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Chicken Household Simulation Model (HHSM)

Domestic Food and Packaging Waste Insights from UK Households

Research Brief

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Natural Environment Research Council
University of Sheffield
University of Greenwich
University of Kent
wrap

Centre for Food Policy
Shaping an effective food system

School of Health & Psychological Sciences

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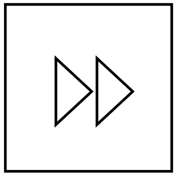
Table of contents

01 Key Findings

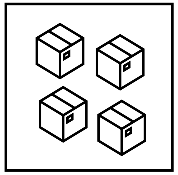
FOOD AND PACKAGING WASTE TRADE-OFFS

The study found an inverse correlation between food and packaging waste: decreases in packaging waste generation in UK households often aligned with increases in chicken waste and vice versa.



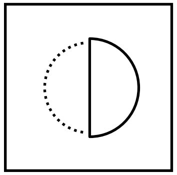
EXTENDED SHELF LIFE REDUCES WASTE

Extending the shelf life of chicken packages notably decreased food waste. This decrease was particularly significant when the shelf-life extension was applied to both opened and unopened packs.



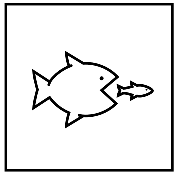
IMPACT OF SMALL PACK SIZES

Making only small-sized packs (containing 2-chicken fillet pieces) available reduced food waste by 7% and packaging waste by around 12% compared to the default UK scenario where supermarkets offered small, medium, and large pack sizes.



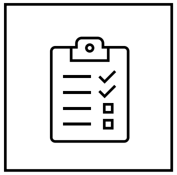
PORTIONING INCREASES WASTE

Food portioning led to a rise in food waste because opening the packs shortened the chicken shelf life, reducing the time available for consumption.



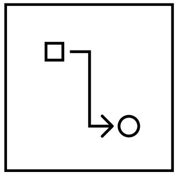
IMPACT OF LARGER PACK SIZES

Removing small-sized packs from supermarket shelves reduced packaging waste generation by 9.4%. However, this change also increased the quantity of food purchased, leading to a rise in chicken waste generation by 147.7%.



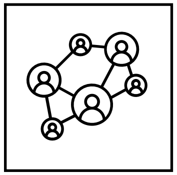
IMPACT OF PLANNING AND CHECKING STORAGE

Consistent inspection of food storage and thoughtful shopping trip planning helped reduce chicken and packaging waste.



CHICKEN WASTE ORIGIN

Across the studied interventions, a decrease in waste generally originated from a reduction in the amount of waste from raw chicken pieces.



VARIABLE IMPACT OF INTERVENTIONS

Different interventions affect waste generation in various ways across different households. Therefore, analysing these interventions for the entire population and independently for each household type and size is crucial for optimising their effectiveness.

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 consumed-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.

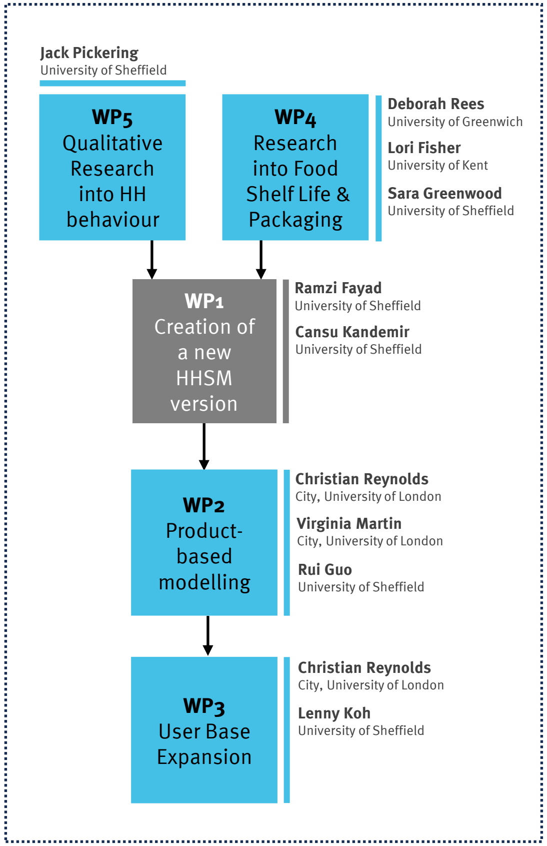


Figure 1. Project work packages (WPs) and their relationship within this NERC-funded project, 'Reducing plastic packaging and food waste through product innovation simulation'.

