

Mushrooms Household Simulation Model (HHSM)

Domestic Food and Packaging Waste Insights from Simulated UK Households

Research Brief

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Natural
Environment
Research Council



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Sheffield



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Centre for Food Policy

Shaping an effective food system

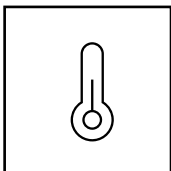
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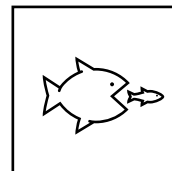
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01 Key Findings



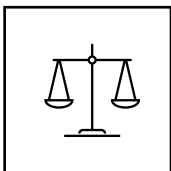
STORAGE TEMPERATURE EFFECT ON WASTE

Mushrooms experience accelerated degradation when stored at higher refrigerated temperatures, resulting in increased waste-to-purchase ratios. Specifically, elevating the storage temperature from 4°C to 7°C leads to a 45% rise in whole mushroom waste and a 51.4% increase in sliced mushroom waste.



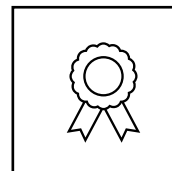
IMPACT OF LARGER PACK SIZES

The presence of larger packs in supermarkets resulted in a rise in mushroom waste. Specifically, with only 625-gram packs available, waste increased significantly, with the mushroom wasted-to-purchased ratio reaching 31.8%, a notable increase from the default value (9.66%). However, packaging waste decreased by 34% as fewer packs were purchased.



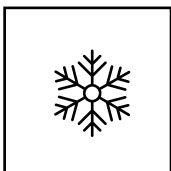
ALIGNED PURCHASE AND CONSUMPTION QUANTITIES

Household archetypes with weekly purchase quantities that closely matched their genuine consumption needs had a diminished likelihood of food spoilage, resulting in reduced food waste generation.



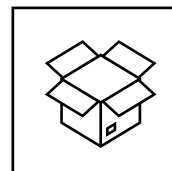
SMALLER PACKS REDUCE MUSHROOM WASTE

In the default scenario, the least mushroom waste is achieved. The presence of medium-sized packs results in less mushroom waste and a lower wasted-to-purchased ratio. For example, when considering the availability of only 250g packs, mushroom waste was reduced by 73% compared to the scenario with exclusively 625g packs available.



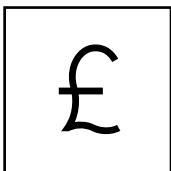
FREEZER UTILIZATION DECREASES MUSHROOM WASTE

With an increase in the likelihood of freezer use from 0% to 100% for both sliced and whole mushrooms, both mushroom and packaging waste decreased. However, the reduction in mushroom waste was more substantial, dropping by 92-93%, while packaging waste decreased by 5-6%.



EARTH BAG USAGE REDUCES MUSHROOM WASTE

Whole and sliced mushrooms packed in Earth Bags cuts domestic food waste compared to plastic punnets, except in the case of storing sliced mushrooms at 4°C. In studied scenarios, waste-to-purchase ratios ranged from 8.97%-11.5% lower than using plastic punnets (9.66%-13.2%).



FREEZER USAGE AND HOUSEHOLD EFFICIENCY

Increased utilization of the freezer resulted in a decrease in mushroom purchases and a lower ratio of unfulfilled consumption needs, signalling more effective management of household resources.



PAPER BAG USAGE REDUCES PACKAGING WASTE

The reduction in packaging waste can be attributed to two factors: lighter paper bags compared to plastic punnets and reduced purchase quantities. This leads to a roughly 20% decrease in sliced mushroom packaging waste and an impressive 86% reduction in whole mushroom packaging waste.

02 The Household Simulation Model (HHSM)

The HHSM continues to advance its use of Discrete Event Simulation (DES) in modelling domestic waste generation, shopping and consumption patterns. The current version enhances the model's functionality, adding the ability to model packaging waste while retaining its ability to assess the impacts of various market and consumer-centred interventions for different food products.

Project Vision

The updated **HHSM** offers a quantifiable measure of **waste reduction** and insight into the **trade-offs** of different market and consumer interventions. It aims to offer optimal solutions to reduce food and packaging waste by integrating data on food product characteristics, plastic packaging, and household behaviors.

Collaborative Impact

This collaborative and multidisciplinary project draws upon the expertise of different institutions (**City University of London, University of Sheffield, University of Greenwich, University of Kent and WRAP, Waste and Resources Action Programme**) to target the major food categories associated with the highest waste and trade-off potential (see Figure 1). It paves the way for rapid product and food system redesign to reduce plastic and food waste.

Model Development

The development of the HHSM is a process that unfolds across four key stages:

- **Stage 1 – Groundwork Research (WP4 and WP5).** This foundational phase involves qualitative research into household behaviour, attitudes and practices. It also quantifies food

shelf-life and food-packaging trade-offs and conducts a comprehensive literature review and consulting food and packaging experts.

- **Stage 2 – Creation of a new HHSM version (WP1).** The information gathered from the groundwork research is used to build the updated HHSM during this stage. It also includes verifying and validating the model based on the UK scenario for a specific food product to ensure its accuracy and reliability in predicting the effects of various interventions on food and packaging waste.
- **Stage 3 – Modelling of Interventions and Innovations (WP2).** In this stage, the validated model simulates the impacts of potential market and consumer interventions and product innovations on food and packaging waste generation.
- **Stage 4 – User Base Expansion (WP3).** In this final stage, we focus on expanding the model's user base, extending its reach to encompass a broad spectrum of stakeholders in the food system. This stage is crucial to ensure the model remains relevant, practical and adaptable to the varying needs of the different stakeholders, hence promoting the broad-base applicability and impact.

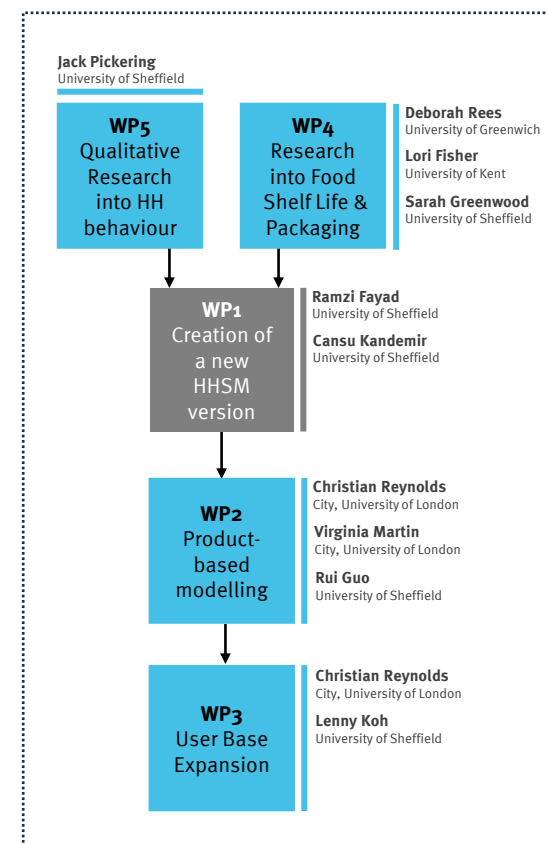


Figure 1. Project work packages (WPs) and their relationship within this NERC-funded project, 'Reducing plastic packaging and food waste through product innovation simulation'.

02 The Household Simulation Model (HHSM)

The new HHSM is divided into three distinct models designed to target specific food types. These models collectively form a comprehensive system covering a broad spectrum of perishable food types and consumption behaviours, providing a robust framework for understanding and optimising household food and packaging waste.

A Multi-dimensional Approach

The new HHSM is differentiated into three unique models, each engineered to tackle waste related to a particular food category (see Table 1).

The **Chicken Model**, initially designed for chicken fillets, extends its application to other food items sold in pieces and requiring cooking before consumption. It considers shelf life (number of days) for quality degradation, allows for cooking and leftovers and has several freezing options, including the ability to freeze upon purchase, raw products and leftovers.

Secondly, the **Grapes Model**, primarily developed to tackle grape waste, can also be used for other perishable food products sold by weight that do not necessitate cooking for consumption. The model considers shelf life (days) or visual score for food quality degradation and does not consider

cooked food, leftovers or product freezing.

