



Mariusz Tichoniuk

Poznań University of Economics and Business

Poznań – the 5th largest city in Poland (ca. 520 000 habitants) / **Poznań** metropolitan area – 1,1 mln
- a very important center of trade, technology, sports, tourism, and education (ca. 130 000 students)
(8 public universities: Adam Mickiewicz Univ. (universal), Universities of Medical Sciences, Technology,
Life Sciences, Music, Fine Arts, Physical Education and Economics & Business)



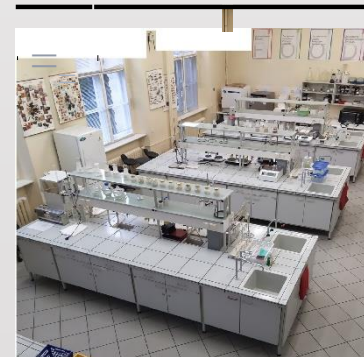


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Programs:

- **Bachelor in Business Administration – English language course**
- **Finance (Bachelor) – English I. c.**
- **Innovation Management (Master) – English I. c.**
- **International Economic Relations (Master) – English I. c.**
- **Quantitative Finance (Master) – English c.**
- **Doctoral School / Doctoral Seminars in English**
- **Product Quality and Development (Engineer / Master) – Polish language course**
- **Production Management and Engineering (Eng. / Master) – Polish I. c.**
- ...





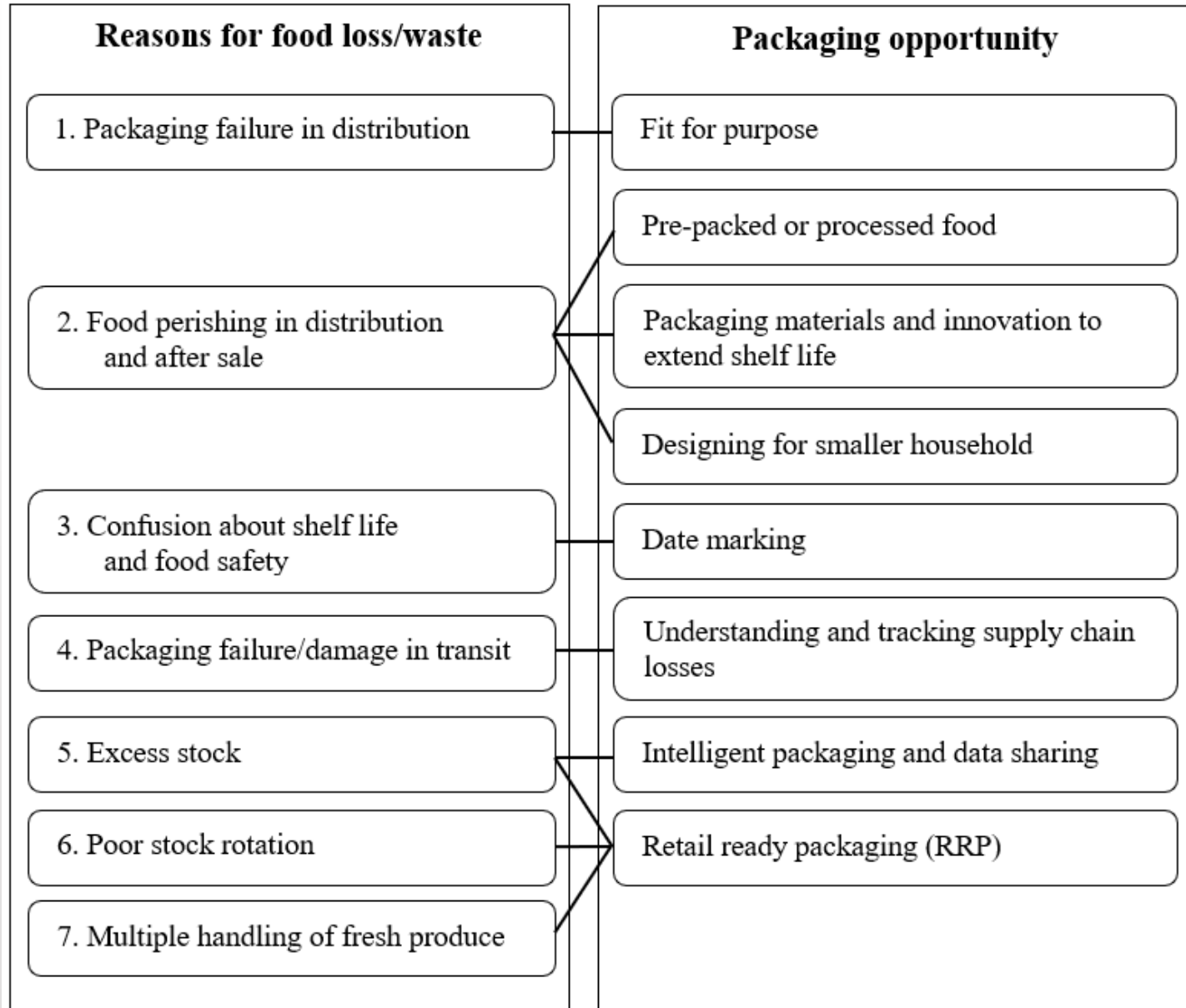
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THE POTENTIAL OF INTELLIGENT PACKAGING IN THE REDUCTION OF FOOD WASTE