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 (Kandemir et al., 2020).

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 Chicken Household Simulation Model

This research introduces a new version of the HHSM, which builds on the previous version by adding functionality to model packaging waste. This new version of the model simulates the amount of food and packaging waste produced from chicken fillets.

Chicken Waste

Chicken meat, particularly **chicken fillets**, is a staple in British households. However, it is also one of the most wasted food items in the UK, with 38% wasted by consumers and 58% loss throughout the value chain (World Bank 2020; de Gorter et al. 2021; Salazar, Billing, and Breen 2020). The **environmental food print** is also considerable, as lost or wasted chicken in the UK represents 8.4 million tonnes of CO2e, around 54% of total chicken production emissions (World Bank 2020; de Gorter et al. 2021).

Model Structure and Input and Output Variables

The model was developed using Arena simulation software version 16.2 (Rockwell Automation, 2022) and comprises **six modules** representing different stages of the **chicken packs' life cycle** from the supermarket shelves to their consumption and disposal in households. These modules are the model setup, market, shopping, storage, consumption and expiry (see Figure 2). Different **Input variables** were used to customise each module, simulating different product characteristics, market interventions and household behaviours.

The model tabulates the weekly averages for several key outcomes. This includes **household chicken waste**, both in total and broken down by storage location (counter, fridge or freezer) and type (raw or cooked). It also takes into account the **plastic waste** generated within households.

The model also records **household consumption and purchasing habits**, such as the weekly chicken requirement, the amount of chicken consumed per week, the average quantity of chicken stored in the household, the average number of chicken pieces purchased per week and the number of shopping trips made.

Lastly, the model outcomes are used to calculate various **ratios** that help analyse the effectiveness of food waste management within households. These include the average ratio of chicken wasted to purchased and the ratio of unfulfilled requirements to the required chicken amount for consumption per household.

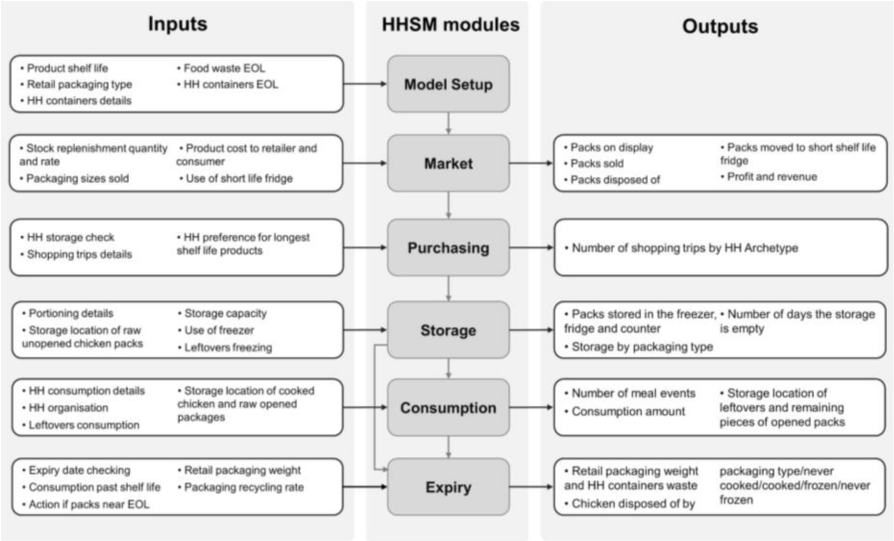


Figure 2. HHSM process chart showing inputs, outputs and the model's structure.

Research Aim and Objectives

This research seeks to identify waste-reducing interventions for chicken fillets in the UK by simulating:

1. The effect of **different pack sizes** available in supermarkets.

2. The impact of **shelf-life extension** due to packaging innovations.

3. The implications of **household storage and planning dynamics**: pack portioning and storage checking.

04 Intervention 1: Pack Size Availability

The study of this intervention provides a deep understanding of potential waste reduction strategies related to the availability of various pack sizes on the market.