Lastly, the **Mushroom Model**, initially aimed at mushroom waste, can be applied to other food items sold by weight that are typically cooked before consumption. It factors in shelf-life or visual score for product quality degradation and allows for the consideration of cooked food and leftovers. However, freezing options are limited to leftovers only.

Household Archetypes

The model results can be adjusted for different household archetypes to represent a variety of UK households' food and plastic waste profiles (see Table 2). These archetypes are based on **WRAP's segmentation of the UK population** and reflect household composition, attitudes and behaviours related to food and packaging waste [1].

Table 1. Differences between the Chicken, Grapes and Mushrooms HHSM versions.

Model Features	Chicken Model	Grapes Model	Mushroom Model
Food Measurement Unit	Pieces	Grammes	Grammes
Food Quality Degradation Method	Shelf Life (i.e., days)	Shelf Life or Visual Score	Shelf Life or Visual Score
Cooked Food	Yes	No	Yes
Leftovers	Yes	No	Yes
Freezing options	Yes (purchase, raw, leftovers)	No	Yes (only leftovers)

Table 2. Household Archetypes and their weight for the UK population based on segmentation research by WRAP.

Household Archetype name and weight (%)	Brief Description
Aspirational Discoverers (AD) Family (11.4%)	4 people, younger children, not willing to take risks with food, confident, good planning
Functional Fuellers (FF) Single (16.6%)	1 person, less willing to take risks, low confidence in the kitchen, poor planning
Functional Fuellers (FF) Couple (8%)	2 people, no children, less risk averse, low confidence in the kitchen, poor planning
Spontaneous Creatives (SC) Single (11.4%)	1 person, less risk averse, moderately low confidence in the kitchen, poor planning
Spontaneous Creatives (SC) Family (11.4%)	3 people, one child, more risk averse, moderately low confidence in the kitchen, poor planning
Ideal Advocates (IA) Family (16.8%)	2 people, no children, less risk averse, high confidence in the kitchen, good planning
Pressure Providers (PP) Family (9.6%)	4 people with (generally older) children, medium confidence in the kitchen, good planning
Pressure Providers (PP) Single Family (10.2%)	2 people, single parent with teenager, medium confidence in the kitchen, good planning

03 The Mushrooms Household Simulation Model

This study adapts the Chicken Household Simulation Model (HHSM) to simulate the flow of mushroom packs from supermarket shelves to consumption and/or disposal in households, assessing the amount of domestic waste produced from mushrooms and their packaging.

Research Objectives

This research endeavours to pinpoint interventions to reduce domestic mushroom waste in the UK. The study investigates how waste generation is impacted by **actions taken in response to the freshness of mushrooms**, including both raw and cooked mushrooms stored in various conditions such as the fridge or freezer. Additionally, it considers the influence of **packaging sizes, shelf-life, storage behaviour** and the availability of **loose mushrooms** at the supermarket on household waste generation.

Four interventions were modelled in this study: (a) **domestic refrigeration temperatures** when storing mushrooms, including both whole and sliced mushrooms, (b) the **actions taken following an assessment of mushroom freshness** in households, considering in the fridge or freezer, (c) **pack sizes availability** on the market, (d) the options of **different packaging materials**, plastics and paper-based.

Model Structure and Input and Output Variables

Constructed with **Arena simulation software** version 16.2 [2], the model comprises six modules that depict the diverse stages of mushrooms' lifecycle, extending from the supermarket to the households. The modules encompass model setup, market, shopping, storing, consumption, and expiry (see Figure 2). Customisable **input variables** in each module support the simulation of various market interventions designed to influence household behaviors.

The model compiles the weekly averages for several significant **outcomes**. This includes mushroom waste, both in total and broken down by storage location (counter or fridge). Furthermore, it accounts for the plastic/paper waste generated from the mushrooms' packs.

In addition, the model captures **household consumption** and **purchasing habits**, such as the weekly mushroom demand, the weekly consumption amount, the average quantity stored in the household, the average purchased amount per week and the frequency of shopping trips.

Research Methodology

The model integrates insights from social sciences and anthropological studies to mirror realistic consumer behaviour about mushroom consumption. This approach was reinforced with primary qualitative research [3,4], focusing on attitudes towards food waste, consumption patterns and storage practices.

Additionally, the model incorporates data from sensory shelf-life evaluations, determining the visual degradation of mushrooms and the point at which they are typically deemed unfit for consumption.

To ensure robustness and account for potential variations over time, the model's results are derived from an average of **60-year simulations**, with each being **repeated 10 times** and averaged. Conducting the simulation over a span of 60 years enables us to capture long-term behaviours and trends, and the inclusion of 10 repetitions per year enhance the precision of our findings, mitigating random fluctuations that might occur in any single run. This extensive simulation approach guarantees that our results are comprehensive and

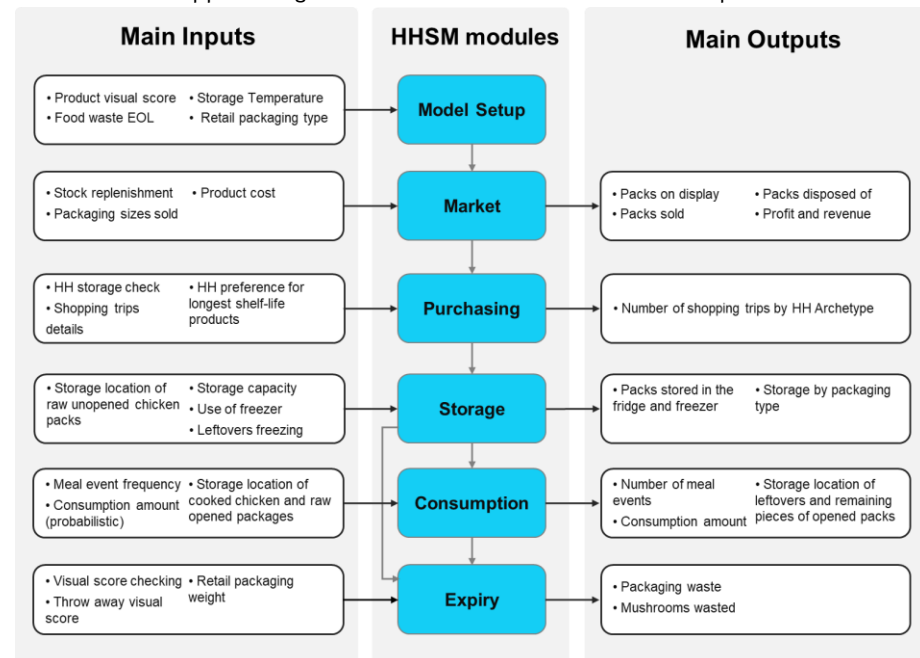


Figure 2. HHSM process chart showing inputs, outputs and the model's structure.

04 Evaluating rates of deterioration for different storage scenarios

The HHSM depends on data on rates of deterioration of mushrooms at specific temperatures and within specific packaging types. We investigated the effects of two different refrigeration storage temperatures; 4 °C and 7 °C for both whole and sliced mushrooms. We also evaluated the effect of a novel paper-based pack; the Earth Bag developed by Sirane.

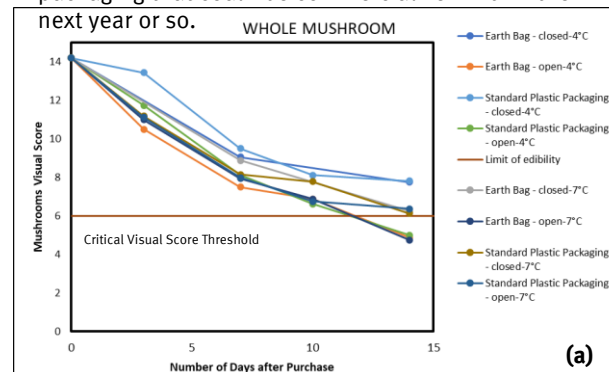
Mushrooms' Quality Score and Measurement of Rates of Deterioration

The empirical study on mushroom **degradation** (WP5) utilised a quality scale for both whole and sliced mushrooms, ranging from **15** (signifying optimal quality) to **0** (indicating complete degradation). This score represents the perceived freshness and quality of the mushrooms and provides a systematic and empirical basis to quantify the physical degradation of mushrooms over time. Trials conducted in November and December 2022 using produce purchased from a major UK retail outlet indicated an average quality at purchase of 14.20 and 13.63 for whole and sliced mushrooms, respectively. In addition, a **critical visual score threshold** of 6 is set in the default scenario and if the visual score of the mushrooms falls below the threshold during the storage phase, the mushrooms are regarded as unsuitable for consumption and consequently **discarded, resulting in mushroom waste**.