According to FAO reports one-third of all food produced for human consumption is lost or wasted. The estimated total cost is 990 billion USD every year around the world. For the European Union, ca. 88 million tons of food is wasted every year (173 kg per person)

The main source of food waste in the food supply chain is **improper household storage and consumption**.







Intelligent packaging react immediately to significantly changing conditions that affect the state of packaged product and they could inform all participant of the supply chain about the current condition of packaged items. They could be applied for direct monitoring of the product quality and **dynamic adjustment** of their **shelf life** (DSL attitude).



Indicators

- Time-temperature indicators (TTI)
- Microbial growth and freshness indicators
- Integrity (gas) indicators



Sensors

- Gas sensors
- Temperature sensors
- Biosensors



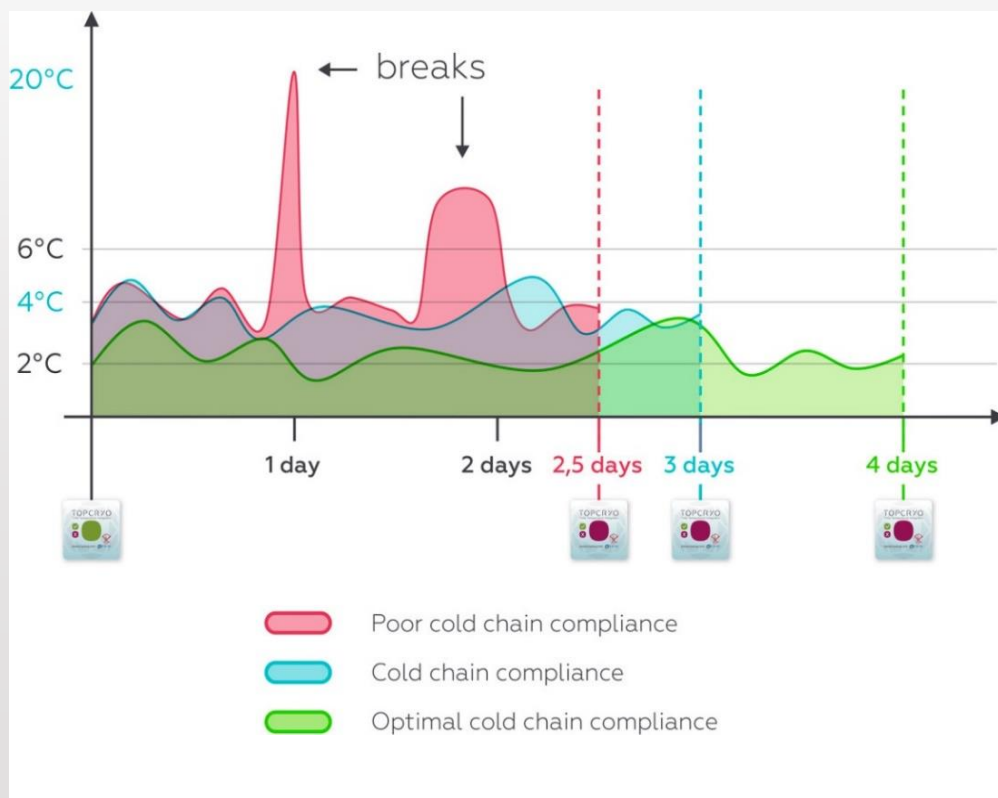
Data carriers

- Barcodes, NFC communications
- Radio-frequency identification (RFID) systems
- Sensor-enabled RFID tags



Regarding the **final consumer** of food, the information provided by intelligent packaging should be **simple** and **easy to understand**.

The most desirable form of the indicator is a graphically attractive label that changes the appearance and/or colour when food quality changes.

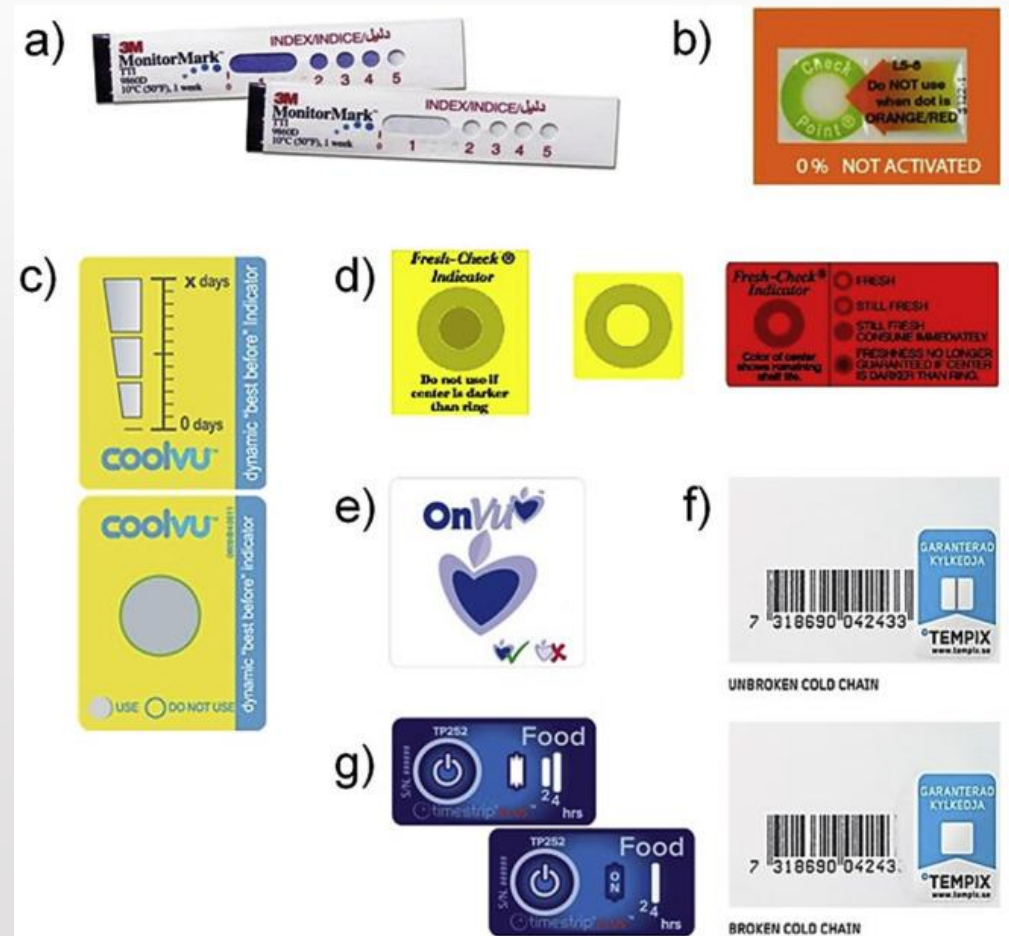


CRYOLOG, <http://cryolog.com/en/topcryo/>



Time-temperature indicators (TTI)

