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Meat packaging sustainability perception among undergraduate university students studying Food and Forensic Science related courses: A Coventry University scoping exercise

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Meat and non-recyclable multilayer film packaging waste has contributed to greenhouse gas (GHG) emissions, which impact the environment. In the UK, the Waste & Resource Action Programme (WRAP) established a plan to tackle meat and plastic waste; however, its success is impossible without extended consumer responsibility. This study aimed to investigate students' perceptions of meat packaging sustainability. Students (n=34; male=9, female=25) were recruited from Coventry University, England. Respondents consisted of students who were staying on and out of campus. The study was conducted via an online JISC questionnaire and images asking about recycling, knowledge and sustainability perception of meat and meat packaging. The survey revealed that a significant number of students living in student accommodation (P=0.006) do not have recycling waste bins and are unaware of recycling collections (P=0.035) compared to those living in houses or flats. The photo-based observation (PBO) study showed that specialistic on-pack recycling labels (OPRL) logos do not increase recycling rates. Also, a significant understanding of packaging and meat waste reduction was observed among females (P=0.044) and those who were enrolled in Food courses (P=0.031). However, a significant understanding of the role of the plastic packaging in shelf life and meat waste reduction was shown among respondents from Food, Nutrition and Health-based courses (P=0.041). Therefore, the problem of packaging and meat sustainability is complex and depends on different variables such as consumer's sociodemographic, knowledge, and perception of plastic packaging design.

Keywords: Meat packaging, meat sustainability, petrochemical-based multilayer packaging, circular economy, plastic perception, On-pack recycling label.

INTRODUCTION

Petrochemical-based packaging has recently gained much attention and is perceived as a harmful environmental factor impacting ocean pollution and climate change (Dilkes-Hoffman *et al.*, 2019). In 2021, Plastics Europe report showed that 53.1Mt of plastic converters were used across market sectors, sharing 39.1% of the total market (Plastics Europe, 2022).

The European Commission (EC) has highlighted the issue of problematic "single-use" plastic packaging, which either ends up in landfill or sea, or leaking into the environment. The biggest concern is marine life ingesting microplastics (<5 mm in diameter) that accumulate in the sea, hence the shift from linear to a circular plastics economy. The approach aims at approximately 55% of plastic packaging to be recycled in the EU by 2025; and by 2030, all plastic to be reusable and recyclable (EC, 2018). Thereafter, Waste & Resource Action Programme (WRAP) launched the UK Plastics Pact in 2018, bringing together multidisciplinary stakeholders, over 100 UK businesses supported by the government to focus on the problematic plastic packaging, constituting nearly 70% of the total UK plastic waste. WRAP set four main targets to be achieved by 2025; (i) to eliminate problematic or unnecessary single-use packaging through redesign, innovation or alternative (reuse); (ii) to have 100% of plastics composed of reusable, recyclable, or compostable materials; (iii) to have 70% of plastic packaging effectively recycled; and (iv) to recycle 30% contents of plastic packaging. According to the 2022 WRAP report, 46%, 70%, 52%, and 18% of each target respectively has been achieved across pact members. However, the report highlighted several difficult-to-conquer barriers, such as customer behaviour, poor recycling infrastructure or material design (WRAP, 2022b). In addition, a plastic packaging tax (PPT) was introduced on 1 April 2022 to enforce CE in the UK. The

PPT charges are applicable for business monthly generating over 10 tons of plastic materials containing less than 30% recycled content (HMRC, 2021).

The UK's most consumed animal species are poultry, beef, pork, and sheep (Giromini & Givens, 2022), contributing to over 4M tonnes of greenhouse gas (GHG) emissions. WRAP report highlighted that reducing meat waste at home for consumers through shelf-life extension by packaging innovations, such as skin packs or modified atmosphere packaging, outweighs additional packaging resources (WRAP, 2021).

Meat and meat products are an indispensable part of the human diet as sources of proteins, iron, zinc, and vitamins (Giromini & Givens, 2022). Due to excellent nutritional values, post-mortem meat muscles are highly perishable because of high water activity (>0.95), moisture content (75%), and acidic pH between 5.5-6.5 (Adams *et al.,* 2018) providing favourable conditions for the growth of spoilage organisms like *Pseudomonas* or *Lactobacillus* and the associated foodborne bacteria like *Clostridium botulinum*, *E. coli*, *Salmonella* or *Campylobacter* (Adams *et al.,* 2018). Packaging is the most used hurdle to extending meat shelf-life (Robertson, 2012).

The most common packaging solutions for meat products are aerobic packaging (AP), vacuum packaging (VP) or modified atmosphere packaging (MAP), using petroleum-based polymers as a barrier film. In the AP packaging system, the product is packed in trays, wrapped with overwrap film, or sealed flow wrap pouch giving an anaerobic condition. In the VP system, the product is heat-sealed under a vacuum inside a thermoformed top and bottom film or vacuum pouch giving anaerobic conditions inside a pack. The meat product is heat-sealed inside a thermoformed bottom film, either a tray with a top film or a vacuum pouch, and air removal. However, in MAP, the air is instantly replaced with a gas mix composed of carbon dioxide, oxygen, and nitrogen in varying proportions, depending on the product microflora. The CO_2 slows antimicrobial activity in

preserving meat (Cenci-Goga *et al.,* 2020). The packaging systems protect fresh meat from moisture losses; reduce bacterial and enzymatic activity, lipid and myoglobin oxidation caused by UV light and oxygen (Robertson, 2012). Meat packaging protects the product from environmental contamination and consumers from foodborne bacteria (Cenci-Goga *et al.,* 2020). The use of MAP in meat packaging extends shelf life of fresh pork, beef and chicken, cooked meat, and fish by 125%, 200%, 300% and 400% respectively compared to unpacked fresh meat (Fellows, 2019).

The AP, VP, and MAP meat plastic packaging require high gas, moisture, aroma, and grease barrier properties to extend meat shelf life effectively, as well as structural strength and sealability to protect the product (Soro *et al.,* 2021). Currently, the most used materials for meat packaging are Polyethylene (PE), Polypropylene (PP), Polyethylene Terephthalate (PET), Polyamide (PA), Polyvinylidene dichloride (PVdC), Ethylene Vinyl Alcohol (EVOH) and Ethylene-vinyl acetate (EVA) are made from synthetic plastic polymers and providing various barrier properties (Bauer *et al.,* 2021). These individual polymers do not fulfil the required functional properties of meat packaging without affecting the product's shelf life (Pauer *et al.,* 2020) resulting in combining 3 to 12 layers of different polymers in the coextrusion or lamination process to achieve a fully functional multilayer film. The most common combination of polymers in multilayer flexible films applied for meat packaging is a 5-layer film composed of PE, PA and EVOH in layer orientation PE/PA/EVOH/PA/PE or 3-layer film, made of PE, PA and PVdC (Bauer *et al.,* 2021; Butler & Morris, 2016).

Nevertheless, flexible multilayer films are challenging to recycle due to the complexity and inability to identify, sort, and separate individual layers through the mechanical process, thereby leading to granulate contamination. Chemical recycling could be exploited to separate multilayer films into monomers; however, the process is expensive,

and the infrastructure is still under development (Soares *et al.,* 2022). Due to the inability to recycle multilayer films, the introduction of the plastic tax and the pressure to move into the CE system, trends increased towards using mono-materials, packaging weight reduction and redesigning it for recyclability (WRAP, 2022a). In the UK, only PET material is classified as recyclable at home. At the same time, the PE or PP films with a maximum of 10% EVOH or other polyolefin can be only recycled by customers in the front-of-the-store collection points (CEFLEX, 2020).

In the UK, OPRL has recently updated the labelling guidelines by simplifying recycling messages to *'Recycle'* for recyclable at-home components and *'Don't Recycle'* for non-recyclable. Also, a new specialistic label has been added, i.e., 'Recycle with bags at large supermarket – Don't Recycle at home' for components recyclable in specific recycling points but not at home (OPRL, 2021). The amendment of existing recycling messages helps consumers distinguish between recyclable and non-recyclable packaging, preventing recyclate contamination during the mechanical recovery process (East, 2019). However, WRAP highlights some concerns about consumers' behaviour and knowledge leading to correct plastic packaging sorting and recycling (WRAP, 2022b).

The Life Cycle Assessment (LCA) of meat products must always be conducted on meat and meat packaging to understand the actual environmental impact. Pauer et al. (2020) compared LCA assessments of bacon lightweight non-recyclable shrink bags, vacuum bags, and the recyclable thermoformed film and the recyclable option had a higher environmental impact. Another LCA study on beef packaging showed that non-recyclable VP had the lowest environmental impact compared to recyclable MAP packaging due to the tripled shelf-life extension of fresh meat. Recyclable solutions of beef packaging improved LCA if there was product shelf-life extension and correct recycling (Casson *et*

al., 2022). PE/EVOH film used for bacon, even if classified as technically recyclable, might not end up in the recyclable waste stream (Pauer *et al.,* 2020).

The meat industry faces sustainability challenges in reducing meat and packaging waste. Clark et al. (2019) reported that industry stakeholders raised major concerns about knowledge gap among consumers regarding the role of plastic packaging in the shelf-life extensions of fast-moving chilled products, food waste reduction, and plastic packaging recycling habits. Consumers who are knowledgeable about recycling separate plastics for recycling. However, the perception of plastic sustainability differed between gender and educational level (Weber Macena *et al.,* 2021). The packaging design and content might negatively impact the perception of packaging, influencing the mis-sorting behaviour by consumers (Nemat *et al.,* 2022).