Modelling Details

An exploration into pack size effects on waste was conducted by manipulating a key variable within the model, identified as **Stock Replenishment** (Variable 2.1). Adjusting this variable allowed for a change in the number of pack sizes available in a hypothetical supermarket scenario. Three pack sizes were assumed **2-piece**, **4-piece**, and **6-piece packs** as options to be available in a typical UK supermarket's chicken aisle (See Figure 3)

The weight of each chicken piece was modeled as a uniform distribution, ranging from **183 grams to 193 grams**, in order to closely mirror real-world chicken piece weight variability.

Packaging Size Availability Scenarios

The examination comprised **seven distinct scenarios**, including a default scenario. Table 3 outlines the specific pack sizes available in each simulation run. In the default scenario, three pack sizes were assumed to be available: 2-piece (small), 4-piece (medium), and 6-piece packs (large). A typical examples of these packs include a plastic tray sealed with a plastic film and label, as shown in Figure 4.

Table 4 provides details on the plastic weight for each pack size and the corresponding packaging-to-chicken weight ratios. To quantify the amount of packaging waste generated for each scenario, the weight of the plastic used for packaging (Variables 6.5a, 6.5b, and 6.5c) across different scenarios was considered, with data sourced from the **EPIC database** (Valpak, 2023). The **packaging-to-chicken weight ratio** is also an important metric in these analyses. This ratio expresses the weight of packaging needed per unit weight of chicken. Lower ratios indicate more efficient packaging, implying less plastic waste per unit of chicken sold.

Table 3. Simulation runs for the study of the influence of chicken fillets pack sizes available on the market and its food and packaging waste generation in UK households.

Run	Pack sizes available on the market
1	**S** (2-piece pack), **M** (4-piece pack), **L** (6-piece pack)
2	**S** (2-piece pack)
3	**S** (2-piece pack) and **L** (6-piece pack)
4	**S** (2-piece pack) and **M** (4-piece pack)
5	**M** (4-piece pack)
6	**M** (4-piece pack), **L** (6-piece pack)
7	**L** (6-piece pack)

Table 4. Plastic weight (Valpak, 2023) and packaging-to-chicken weight ratio of the different packs investigated.

Pack	Plastic Weight (grammes)	Packaging-to-Chicken Weight Ratio (%)
2-piece pack	15.76	4.19
4-piece pack	20.10	2.67
6-piece pack	25	2.22

Figure 3. Typical UK supermarket aisle for poultry. Reference

Figure 4. Typical chicken fillets packaging format available in UK supermarkets, consisting of a plastic tray sealed with plastic film and label

04 Intervention 1: Pack Size Availability

An inverse correlation between chicken and packaging waste was found, showcasing that increases in packaging waste often aligned with increases in chicken waste, and conversely, establishing a challenge for waste management efforts.

Impact of Smaller Packs

Favouring the purchase of small-sized packs, such as the 2-piece packs, led to noticeable reductions in food waste. This effect was particularly pronounced in smaller households, where the average chicken consumption is typically lower. Generally, in scenarios where 2-piece packs were purchased (that is, either having a choice of 2&6 piece-packs or only 2-piece packs available), there was an average reduction in chicken waste by approximately 7% across the UK compared to the default scenario. However, this shift resulted in a roughly 12% increase in packaging waste. This is attributed to smaller pack sizes possessing a lower packaging-to-chicken weight ratio than their larger counterparts, as shown in Table 4.

Impact of Larger Packs

In contrast, removing 2-piece packs from supermarket shelves nudged households towards buying larger pack sizes. For example, when only 4-piece packs were available, there was a notable decrease in plastic packaging waste—around 9.4%—compared to the default scenario. This is due to these larger packs having a lower packaging-to-chicken weight ratio. However, a potential drawback arose among households that typically require only one 2-piece pack per week. The necessity of transitioning to a 4-piece pack led to a weekly increase in the quantities of chicken purchased, resulting in a significant rise—147.4%—in chicken waste when larger pack sizes were sold.