- a) Monitor Mark™ (3M)
- b) Fresh-Check® (Lifelines Technologies Inc.)
- c) CoolVu™ (Freshpoint)
- d) Checkpoint® (Vitsab International AB)
- e) OnVu™ (Freshpoint)
- f) Tempix® (Tempix AB)
- g) Timestrip® (Timestrip Plc)



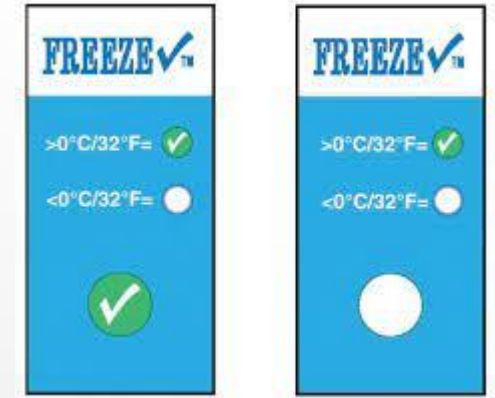


Time-temperature indicators (TTI)

TTI indicator (company, country)	Type of action	Need of activation	Colour change (optical response)	Application
<u>Checkpoint</u> [®] types M, L (<u>Vitsab Int.</u> AB, Sweden)	enzymatic	yes	tricolour: green to yellow to red	meat, fish, dairy products
(e0) [®] (<u>Cryolog</u> , France)	microbial	no	green to red	cold chain
<u>FreshCheck</u> [®] (TEMPTIME Corp. USA)	polymeric	no	colourless to blue	all kind of fresh products
<u>On Vu</u> [™] (<u>Freshpoint</u> , Switzerland)	photochromic	yes	dark blue to colourless	meat, fish, dairy products
<u>Monitor Mark</u> [™] and <u>Freeze Watch</u> (3M Comp. USA)	diffusion- reaction	yes	diffusion of coloured path/material	bakery products, beverage, meat



Thermochromic packaging elements





Time-temperature indicator => freshness indicator

CheckPoint L5-8 Smart TTI Seafood Label

– before activation (*white*) and activated (*green*)



CheckPoint label L5-8 Smart TTI Seafood Label showing thermal exposure over the safe levels recommended by the FDA





Time-temperature indicator => freshness indicator

Fresh-Check TTI showing when the product is safe and not safe for consumption



**Fresh-Check® self-adhesive
time temperature indicator**

As the Fresh-Check indicator is exposed to heat, it gradually changes color to alert the consumer of optimal freshness.





Chemical sensors / indicators

Target compounds (metabolites)	Food product	Freshness indicator / sensor
Biogenic amines	Fish, Seafood, Meat	Colour-changing indicator with pH-sensitive dye / electrochemical sensor for enzyme redox reaction
Carbon dioxide	Fermented food, Meat	pH sensitive with colorimetric response / electrochemical sensor <i>e.g.</i> with silicon-based polymer recognition layer
Glucose / Lactic acid	Fermented food, Meat	pH sensitive with colorimetric response / electrochemical sensor for redox reaction
Oxygen	Meat, Fruits, Vegetables	oxygen sensitive indicator with pH-sensitive dye / optical sensor by fluorescence