Currently, local authorities and councils in the UK have diverse recycling rules; therefore, people moving from one area to another could confuse and mis-sort their recycled waste. Barriers include recycling infrastructure, such as the availability of recycled waste bins, distance to them; storage space and frequency of waste collection are the main barriers impacting general recycling efficiency (Oluwadipe *et al.,* 2022). In Coventry, in the period 2021/22, only 28.6% of recycled household waste collections have been recorded compared to 42.5% in England. Coventry University (CU) students contribute to the movement towards CE (Coventry City Council, 2021); therefore, their perception of meat and meat packaging sustainability should be examined. This study aims to investigate Coventry University students' perception and knowledge of meat and meat packaging sustainability and their behaviours towards recycling flexible plastics.

METHODS

Questionnaire Design

A structured online JISC questionnaire (JISC v2, 2022), containing multiple-choice questions was designed by partially or fully adapted questions from the previous studies (Jatau & Binbol, 2020; Nemat *et al.*, 2020; Weber Macena *et al.*, 2021). The survey questionnaire was divided into five sections: (I) sociodemographic section (course type, gender, age range, and accommodation type on participants' perception, knowledge, and behaviour towards the sustainability of meat products' packaging), (II) recycling behaviour, (III) recycling knowledge, (IV) photo-based recycling choices of meat products packaging and (V) perception of meat and sustainability. The section IV, photo-based observations (PBO), was developed based on a similar study by Nemat et al. (2022). Photos (Table 1 and 2) of the samples were taken from products found in local shops located near student accommodation in the city centre. The photos were used to investigate participants' sorting behaviour of meat packaging and reaction to labelling information of different products. The 1 to 5 Linkert scales were used with an ascending frequency from Never (0%), Sporadically (25%), Sometimes (50%), Frequently (75%), and Always (100%) or level of agreement: Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree.

Participant Recruitment

Self-selection sampling was used to collect data through an administered online questionnaire. The online survey contained the participant information about the purpose of the project and a consent form. Participants consented to participate in the research by confirming that they were over 18 years old, and they understand that their data could

not be withdrawn at any time after opting in to take part in the study as the survey was anonymous. Participants were recruited from Food related courses, who had learned about food and food packaging from their courses and Forensic Science related courses who did not. The two groups were selected to understand if students from Food related courses would apply their academic knowledge in practise and if that would impact on recycling and correctness of recycling rates.

Sample Size Calculation

For sample size calculation two assumptions were adopted for sample size. Assumption 1: that the sample population was unknown (number of students on one level could not be determined but others were a total of 135 students). According to the law of large numbers, 95% confidence level and 5 % margin error for a population of approximately 150, the minimum sample size will be 108 (Saunders et al, 2012 pg 266). However, for surveys with a percentage response rate, this sample size would change.

$$Na = \frac{\text{n x } 100}{\text{re } \%}$$ (Saunders et al, 2012 pg 269)

Where Na = actual sample size required

n = adjusted minimum sample size

re = estimated response rate, expressed as percentage

$$Na = \frac{108 \text{ x } 100}{95\ \%}$$

Therefore, Na = 113 as the actual sample size required with

Assumption 2: that the sample population was 135 (number of students we certainly knew from some of the courses), confidence level of 95 %, margin error of 5%, and using a Qualtrics (2024) calculator, we got an actual sample size of 100. The estimate population of 150 would give an actual sample size of 108. However, a decision was made to use the lower number of 100 in the event that one level does not complete the survey. The survey opened from 09:00 on 16/01/2023 to 23:59 on 10/02/2023. Only meat eater

participants' responses were included in the study and to remove bias, non-meat eaters but those purchasing meat and meat products were excluded.

Data Analysis

The Statistical Package for Social Sciences v28 (SPSS) was used to analyse the data. Descriptive statistics were used for exploratory data analysis. The categorical data have been analysed using crosstabs and chi-square tests to assess the relationship between sociodemographic variables. The Fisher's Exact Probability test value has been used in all cases as more than 20% of cells had a count of less than 5. The Phi coefficient has been used for the 2x2 table and Cramer's V for more than 2x2 to determine the strength of relationships between variables. Values of the coefficients range from 0 to 1, and the strength of relationships of two categories as follows: small = 0.01, medium = 0.30 and large = 0.05 and three categories: small= 0.07, medium = 0.21 and large = 0.35 (Pallant, 2020). The data obtained from Linkert scales were tested for normality using the Kolmogorov-Smirnov test. The Kruskal-Willis test was applied to determine the relationship between independent sociodemographic groups and the impact of perception and knowledge of meat plastic packaging sustainability. The differences between multiple groups were analysed using the Mann-Whitney U test. Significance ($P \leq 0.05$) was considered (Pallant, 2020).

Table 1: Heat-sealed pouches: Images of meat and meat packaging used in the PBO study.

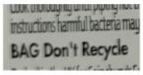
Picture	Picture	Type of Packaging	Type of Product	On Pack Information	Waste Stream	Does packaging need cleaning	Food Safety statement on pack
1		Heat-sealed bag	Sausages	Rinse Don't Recycle at home RECYCLE WITH BAGS AT LARGE SUPERMARKET 	Collect it separately and dispose of it in the designed collection point.	Cleaning is preferred for recycling. On the pack, information indicates to rinse.	Clear Food Safety information is available on the pack label warning the customer to wash hands and surfaces after handling raw meat and packaging.
2		Vacuum Shrinkable Skin Pouch	Cured Gammon Joint	BAG Don't Recycle 	General Waste	Cleaning is not required for general waste.	A detailed Food Safety statement on the pack label warns the customer to wash hands and surfaces after handling raw meat.
3		Vacuum Shrinkable Skin Pouch	Cured Gammon Joint	Don't Recycle 	General Waste	Cleaning is not required for general waste.	Clear Food Safety information is available on the pack label warning the customer to wash hands and surfaces after handling raw meat and packaging.
4		Vacuum Shrinkable Skin Pouch	Cured Gammon Joint	Bag Don't Recycle 	General Waste	Cleaning is not required for general waste.	A detailed Food Safety statement on the pack label warns the customer to wash hands and surfaces after handling raw meat.

Table 2: Heat-sealed top and bottom film: meat packaging used in the PBO study.

Picture	Picture	Type of Packaging	Type of Product	On Pack Information	Waste Stream	Does packaging need cleaning	Food Safety statement on pack
1		Vacuum Heat-Sealed Flexible top and bottom film	Bacon	Don't Recycle 	General Waste	Cleaning is not required for general waste.	No
2		MAP rigid tray with heat-sealed lidding film	Turkey Mince	TRAY Recycle FILM Don't 	Dispose of the top film with mixed waste and the bottom film with recycled waste.	Tray - cleaning is preferred for recycling. Film - cleaning is not required for general waste.	No
3		MAP rigid tray with heat-sealed lidding film	Bacon	TRAY Recycle & Film Don't Recycle 	Dispose of the top film with mixed waste and the bottom film with recycled waste.	Tray - cleaning is preferred for recycling. Film - cleaning is not required for general waste.	No
4		Vacuum Skin Pack with rigid tray	Cured Gammon Steaks	TRAY Don't Recycle Film Don't Recycle 	General Waste	Cleaning is not required for general waste.	A detailed Food Safety statement on the pack label warns the customer to wash hands and surfaces after handling raw meat.
5		MAP rigid tray with heat-sealed lidding film	Chicken Breast Strips	Rinse TRAY Recycle & Film Don't Recycle 	Dispose of the top film with mixed waste and the bottom film with recycled waste	Tray - cleaning is preferred for recycling. On the pack, information indicates to rinse. Film - cleaning is not required for general waste.	Clear Food Safety information on the pack label warns the customer to wash hands and surfaces after handling raw chicken and packaging.
6		Rigid tray with heat-sealed lidding film	Pork Sausages	Rinse TRAY Recycle & Film Don't Recycle at home. RECYCLE AT STORE 	Separate the Top and Bottom Films. Collect the top film, take it to the recycling point, and dispose of the bottom film with recycled waste.	Tray & film - cleaning is preferred for recycling. On the pack, information indicates to rinse.	Clear Food Safety information is available on the pack label warning the customer to wash hands and surfaces after handling raw meat and packaging.
7		Vacuum Skin Pack with rigid tray	Beef Steaks	TRAY Recycle FILM Don't Recycle 	Dispose of the top film with mixed waste and the bottom film with recycled waste.	Tray - cleaning is preferred for recycling. Film - cleaning is not required for general waste	A detailed Food Safety statement on the pack label warns the customer to wash hands and surfaces after handling raw meat.

RESULTS

The JISC survey was completed by 37 students. Responses of 3 participants who do not consume meat but purchase it were rejected to remove potential bias, assuming they have limited contact with meat packaging. A total of 34 survey responses (male n=9, female n=25) were considered for this study. The questionnaire data were exported to SPSS, and empty cells were coded before SPSS data analysis.

Sociodemographic Characterisation

The sample (female 73.5% and male 26.5%) consisted of undergraduate students, most of whom attended Food related studies (82.4%). Sample was predominantly young adults aged 18-25 (76.5%), equal groups of students living in student's accommodation and house (47.1%) but smaller percentage of those living in the flats (5.9%) as illustrated in Table 3.

