Keep It Fresh

CROSS-SITE DESIGN CHALLENGE STUDENT GUIDE

Time	Ages	Cost	Group size
3 hours	15 - 18	Low	4 - 5
Engineering Areas			
• Packaging Engineering			

Overview

Ready-made fresh deli sandwiches are often sold in cafés, supermarkets, and convenience stores. These products must balance food safety, shelf life, sustainability, usability, and cost, all while appealing to customers and fitting into existing retail systems.

Most fresh sandwiches without special packaging have a shelf life of less than 24 hours. With careful packaging design and temperature control, however, this can be extended to 3–5 days. Unfortunately, many methods that increase shelf life, like plastic-heavy modified atmosphere packaging (MAP) often create a lot of waste.

You are part of a packaging engineering team tasked with designing a next-generation sandwich packaging that balances these competing requirements.

Your brief

Your team of packaging engineers has been asked by Fooodie, a national food and beverages manufacturer, to design a zero-waste packaging solution for a new line of fresh deli sandwiches distributed and stored under refrigerated conditions.

The specific requirements are that your design must:

- Maintain food safety and quality for 3–5 days under refrigeration (≤4 °C)
- Be easy to transport, pack, display, and open
- Be fully recyclable, compostable, reusable, or a justified combination
- Be cost-effective for large-scale production (ideally no more than US$ 0.3 per unit)
- Be appealing to customers

Specific constraints are that:

- No preservatives may be added to the food
- At no point may the food be frozen

MODIFIED ATMOSPHERE PACKAGING (MAP)

Modified Atmosphere Packaging (MAP) is a technique that replaces the air inside a food package with a protective gas mixture (normally Nitrogen, Carbon Dioxide, and Oxygen) to inhibit the growth of spoilage microorganisms and extend shelf life and maintain freshness.

Your design proposal must:

- Describe your proposed packaging (including design sketches is a good idea).
- Explain how your design will ensure food safety and a production to consumption life of 3 – 5 days.
- Identify and justify all the materials used and state whether each is recyclable, compostable and/or reusable to minimize waste.
- Explain how it will protect the sandwich from crushing or leaking.
- Describe how it will allow for easy transport and display fridge stacking.
- Describe how it will allow customers to see and understand the product.
- Describe how it is easy to open without any tools.
- Estimate the cost per packaging unit.
- Note any trade-offs and limitations of your design.

At the end of the time, you will present your proposal to the Foodies CEO. You may present your thinking in whatever form you choose (e.g., a slide deck, a document, an info-graphic) but your presentation should include annotated sketches, justifications for key decisions, and acknowledgement of any trade-offs or limitations inherent in your design. You will have **5 – 10 minutes** for this presentation.

What to do

Step 1: Clarify the problem

Before designing anything, make sure you clearly understand:

- What problem are you solving?
- Who are the users? (retail staff, transporters, customers, waste processors)
- What does "success" look like?

You can even write a short design statement – "We are designing a packaging system that…"

Step 2: Identify constraints and priorities

Next, list all requirements and constraints you are aware of like shelf life, costs, and user experience.

It can help to rank these from most to least important. This makes it's easier to decide what trade-offs to make. Just be prepared to justify your ranking.

Step 3: Research

Start by using the **MAP background** provided below to answer these questions:

- What causes sandwiches to spoil?
- How can oxygen, moisture, and temperature be controlled?
- What material properties matter and which matter most? (e.g. barrier properties, rigidity, compostability)

You are welcome to use the internet to expand your research as well. By the end, try and summarize the key ideas that will influence your design.

GET A HEAD START

Because time on the day is limited, you and your team should try and make a start on the challenge if you can. Read through the design requirements and constraints, get familiar with packaging technologies like MAP, and start investigating what different materials might be available to you.

Step 4: Generate multiple ideas

Start by individually sketching at least two different packaging concepts. Then as a team, compare your ideas, combine the strongest features of the different ideas together, and challenge any weak or unsubstantiated assumptions.