Table 3. Rate of deterioration (decrease in quality score per day) for sliced and whole mushrooms in standard plastic packaging and in Earth Bag.

	Rate of deterioration (decrease in score per day)			
	Sliced mushrooms		Whole mushrooms	
	4°C	7°C	4°C	7°C
Standard Plastic Packaging – closed	0.51	0.58	0.55	0.67
Standard Plastic Packaging – open	0.73	0.89	0.72	0.67
Earth Bag – closed	0.54	0.52	0.52	0.61
Earth Bag – open	0.68	0.81	0.74	0.73

For both whole and sliced mushrooms two storage environments were used, a domestic refrigerator set to 4 °C and a domestic refrigerator set to 7 °C. In each case two pack types were used; standard plastic commercial packs, and a novel paper-based pack developed by Sirane. In addition, each pack type was tested either sealed or opened. For whole mushrooms, the commercial pack comprised a plastic punnet top sealed with perforated film. For sliced mushrooms, the commercial pack comprised a plastic punnet top sealed with film that was designed to maintain a modified atmosphere (MA) to extend the shelf-life of the product. The Earth Bag C3o8S5 developed by Sirane is a novel paper-based pack with water-based coatings, and therefore compatible with paper recycling. The Earth Bag is semi-transparent and capable of maintaining modified atmospheres. It is not currently used commercially for mushrooms, but was chosen as an example of packaging that could be commercialized within the next year or so.



Implementing the Mushroom HHSM

During the purchase phase in the simulation, a pack of whole mushroom with a quality score operating under a probabilistic **triangular distribution**: TRIA (12, 14.2, 15) is selected at the supermarket by the household. The distribution for sliced mushroom is TRIA (12, 13.63, 15). After purchase, the mushrooms' quality score becomes an essential determinant of their fate in the household. The **daily rate of quality score decline** differed based on each **storage temperature, pack type** and whether the mushrooms' pack is **opened or unopened** (refer to Table 3 and Figure 4).

A 15-point quality scale was used for each of whole and sliced mushrooms. For whole mushrooms, the average starting score (at purchase) was 14.20, and it is assumed that the mushrooms become unusable at 6.00. For sliced mushrooms, the average starting score (at purchase) was 13.63, and it is assumed that they become unusable at 6.00.

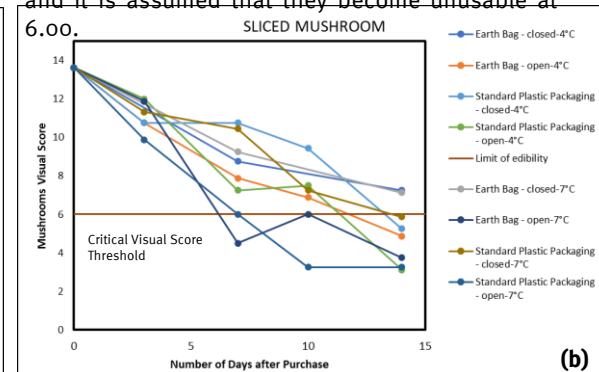


Figure 4. Mushroom degradation rates for different storage temperatures, packaging and conditions (opened VS unopened pack) (a) whole mushrooms (b) sliced mushrooms.

04 Storage Temperature's Influence on Waste Generation

The model revealed the correlation between storage temperature and waste generation for different forms of mushroom, highlighting the necessity for ideal temperature regulation in storage of different forms of food to minimise waste

Refrigerated Storage Impact on Whole Mushroom Waste

In the study, we assumed that the mushrooms are only stored in fridge. The default scenario considered a fridge temperature of 4 °C and led to an average **waste of 38.9 g per week** and **31 g of plastic per week**. When the mushroom package is kept sealed, a minor increase in fridge temperature to 7 °C triggered faster degradation of the mushrooms' visual score compared to the lower storage temperature at 4 °C (see Table 3), leading to a rise in mushroom waste production. However, an exception was noted for mushroom opened packs, where degradation was slightly faster at 4 °C compared to 7 °C, possibly due to product dehydration.

Refrigerated Storage Impact on Sliced Mushroom Waste

Compared to whole mushrooms, the degradation of quality score for sealed sliced mushroom packs where the seal has not been broken is slower at both 4 °C and 7 °C. Unlike whole mushrooms, sliced mushrooms are stored under modified atmospheres (MA), so this is probably an indication of the effectiveness of MA in extending shelf-life. However, opened sliced mushroom packs deteriorate faster than opened whole mushrooms (see Table 3), indicating that the effect of refrigerated temperature on sliced mushroom waste generation is slightly stronger than that for whole mushrooms.

An increase in storage temperature is associated with a rise in sliced mushroom waste. Nonetheless, the amount of waste generated is

still lower than that of whole mushrooms at the same storage temperature (see Figure 3).

Storage Temperature Impact on Packaging Waste

The weight of plastic packaging for whole mushrooms surpasses compared to sliced mushroom substantially (see Table 4). Consequently, the packaging waste generated by whole mushrooms is much higher than that of sliced mushroom. Regarding storage temperature impact, storing mushrooms at higher temperature (7 °C in this study) led to a slight increase in the amount of packaging waste generated (see Figure 4), mainly due to an increase in the number of packs that need to be purchased to fulfill the household consumption requirement. The households with a higher number of occupants produced a greater amount of packaging waste because they tended to buy a greater number of packs.

Table 4. Plastic packaging weight for whole mushroom and sliced mushroom.

Mushrooms Pack (g)	Weight of plastic packaging (g)	
	Whole mushroom	Sliced mushroom
150	16.3	2.51
250	17.9	4.11
300	18.0	11.10

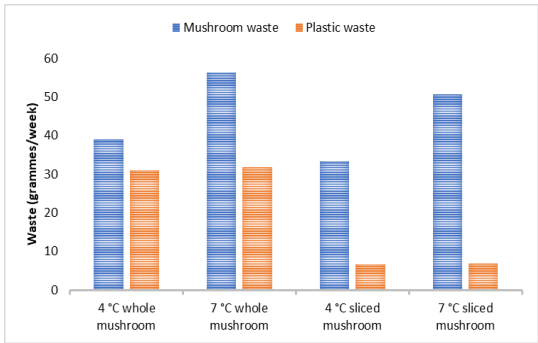


Figure 3. Influence of storage temperature on the whole and sliced mushrooms and packaging waste for UK average households. Simulation details: 10 replications, 60 years.

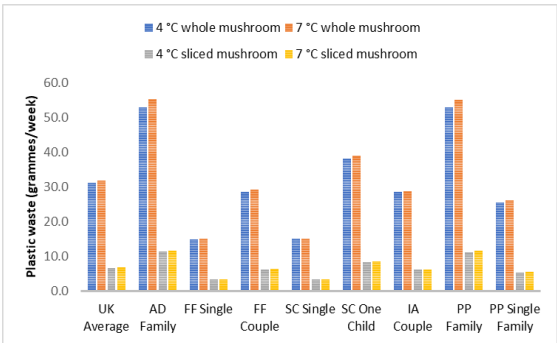


Figure 4. Influence of storage temperature on the average packaging waste generated from whole and sliced mushroom purchases for the eight UK household archetypes. Simulation details: 10 replications, 60 years.

Highlights

The scenario storing at 4 °C led to the lowest average mushroom and plastic waste generated for both whole and sliced mushroom

Whole mushroom:

+2.6%

Packaging waste increase when stored at 7 °C compared to 4 °C*

+45%

Whole mushroom waste increase when stored at 7 °C compared to 4 °C*

Sliced mushroom:

+3.0%

Packaging waste increase when stored at 7 °C compared to 4 °C*

+51.8%

Sliced mushroom waste increase when stored at 7 °C compared to 4 °C*

* Just this temperature was considered for this figure, the other was kept constant at the default's scenario value

04 Storage Temperature's Influence on Waste Generation

Storage temperature plays a key role in wastage and unfulfilled consumption requirements in households, primarily through its influence on the visual score degradation rate. Better understanding and management of storage conditions could be key to reducing waste and improving consumption efficiency

Mushrooms Wasted to Mushrooms Purchased Ratio

The model provided an accurate estimate of the wasted to purchased ratio of mushrooms for the UK average. The derived value was **9.66%**, closely aligning with the **9.44%** of wasted to purchased ratio reported in the literature (WRAP, 2014).