Table 3: Sociodemographic characteristics of the population

Variable	Group	Count	%
Do you consume meat and meat products?	Yes	34	91.9
	No	3	8.1
When you purchase meat products, how often are you choosing already pre-packed?	Always	13	38.2
	Frequently	8	23.5
	Sometimes	10	29.4
	Sporadically	3	8.8
	Never	0	0.0
Course Type	Bio and Forensic science-based studies	6	17.6
	Food Science, Nutrition and Health based studies	28	82.4
What course type are you doing now?	Undergraduate	34	100.0
Gender	Male	9	26.5
	Female	25	73.5
	Prefer not to say	0	0.0
Age Group	18-25 years	26	76.5
	26-35 years	6	17.6
	36 years and over	2	5.9
Accommodation	Student's accommodation	16	47.1
	House	16	47.1
	Flat	2	5.9

Recycling Behaviour

Most respondents (41.2%) declared they frequently sorted waste for recycling, and 14.7% always did (Figure 1). A couple of participants recycled soft/flexible plastic waste, 17.6% frequently recycled and 11.8% always did. Nevertheless, the recycling rates decreased further when participants were explicitly asked about meat soft/flexible plastic packaging recycling with only 5.9% frequently recycled and 14.7% always recycled, and over one-third (35.3%) declaring they never recycled. Only 14.7% confirmed that they frequently

checked the packaging information before recycling, whereas 23.5% always did it. Most students responded that they never (32.4%) cleaned it or only sporadically (26.5%) before recycling.

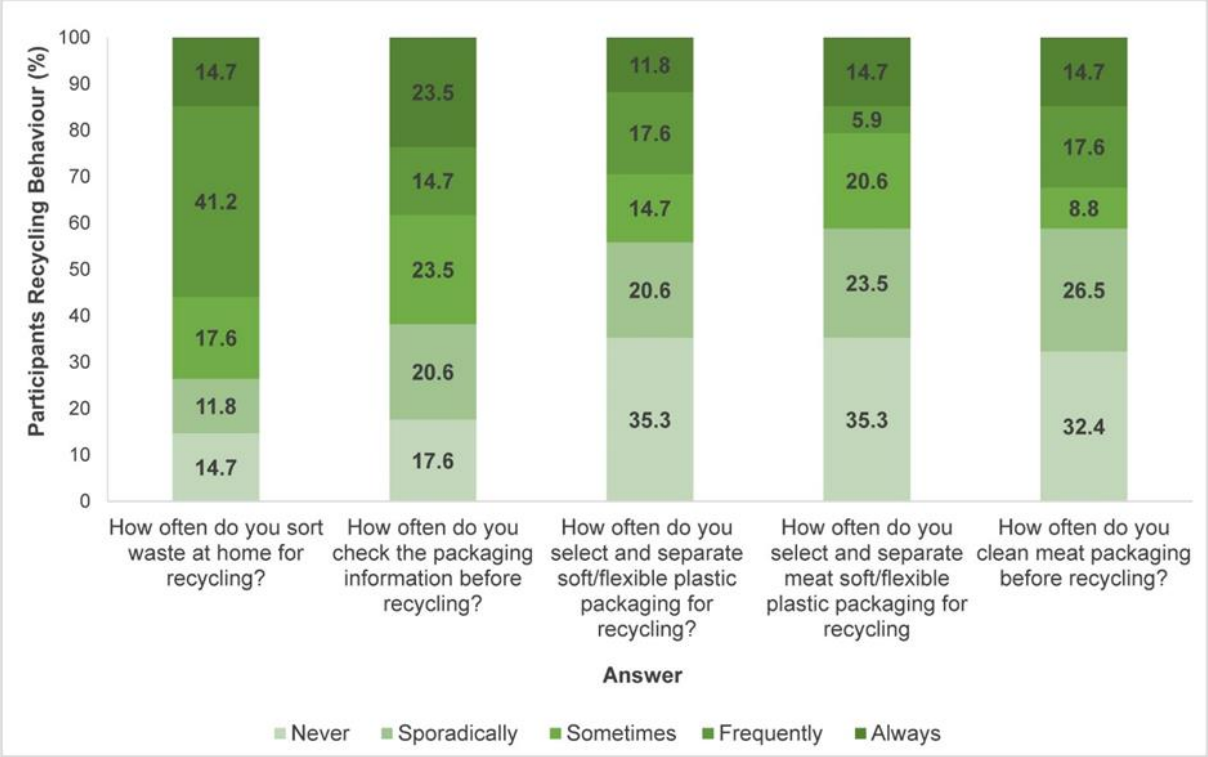


Figure 1: Behaviour and attitudes towards recycling of waste

A difference of 58.8% has been observed between students possessing a recycling bin from a council or accommodation provider (79.4%) and those not (20.6%). Among respondents who own recycled waste bins (Figure 2), 37% declared that they frequently filled them before the following collection,18.5% always did; and 55.6% thought they would require another recycled waste bin. Among respondents who did not have a recycling waste bin (Figure 3), most were not aware of why it was missing (42.9%) or just never received one (42.9%).

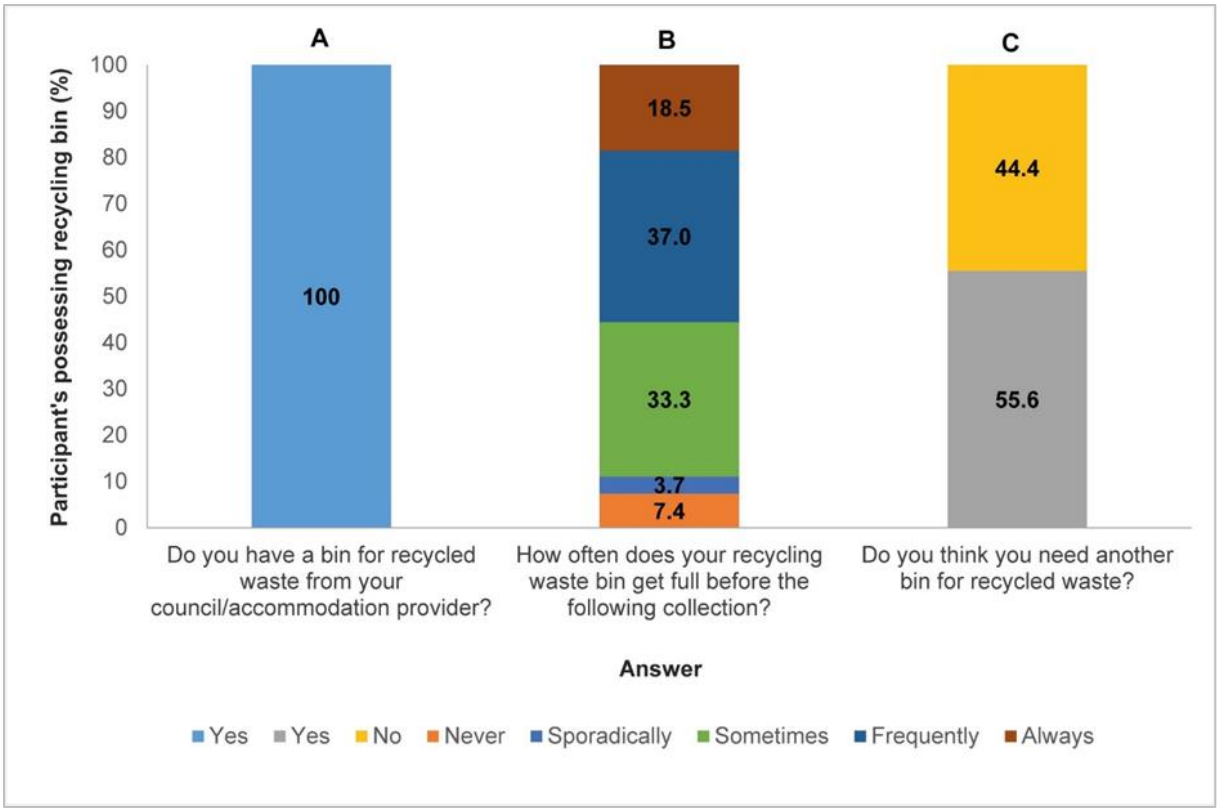


Figure 2: Column A: 79.4% of the sample size declared that they possess recycling bin, column B and C are responses on follow up questions.

Figure 3: Column A 20.6% of the participants declared that they do not possess recycling bin, column B are responses on follow up questions.

Only just over half (52.9%) knew when collections were done (Figure 4) in their area. However, a substantial proportion of students (70.6%) had specially designed containers to collect recycling waste inside their living places. In contrast, the remaining part (29.4%) did not, of which 60% claimed to use a bag instead.