Chemical sensors – integrity indicators

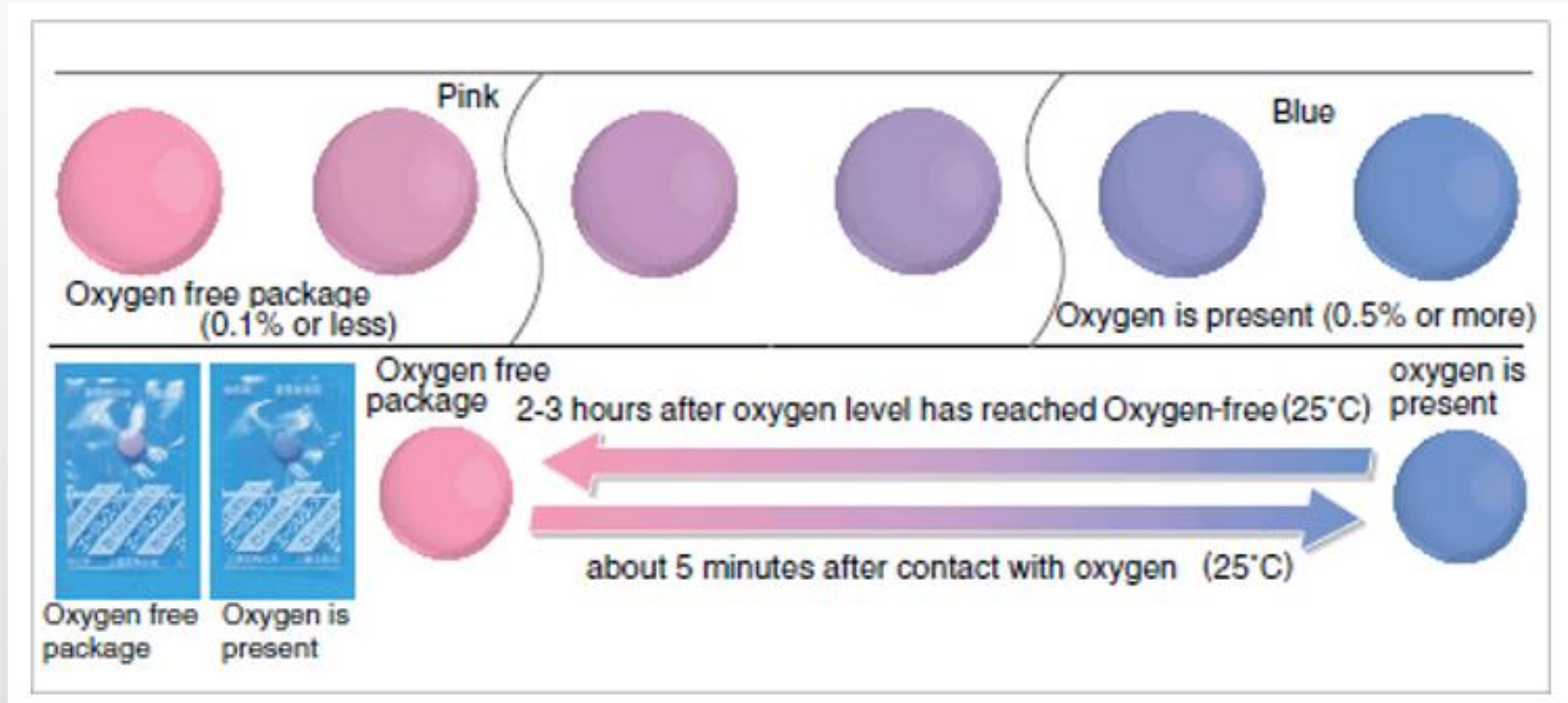
Type of indicator	Commercial name	Company (country)	Area of application
<u>Integrity (gas) indicator</u>	Ageless Eye®	Mitsubishi Gas Chemical (Japan)	All packed food products – specially applicable in aseptic and modified atmosphere packaging systems
<u>Integrity (gas) indicator</u>	Novas®	Insignia Technologies (United Kingdom)	