Higher refrigeration temperatures increased the ratio of mushrooms wasted to mushroom purchased in households (see Figure 5). The data revealed that escalating storage temperature from 4 to 7 °C led to around **36.4% average increase** in the wasted-to-purchased ratio for whole mushroom (see Figure 5 and Figure 6). Sliced mushroom sees a larger **51.4% average increase** in the ratio. This is primarily attributed to the reduced shelf-life of mushrooms stored at elevated temperatures, a factor directly linked to the visual degradation rate identified in Table 3. Higher storage temperatures accelerated the rate of visual score degradation. For instance, for sliced mushroom, the unopened packs' degradation rate rose from 0.51 at 4 °C to 0.58 at 7 °C. For opened packs, these values escalated from 0.73 to 0.80.

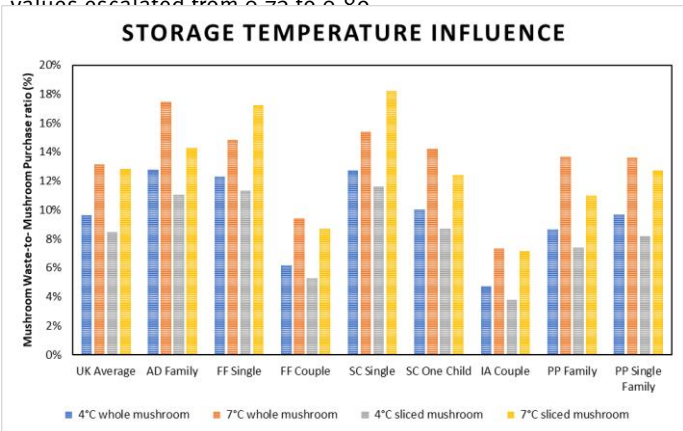


Figure 5. Influence of storage temperature on the mushrooms wasted/purchased ratio for UK average households and the eight household archetypes. Simulation details: 10 replications, 60 years

Not surprisingly the temperature effect occurred across all the household archetypes, as depicted in Figure 5. However, it is worth noting that some archetypes –the IA Couple and FF couple – exhibited significantly lower mushrooms wasted-to-purchased ratios than the others. This result is largely attributed to the fact that the amounts of mushrooms they purchased were **more closely aligned with their consumption requirements**, thereby reducing waste.

Mushrooms Requirement Unfulfilled-to-Consumption Requirement Ratio

Inefficient storage patterns and behaviours, like higher temperatures, can disrupt resource management, increasing food waste and costs. Further inefficiencies emerge when mushrooms aren't available for consumption. For instance, the model recorded an **average 7% and 10% rise** in unfulfilled consumption requirement-to-requirement ratio when whole and sliced mushrooms were stored at 7°C instead of 4°C, respectively (see

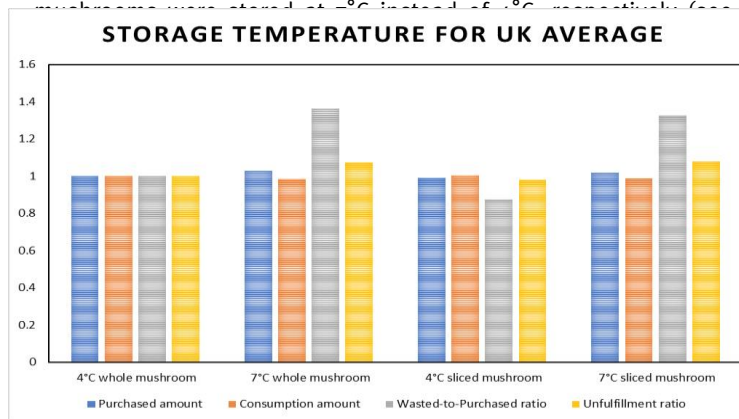


Figure 6. UK averages for refrigeration storage temperatures scenarios. The chart normalises factor values per scenario, dividing them by default scenario values against mushrooms purchased (g), consumed (g), wasted-to-purchased (%) and unfulfilled-to-required (%). A normalised value of 100 denotes the default scenario (whole mushroom stored at 4 °C). Values above or below 100 indicate a scenario factor greater or lesser than the default. Simulation specifics: 10 replications, 60 years.

Highlights

+36.4%

Whole mushroom wasted-to-purchased ratio increase when stored at 7 °C compared to 4 °C*

+51.4%

Sliced mushroom wasted-to-purchased ratio increase when stored at 7 °C compared to 4 °C*

+2.9%

Whole and sliced mushroom purchased increase when stored at 7 °C compared to 4 °C*

+7.28%

Whole mushroom unfulfilled requirement increase when stored at 7 °C compared to 4 °C*

+9.84%

Sliced mushroom unfulfilled requirement increase when stored at 7 °C compared to 4 °C*

* Just this temperature (either refrigeration or ambient) was considered for this figure, the other was kept constant at the default's scenario value

05 Freezer Usage Influence on Waste Generation

The objective of this study was to investigate the impact of storing mushrooms in the freezer as opposed to fridge, focusing on the waste generated from both the mushrooms and their packaging within UK households

Simulation details

This intervention was carried out by adjusting an input variable in the model's storage module called '**Likelihood of storage of mushrooms by location**' (variable 4.1). This variable designates two potential storage locations: the **fridge** and **freezer**. The study juxtaposes the default scenario – where the likelihood of storage location remains constant across different **household archetypes** (where all the mushrooms are stored in the fridge) – with a series of scenarios ranging from 0% likelihood of refrigeration used to a 100% inclination towards freezer storage in the UK average scenario. The rate of deterioration is programmed to be slower compared to storage in a refrigerator, resulting in an extended shelf life.

Results

The findings highlighted a correlation between **increased freezer** use for mushroom storage and a **decrease in waste**. While both mushroom and packaging waste show a downward trend, the reduction was more substantial for mushroom waste (see Figure 7). Despite the milder reduction in packaging waste, the overall results underscore the potential of enhanced freezer practices in effectively managing household waste.

As the decreasing trend is similar for whole and sliced mushroom. Only whole mushroom is shown as an example. Packaging waste slightly decreased across all archetypes as freezer usage increased (see Figure 8). However, the SC and FF Single, FF Couple and IA couples saw a slightly lower reduction in packaging. This effect was attributed to the intervention's minimal impact on their shopping trips and the quantity of the mushrooms purchased. For instance, the FF and IA couples experienced less than a 5% decrease in the number of shopping trips when transitioning from 0% to 100% freezer usage. This contrasted with other archetypes, which registered around 7%-12% decrease in shopping trips. These findings highlight the role of **shopping and storage habits** in driving packaging waste reduction and the importance of targeting each demographic group to maximise waste reduction.

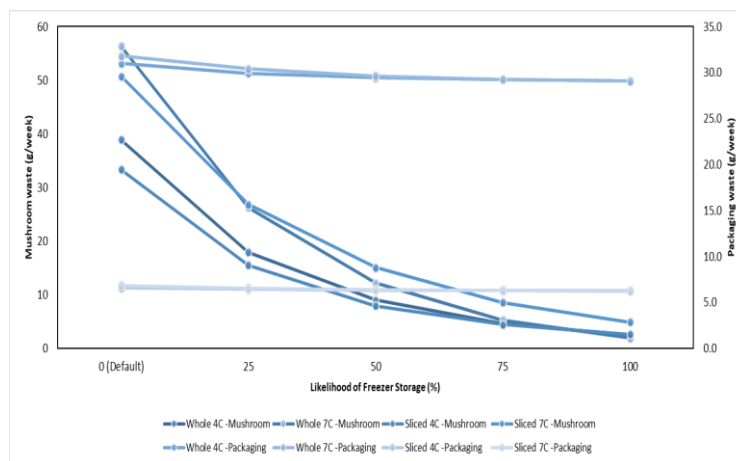


Figure 7. Influence of likelihood of freezer storage on the mushrooms and packaging waste for UK average households. Simulation details: 10 replications, 60 years



Figure 8. Influence of freezer use likelihood on the packaging waste generated from mushrooms purchases. Simulation details: 10 replications, 60 years

Highlights

93.5%
Whole Mushroom waste decrease when the likelihood of storing in the freezer increased from 0% (default scenario) to 100%

6.1%
Packaging waste decrease when the likelihood of storing in the fridge increased from 0% to 100%

92%
Sliced mushroom waste decrease when the likelihood of storing in the fridge increased from 0% (default scenario) to 100%

5%
Packaging waste decrease when the likelihood of storing in the fridge increased from 0% (default scenario) to 100%

05 Freezer Usage Influence on Waste Generation

The results underscore the effectiveness of freezer use in reducing mushroom waste and the amount of mushroom purchased to fulfil the households' consumption requirement

Mushrooms' Wasted-to-Mushrooms Purchased Ratio

The results underscore the effectiveness of freezer use in reducing mushroom waste. When the likelihood of fridge storage increase from the default scenario – 0% freezer usage for UK entire population- to 100% usage, the **wasted-to-purchase ratio of mushrooms notably decreased by 8.5%**.