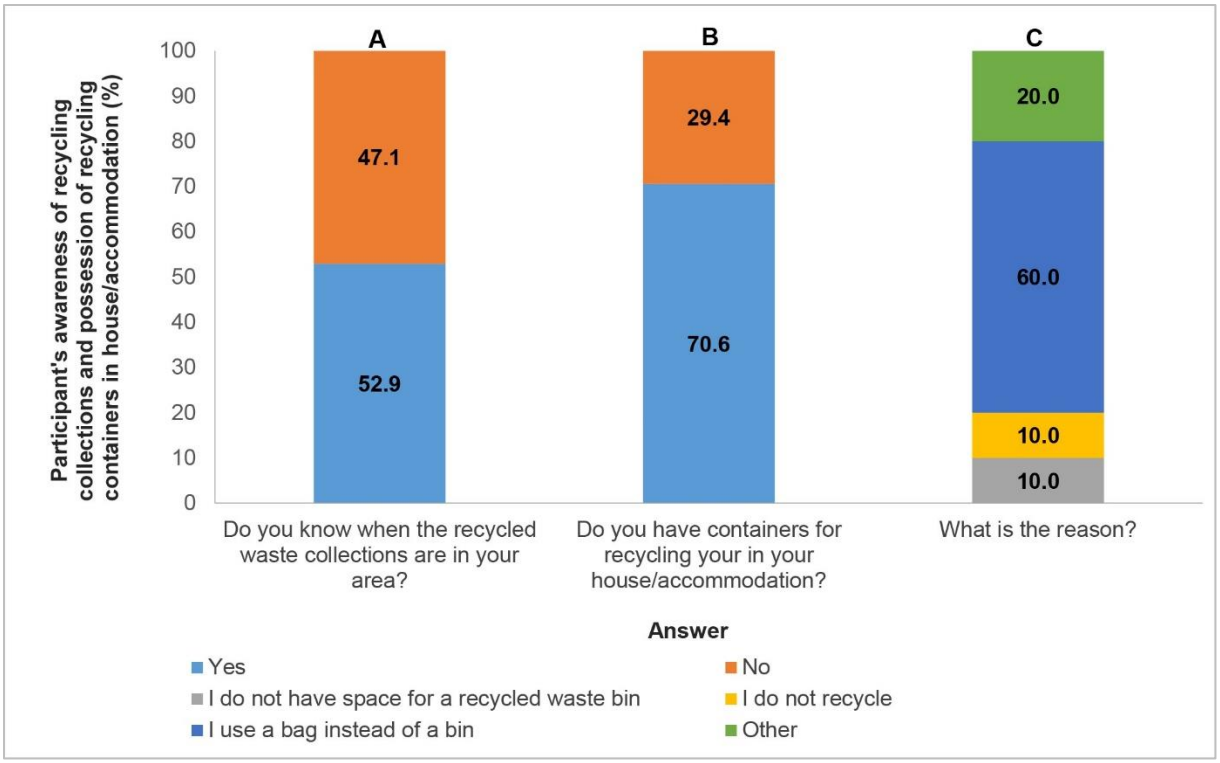


Figure 4: Awareness of recycling collections and possession of recycling containers in house or accommodation. Column C, follow up question if answer from column B was 'No'.

Source of Recycling Knowledge

One-third of the participants (32.4%) frequently obtained information about recycling from the internet and social media, with 13.51% confirmed it was their primary source (Figure 5). Family and friends, city council, educational, and governmental institutions were their second source of information whilst the least were television and radio, with 40.54% and 62.16% respectively. However, none of the participants indicated 'always' obtained recycling knowledge from radio and television.

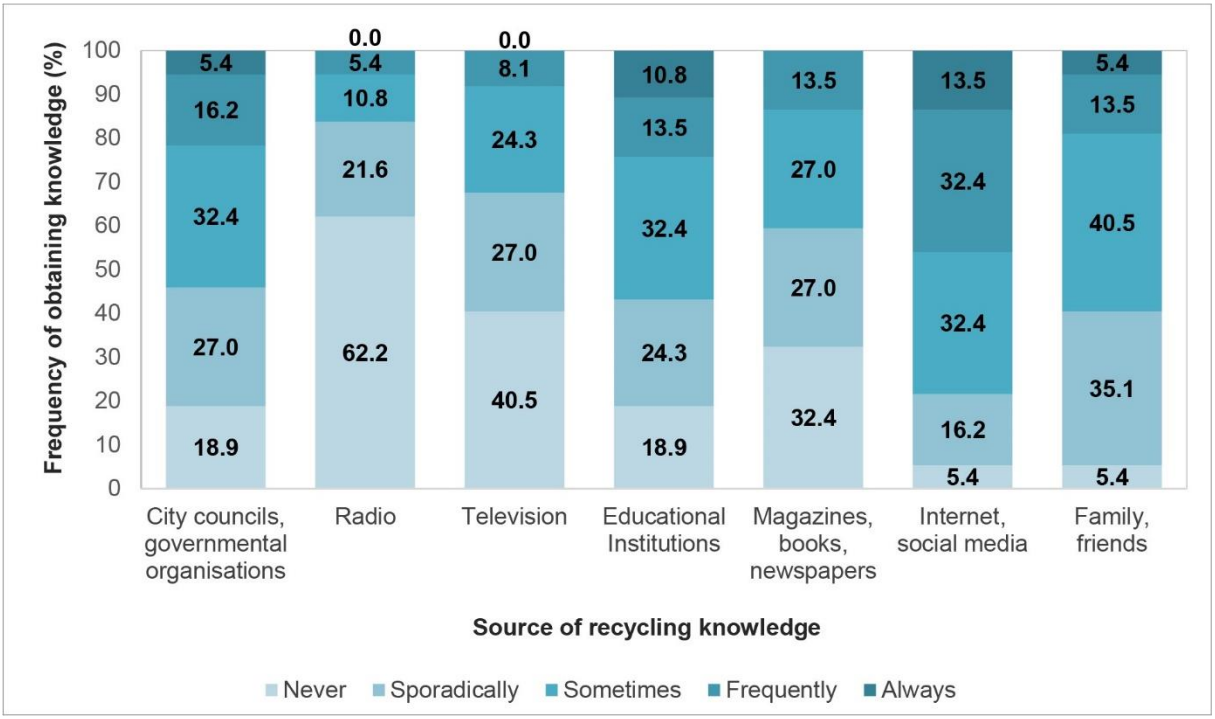


Figure 5: Frequency of obtaining information about recycling from different sources.

Recycling Behaviour Based On PBO Study

The results are summarised in Table 4 for packaging composed of top and bottom films and in Table 5 for a single bag or pouch. On average, nearly two-thirds of students declared they actively select and separate soft/flexible meat packaging for recycling in their households. Most participants correctly recycled recyclable meat packaging pictures 2 (26.5%), 3 (41.2%), 5 (41.2%) and 7 (41.2%) in the correct waste stream (Table 4). Some packaging contains the specialistic label (picture 6 [Table 2] and 1 [Table 1]) and specific information about the recycling of the packaging. For example, consumers could be instructed to recycle the whole packaging or part of its component is not recyclable at

home or at a specific location, i.e., store. Only 45.9% would separate the top and bottom films per the label instructions. A third of participants (37.8%) would dispose of the top film in a mixed waste fraction instead of taking it to the designated recycling point. Similar results were obtained for picture 1 (Table 5), where 51.4% would recycle the bag, 18.9% did it correctly at the recycling point, and 32.4% contaminated the recycled waste fraction. The most mistakenly recycled packaging was picture 3 (Table 4), of which 45.9% would throw away the non-recyclable plastic in the recycled waste fraction. On average, 60% of packaging from Table 4 and 80% from Table 5 would be recycled without being cleaned, regardless of the information on the pack label advice or intention to recycle.

Figure 6 shows that, out of the presented three pairs of recycling information examples, two-thirds of the participants chose the icon design, confirming it is significantly noticeable over the same message written in text. The follow up question aimed to check participants' behaviour towards the specialistic labels. Only 44.1% (Figure 7) of the participants would make an additional effort to collect the recycled waste separately and take it to the designated recycling point. Among those who did not take recycling to the recycling point (55.9%), the majority confirmed they would dispose of recycled waste in a mixed waste bin instead.

Table 4: PBO study on meat packaging composed of sealed top and bottom film.

Picture number (from Table 2)	**1**		**2**		**3**		**4**		**5**		**6**		**7**	
Result	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
How would you dispose of the packaging shown in the picture?														
Don't recycle; dispose of a whole in the mixed waste bin	21	61.8	12	35.3	10	29.4	19	55.9	10	29.4	9	26.5	10	29.4
I would recycle	13	38.2	22	64.7	24	70.6	15	44.1	24	70.6	25	73.5	24	70.6
How would you recycle it?														
Whole as it is	10	29.4	12	35.3	9	26.5	9	26.5	9	26.5	10	29.4	10	29.4
Separate the top and bottom films	3	8.8	10	29.4	15	44.1	6	17.6	15	44.1	15	44.1	14	41.2
How would you dispose of it?														
Dispose of the top film with mixed waste and the bottom film with recycled waste	2	5.9	9	26.5	14	41.2	6	17.6	14	41.2	13	38.2	14	41.2
Dispose of the top film with recycled waste and the bottom film with mixed waste	0	0.0	0	0.0	0	0.0	0	0.0	1	2.9	0	0.0	0	0.0
Collect the top film and take it to the recycling point and dispose of the bottom film with mixed	0	0.0	0	0.0	1	2.9	0	0.0	0	0.0	0	0.0	0	0.0
Collect the top film and take it to the recycling point and dispose of the bottom film with recycled waste	1	2.9	1	2.9	0	0.0	0	0.0	0	0.0	2	5.9	0	0.0
Why would you not recycle?														
I am not in the habit of doing it	4	11.8	5	14.7	5	14.7	7	20.6	6	17.6	7	20.6	7	20.6
I do not have the facility to do it	0	0.0	3	8.8	2	5.9	0	0.0	2	5.9	0	0.0	0	0.0
The packaging is not suitable for recycling	16	47.1	3	8.8	1	2.9	11	32.4	1	2.9	1	2.9	2	5.9
I am confused about how I should recycle it	1	2.9	1	2.9	2	5.9	1	2.9	1	2.9	1	2.9	1	2.9
Would you clean this packaging before disposal?														
Yes	11	32.4	15	44.1	12	35.3	11	32.4	13	38.2	12	35.3	14	41.2
No	23	67.6	19	55.9	22	64.7	23	67.6	21	61.8	22	64.7	20	58.8
If Yes, is it influenced by:														
On pack information	2	5.9	1	2.9	1	2.9	1	2.9	3	8.8	3	8.8	2	5.9
I am in the habit of doing it	5	14.7	10	29.4	9	26.5	7	20.6	6	17.6	6	17.6	8	23.5
Both	4	11.8	4	11.8	2	5.9	3	8.8	4	11.8	3	8.8	4	11.8
If No, is it influenced by:														
I think it is a waste of water	3	8.8	3	8.8	3	8.8	1	2.9	3	8.8	1	2.9	1	2.9
I have some safety concerns	4	11.8	5	14.7	3	8.8	2	5.9	5	14.7	4	11.8	3	8.8
I do not think this is required	12	35.3	7	20.6	8	23.5	9	26.5	5	14.7	6	17.6	5	14.7
All of the above	4	11.8	4	11.8	8	23.5	11	32.4	8	23.5	11	32.4	11	32.4

Table 5: PBO study on meat packaging composed of the vacuum pouch or bag.

