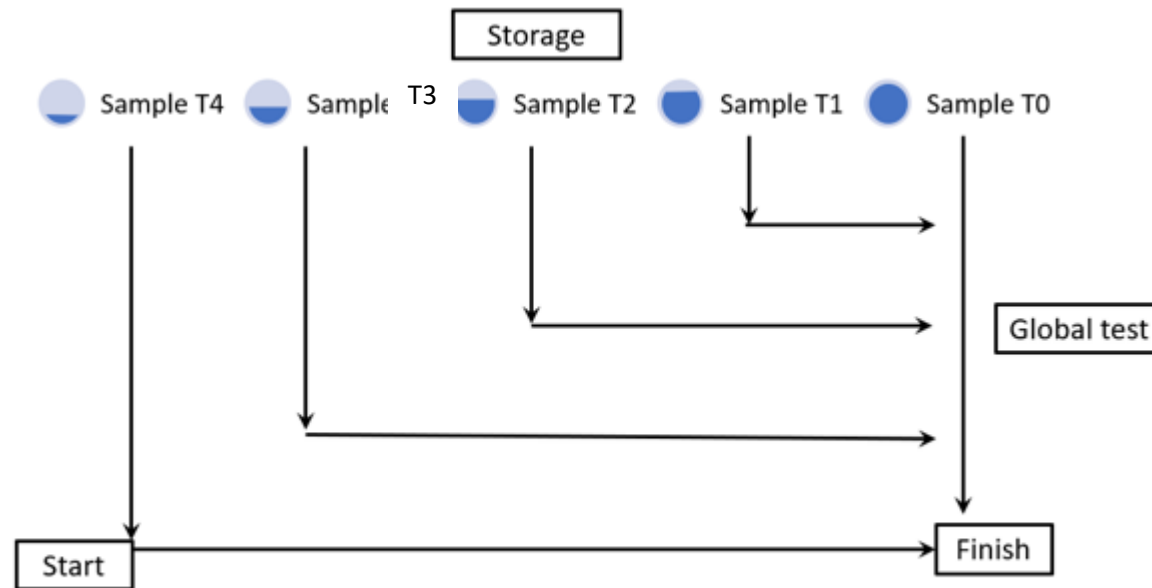
A partially staggered design for shelf-life testing



I. Shelf-life evaluation & measurement

Establishing the shelf-life of foods: predicting

The design of shelf-life experiment



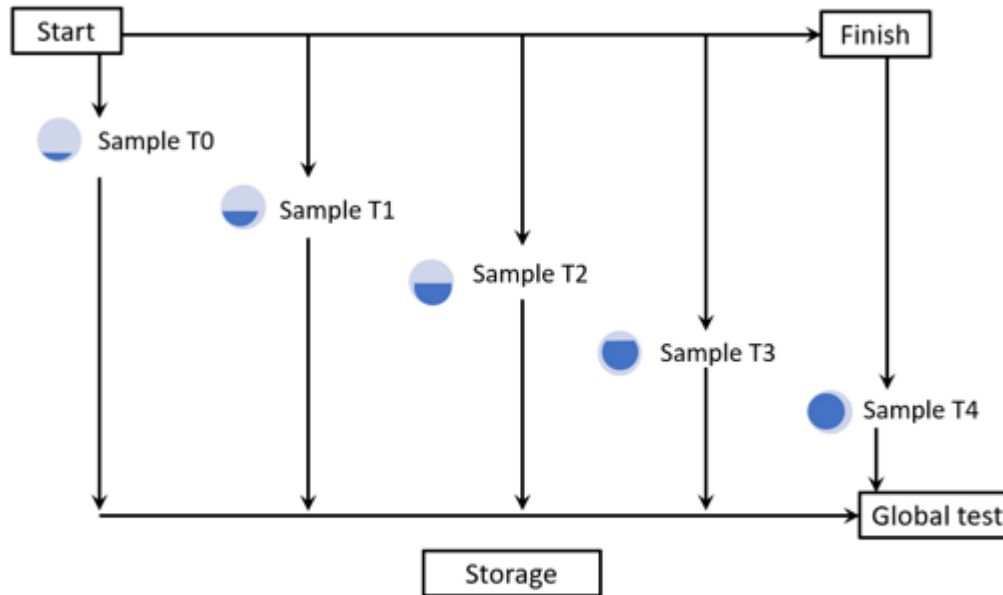
Simple design for shelf-life testing



I. Shelf-life evaluation & measurement

Establishing the shelf-life of foods: predicting

The design of shelf-life experiment



|Another design for shelf-life testing



II. Shelf-life and food waste relation

- ✓ **communicating shelf-life of foods on the package**
 - ✓ Best before ...
 - ✓ Use by ...
- ✓ **shelf-life and food waste in production**
- ✓ **shelf-life and food waste in retail**