Across all archetypes, the ratio of mushrooms wasted-to-purchased significantly declined as the likelihood of freezer use increased (see Figure 9). However, while the FF Single and SC Single archetypes also demonstrated a decrease in the wasted-to-purchased ratio with higher freezer usage, the reduction was less substantial compared to other archetypes. This can be attributed to this archetype purchasing habits, as they tended to procure a relatively higher quantity of mushrooms per person on a weekly basis. This finding underlines the importance of considering household characteristics and shopping habits in strategies aiming to reduce food waste. On the contrary, the Family AD and One Child SC archetypes show a significant reduction in the wasted-to-purchased ratio, primarily due to lower weekly consumption per person and longer storage.

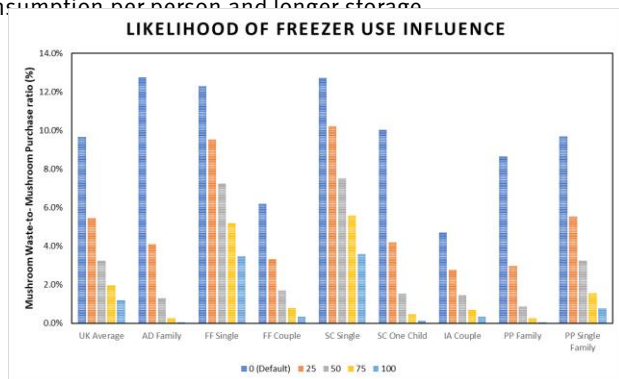


Figure 9. Influence of freezer use likelihood on the mushrooms wasted-to-purchased ratio for UK average households and the eight household archetypes. Simulation details: 10 replications, 60 years

Impact on Mushroom Consumption and Purchases

The results indicate that an increased likelihood of using the freezer for mushroom storage gradually diminishes the amount of mushrooms purchased and the mushrooms requirement unfulfilled-to-requirement ratio (see Figure 10). This can be attributed to the extended shelf life of mushrooms stored in the freezer, reducing waste and making the food available for a longer period. Specifically, when the likelihood of freezer storage rose from the default (0%) to 100%, the quantity of **mushrooms purchased decreased by 6.6%**, and an increase in freezer usage from 50% to 100% saw a **1.2% marginal decrease in purchased quantity**. Still, the requirement **unfulfilled-to-requirement ratio decreased with freezer use by 2%** when freezer use increased from default (0%) to 100%. Despite these small variations in purchase and unfulfillment patterns, **mushroom consumption increased by 2.5%** when the likelihood of freezer storage rose from 0% to 100%, which shows a more efficient household resource management will.

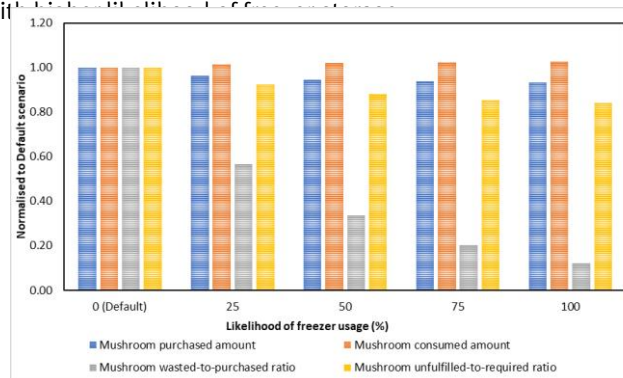


Figure 10. UK averages for different likelihoods of fridge use. The chart normalises factor values per scenario, dividing them by default scenario values against mushrooms purchased (g), consumed (g), wasted-to-purchased (%) and unfulfilled-to-required (%). A normalised value of 100 denotes the default scenario. Values above or below 100 indicate a scenario factor greater or lesser than the default. Simulation specifics: 10 replications, 60 years.

Highlights

8.5%

Whole mushrooms **wasted-to-purchased ratio** decrease when the likelihood of storing in the freezer increased from 0% to 100%

7.2%

Sliced mushrooms **wasted-to-purchased ratio** decrease when the likelihood of storing in the freezer increase from the 0% to 100%

2.4%

Whole mushrooms **requirement unfulfilled-to-requirement ratio** decrease when the likelihood of storing in the freezer increased from 0% to 100%

2%

Sliced mushrooms **requirement unfulfilled-to-requirement ratio** decrease when the likelihood of storing in the freezer increased from the default values to 100%

6.7%

Whole mushroom **purchased amount** decreased when the likelihood of storing in the freezer increased from 0% to 100%

5.7%

Sliced mushroom **purchased amount** decreased when the likelihood of storing in the freezer increased from 0% to 100%

o6 Pack Size Availability

This study investigates how modifying supermarket pack sizes can influence household purchasing, offering valuable insights into potential strategies for reducing mushroom and packaging waste

Mushroom Packaging Formats

Several mushroom pack sizes and formats are available to consumers in today's supermarkets. **PET** (Polyethylene terephthalate), **PP** (Polypropylene) and **PS** (Polystyrene) punnets take the lead in popularity. These punnets come in two major variations: either covered with a lidding film or packaged using a flow wrap method. An additional prevalent format is the plastic (so likely **OPP** (oriented polypropylene) or **LDPE** (low density polyethylene)) bag-only for frozen mushroom, which is **not considered** in this study. These three dominant formats can be found in Figure 11. For this study on pack size, only fresh whole mushrooms are considered.

While **cardboard trays** are also used as packaging solutions, this study narrows its scope to PET, PP and PS punnets for fresh mushroom, as this format present a potential f

Pack Size Scenarios

This study examined 10 pack scenarios, each exhibiting a unique assortment of pack sizes, as outlined in Table 5. The model assumes a supermarket can offer a maximum of three pack sizes concurrently. Certain scenarios encompassed the full range of three pack sizes: small, medium and large. Meanwhile, others provided only two sizes or a singular pack size.

Overall, the study considers **seven possible pack sizes**: 150, 250, 300, 400, 485, 500, and 625g. All packs are punnets. Information on these packs (Table 6) was sourced from the EPIC database (Valpak, 2023) and various UK supermarkets (e.g. Sainsbury's and Tesco, etc.) for fresh produce. The study assumed the default scenario consists of three pack sizes: 150 g (small), 250 g (medium) and 300 g (large). Simulation runs for the study of the influence of pack size available on the market on mushrooms and its packaging waste generation in UK households. The default scenario run corresponds to Run 1.

Run	Pack sizes available on the market
1	S (150 g punnet), M (250 g punnet), L (300g punnet)
2	S (150 g punnet), M (300 g punnet), L (400 g punnet)
3	L (625g punnet)
4	L (400 g punnet)
5	L (485 g punnet)
6	M (250 g punnet)
7	M (300 g punnet)
8	M (250 g punnet), L (500g punnet)
9	M (300 g punnet), L (625g punnet)
10	L (500g punnet)

The study also considered the weight of the plastic material constituting each pack format. In practice, the weight of the lid will be only a small proportion of the whole pack, however, incorporating the weight of the lid/ wrap in the evaluation is an area for further investigation.

In addition, incorporating the 'mushroom weight-to-packaging weight ratio' into the analysis allows for evaluating material efficiency for each packaging format relative to the weight of the mushrooms they contain (see Table 6).

Table 6. Plastic Weight and Mushroom Weight-to-Packaging Weight Ratio for the different packs investigated. For the punnets weight the film weight is not considered, the weight specified just refers to the punnet (i.e., tray that contains the mushrooms). Herein, the weight pertains to whole mushroom.