Picture number (from Table 1)	**1**		**2**		**3**		**4**	
Result	Count	%	Count	%	Count	%	Count	%
How would you dispose of the packaging shown in the picture?								
Don't recycle; dispose of a whole in the mixed waste bin	16	47.1	28	82.4	24	70.6	27	79.4
I would recycle	18	52.9	6	17.6	10	29.4	7	20.6
How would you recycle it?								
In recycling waste bin	11	32.4	5	14.7	6	17.6	6	17.6
Collect it separately and dispose of it in a designed collection point	7	20.6	1	2.9	4	11.8	1	2.9
Why would you not recycle?								
I am not in the habit of doing it	5	14.7	7	20.6	5	14.7	5	14.7
I do not have the facility to do it	2	5.9	2	5.9	1	2.9	2	5.9
The packaging is not suitable for recycling	5	14.7	17	50.0	16	47.1	16	47.1
I am confused about how I should recycle it	4	11.8	2	5.9	2	5.9	4	11.8
Would you clean this packaging before disposal?								
Yes	8	23.5	4	11.8	7	20.6	6	17.6
No	26	76.5	30	88.2	27	79.4	28	82.4
If Yes, is it influenced by:								
On pack information	1	2.9	1	2.9	1	2.9	1	2.9
I am in the habit of doing it	4	11.8	2	5.9	4	11.8	3	8.8
Both	3	8.8	1	2.9	2	5.9	2	5.9
If No, is it influenced by:								
I think it is a waste of water	1	2.9	2	5.9	1	2.9	2	5.9
I have some safety concerns	3	8.8	2	5.9	3	8.8	2	5.9
I do not think this is required	14	41.2	14	41.2	12	35.3	14	41.2
All of the above	8	23.5	12	35.3	11	32.4	10	29.4

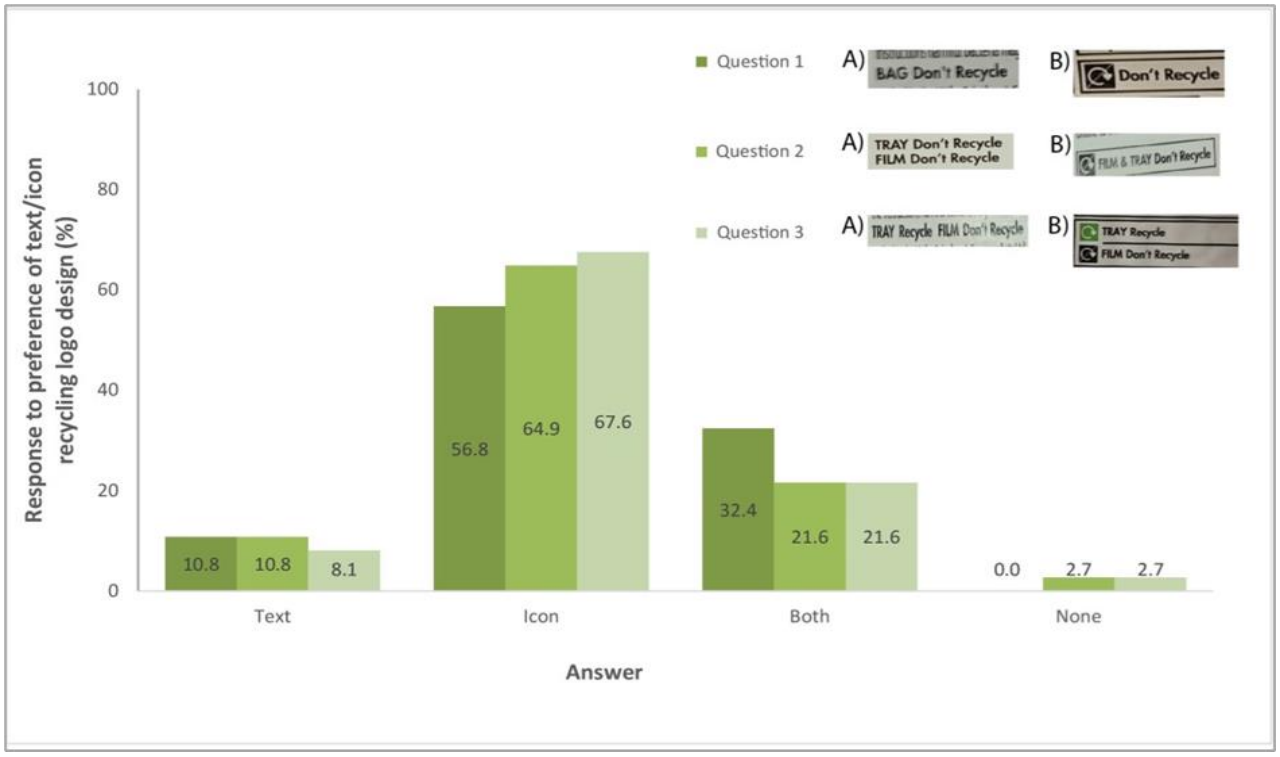


Figure 6: Comparison of text and icon recycling information

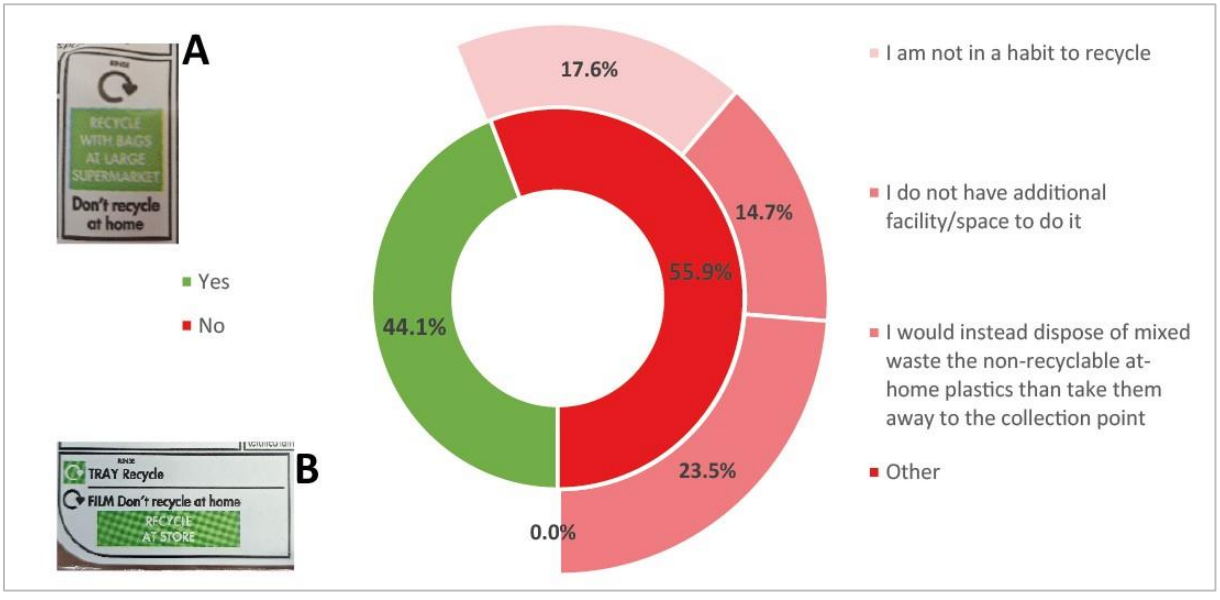


Figure 7: If participants noticed A or B on-pack recycling information, would they use the appropriate recycling locations?

Perception of Meat and Plastic Packaging Sustainability

The participants' perceptions of meat and plastic packaging sustainability have been examined through a level of agreement with seven statements (Figure 8). Most participants agreed to S1 (50.0%) and S2 (52.9%), and about one-third (29.4%) strongly agreed, showing an overall high level of awareness of the negative impact of plastics on the environment. Despite the agreement with the first two statements, a huge proportion of the participants (61.8%) held back from giving a definite answer to S3, indicating that they were unsure about paying more for meat if packed in recyclable packaging. About 40% of students agreed, and 20% strongly agreed that they are confident about recycling meat packaging materials (S4) and that packaging attributes impact their decisions (S5). However, in both cases, around 26.5% neither agree nor disagree with the statements. In the case of food waste reduction (S6), the majority (41.2%) agreed or strongly agreed (32.4%) that the issue is equally meaningful as plastic waste reduction, with 20.6% undecided. Some participants did not agree or disagree (35.3%), with S7 indicating little unawareness of meat packaging functions.