II. Shelf-life and food waste relation

Communicating shelf-life of foods on the package

"USE BY"
informs you about

FOOD SAFETY

USE BY: 4 Oct 2016



Mind the date!
Food can be **eaten UP UNTIL**
THE END of this date but not after,
even if it looks and smells fine

"USE BY..." is a term related to food **safety**.

The food **CAN NOT** be consumed after the date printed on the packaging, even if it is sensorially acceptable.

"BEST BEFORE"
informs you about

FOOD QUALITY

BEST BEFORE: 4 Oct 2016



Judge for yourself!
Food can be **eaten AFTER this date**
but it may no longer be at
its best quality

"BEST BEFORE..." it is a term related to the **quality** of food products.

The food **can still be consumed AFTER** the printed date, but it may no longer have the appropriate sensory or nutritional qualities.



II. Shelf-life and food waste relation

Shelf-life and food waste in production

European Union alone, approximately **59 million tons of food** are discarded annually, translating into **lost resources, increased greenhouse gas emissions**, and **missed opportunities** for feeding those in need. (Source: <https://ec.europa.eu/>)

To tackle this challenge, a dual approach is required, addressing both upstream (production and processing) and downstream (retail and consumer) inefficiencies.



II. Shelf-life and food waste relation

Annual global medium food waste

1/3 from total foods
global

1.3 billion tons

1 trillions of
dollars

 **45 %**

From the quantity of
fruits and vegetables.

 **35 %**

From the quantity of
fish and seafood

 **30 %**

From the quantity
of cereals

 **20 %**

From the quantity
of dairy products

 **20 %**

From the quantity of
meat



II. Shelf-life and food waste relation

Shelf-life and food waste in production

Food waste by food chain segment categories

39% of total food production is wasted



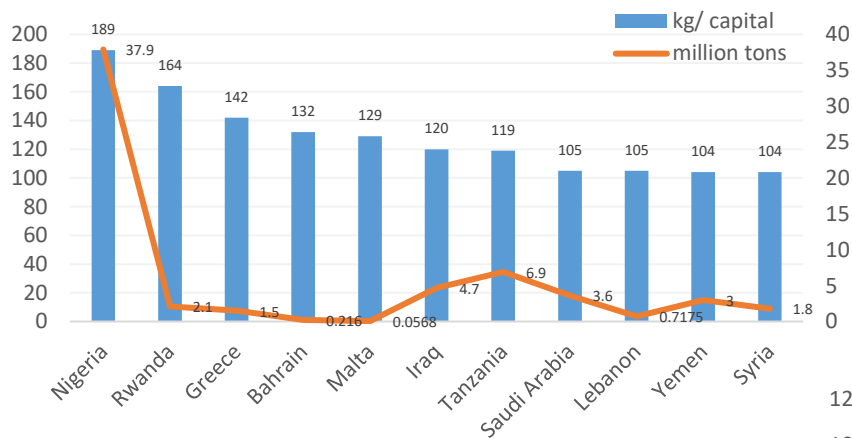
Source: SDG Target 12.3 on Food Loss and Waste: 2023 Progress Report