Mushrooms Pack	Packaging Weight (g)	Mushroom Weight-to-Packaging Weight Ratio	Reference
150 g punnet	16.3 g	9.2	[3]
200 g punnet	17.1 g	11.7	
250 g punnet	17.9 g	13.97	
300 g punnet	18 g	26.77	
400 g punnet	19.6 g	20.41	
485 g punnet	20.96 g	23.14	
500 g punnet	21.2 g	23.58	
625 g punnet	23.2 g	26.94	



Figure 11. Most common mushroom packaging formats: (a) a flow wrapped PET/PP/PS punnet, (b) a PET/PP/PS punnet with a plastic lid and (c) an OPP bag

o6 Pack Size Availability

The findings show that the availability and selection of pack sizes in the market can significantly influence waste generation, underlining the potential of packaging strategies in waste reduction efforts.

Pack Sizes Preference

The simulation showed **small and medium-sized packs** were optimal for households, never opting for large-sized packs. This preference is due to the model's design, which prioritises the acquisition of smaller and medium-sized packs when available, simulating their more prevalent availability in the market (see Table 7). The priorities are posited in the model based on validation, demonstrating alignment with actual waste levels in the UK. Consequently, scenarios with identical small and medium-sized packs yielded identical results. Therefore, the scenario where small and medium sizes remained constant while only the large size was modified produced results indistinguishable from the default scenario (Run 1) and was consequently omitted from the study.

The Influence of Larger Pack Sizes

With the market offering only larger pack sizes (such as 500-gramme or 625-gramme packs), there was a notable increase in mushroom wastage, as illustrated in Figure 12, particularly when only **625-gramme packs** were available. This surge was mainly due to an increase in the quantity purchased per shopping trip, especially during top-up shops. The scenario where only 625-gramme packs exist also led the mushrooms wasted-to-purchased ratio peaked at 31.8%, a significant disparity compared to the 9.66% ratio in the default. In addition, it also led to the highest average weekly mushroom purchases, a critical increase of 34.9% from the default. In addition, due to the larger quantity purchased, the consumption amount increased by 4.2% and the requirement unfulfilled-to-required ratio decreased by 3.5%.

Smaller and Medium Pack Sizes

The most effective scenarios for having relatively less food waste involved the use of smaller and medium pack

The scenario involving the default scenario yielded the lowest mushrooms wasted-to-purchased ratio (9.66%), followed by the scenario offering only 250 g packs (10.15%). Both scenarios resulted in slightly lower mushroom purchases than other scenarios, they promoted more efficient household consumption patterns, consequently reducing unfulfilled consumption requirements.

Table 7. Modelled household preference for specific pack sizes according to their purchased amount

Weekly Mushroom Purchase amount (g)	First-Choice Pack to Purchase	Second-Choice Pack to Purchase	Third-Choice Pack to Purchase
≤Small size pack containment	Small Size	Medium Size	Large Size
≤Medium size pack containment	Medium Size	Small Size	Large Size
≤Large size pack containment	Medium Size	Large Size	Small Size

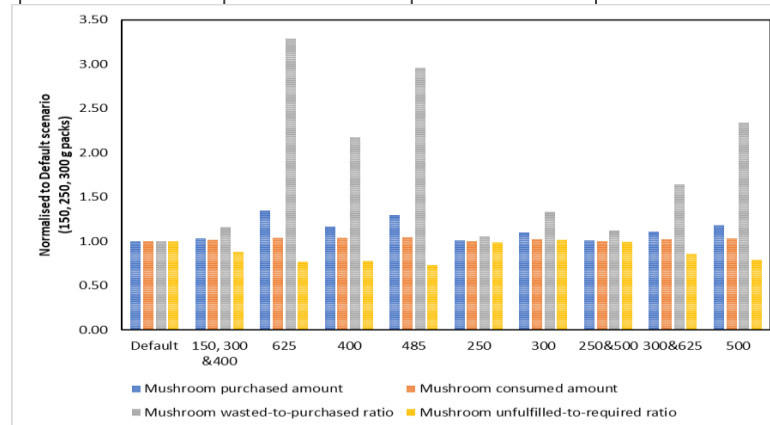


Figure 12. UK averages for various pack sizes scenarios. The chart normalises factor values per scenario, dividing them by default scenario values against mushroom purchased (g), consumed (g), wasted-to-purchased (%) and unfulfilled-to-required (%). A normalised value of 100 denotes the default scenario. Values above or below 1 indicate a scenario factor greater or lesser than the default. Simulation specifics: 10 replications, 60 years.

Highlights

Only 250g packs Scenario

6.26%

Mushroom waste increase compared to the default

5.2%

Packaging waste decrease

250 g & 500 g packs Scenario

14.4%

Mushroom waste increase compared to the default

21.4%

Packaging waste decrease

150, 300 & 400 g packs Scenario

17.4%

Mushroom waste increase compared to the default

18%

Packaging waste increase

o6 Pack Size Availability

Developing and selecting materials for lightweight packaging that adhere to strength and waste management standards are integral to reducing waste and moving towards a more sustainable food supply chain.

Packaging Waste

When only **250 g packs** were available, a **5.2% reduction** in average weekly packaging waste generation was observed compared to the default scenario. When only **625 g packs** were available, the reduction reaches **34%** (see Figure 13). It complies with the common inefficiency often associated with smaller packages. This data highlights the crucial influence of plastic packaging weight on packaging waste generation. The 625 g pack available scenario also produced the lowest **packaging waste-to-mushrooms purchased ratio** (0.04) for all the household archetypes, indicating a decrease in packaging waste generated per gram of mushrooms purchased (see Table 8).

On the other hand, scenarios offering **150, 300 & 400 g packs** resulted in the highest packaging waste, marking a **18% increase** compared to the default scenario (See Figure 13). This significant rise was mainly due to the 300 g packs having relatively high mushroom weight-to-packaging weight ratio compared to the other packs studied (26.77).

Trade-Offs

The findings of this study accentuate the role of **packaging optimisation** in waste reduction and sustainability. The use of smaller packaging sizes, like the 250 g punnets, illustrates how adjusting to purchase patterns can aid in waste reduction.

From a sustainability perspective, **lightweight of packaging materials** is a crucial element of packaging optimisation. The goal is to minimise packaging waste generation (and the use of raw materials) without compromising the essential function of packaging – to protect and preserve the product until consumption. These materials must withstand the physical demands of transport and handling while reducing the environmental footprint.

Furthermore, efforts to optimise packaging should be complemented by educating consumers on proper **food storage and packaging waste management practices**. This can amplify the environmental impact mitigation efforts, contributing to a more sustainable future.



Figure 13. Influence of pack size availability on the packaging waste generated from mushrooms purchases. Simulation details: 10 replications, 60 years

Table 8. Packaging waste-to-mushrooms purchased ratio

Demographic	Default	150, 300 & 400 g	625 g	400 g	485 g	250 g	300 g	250 & 500 g	300 & 625 g	500 g
UK weekly average	0.08	0.09	0.04	0.05	0.04	0.07	0.06	0.06	0.05	0.04
Family AD	0.08	0.07	0.04	0.05	0.04	0.07	0.06	0.05	0.05	0.04
Single FF	0.08	0.11	0.04	0.05	0.04	0.07	0.06	0.07	0.06	0.04
Couple FF	0.08	0.09	0.04	0.05	0.04	0.07	0.06	0.06	0.06	0.04
Single SC	0.07	0.11	0.04	0.05	0.04	0.07	0.06	0.07	0.06	0.04
One Child SC	0.07	0.08	0.04	0.05	0.04	0.07	0.06	0.06	0.05	0.04
Couple IA	0.08	0.10	0.04	0.05	0.04	0.07	0.06	0.06	0.06	0.04
Family PP	0.08	0.08	0.04	0.05	0.04	0.07	0.06	0.05	0.05	0.04
Single Family PP	0.08	0.10	0.04	0.05	0.04	0.07	0.06	0.06	0.06	0.04

07 Packaging Material Usage – Plastics vs Paper

The study explores the effectiveness of using two different types of packaging – plastic punnets and a novel paper-based pack, the Earth Bag (Sirane), revealing the influence on mushroom and packaging waste generation, and potentially even lower waste at the retail level due to lower degradation rates from paper-based packaging.