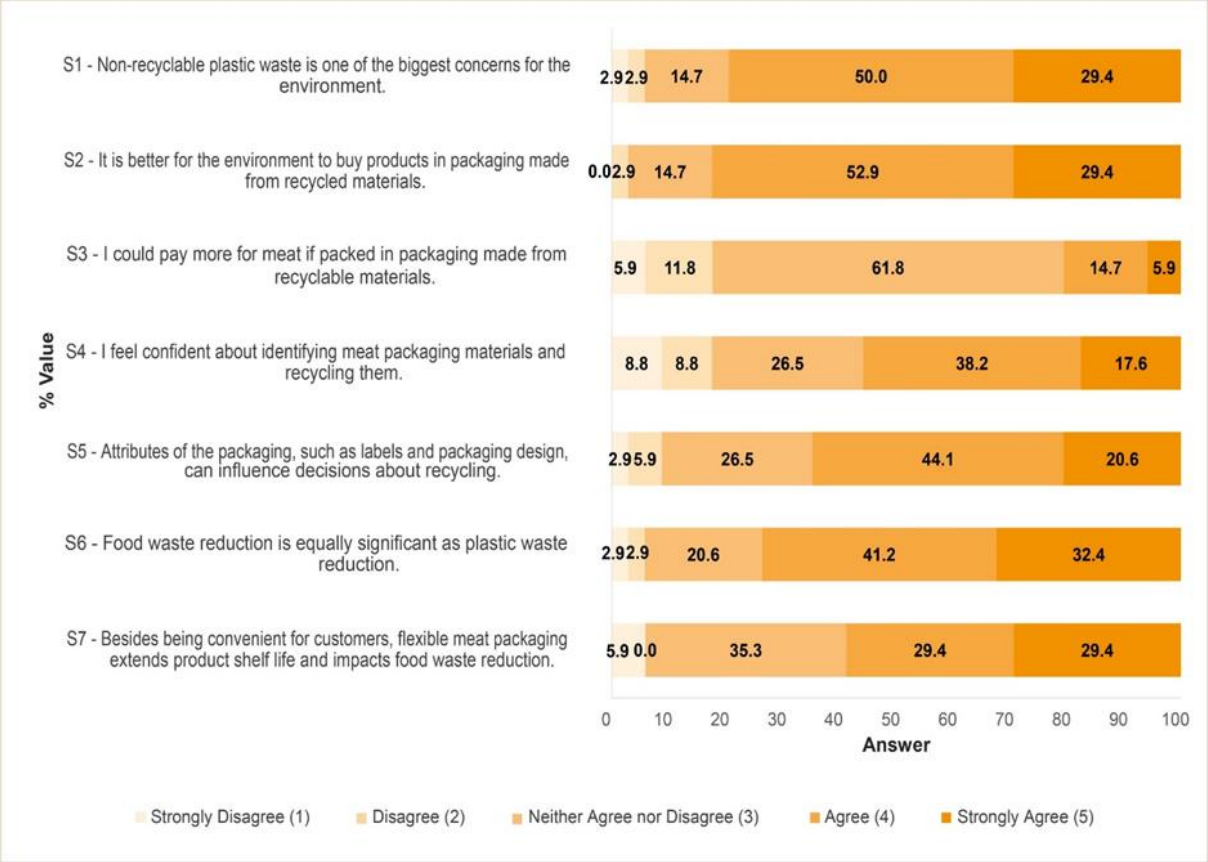


Figure 8: Participant's perception of meat and packaging sustainability.

Impact of Accommodation on Recycling Behaviour

The type of accommodation and possession of recycling bins are significantly correlated (Fisher Exact Test p=0.006) and largely associated (Cramer's V=0.540). The other correlation is between accommodation and awareness of the recycled waste collection dates (Fisher Exact Test p=0.035), showing a low association (Cramer's V=0.425). However, nearly 50% of students living in the house (75 %) declared that they know about recycled waste collection days in the area.

Table 6: Relationship between sociodemographic variables and recycling behaviour

Question	Age Group			Gender		Accommodation			Course Type	
	18-25 years	26-35 years	36 years and over	Male	Female	Student's accommodation	House	Flat	Bio and Forensic science-based studies	Food, Nutrition and Health based studies
How often do you sort waste at home for recycling?										
Never	19.2	0.0	0.0	22.2	12.0	25.0	0.0	50.0	16.7	14.3
Sporadically	11.5	16.7	0.0	0.0	16.0	18.8	6.3	0.0	16.7	10.7
Sometimes	19.2	0.0	50.0	33.3	12.0	25.0	12.5	0.0	16.7	17.9
Frequently	42.3	50.0	0.0	44.4	40.0	18.8	62.5	50.0	50.0	39.3
Always	7.7	33.3	50.0	0.0	20.0	12.5	18.8	0.0	0.0	17.9
Fisher Test p-value	0.219			0.275		0.074			0.919	
Cramer's coefficient, V	0.366			0.400		0.418			0.202	
How often do you check the packaging information before recycling?										
Never	19.2	0.0	50.0	22.2	16.0	18.8	12.5	50.0	16.7	17.9
Sporadically	19.2	33.3	0.0	22.2	20.0	18.8	25.0	0.0	50.0	14.3
Sometimes	26.9	16.7	0.0	33.3	20.0	31.3	12.5	50.0	33.3	21.4
Frequently	15.4	16.7	0.0	11.1	16.0	6.3	25.0	0.0	0.0	17.9
Always	19.2	33.3	50.0	11.1	28.0	25.0	25.0	0.0	0.0	28.6
Fisher Test p-value	0.822			0.857		0.609			0.210	
Cramer's coefficient, V	0.278			0.215		0.311			0.425	
How often do you select and separate soft/flexible plastic packaging for recycling?										
Never	42.3	16.7	0.0	22.2	40.0	43.8	25.0	50.0	33.3	35.7
Sporadically	11.5	50.0	50.0	22.2	20.0	6.3	37.5	0.0	33.3	17.9
Sometimes	19.2	0.0	0.0	22.2	12.0	12.5	12.5	50.0	16.7	14.3
Frequently	19.2	16.7	0.0	22.2	16.0	25.0	12.5	0.0	16.7	17.9
Always	7.7	16.7	50.0	11.1	12.0	12.5	12.5	0.0	0.0	14.3
Fisher Test p-value	0.116			0.874		0.379			0.924	
Cramer's coefficient, V	0.401			0.190		0.349			0.207	
How often do you select and separate soft/ flexible plastic meat packaging for recycling?										
Never	42.3	16.7	0.0	22.2	40.0	50.0	18.8	50.0	33.3	35.7
Sporadically	15.4	50.0	50.0	33.3	20.0	6.3	37.5	50.0	50.0	17.9
Sometimes	23.1	16.7	0.0	33.3	16.0	25.0	18.8	0.0	16.7	21.4
Frequently	3.8	16.7	0.0	0.0	8.0	0.0	12.5	0.0	0.0	7.1
Always	15.4	0.0	50.0	11.1	16.0	18.8	12.5	0.0	0.0	17.9
Fisher Test p-value	0.187			0.642		0.167			0.652	
Cramer's coefficient, V	0.371			0.291		0.377			0.331	
How often do you clean meat packaging before recycling?										
Never	34.6	33.3	0.0	22.2	36.0	43.8	18.8	50.0	16.7	35.7
Sporadically	26.9	16.7	50.0	22.2	28.0	25.0	25.0	50.0	33.3	25.0
Sometimes	7.7	16.7	0.0	11.1	8.0	6.3	12.5	0.0	16.7	7.1
Frequently	15.4	16.7	50.0	22.2	16.0	12.5	25.0	0.0	16.7	17.9
Always	15.4	16.7	0.0	22.2	12.0	12.5	18.8	0.0	16.7	14.3
Fisher Test p-value	0.925			0.870		0.845			0.862	
Cramer's coefficient, V	0.228			0.185		0.253			.189	