Chicken Waste Origin

In the default scenario, most chicken waste derived from raw pieces never frozen (around 71%), followed by defrosted raw pieces (22%), never-frozen cooked pieces (7%) and defrosted cooked pieces (<1%). This pattern remained largely consistent across all the scenarios simulated.. Waste generation reduction across the pack size interventions studied was linked to a decrease in waste from raw pieces. For example, the scenario offering only 2-piece packs yielded the lowest chicken waste, with 92.5% from raw pieces (both never frozen and defrosted). In contrast, the 6-piece packs' scenario, yielding the highest waste (391% increase compared to the default), showed a raw-piece waste of 97.8%.

Table 5. Simulated amount of chicken and packaging waste generated in UK households for Intervention 1, Pack Size Availability. For each column, the figures representing a reduction in waste compared to the default scenario are highlighted in blue.

Pack Sizes Available	Packaging Waste (g/week)	Packaging-to-Chicken Purchased ratio (%)	Chicken Waste (g/week)	Chicken Wasted-to-Purchased ratio (%)	Raw Pieces Never Frozen (%)	Raw Pieces Defrosted (%)	Cooked Pieces Never Frozen (%)	Defrosted Cooked Pieces (%)
2, 4 & 6 pieces	25.5±7	3.08	60.8 ±25	8.3	70.74	22.29	6.77	0.20
2 pieces	28.6±10	3.38	56.4±22	7.8	73.76	18.71	7.28	0.25
2 & 6 pieces	28.6±10	3.38	56.9±22	7.9	73.99	18.47	7.30	0.24
2 & 4 pieces	25.5±7	2.96	61.1±25	8.4	70.62	22.38	6.79	0.21
4 pieces	23.1±6	2.31	150.4±57	17.6	54.41	41.74	3.80	0.05
4 & 6 pieces	23.1±6	2.31	150.6±57	17.6	54.45	41.72	3.77	0.05
6 pieces	23.5±6	1.98	298.8±121	27.8	44.04	53.82	2.13	0.01

05 Intervention 2: Shelf-Life Extension

The purpose of this investigation was to assess the effectiveness of hypothetical packaging innovations in extending the shelf life of chicken packs in the market shelves and at home after the pack is open.

Intervention and Modelling Details

This intervention focuses on extending the shelf life of chicken packs with three sub-interventions: (1) extending unopened packs' shelf life (up to six days), (2) extending opened packs' shelf life (up to three days) and (3) combined extension of unopened and opened packs' shelf life. This study modified Variables 1.1a and 1.1b, representing the retail shelf-life of unopened chicken packs and the shelf life of opened packs stored in households, respectively

In the default scenario, the unopened fridge shelf life was assumed to follow a triangular distribution with a minimum value of 2, a maximum value of 9 and an average of 5.2 days. The default

Shelf-Life Extension and Waste Reduction

For unopened packs, chicken waste reduction ranged from 17.3% with a one-day extension, up to 29.4% with a five-day extension.

For opened packs, a one-day extension resulted in a 15.6% waste reduction, with larger households showing greater response due to their preference for larger pack sizes. However, further extension didn't yield additional waste reductions.

This is largely attributed to household consumption patterns. Households are more inclined to consume and deplete the contents of opened chicken packs in anticipation of the upcoming meal event, which is scheduled every four days. Therefore, additional extensions in shelf life do not contribute significantly to chicken waste reduction, as the likelihood of households retaining opened packs until the next meal event is relatively low.

In terms of packaging waste, a slight decrease was observed with the extension of shelf-life. However, this reduction was not statistically significant, accounting for less than 1% in the scenarios extending the shelf life of opened packs. The decrease was slightly more noticeable for the unopened packs and combined extensions, at around 2-3%.

Synergistic Effect of Shelf-Life Extension

The simultaneous shelf-life extension for both opened and unopened packs translated into substantial mitigation of chicken waste. A one-day extension for both pack types led to a 40.5% reduction in average chicken waste. In addition, a combination of a three-day extension for unopened packs and a single-day extension for opened ones resulted in a 60% cutback in chicken waste.

Table 6. Simulated amount of chicken and packaging waste generated in UK households for Intervention 2, Shelf-life extension.