Scenarios

This study investigates the potential benefits of novel paper-based packaging for mushrooms. The degradation rates are different from using plastics punnets (see Table 3). The research was structured around two scenarios. We assume that mushrooms are stored at home using the packaging they were originally purchased in from supermarkets.

- **Scenario 1.** Whole mushrooms in Earth Bags and plastics punnets are purchased and stored at 4 °C and 7 °C, respectively.
- **Scenario 2.** Sliced mushrooms in Earth Bags and plastics punnets are purchased and stored at 4 °C and 7 °C, respectively.

Results

Scenario 1 witnessed a decline in food waste when transitioning to Earth Bags as the packaging choice, primarily driven by reduced degradation rates (see Figure 14). More precisely, when mushrooms were stored at 4 °C, there was a **9% decrease** in waste, and at 7 °C, there was a more substantial **16% reduction** in mushroom waste. This can be attributed to a more significant reduction in degradation rates observed when storing mushrooms at 7 °C in Earth Bags. Earth Bags, being a potentially more environmentally friendly packaging option compared to some plastics, may not only reduce waste but also align with sustainability goals. Choosing sustainable packaging materials can contribute to responsible consumption and production practices [4,5].

In Scenario 2, using paper packaging at 4 °C resulted in a **5.5% increase** in sliced mushroom waste. However, at 7 °C storage, there was a notable 23.6% reduction (see Figure 15). This rise in waste at 4 °C might be due to a higher degradation rate observed in sealed Earth Bags compared to the plastic packs which are designed to extend the life of sliced mushrooms through atmospheric modification. To minimize food waste, consumers and food retailers should consider the combined effect of packaging and storage conditions. The findings underscore the importance of aligning packaging choices with appropriate storage temperatures to achieve the best outcomes in terms of food shelf life and waste reduction.

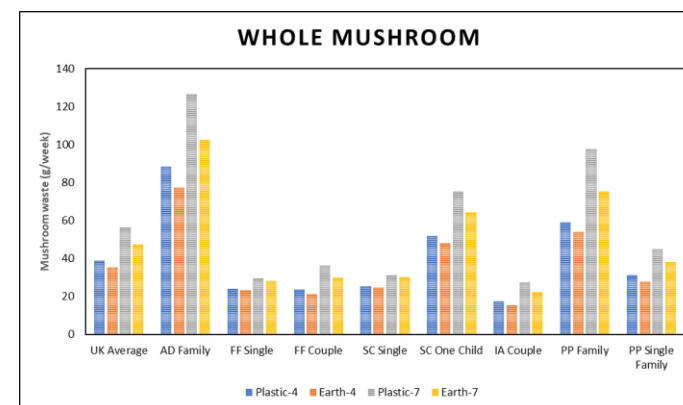


Figure 14. Influence of packaging material on the whole mushroom waste for UK average households and the eight household archetypes. Simulation details: 10 replications, 60 years

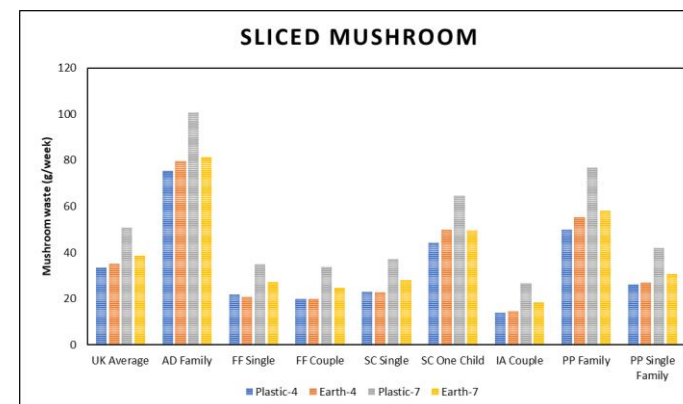


Figure 15. Influence of packaging material on the sliced mushroom waste for UK average households and the eight household archetypes. Simulation details: 10 replications, 60 years

07 Packaging Material Usage-Plastics vs Paper

The study explores the effectiveness of using two different packaging – plastics punnet and paper bags, revealing the influence on mushroom and packaging waste generation, and potentially even lower waste at the retail level due to lower degradation rates from the Earth Bag.

Table 9. Earth Bag Weight and Mushroom Weight-to-Packaging Weight Ratio for the different packs investigated.

Mushrooms Pack	Earth Bag				Plastic Package		Reference
	Packaging Weight (whole mushroom)	Mushroom Weight-to-Packaging Weight Ratio (whole)	Packaging Weight (sliced mushroom)	Mushroom Weight-to-Packaging Weight Ratio (sliced)	Packaging Weight (sliced mushroom)	Mushroom Weight-to-Packaging Weight Ratio (sliced)	
150	1.66 g	90.2	2.00 g	75.2	2.51 g	59.8	Market container & [3]
250	2.77 g	90.2	3.33 g	75.2	4.11 g	60.8	
300	3.33 g	90.2	3.99 g	75.2	11.10 g	27.0	

Packaging waste impacts

In Scenario 1, employing Earth Bags led to a significant **86%** reduction in packaging waste for both storage temperatures, as Earth Bags weigh less than plastic punnets (see Table 9). In Scenario 2, the reduction in packaging waste was around **20%** because the plastic punnet used for sliced mushrooms is only slightly heavier than paper bags for small and medium-sized packs (see Table 8). This highlights the need to consider the specific attributes and requirements of the product when choosing packaging materials. When making packaging choices, it's essential to strike a balance between sustainability objectives and the functionality and suitability of the packaging for the product.

Mushrooms Requirement Unfulfilled-to-Consumption Requirement Ratio

The transition to Earth Bags appeared to influence consumer behaviour by slightly decreasing the quantity of whole mushrooms purchased by 1% but encouraging higher consumption by 0.2%-1% (see Figure 16). Most importantly, it resulted in a substantial reduction in the waste-to-purchased ratio, indicating a more efficient utilization of the purchased mushrooms, especially at higher storage temperatures. However, the impact of paper bags on sliced mushrooms differed depending on the storage temperature, with a more noticeable effect at 7 °C and minimal impact at 4 °C. At 7 °C storage, there was a 2% decrease in the quantity of sliced mushrooms purchased. However, consumption increased by 1% (see Figure 17), suggesting that the use of Earth Bags facilitated consumption despite a minor reduction in purchases. These findings highlight the importance of considering both packaging and storage conditions in understanding consumer

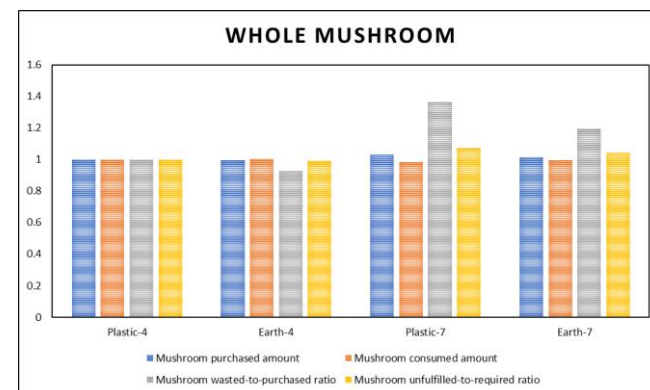


Figure 16. UK averages for packaging material usage scenarios. The chart normalises factor values per scenario, dividing them by default scenario values against whole mushrooms purchased (g), consumed (g), wasted-to-purchased (%) and unfulfilled-to-required (%). A normalised value of 100 denotes the default scenario (whole mushroom stored at 4 °C). Values above or below 100 indicate a scenario factor greater or lesser than the default. Simulation specifics: 10 replicates.