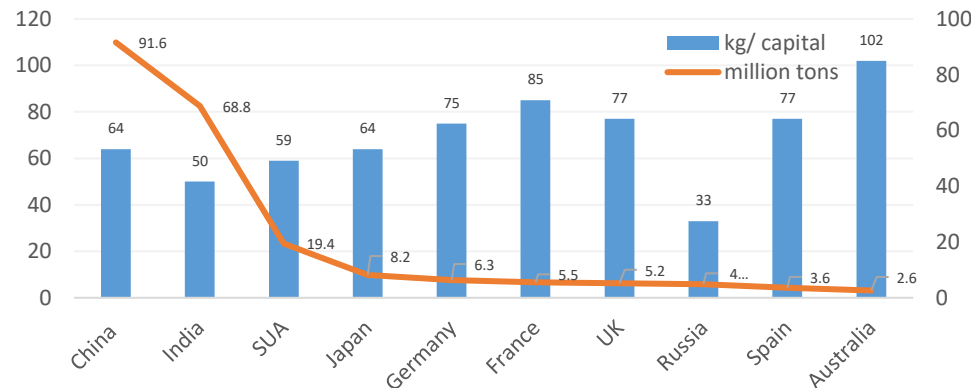
II. Shelf-life and food waste relation

Annual food waste by country 2023

Annual food waste by country



Annual food waste by country





II. Shelf-life and food waste relation

Shelf-life and food waste in retail

- ✓ **Food waste** is often driven by misaligned inventory management, overstocking, and conservative shelf-life settings for perishable items.
- ✓ Solution = **dynamic shelf life (DSL)** models offer a more flexible approach by adjusting expiration dates based on real-time product quality indicators, which can be combined with discounting strategies to incentivize consumer purchases of near-expiration items.
- ✓ **DSL + discounting** have the potential to reduce waste significantly while maintaining food safety and maximizing retailer profits.



III. Shelf-life and food waste reduction in retail

A case study* based on evaluation of the strategies applied in order to reduce food waste

Retail Waste Reduction Strategies:

Data and models were derived from a study examining the effects of DSL and discounting on waste, profit, and stock levels for highly perishable products.

Primary Production and Processing Loss Quantification:

Data on food losses were sourced from a quantification study focusing on the primary production and initial processing stages, covering sectors such as cereals, fruits and vegetables.

* Source: Buisman, et al., 2019



III. Shelf-life and food waste reduction in retail

Direction (1) - retail-level waste management using dynamic shelf life (DSL) and discounting strategies (DS)

Direction (2) - recycling and reuse as a supplementary waste reduction strategy

Combining these approaches provides a holistic assessment of food waste reduction across the supply chain.



Results and discussions

Direction (1) DSL – dynamic shelf-life

- The key innovation is the integration of a simulation-based optimization model that evaluates the impact of discounting and DSL on profit, waste, shortages, and food safety in retail inventory management. DSL adjusts a product's shelf life based on actual quality, providing a significant advantage over the traditional fixed shelf life (FSL).

Key Findings:

- ✓ **Reduction in Waste:** DSL outperforms FSL in minimizing waste
- ✓ **Profit Maximization:** DSL, with or without discounting, achieves higher profits compared to FSL strategies.
- ✓ **Improved Replenishment:** DSL allows for higher stock levels with reduced shortages.
- ✓ **Consumer Behavior and Safety:** Discounting shifts consumer preference to older products, further reducing waste.



Results and discussions

Direction (1) DSL – dynamic shelf-life

- ✓ Both methods (**Dinamic Shelf-Life & Discounting Strategies**) are effective, but DSL, which adjusts product expiration dates based on actual quality, proves more beneficial in minimizing waste, improving food safety, and enhancing profitability.
- ✓ Combining DSL with discounting yields (DS) the most significant waste reduction and profit gains.
- ✓ The research underscores the importance of precise inventory management and calls for further exploration into consumer behavior and the application of DSL in diverse perishable products.



Results and discussions

Direction (2) - recycling and reuse as a supplementary waste reduction strategy

- ✓ The importance of **recycling** and **reuse** to **minimize waste** across the supply chain. When products are unsuitable for direct consumer sales but still safe for consumption, they are often diverted to animal feed or food donations.
- ✓ In France, this practice is prevalent in the dairy and bakery sectors, where unsellable food items are frequently redirected rather than discarded.
- ✓ Expanding food donation programs, particularly for fruits and vegetables, could further reduce food loss while supporting communities in need.
- ✓ However, the effectiveness of these efforts depends on well-coordinated logistics and partnerships between producers, retailers, and charitable organizations.



Results and discussions

Direction (2) - recycling and reuse as a supplementary waste reduction strategy

Food Donation

The primary focus of food waste prevention should be to act directly at source by limiting the generation of surplus food at each stage in the food supply chain (i.e. production, processing, distribution and consumption). If this cannot be achieved, the best destination for food surplus, which is still prevention, and that ensures the highest value use of edible food resources in line with the waste hierarchy, is to redistribute this food for human consumption where safe to do so.