Shelf-life extension	Packaging Waste (g/week)	Chicken Waste (g/week)	Chicken Wasted-to-Purchased ratio (%)	Raw Pieces Never Frozen (%)	Raw Pieces Defrosted (%)	Cooked Pieces Never Frozen (%)	Cooked Pieces Defrosted (%)
Default	25.5±7	60.8 ±25	8.3	70.7	22.3	6.8	0.2
+1 day opened	25.3±7	51.3±21	7.2	63.5	27.7	8.5	0.2
+2 day opened	25.3±7	51.3±21	7.2	63.5	27.7	8.5	0.2
+3 day opened	25.3±7	51.3±21	7.2	63.5	27.7	8.5	0.2
+1 day unopened	25.3±7	50.3±23	7.1	63.8	27.5	8.4	0.3
+2 day unopened	25.2±7	46.3±22	6.6	61.0	29.5	9.1	0.3
+3 day unopened	25.2±7	44.6±21	6.4	59.4	30.9	9.4	0.3
+4 day unopened	25.1±7	43.4±21	6.2	58.5	31.5	9.6	0.3
+5 day unopened	25.1±7	42.9±20	6.2	57.8	32.2	9.7	0.3
+6 day unopened	25.1±7	42.8±20	6.2	57.6	32.3	9.8	0.3
+1 day opened, +1 unopened	25.0±7	36.2±18	5.3	47.6	39.9	12.2	0.2
+1 day opened, +2 unopened	24.8±7	28.7±16	4.4	33.1	50.8	15.6	0.2
+1 day opened, +3 unopened	24.8±7	24.4±15	3.8	22.3	58.8	18.3	0.1

06 Intervention 3: Portioning of Chicken Packs

This interventions investigates the household practice of storing chicken packs into household containers (e.g., Tupperware or freezing bags), creating smaller, more manageable portions that align better with their storing or eating habits.

Intervention details

The intervention explored the effects of different household storage practices on waste generation. Three distinct scenarios were identified from qualitative research (Pickering, 2022a):

- **Scenario A.** Households transfer the chicken from the original packaging to a household container, such as a Tupperware or a plastic bag without portioning. This action adjusts the shelf life to n 'opened shelf life' status.
- **Scenario B.** Households portion the chicken by dividing it between two household containers after removing it from the retail packaging. As in Scenario A, the 'opened shelf life' applies
- **Scenario C.** Households store the chicken in its original packaging, without portioning.

Modelling Details

In the simulation, Variables 4.4a, 4.4b and 4.4c were manipulated to reflect the likelihood of Scenarios A, B and C, respectively, occurring. To fully encompass the diverse range of household behaviours, **five different portioning patterns** were studied:

- Entirely adopting Scenario A.
- Equal adoption of Scenarios A and B (i.e., 50% Scenario A and 50% Scenario B).
- Entirely adopting Scenario B.
- Equal adoption of Scenarios B and C (i.e., 50% Scenario B and 50% Scenario C).
- Entirely adopting Scenario C.

Key Findings

While portioning larger food packs into smaller units might intuitively seem like a viable strategy for reducing food waste – aligning stored portions with consumption needs – the model's findings were somewhat counterintuitive as It showed an increase in chicken waste when households portioned their chicken packs (see Table 7). This outcome is because opening and partially consuming chicken packs inevitably shorten the shelf life of the remaining portions, thus reducing the likelihood of their consumption before spoilage.

Table 7. Simulated amount of chicken and packaging waste generated in UK households for Intervention 3, Portioning of Chicken Packs.

Portioning Scenario	Packaging Waste (g/week)	Chicken Waste (g/week)	Chicken Wasted-to-Purchased ratio (%)	Raw Pieces Never Frozen (%)	Raw Pieces Defrosted (%)	Cooked Pieces Never Frozen (%)	Cooked Pieces Defrosted (%)
100% A	26.7±7	122.7±42	14.9	86.2	11.1	2.6	0.7
100% B	27.3±6	136.9±45	16.5	92.8	4.5	2.6	0.7
100% C	25.5±7	60.8±25	8.3	70.7	22.3	6.8	0.3
50% A, 50% B	26.9±6	127.0±43	15.4	88.9	8.5	2.5	0.7
50% B, 50% C	26.4±6	98.8±35	12.5	85.6	10.4	4.0	0.5

07 Intervention 4: Storage and Shopping List Checking

This intervention examines the effect of households checking their chicken storage before shopping and using a shopping list on domestic waste generation. Simulations were conducted at varying checking probabilities, from 0% to 100%.

