decision support system for packaging design

DSS packaging design

Identification

Key words
Decision support system, food packaging system, mass transfer, composite food, edible coating

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How does it work?

Primary objective
This tool is a decision support system that simplifies the package design steps by predicting the required window of packaging permeability (mainly O2 and CO2 permeabilities) for maintaining the quality and safety of the packed food (fresh and fresh-cut fruits and vegetables). The decision support system also helps to design and dimension edible film and coating as moisture barrier for the development of new composite food products. This procedure minimizes the number of experiments and the economic and hazard safety consequences of empirical approaches (“pack and pray” or “trials and error” methods).
Working principle

The decision support system (DSS) for packaging design is a numerical interface gathering different mathematical models of mass transfer programmed on Matlab® software. The first application is devoted to the design of active and passive MAP (modified atmosphere packaging) for fresh and fresh-cut fruits and vegetables. It takes into account mass transfer (O2/CO2) through the packaging material (Fick’s laws and derivatives), the physiology of the product (respiration modelled by using the Michaelis-Menten equation) and the absorption/emitting of gas by active components such as O2 scavengers, intentionally added in the packaging (Charles et al. 2003, 2005, 2006; Guillard et al. 2012; Cagnon et al. 2012). The second application is devoted to the design of edible films and coatings as moisture barrier for improving stability of composite food products and creating new products (Bourlieu et al. 2010; Roca et al. 2006, 2007, 2008a, b; Guillard et al. 2003a, b, 20004).

The DSS for designing packaging for fresh produce has been promoted to a web-interface: it is a free software (www.tailorpack.com) aiming at predicting evolution of O2 and CO2 internal concentrations in a food/packaging system in the case of respiring product and passive modified atmosphere packaging (MAP); i.e. none active system is used and MAP is the result of interplay between gas diffusion through the packaging material and consumption/production of gases by the product. It also enables to predict in advance the required range of gas permeabilities (O2 and CO2) for a given product. Recent improvement permits to take into account biological uncertainty and its impact on the reliability of predictions (Destercke and Guillard 2011).

In the framework of the FP7 EcoBioCap project, this decision support system (DSS) is currently being updated to obtain a tool for multi-criteria design. Indeed, beyond gas permeabilities, the choice of a packaging material for fresh produce must take into account numerous other factors such as the cost, availability, potential contaminants of raw materials, process ability, waste management constraints, etc. (Destercke et al. 2011)

Needs, acceptances and preferences of stakeholders regarding packaging material for fresh produce are taken into account in the DSS. This DSS contains different components:
1) databases with all information regarding packaging material and respiration parameters for fresh fruits and vegetables,  
2) virtual MAP modelling Matlab modules (Tailorpack models)  
3) a Java module to manage stakeholder’s preference aggregation as regard packaging material. This module permits to detect conflicts between preferences and manage a negotiation phase between stakeholders to find compromises.  
4) a Java module enabling flexible querying of the packaging database. A specific methodology is used to query databases when user’s preferences are bipolar (i.e., express both constraints and wishes about the desired result) and enables to solve the dilemma of multi-criteria demands with guaranteed result. Such DSS is indispensable to give an answer to complex query such as “I want optimal gas permeabilites in order to guarantee the product quality and I would like a packaging material made from renewable ressources, transparent if possible and with a cost for raw material less than 3 € / kg ...”.

Active MAP (O2 scavenging properties of sachet intentionally added in the packaging or of packaging material itself) will be also added in the mathematical model for mass transfer, as well as equation for predicting food shelf life. A novel user-friendly interface will be then built up to complete the Tailorpack’s one (French/German collaboration “NextGenPack”).

The DSS in active MAP is also currently being upgraded in the framework of the French ANR Map’opt and in link with the development of the software of predictive microbiology Sym’Previus, by coupling the mass transfer models to models of predictive microbiology. Objective is to predict effect of gases O2 and CO2 on microorganisms’ growth. This tool will enable to dimension active MAP by permitting to identify in advance gas permeabilites, internal gas composition, system geometries, etc. required for preventing pathogens’ growth (Pénicaud et al. 2011).