Results and discussions

Direction (2) - recycling and reuse as a supplementary waste reduction strategy

EU Food donation guidelines

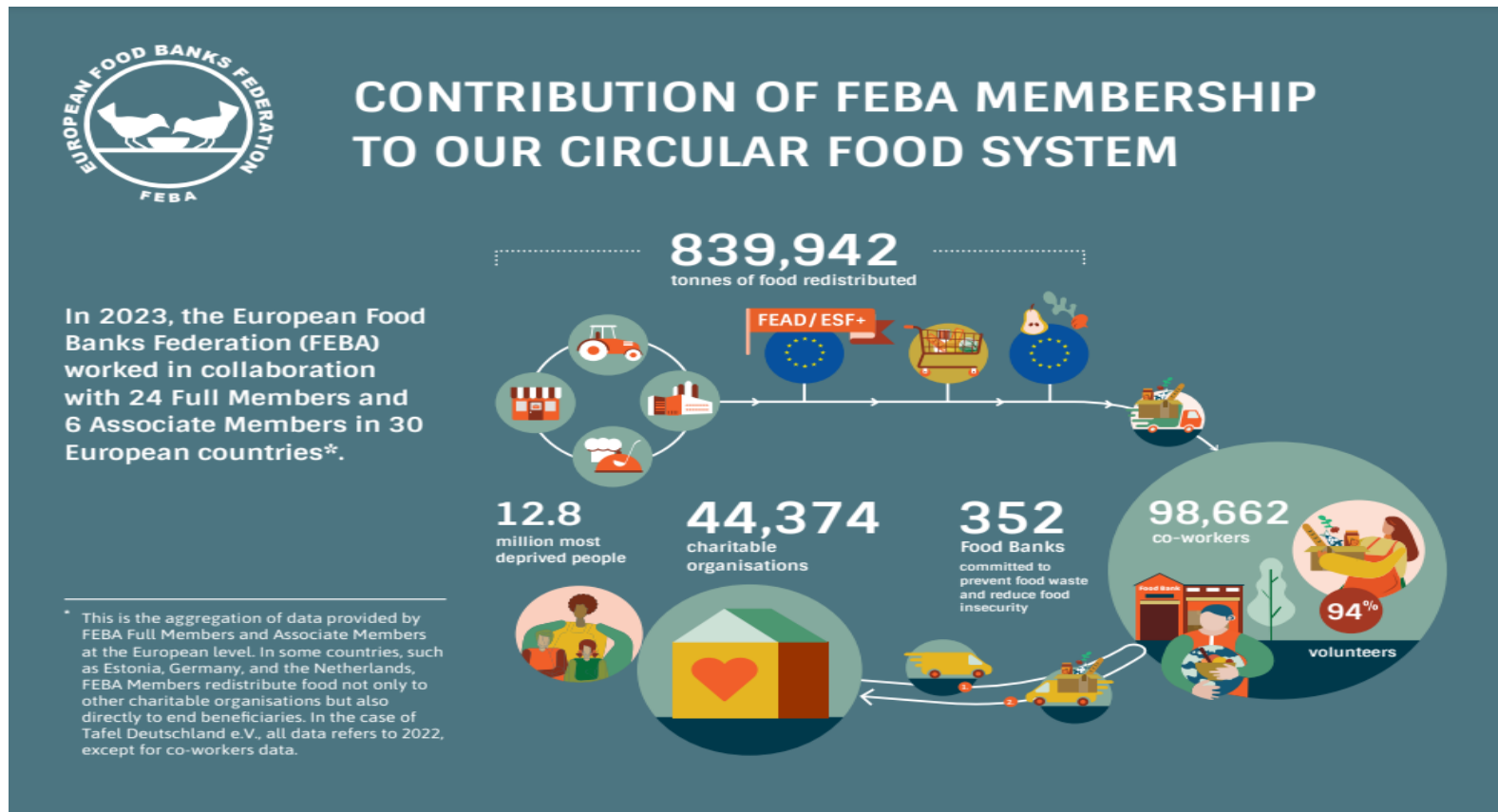
As part of the Circular Economy Action Plan, the Commission has adopted EU food donation guidelines in order to facilitate the recovery and redistribution of safe, edible food to those in need. Developed in consultation with the EU Platform on Food Losses and Food Waste, the EU food donation guidelines seek to:

- ✓ facilitate compliance of providers and recipients of surplus food with relevant requirements laid down in the EU regulatory framework (e.g. food safety, food hygiene, traceability, liability, VAT, etc.);
- ✓ promote common interpretation by regulatory authorities in the EU Member States of EU rules applying to the redistribution of surplus food.