Table 7: Relationship between sociodemographic variables and recycling behaviour

Question	Age Group			Gender		Accommodation			Course Type	
	18-25 years	26-35 years	36 years and over	Male	Female	Student's accommodation	House	Flat	Bio and Forensic science-based studies	Food, Nutrition and Health based studies
Do you have a bin for recycled waste from your council/accommodation provider?										
Yes	76.9	83.3	100.0	77.8	80.0	56.3	100.0	100.0	83.3	78.6
No	23.1	16.7	0.0	22.2	20.0	43.8	0.0	0.0	16.7	21.4
Fisher Test p-value	1.000			1.000		**0.006**			1.000	
Phi* / Cramer's coefficient, V**	0.141**			-0.024*		**0.540****			0.045*	
How often does your recycling waste bin get full before the following collection?										
Never	10.0	0.0	0.0	14.3	5.0	0.0	6.3	50.0	20.0	4.5
Sporadically	0.0	20.0	0.0	14.3	0.0	0.0	6.3	0.0	20.0	0.0
Sometimes	40.0	0.0	50.0	28.6	35.0	55.6	18.8	50.0	20.0	36.4
Frequently	35.0	40.0	50.0	28.6	40.0	33.3	43.8	0.0	20.0	40.9
Always	15.0	40.0	0.0	14.3	20.0	11.1	25.0	0.0	20.0	18.2
Fisher Test p-value	0.311			0.476		0.297			0.218	
Cramer's coefficient, V	0.410			0.375		0.447			0.492	
Do you think you need another bin for recycled waste?										
Yes	55.0	80.0	0.0	42.9	60.0	42.9	62.5	0.0	60.0	54.5
No	45.0	20.0	100.0	57.1	40.0	57.1	37.5	100.0	40.0	45.5
Fisher Test p-value	0.280			0.662		0.417			1.000	
Phi* / Cramer's coefficient, V**	0.371**			-0.151*		0.323**			0.043*	
Why do you not have a recycled waste bin from the council/accommodation provider?										
I never received one	33.3	100.0	0.0	0.0	60.0	42.9	0.0	0.0	0.0	50.0
I do not know	50.0	0.0	0.0	50.0	40.0	42.9	0.0	0.0	100.0	33.3
Other	16.7	0.0	0.0	50.0	0.0	14.3	0.0	0.0	0.0	16.7
Fisher Test p-value	1.000			0.571		No statistics			1.000	
Cramer's coefficient, V	0.471			0.730		No statistics			0.471	
Do you know when the recycled waste collections are in your area?										
Yes	46.2	83.3	50.0	33.3	60.0	31.3	75.0	50.0	50.0	53.6
No	53.8	16.7	50.0	66.7	40.0	68.8	25.0	50.0	50.0	46.4
Fisher Test p-value	0.216			0.250		**0.035**			1.000	
Phi* / Cramer's coefficient, V**	0.282**			-0.236*		**0.425****			-0.027*	
Do you have containers for recycling in your house/accommodation?										
Yes	69.2	83.3	50.0	77.8	68.0	56.3	81.3	100.0	66.7	71.4
No	30.8	16.7	50.0	22.2	32.0	43.8	18.8	0.00	33.3	28.6
Fisher Test p-value	0.671			0.692		0.253			1.000	
Phi[a] / Cramer's coefficient, V[b]	0.163[b]			0.095[a]		0.311[b]			-0.040[a]	

Impact of Sociodemographic Differences on the Perception of Meat Sustainability and Plastic Recycling

No correlation between sociodemographic variables and the participants' perception of meat and plastic sustainability (Kurskal-Wallis test, $p>0.05$). However, there has been an association between the awareness of food waste reduction and gender (Kurskal-Wallis test, $p=0.028$). The post hoc Mann-Whitney U test results (Table 8) showed a significant difference between gender ($p=0.044$). An association has been observed between courses and awareness of food waste reduction issues with a significant value of $p=0.021$. The post hoc Mann-Whitney outcome indicated a significant difference between courses ($p=0.031$), and the direction leaned towards Food, Nutrition and Health based studies, implied by higher mean rank value. Between courses, a difference in perception of flexible meat packaging impacts product shelf-life extension and food waste reduction (Kurskal-Wallis test, $p=0.041$). However, the post hoc Mann-Whitney U test showed no significant difference ($p=0.53$) between courses.

Table 8: Meat and packaging suitability perception against sociodemographic variables.

Statement (an assumption that there is no difference)		Kolmogorov-Smirnov	Age Group	Gender	Accommodation	Course Type
S1	Non-recyclable plastic waste is one of the biggest concerns for the environment.	<.001[a]	0.640	0.319	0.373	0.162
S2	It is better for the environment to buy products in packaging made from recycled materials.	<.001[a]	0.686	0.292	0.490	0.106
S3	I could pay more for meat if packed in packaging made from recyclable materials.	<.001[a]	0.509	0.146	0.932	0.108
S4	I feel confident about identifying meat packaging materials and recycling them.	<.001[a]	0.703	0.309	0.964	0.221
S5	Attributes of the packaging, such as labels and packaging design, can influence decisions about recycling.	<.001[a]	0.715	0.917	0.678	0.114
S6	Food waste reduction is equally significant as plastic waste reduction.	<.001[a]	0.602	0.028[a]	0.417	0.021[a]
S7	Besides being convenient for customers, flexible meat packaging extends product shelf life and impacts food waste reduction.	0.007[a]	0.583	0.119	0.732	0.041[a]

a. The significance level is .050.

DISCUSSION

Recycling Habits

The study aimed to investigate the perception and knowledge of meat packaging sustainability by some undergraduate students at Coventry University (CUUG) and understand their behaviour towards recycling flexible plastic packaging used for meat products. Purchasing pre-packed meat in plastic packaging became convenient due to the perception of better quality, improved food safety, shelf-life indication and the availability of product information on the label driving customers' choices (Font-i-Furnols & Guerrero, 2014). Besides convenience, pre-packed meat products also generate plastic waste and require consumers to follow the specific disposal rules. However, the actual

consumers' actions might be far from expectations due to emerging factors such as Coventry City and Coventry University being recognised as diverse communities (Coventry University, n.d.) with varying levels of English literacy.

The frequency rates decreased from 74% (total of always, frequently and sometimes) to 44% and 41% when specifically asked about recycling soft/flexible plastics and recycling plastic meat packaging respectively. Similar recycling patterns were observed in a study conducted on 128 Coventry University postgraduate students (CUPG), of whom 77% declared they recycled general waste, but only 30% recycled plastic materials (Jatau & Binbol, 2020). On the contrary, the study on the Portuguese population (of which students, n=134), showed that 74% usually recycled and had comparably higher engagement in food plastic packaging recycling, declaring that 99% do it moderately (total of always, frequently and sometimes) (Weber Macena *et al.,* 2021). The studies (Jatau & Binbol, 2020; Weber Macena *et al.,* 2021) show that general waste recycling (common glass, metal, or paper), was much higher than plastic. Plastic packaging waste was problematic and difficult to distinguish what is recyclable hence usually mixed with general waste. However, meat plastic packaging has other underlying issues such as perception of unpleasant fresh meat content and requiring cleaning before disposal that hinder consumers from recycling (Nemat *et al.,* 2022).

Approximately 61% (total of always, frequently and sometimes) declared moderate tendency to check recycling information before recycling. However, the value does not correspond to the quantity of declared plastic recycling (44%) or even lower for meat packaging (41%) (total of always, frequently and sometimes). Worldwide there are many designs of recycling labels (Shamsuyeva & Endres, 2021) which could affect the frequency of recycling packaging waste. CUUG students might be confused on how to interpret recycling labels on the less obvious to recycle plastic waste. On the other hand,

students (39%) (total of sporadically and never) who showed unwillingness to check on-pack recycling information could be international students for whom the UK recycling rules are confusing, language barrier to interpret label information and, thereafter not attempting to read them (Buelow *et al.*, 2010). Poor packaging design without colour or sign inclusion, soft/flexible structure, and glossy appearance is more likely to be perceived as low value or non-recyclable and often missorted with general waste (Nemat *et al.*, 2022).

Less than half of respondents (41%) (total of always, frequently and sometimes) stated that they cleaned meat packaging before disposal whilst two-thirds (59%) did not clean meat packaging before recycling. Nemat et al. (2022) reported that recyclable meat trays were not washed due unpleasant content, wastage of water and detergent, time and effort required, thereby ending up missorted. The possession of recycled waste bin from council/ accommodation providers was relatively high (79%) by CUUG (Figure 2). Amongst these students, 89% (total of always, frequently and sometimes) said the bin gets full before the following collection and 44% of them declared they would need another due to bulkiness of the waste (Wikström *et al.*, 2016). In the CUPG study, 93% respondents required more bins and 33% already did, indicating disparities in Coventry's recycling infrastructure (Jatau & Binbol, 2020). However, those students not owning a recycled waste bin (21%) (Figure 3) largely answered that they never received one or was damaged (43%). This could mean that students might not be aware to whom they should report the issues to or may be not concerned about not having the bins. A similar observation was noticed by Jatau et al. (2020) among CUPG.

Another factor impacting on overall recycling is awareness of recycling waste collections (Figure 4). Among all participants, 47% were not aware of recycled waste collection services in their area. Some of the students were not aware of the collection dates, hence

leading to waste accumulation. With little and no cleaning of the packaging, development of odours, and sight of piled rubbish would put the students off from recycling. Similar consistency in the knowledge of the collection dates in their area, CUUG (53 %) and CUPG (54 %) (Jatau *et al.*, 2020).

Recycling Knowledge

The most popular source of recycling knowledge was the internet and social media (78%), followed by family and friends (59%) and educational institutions (57%) (Figure 5). The results were consistent with previous study (Nemat *et al.*, 2022) that social media, and family and friends, were described as the informal sources of knowledge and driving the sorting behaviour of soft, rigid, and recyclable plastic packaging within the community. Participants based their recycling decisions on beliefs and perceptions of the packaging value rather than the actual on-pack recycling message (Nemat *et al.*, 2022), which could be linked to some of the recycling choices (Figure 5). Weber Macena et al. (2021) reported that the internet was the most frequent source of knowledge, whereas using educational and governmental institutions was the least used source of information. However, better engagement of governmental and educational institutions in communicating recycling knowledge improved recycling quality (Lee & Krieger, 2020) as half of the participants already use them as sources of information. Television (32%) and Radio (16%) were least common sources of obtaining recycling information with 41% and 62% of participants confirming never accessing them respectively. Both television and radio are common accessible methods of communication used by the UK government. Predominantly, in student accommodation there is no access to television and radio and nowadays most of the student generation uses smartphones to access information online. Television and radio adverts are more expensive than internet websites. Among the Portuguese population of whom 35.3% were students, and likewise

radio was the least chosen source of information (34%) but not last. On the contrary, television was more popular (58%) and preferred over family and friends (52%) (Weber Macena *et al.*, 2021).