Chemical sensors – integrity indicator

Ageless Eye[®] gas (oxygen) indicator





Chemical sensors – integrity indicator

Food fresh™ indicator





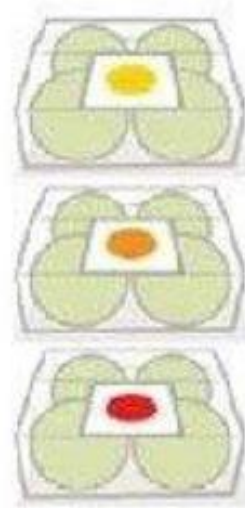
Chemical sensors – freshness indicators

Type of indicator	Commercial name	Company (country)	Area of application
<u>Freshness indicator</u>	Fresh Tag [®]	COX Technologies (USA)	Perishable food products, with volatile metabolic products <i>e.g.</i> meat, fish and seafood, dairy products, vegetables and fruits
<u>Freshness indicator</u>	<u>Raflatac</u>	VTT and UPM <u>Raflatac</u> (Finland)	
<u>Freshness indicator</u>	<u>RipeSense</u>	<u>RipeSense</u> (New Zealand)	
<u>Freshness indicator</u>	<u>SensorQ[®]</u>	DSM NV and Food Quality Sensor <u>Interational Inc.</u> (Denmark)	



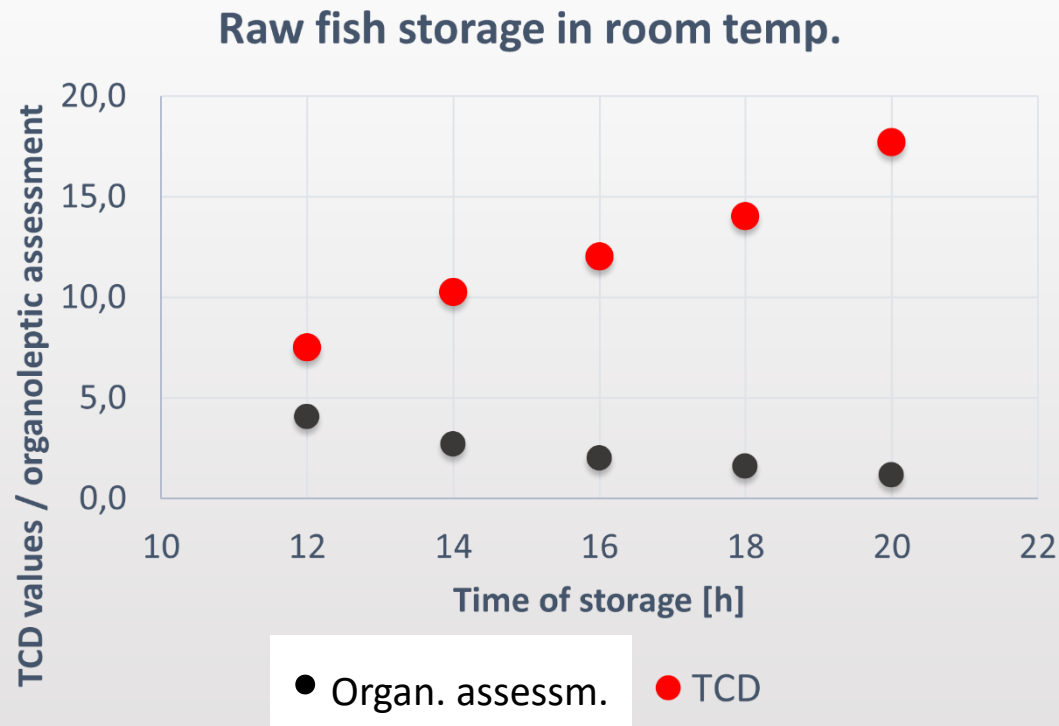
Chemical sensors – ripening indicator

ripeSense fruits ripening indicator





Chemical sensors – freshness indicator



Organoleptic assessment scale: (appearance, color, smell, texture):
5 – very good / 4 – good / 3 – sufficient / 2 – insufficient / 1 - bad

Chemical sensors – freshness indicator

[illegible]



Chemical sensors – freshness indicator

A sensor that monitors carbon dioxide as indication for the freshness of the dessert golden drop (Nopwinyuwong et al., 2010).