Simulation Details

This investigation was performed by adjusting Variable 3.1, in the Storage Module, representing the **likelihood of households checking their storage** before shopping. Simulations were run for a range of probabilities: 0%, 20%, 32% (default scenario), 40%, 60%, 80% and 100%.

The checking behaviour directly influences purchasing quantities. For example, a household that requires a 4-piece chicken pack per week will purchase this quantity regardless of its storage content if it never checks its storage. Conversely, a household that always assesses its storage will adjust its purchase to its needs. Thus, if the household already has a 2-piece pack in storage, it will only purchase an additional 2-piece pack to meet its weekly requirement.

Key Findings

As shown in Table 8, the modelling results underscored that **storage-checking practices can reduce chicken waste** by ensuring purchases align with current storage content and consumption needs. If UK households never checked their storage, it would result in an **11% increase in chicken waste** and a **2% rise in packaging waste**. On the other hand, when storage checking was performed 100% of the time, there was a decrease in chicken and packaging waste by 29% and 4.5%, respectively, compared to the default scenario.

Interestingly, the impact of storage checking behaviour varied with **household size**. Smaller households, when checking their storage, purchased fewer chicken packs and thus generated less packaging waste. In contrast, larger households produced more packaging waste when they checked their storage, likely because they purchased smaller packs (i.e., 2-piece packs) more frequently than they typically would. This finding highlights how nuanced the relationships between **storage checking**, **pack size** and **waste generation** can be.

Table 8. Simulated amount of chicken and packaging waste generated in UK households for Intervention 4, Storage and Shopping List Checking.

Portioning Scenario	Packaging Waste (g/week)	Chicken Waste (g/week)	Chicken Wasted-to-Purchased ratio (%)	Raw Pieces Never Frozen (%)	Raw Pieces Defrosted (%)	Cooked Pieces Never Frozen (%)	Cooked Pieces Defrosted (%)
0%	25.9±6	67.4 ±27	8.7	64.4	23.3	6.1	0.4
20%	25.6±6	63.4 ±26	8.5	69.9	23.2	6.7	0.3
32%	25.5±7	60.8 ±25	8.3	70.7	22.3	6.8	0.2
40%	25.4±7	59.1 ±25	8.2	70.6	22.3	6.8	0.3
60%	25.0±7	54.0 ±22	7.8	71.9	21.0	6.9	0.3
80%	24.7±7	48.7 ±21	7.3	72.5	20.2	7.1	0.3
100%	24.4±8	43.2 ±19	6.7	73.6	18.9	7.3	0.2

08 Conclusion

Table 9 presents a summary of the **interventions investigated** in this study, showing their impact on the generation of chicken and packaging waste in UK households compared to the default scenario. Noteworthy outcomes from these interventions, such as implementing storage checks and extending the shelf life of the packs, indicate their potential to reduce both types of waste.

However, the data also elucidated a critical **trade-off** that must be taken into consideration in waste management strategies. In many instances (especially linked to pack size availability), strategies that decreased food waste correspondingly led to an increase in packaging waste, and vice versa. This finding necessitates careful balancing a strategic planning in order to optimize environmental outcomes.

Furthermore, the results highlighted the **heterogeneity in waste generation** among different household sizes and the potential impact of intervention strategies. They underline the need for tailored waste reduction strategies that take into account the characteristics of individual households, such as size and consumption patterns.

The next section will present more detailed discussions concerning the interventions investigated. These discussions will delve into potential **market strategies** and **policy recommendations** to achieve significant waste reductions.

Table 9. Summary of the interventions investigated in this study bringing reductions in chicken and/or packaging waste generated in UK households.