PBO Study

The packaging design, content, label information, and ease of disposal substantially impact consumers' recycling behaviour (Wikström *et al.*, 2016). On average 70% of recyclable rigid packaging from picture 2, 3, 5, 6 and 7 in Table 4 would get recycled but between 26.5 to 35.4% would be recycled as whole, rather than separate top film from recyclable at home tray, leading to contamination of recycled waste. The additional effort required by participants to separate waste into different fractions could be perceived as not worth it, difficult, or lack of awareness (Williams *et al.*, 2018). Moreover, WRAP reported that 20% of pork and 17% of beef meat is thrown away annually still in packaging, because it was not used in time (WRAP, 2021). Some students reported that they would recycle whole product with recyclable packaging, that is the meat and it's packaging rather than separate, therefore, not emptying meat waste into an organic or general waste. Not separating meat waste from synthetic plastics designated for recycling also contaminates recycled waste streams and impacts recycling quality. Not separating meat content from plastic packaging was explained by its disgusting content, presence of blood, fat or mould was undesirable to handle meat (Williams *et al.*, 2018). Alternatively, film and tray type packaging from picture 1 (38%) and 4 (44%) (Table 4), despite being not recyclable, showed higher percentage of students wanting to recycle them rather than flexible vacuum pouches presented in pictures 2 (18%), 3 (29.4%) and 4 (21%) (Table 5). Such consumers' missorting behaviour was earlier shown by Nemat et al (2020), where items perceived as lower in value would be less likely recycled. Also, in a small study (n=10), 50% respondents always recycled rigid meat trays opposed to only

10% in case of flexible bacon packaging and confirming the value of perception (Williams *et al.*, 2018).

Different designs of on-pack recycling information were assessed (Figure 6) and most (63%) selected pictograms over text, meaning that they have a more noticeable design, hence more likely reading affecting correct packaging disposal. Therefore, the incorrect interpretation of recycling messages became an issue since non-recyclable plastics were understood as recyclable, contaminating recycled waste streams, explains why such a high percentage (56%) of students would recycle non-recyclable packaging from picture 4 (Table 4) displaying recycling information as text. The missorting problem was raised by WRAP (2022b) as limiting smooth movement to CE (Bening *et al.*, 2021).

The PBO study, incorrect interpretation of specialists' labels for plastics not recyclable at home where only 6% from 74% of students would take non-recyclable at home plastic packaging displays in picture 4 (Table 4) and 21% out of 53% in picture 1 (Table 5). However, 56% students displayed unwillingness to make an additional effort to depose recycling at the recycling points (Figure 7). Wikström et al. (2016) argued that the packaging must be convenient to dispose of, and increasing the distance to the recycling location might end up in a mixed waste stream closer as observed in the current study.

Sustainability Perception

The outcome of knowledge and sustainability perception, as presented in Figure 8, showed immense concern of students about the plastics' negative impact on the environment (79%) and the higher environmental value of recycled packaging materials (82%) (total of strongly agree and agree), implying a broad understanding of a global problem. The same concerns have been raised by a study on the Australian population,

where almost 70% of respondents perceived plastic as a severe ocean pollutant and 88% associated it with food packaging (Dilkes-Hoffman *et al.,* 2019). However, the same study also found an attitude-behaviour gap linking the perception of the plastic pollution problem not always translated to the actions regarding increased plastic recycling (Dilkes-Hoffman *et al.,* 2019), which could be associated with decreased recycling rate of meat packaging (Figure 1). In the German study, despite students' concern about the environment, well-educated young women were unwilling to pay more for recycled plastic materials as they were not perceived as sustainable (Herrmann *et al.,* 2022). Therefore, many students could have an incorrect understanding of meat packaging recycling based on poor results obtained from PBO study (Table 4 and 7). The role of packaging in shelf-life extension and food waste reduction was similar (59%) (total of strongly agree and agree) to what participants declared in the national UK study (56%). In contrast, previous WRAP research showed that only 22% of people from the public recognised packaging's role in shelf-life extension like current study's results (Herbert *et al.,* 2013).

Recycling Habits among Sociodemographic Groups

In addition, the current study population of Food, Nutrition and Health-based courses would have knowledge of recycling from their undergraduate course, thereby increasing the rates of recycling plastics and consciously checking dates for recycling services. The high declaration of lack of recycling bins (44%) in accommodation seems to hinder the students from contributing to a circular economy, affecting general waste recycling. About 44% of students in accommodation (total of never and sporadically) declared not recycling in comparison to 6% (total of never and sporadically) living in house but the difference was not significant (p=0.074) (Table 6). The CU and student accommodation

service provider should improve living infrastructure for students to be more recycling-friendly by allocating big, recycled waste bins outside flats and in-house small bins to separate the waste. The stratified sample of science students CUUG and mixed sample for CUPG demonstrated that neither the type of course nor the level of study had influence on the recycling collection services (use of bins and dates of collection).

Environmental and Sustainability Perception among Sociodemographic Groups

The analysis of the perception of seven emerging environmental and sustainability issues across sociodemographic groups revealed three significant associations (Table 8). There has been a significant difference in opinion on issues affecting the reduction of food and packaging waste, which are equally crucial between genders (p=0.028), where females showed a better understanding of the problem than males. The campaign about plastic reduction is well-known to many people, but an understanding of the food waste reduction problem is not always brought to light (Langley *et al.*, 2021). In the previous studies, Weber Macena et al. (2021) demonstrated that Portuguese women significantly (p=0.018) understood the impact of plastics on the environment than men. The other study on the Australian population (n=965) showed that females (p=0.018) expressed significantly higher motivation than men to reduce both food and packaging waste (Brennan *et al.*, 2023), which is consistent with the current study results. The current study found out that students from Food, Nutrition and Health-based have a significant (p=0.021) understanding of both plastic and food waste issues but also understood significantly (p=0.041) the role of plastic packaging in shelf-life extension from Bio and Forensic science. The results could suggest that people with specific knowledge of food science understand the functions of packaging and both problems of single-use plastic and food waste better than the public due to knowledge about food waste and plastic

waste recycling acquired from the taught course. Moreover, it can be implied that institutions such as Coventry Council and CU should offer educational programmes to students and the general population to broaden their knowledge about the role of packaging in shelf-life extension and food waste problem, as suggested by Langley et al. (2021).

CONCLUSION

The study investigated CUUG students' knowledge, attitudes, and perceptions regarding meat packaging sustainability. When considering recycling behaviour, there were significant differences (p=0.006, p=0.035) observed. The first difference (p= 0.006) was found in possession of a recycling waste bin by students living in student accommodation (56.3%) and in a house or flat (100%). The second significant difference (p=0.035) was observed in the knowledge of recycled waste collections among students living in student accommodation (31.3%) and house (75%) or flat (50%). Following the PBO study, the packaging design, such as a rigid tray, was valued more than if it was made of soft/flexible plastics, which was often then missorted. Recycling label design, like the inclusion of the OPRL logo, was preferred over text and led to better separation of plastic materials. However, concerning specialistic labels, although these are meant to increase the percentage of recycled waste, they can lead to missorting waste. Additionally, cleaning meat packaging before disposal with recycled waste is not a common practice.

Knowledge of the sustainability of packaging and meat waste reduction was more significant among females (p=0.028) and students from Food, Nutrition and Health-based courses (p=0.021) than among males and Forensic Science students, respectively. As

expected, the knowledge of the role of packaging and shelf-life extension in meat waste reduction was better understood by students from Food, Nutrition and Health-based courses (p=0.041) than Forensic Science. Lastly, consumers had a gap in knowledge and understanding of meat packaging sustainability, which could delay the smooth movement to CE. The government and councils still have much work to do to implement policies and strategies that would foster a circular economy in the UK whilst working with educational institutions such as universities which have diverse communities.

RECOMMENDATIONS

Firstly, UK companies could improve CE by using QR codes on food label information to enable consumers to access knowledge about the specific packaging recycling rules and product shelf life. Secondly, the UK companies, government and universities could get together to create a simple mobile application for UK nationals to improve their knowledge and recycling behaviour, including up-to-date recycling rules and food waste reduction practices, which should be made consistent across the UK. Thirdly, the local authorities and universities could work together to synchronise the recycling and food waste reduction practices for students regardless of the type of accommodation. Lastly, giving households incentives in the form of vouchers, cash credits, reward points via app converted to shopping money for returned recycled single-use plastics to recycling points or store collection to attract more recycling by consumers.

AUTHOR CONTRIBUTION

Kinga Comblik: Conceptualization, Formal analysis, Data curation, Methodology, Investigation, Project administration, Software, Original draft, Writing-review and

editing; **Marie Jane Hawkes**: Conceptualization, Formal analysis, Methodology, Investigation, Project administration, Original draft, Writing-review and editing; **Marie Lunel**: Conceptualization, Formal analysis, Methodology, Writing-review and editing; **Isabella Nyambayo**: Conceptualization, Formal analysis, Data curation, Methodology, Investigation, Project administration, software, Original draft, Writing-review and editing.

ETHICS

The project ethical approval was done by Coventry University's Ethical Committee, reference number P142728.

CONFLICT OF INTEREST

There is no conflict of interest during the completion of the research.

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