Images

Additional effects

The decision support system for packaging design can help to design new experimental plans.
### Important process parameters

**For passive and active MAP models:**
- O2/CO2 permeabilities for packaging materials
- Physiology of the product (respiration modeled by using the Michaelis-Menten equation)
- Absorption/emission of gas by active components such as O2 scavengers
- O2 and CO2 solubility and diffusivity
- Equations representing food shelf life evolution with time
- Models of predictive microbiology including effect of gases on microorganism’s growth

**For multicriteria DSS:**
- Data and databases containing data on fresh produce, and packaging properties (composition, gas permeabilities, mechanical properties, cost, etc.)

### Important product parameters

**for water transfer model in composite food:**
- Water activity
- Temperature
- Water diffusivity and water sorption isotherm
- Food geometries

### What can it be used for?

<table>
<thead>
<tr>
<th>Products</th>
<th>Respiring products (fruits and vegetables, cheese) and composite food product (e.g. sandwiches, sponge cake with a fresh filling, snacks and confectionary) Non respiring product (for predictive microbiology)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations</td>
<td>Packaging design, packaging development, edible film and coating design</td>
</tr>
<tr>
<td>Solutions for short comings</td>
<td>Optimisation of packaging Biodegradable packaging material</td>
</tr>
</tbody>
</table>

### What can it NOT be used for?

<table>
<thead>
<tr>
<th>Products</th>
<th>Limited interest for dry products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations</td>
<td>Storage (currently, no heat transfer, cooking and/or thermal operation or any processing unit other than storage taken into account)</td>
</tr>
<tr>
<td>Other limitations</td>
<td>Lack of reliability of the prediction due to a too large uncertainty of input parameters</td>
</tr>
<tr>
<td>Risks or hazards</td>
<td></td>
</tr>
</tbody>
</table>
Implementation

**Maturity**
The decision support system for packaging design has been implemented as a user-friendly webportal (http://www.tailorpack.com/).
This application is devoted to the design of packaging for respiring products (e.g. cheese, fruits and vegetable). The same user-friendly software has to be developed for the application concerning edible films and composite foods (under progress).
The database associated with the decision support system for packaging design (gathering the input parameters required to realize the simulations, e.g. gas permeabilities, water diffusivity, respiration rate, ...) has been updated using the large panel of data available in the scientific literature
The next step for this technology is to be enriched in such a way that it will take into account the diffusion and antimicrobial effect of active compounds (such as volatile aroma compounds). The objective is to be able to design active packaging with antimicrobial activity

**Modularity**
The decision support system for packaging design is a tool for research and development (packaging manufacturers).

**Consumer aspects**
Needs, acceptances and preferences of consumers regarding packaging material for fresh produce can be taken into account in the DSS thanks to the preference aggregation module presented above (see section working principle).

**Legal aspects**
The decision support system for packaging design is registered at the french program protection agency : Agence de Protection des Programmes n° IDDN.FR.001.190007.000.R.P.2009.000.30605. (2009-05-05)
The databases are registered at the french program protection agency : Agence de Protection des Programmes n° IDDN.FR.001.130006.000.R.P.2011.000.31235.

**Environmental aspects**
Not applicable

Facilities that might be interesting for you

Further Information

**Institutes**
INRA - GENIAL, CIRAD - Qualisud, ENSCM - IEM, INRA - SPO, CNRS - LCP, AgroSup Dijon - EMMA, ENSAIA, KU Leuven LFT, University of Parma, University of Milan, UNINA - DMA, Akdeniz University, University College Cork - FNS, EMPBRAPA, CSIC - IATA, Fraunhofer IVV, INRA - IATE

**Companies**
Software application companieswarning.png
- "Software application companies" cannot be used as a page name in this wiki.
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