Intervention/Scenario	Chicken Waste Variation (%)	Packaging Waste Variation (%)	Chicken Waste-to-Chicken Purchase Ratio Variation (%)
Default	0.0	0.0	0.0
Only Small-Size Packs Available (i.e., 2-piece packs)	-7.2	+12.2	-6.0
Small and Medium-Size Packs Available (i.e., 2 & 4-piece packs)	+0.5	+0.0	+1.2
Only Medium-Size Packs Available (i.e., 4-piece packs)	+147.4	-9.4	+112.0
Only Large-Size Packs Available (i.e., 6-piece packs)	+391.4	-7.8	+234.9
+1-Day Opened Pack Shelf-Life Extension	-15.6	-0.8	-13.3
+1-Day Unopened Pack Shelf-Life Extension	-17.3	-0.8	-14.5
+3-day Unopened Pack Shelf-Life Extension	-26.6	-1.2	-22.9
+5-Day Unopened Pack Shelf-Life Extension	-29.4	-1.6	-25.3
+1-Day Opened & +1-Day Unopened Packs Shelf-Life Extension	-40.5	-2.0	-36.1
+1-Day Opened & +3-Day Unopened Packs Shelf-Life Extension	-59.9	-2.7	+54.2
60% Likelihood of Checking the Storage	-11.2	-2.0	-6.0
100% Likelihood of Checking the Storage	-28.9	-4.3	-19.3

09 Recommendations

Adjusting Pack Sizes

The results show that pack size plays a significant role in both chicken and packaging waste. Smaller packs increase packaging waste but decrease chicken waste generated since they are more suitable for households requiring less consumption and reducing leftovers.

• **Market Strategy**: to introduce a scheme in supermarkets that allows consumers to select the exact number of chicken pieces they require without compromising their shelf life. This system could be designed with strict hygiene protocols to ensure food safety, and it could incorporate reusable or returnable packaging to minimise environmental impact.

• **Policy Recommendation:** encourage manufacturers to invest in research and development of packaging systems/technologies up the waste hierarchy (i.e., reuse, recycle). These could include incentives for companies that develop and implement sustainable packaging solutions.

Extending Shelf Life

Extending the shelf life of chicken packs considerably reduces chicken waste, particularly for larger households. However, extended shelf life should not lead to increased packaging waste sent to landfills.

• **Market Strategy:** to explore packaging solutions such as vacuum packaging, modified atmosphere packaging or intelligent packaging that includes freshness indicators. These innovations not only extend shelf life but can also help consumers better gauge the freshness of their food.

• **Policy Recommendation:** develop guidelines or regulations that mandate using recyclable or compostable materials in food packaging without compromising the food's shelf life.

Food Portioning

Although portioning can lead to more food waste due to a possible decrease in shelf life with the current methods, it significantly reduces chicken waste by preventing over-purchase and over-preparation.

• **Market Strategy:** to offer portioning services in supermarkets where consumers can choose the exact quantity of food they require or packaging solutions where individual pieces are sealed separately within a larger package (e.g., vacuum packaging). This can be particularly useful for customers who live in smaller households. Retailers can also consider educational efforts on proper food storage and preparation to further minimise waste

• **Policy Recommendation:** to encourage innovation in sustainable packaging methods for portioning (e.g., vacuum packaging). Also, information about the best practices, benefits and disadvantages of food portioning into existing awareness campaigns.

Promoting Storage Checking and Shopping List Preparation

Regularly checking food storage and planning shopping trips can lead to a reduction in both chicken and packaging waste.

• **Market Strategy:** Retailers can incorporate technology, such as mobile apps, to assist consumers in tracking their food inventory at home and planning their shopping accordingly. These apps could provide reminders to check storage before shopping, suggest meal plans based on available items and create shopping lists to be created and updated.

• **Policy Recommendation:** Governmental bodies can work with educational institutions to include food waste reduction and efficient shopping planning in their curriculum.

Holistic Approach

All these measures should be supported by a holistic approach to consumer education about the importance of reducing waste and properly storing food items. By integrating these strategies, a significant reduction in both chicken and packaging waste can be achieved, leading to a more sustainable food supply system.

City, University of London
Northampton Square
London EC1V OHB
United Kingdom

www.city.ac.uk

Telephone enquiries
+44 (0) 2070405 5060

Make an enquiry
www.city.ac.uk/foodpolicy

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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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Virginia Martin Torrejon

Adrian White

Christian Reynolds

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Contact:
Christian.Reynolds@city.ac.uk

Project Twitter Account:
@_Reduce_Waste_