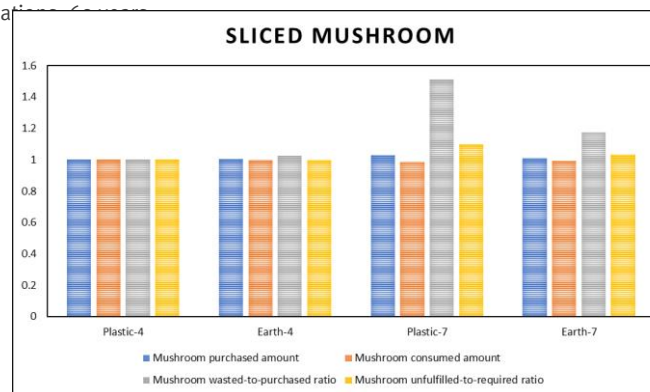


Figure 17. UK averages for packaging material usage scenarios. The chart normalises factor values per scenario, dividing them by plastic package with 4 °C scenario values against sliced mushrooms purchased (g), consumed (g), wasted-to-purchased (%) and unfulfilled-to-required (%). A normalised value of 100 denotes the default scenario (whole mushroom stored at 4 °C). Values above or below 100 indicate a scenario factor greater or lesser than the default. Simulation

o8 Conclusions and Recommendations

Intervention 1. Storage Temperature

Higher fridge temperature leads to faster degradation of mushrooms, increasing waste, mushroom wasted-to-purchased ratio and unfulfilled consumption requirements. For some household archetypes, however, the waste increase was less significant. This was attributed to their weekly mushroom purchase amounts aligning more closely with their consumption requirements.

- **Market Strategy.** Enhanced consumer education is crucial, highlighting the impacts of storage temperature on food waste. Identify and target household archetypes that have demonstrated a better alignment between their mushroom purchases and consumption requirements despite higher fridge temperatures. Create marketing campaigns that resonate with these consumer segments and emphasize the benefits of waste reduction and cost savings. The industry should also encourage innovation in packaging that can respond to temperature changes. As an example, consider the development of packaging solutions equipped with built-in temperature and humidity regulation mechanisms to preserve the freshness of mushrooms and extending their shelf life. Additionally, collaborating with appliance manufacturers to integrate smart fridge technology that optimizes temperature settings based on the types of products stored is an option. This can ensure that mushrooms and other perishables remain fresh for longer periods.

- **Policy Recommendations.** Formulating guidelines for optimum food storage and sustainable and functional packaging is essential to help preserve food freshness and reduce waste. Commissioning studies to better understand consumer behaviour regarding food purchase and storage habits. This data will inform the design of more targeted and effective policies for reducing food and packaging waste. These studies will enable policymakers to understand how consumers respond to different interventions. An additional policy recommendation is to collaborate with grocery retailers to promote responsible mushroom purchasing and storage practices, and to offer discounts on temperature-regulating packaging for perishable items.

Intervention 2. Freezer Usage

An important relationship was observed between the expanded utilization of freezers for mushroom storage and a reduction in waste. As freezer usage increased, both mushroom and packaging waste demonstrated a consistent decline, with mushroom waste experiencing a particularly notable reduction. The study's findings underscored the influence of shopping habits in contributing to the reduction of packaging waste, emphasizing the significance of targeting specific demographics to enhance waste reduction efforts. Additionally, the research indicated that higher freezer usage resulted in a slight reduction in mushroom purchases and the unfulfilled-to-requirement ratio, indicating more effective management of household resources.

- **Market Strategy.** Promote the creation and adoption of packaging and labels explicitly tailored for the freezer storage of mushrooms could increase freezer usage to reduce waste. Education campaigns can inform consumers about the advantages of fridge and freezer use, such as extended shelf life and waste reduction, and encourage positive changes in storage behaviours. Furthermore, it is suggested to engage in community initiatives that promote responsible freezer usage and food storage practices, and to collaborate with local organizations to host workshops and events focused on reducing food waste. Incentives, discounts, or rewards can be offered to consumers who actively reduce waste through increased freezer utilization. Partnering with retailers to implement such programs can be considered.

- **Policy Recommendations.** Industry standards and regulations can be established for freezer-friendly packaging, ensuring that packaging materials and designs are optimized for freezer storage, especially for perishable items like mushrooms. Educational materials on proper freezer usage can be developed and disseminated, including temperature settings and the types of foods suitable for freezer storage. Distribute these materials through government websites, schools, and community organizations. Policymakers can also commission additional studies to understand behaviour patterns across different demographic groups. Furthermore, regulations encouraging retailers to promote best storage practices can be an effective strategy.

o8 Conclusions and Recommendations

Intervention 3. Pack Size Availability

The model assumed smaller and medium-sized packaging were optimal for households, aligning with the model's emphasis on these sizes. The presence of smaller packs was directly linked to a reduction in weekly mushroom waste but an increase in packaging waste. Nonetheless, the total waste quantity decreased due to the compensatory effect of reduced mushroom waste. Conversely, the introduction of larger pack sizes resulted in a significant increase in mushroom waste, primarily due to tendencies to over-purchase and subsequent spoilage. When only larger packs are available, there is a reduction in package waste because fewer packs are purchased. However, this reduction cannot compensate for the increase in mushroom waste.

In terms of packaging waste, the mushroom-to-packaging weight ratio emerged as a critical factor in pack size efficiency. Alongside the quantity of mushroom purchased, this ratio played a pivotal role in influencing packaging waste. Among the scenarios examined in the study, the default scenario with 150, 250 and 300 g packs available stood out as the most effective, resulting in the least amount of food and packaging waste. This was attributed to its combination of a relatively lower mushroom content and a favourable mushroom-to-packaging weight ratio.

- **Market Strategy.** The central element of the market strategy should revolve around enabling access to correct smaller pack sizes and improving packaging materials. Embracing lightweight yet sturdy packaging materials has the potential to customise the packaging shapes and sizes while maintaining the packaging's primary role of safeguarding the product until consumption. Consequently, supermarkets should prioritize expanding their range of smaller and medium-sized packaging choices that match the typical mushroom requirements of the average consumer. Furthermore, exploring alternative packaging solutions that strike a harmonious balance between efficiency, cost-effectiveness, and sustainability, such as lightweight designs, recyclable materials and specific design for different household archetypes, should be explored as well.

- **Policy Recommendations.** Regulatory bodies can promote industry standards that encourage the availability of waste-minimizing packaging sizes. Furthermore, online tools and mobile applications can be designed to help consumers choose the optimal packaging size tailored to their household requirements. And advice should be offered to consumers on reducing waste and guidance on proper storage practices. An additional recommendation is to Implement labelling systems that clearly indicate the optimal mushroom-to-

make waste-conscious choices.

Intervention 4. Package material usage –Plastics vs Paper-based Bags

The research findings indicate that the adoption of paper-based packaging (Earth Bags) for mushroom packaging can be an effective strategy in reducing both mushroom and packaging waste. Notably, a reduction of approximately 1%-3% in the mushroom wasted-to-purchased ratio was observed in two distinct scenarios -except for sliced mushrooms stored at 4 °C- highlighting the potential for more responsible consumption patterns when Earth Bags are utilized. Moreover, the increase in consumption coupled with reduced purchases indicates a shift toward more efficient household resource management. This shift not only aligns with sustainability goals but also suggests that consumers can play a significant role in minimizing food and packaging waste through their choices. Therefore, encouraging the adoption of eco-friendly packaging options such as paper-based packs can have positive implications for waste reduction and sustainable resource utilization. However, in addition to environmental considerations, it is recommended to explore consumer acceptance of Earth Bags, particularly regarding their marketability in situations where the product is not visible.

- **Market Strategy.** Regulatory bodies can launch a comprehensive consumer education campaign highlighting the benefits of using paper-based packs for mushroom packaging and emphasize the potential advantages of waste reduction, responsible consumption, and environmental-friendliness. Retailers can encourage consumers to choose paper-based packs by offering discounts, rewards, or loyalty programs that promote responsible packaging choices. In addition, retailers should ensure that paper-based-packaged mushrooms are prominently displayed and easily accessible in stores to encourage their adoption.

- **Policy Recommendations.** Regulatory bodies can develop and enforce guidelines for packaging materials that prioritize eco-friendliness, recyclability, and sustainability. Encourage the use of paper-based packs and other environmentally responsible options. Policies should promote investment in research and development to further improve paper-based pack designs, making them even more efficient and eco-friendly. Furthermore, incentives and tax benefits can be offered to businesses that use eco-friendly packaging materials. A monitoring and reporting system can be established to track the adoption of eco-friendly packaging materials and measure their impact on waste reduction. In addition, regulatory bodies can engage consumers through surveys and feedback mechanisms to gauge their preferences for eco-friendly packaging and

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The Centre for Food Policy at City, University of London, is an interdisciplinary unit working to shape food systems that improve the health of people, society, the environment and the economy. We engage with people across the food system to uncover how it really works in practice. We use these insights to educate, influence and to inform effective, joined-up food policy.

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Project Twitter Account:
[@_Reduce_Waste_](https://twitter.com/_Reduce_Waste_)

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