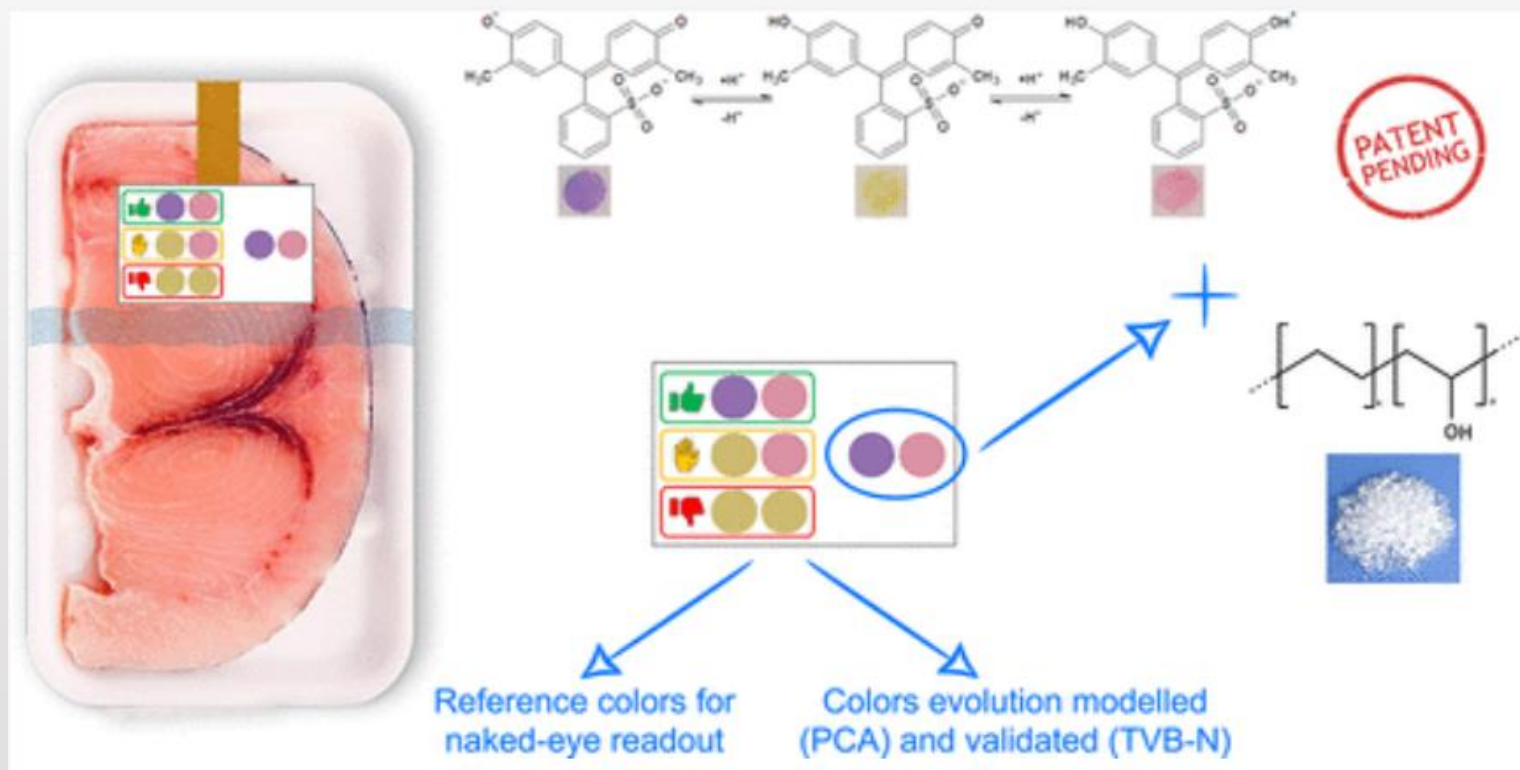




Chemical sensors – freshness indicator

Dual-Optode Label to Monitor Fish Spoilage in Sales Packages

(Magnaghi et al., *ACS Food Sci. Technol.* 2022, 2, 6, 1030–1038).





Chemical sensors – freshness indicator

Dual-Optode Label to Monitor Fish Spoilage in Sales Packages

(Magnaghi et al., *ACS Food Sci. Technol.* 2022, 2, 6, 1030–1038)

Fish fillet storage at 4°C for 1-5 days (freshness sensor response)