Results and discussions

Direction (2) - recycling and reuse as a supplementary waste reduction strategy





Results and discussions

Direction (2) - recycling and reuse as a supplementary waste reduction strategy

Romania Food donation



Network of Food Banks in Romania and the quantities (tons) of food collected in 2021.



Conclusions and recommendations

Extending the shelf life of fresh products is essential for reducing food waste and advancing food sustainability.

- ❑ Dynamic shelf life (DSL) systems, especially when combined with discounting, can significantly decrease waste in retail by adjusting expiration dates based on real-time quality assessments.
- ❑ DSL allows retailers to maintain products on shelves as long as they are safe, preventing premature disposal and increasing profitability.
- ❑ For highly perishable items like fruits, vegetables, DSL enhances inventory flexibility, reducing the risks of spoilage and overstocking.



Conclusions and recommendations

- ✓ Beyond retail, addressing waste during production and processing stages is critical.
- ✓ Addressing waste during production and processing is essential for sustainability. By improving handling, storage, and grading, losses can be minimized, ensuring more fresh products reach consumers.
- ✓ Integrating DSL with loss prevention fosters a sustainable food system. Innovations in shelf-life extension and acceptance of "imperfect" produce are crucial. These steps will support a circular, waste-reducing food economy.



Conclusions and recommendations

- ✓ Combining DSL with discounting is the most optimal strategy for retailers to manage perishable inventory.
- ✓ While discounting alone is beneficial, DSL offers a more robust approach to ensure food safety and optimize inventory without incurring unnecessary waste.
- ✓ The study underscores the importance of adopting innovative inventory strategies like DSL to address significant challenges in the perishable food supply chain.



References

1. Barbara Redlingshofer*, Bernard Coudurier , Martine Georget (2017) Quantifying food loss during primary production and processing in France.
2. Buisman, M. E., Haijema, R., and Bloemhof-Ruwaard, J. M. (2019). Discounting and dynamic shelf life to reduce fresh food waste at retailers. *International Journal of Production Economics*, 209, 274–284.
3. Bruckner, S., 2010. Predictive Shelf Life Model for the Improvement of Quality Management in Meat Chains. University ats-und Landesbibliothek Bonn.
4. Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R., Meybeck, A., 2011. Global food losses and food waste: extent, causes and prevention, FAO. Rome,Italy. <https://www.fao.org/4/mb060e/mb060e.pdf>
5. Hanson, C., and Mitchell, P. (2017). The Business Case for Reducing Food Loss and Waste: A Report on Behalf of Champions 12.3. World Resources Institute.
6. Herbon, A., Levner, E., Cheng, E., 2012. Perishable inventory management and DynamicPricing using TTI technologies. *Int. J. Innov., Manag. Technol.* 3, 262.
7. Monier, V., Mudgal, S., Escalon, V., O'Connor, C., Gibon, T., Anderson, G., and Morton, G. (2010). Preparatory Study on Food Waste across EU 27. European Commission.
8. Tsiros, M., Heilman, C.M., 2005. The effect of expiration dates and perceived risk on purchasing behavior in grocery store perishable categories. *J. Mark.* 69, 114–129.
9. Stenmarck, Å., Jensen, C., Quested, T., Moates, G., 2016. Estimates of European Food Waste Levels. Stockholm, Sweden.
10. Wang, X., Li, D., 2012. A dynamic product quality evaluation based pricing model for perishable food supply chains. *Omega* 40, 906–917
11. https://agriculture.ec.europa.eu/data-and-analysis/markets/overviews/market-observatories/fruit-and-vegetables_en?prefLang=ro
12. <https://refreshcoe.org/>
13. <https://rocesp.ro/>
14. <https://www.eurofoodbank.org>
15. https://commission.europa.eu/index_en
16. <https://ec.europa.eu/>

Thank you for your attention!

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