You can also use a decision matrix to compare and evaluate different ideas. Create a simple table with the important design criteria in the first column. Then score each idea 1 – 5 against each criterion. The idea with the highest score should be the best one

Step 5: Refine the chosen design

Take some time to develop and refine your chosen idea. Draw some annotated diagrams that help describe it in more detail and explain how it will work.

Also develop more detailed descriptions of:

- The materials that will be used and what will happen to them after use
- How it will be packed and sealed
- How it will be transported and displayed
- How it will be opened
- The estimated cost breakdown of production

As much as possible, avoid vague and unsubstantiated claims like “eco-friendly”. You need to explain why and how your design is “eco-friendly”.

Step 6: Analyze trade-offs

No design is perfect. So, you need to identify the trade-offs that you have made.

- What did you optimize?
- What did you sacrifice?
- What risks remain?

Clearly explain why you made these trade-offs and why you think they are acceptable.

If possible, you should also think about if or how your design would mitigate against situations like a loss in refrigeration or damage during transportation.

Step 7: Prepare your presentation

There is no set format for your presentation. You can create a slide deck, a document, or maybe even an infographic. The most important thing is that you justify your design. For the CEO to take your proposal seriously, they need to understand how you came to it, why you think it is feasible and how it optimizes between various trade-offs.

Step 8: Present your proposals

You have **5 – 10 minutes** to present your recommendations. Thereafter, the CEO is likely going to want to ask you some additional questions about your design proposal.

It is important that everyone on your team participates in the presentation.

What is MAP?

Modified Atmosphere Packaging (MAP) is a technique where the air inside a food package is changed to reduce or retard spoilage.

Normal air contains about:

- 21% oxygen (O_2)
- 78% nitrogen (N_2)
- 0.04% carbon dioxide (CO_2)

MAP for fresh sandwiches typically changes this to:

- Less than 1 - 2% oxygen (O_2)
- 20 - 40% carbon dioxide (CO_2)
- Balance nitrogen (N_2)

Most of the **oxygen** is removed because it supports the growth of many spoilage microorganisms and causes staling and discoloration through oxidation. The concentration of **carbon dioxide** is substantially increased because it inhibits the growth of many bacteria and molds. However, carbon dioxide dissolves quite easily into water and food and can change the pH of the product, altering its taste and texture. Too high a concentration of carbon dioxide damages the product.

Therefore, **nitrogen** is used as a filler gas to prevent packaging collapse. It is chemically inert, abundant, cheap to produce at food grade purity, and has low-solubility meaning that it does not dissolve into the food product as readily as carbon dioxide.

It's important to note that MAP does not sterilize the food in any way and refrigeration is still needed.

A typical MAP for a sandwich
Image by Colpac Packaging is used under fair use
https://colpacpackaging.com/products/sandwich-packaging/extended-shelf-life-sandwich-packaging/black-heat-seal-sandwich-packs/

PERMEABILITY

Permeable materials allow liquids and/or gases to pass through them. Low gas permeability means that the material does not allow gas molecules to easily pass through it.

Also, for MAP to work, it's important that the modified atmosphere be sustained. Therefore, leaks must be prevented and packaging materials with low gas **permeability** must be used.

For this reason, MAP often relies on plastic films which are excellent gas barriers but are not very environmentally friendly. Compostable and paper-based materials are friendlier but are more permeable, absorb moisture and have shorter shelf-lives. Thus, there is a trade-off between environmental impact and food waste.

If you want to learn more about MAP, watch the following videos:

- ***Modified Atmosphere Food Packaging (MAP) - how it works, benefits, gases, requirements*** *(7:24)*
  https://www.youtube.com/watch?v=CquXUa7ZPjA
- ***Equipment for Modified Atmosphere Packaging - gas mixers, analysers, leak detectors*** *(6:54)*
  https://www.youtube.com/watch?v=dIB43T9z4pU