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A Waste of Food-Waste Bags

A Case Study of Helsingborg's Municipality

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Abstract

It is estimated that the average Swede throws away 61 kg of food waste annually. The more food waste there is, the more food waste bags are required. Since the implementation of a tax on thin plastic bags, grocery stores have been providing fruit bags of paper as an eco-friendly alternative. This study examines the current usage of paper fruit bags in the municipality of Helsingborg and explores the potential for reusing them for food waste. Reusing fruit bags for food waste would minimise the waste of this type of bag and reduce the need for manufacturing additional bags, thereby conserving renewable resources. However, the municipality treats the food waste through anaerobic digestion to produce a certified digestate. This certification scheme has specific requirements on the type of food waste bags that can be used to minimise contaminants. The local waste company therefore insists on using only their designated food waste bags.

The results of this study indicate that a total amount of approximately 4.3 million fruit bags is discarded annually in the municipality of Helsingborg after been used for groceries. Furthermore, 32% of households already use fruit bags for food waste. Additionally, 28% of the municipality's grocery stores offer fruit bags that are approved for food waste according to the digestate certification scheme. Biond, the digestate producer, prefers the utilisation of paper bags since plastic and bioplastic do not degrade during the digestion and is instead sorted out as much as feasible. Future studies should include testing occurrence of contaminants in fruit bags approved according to the EU regulation (EC) No 1935/2004 under what is considered normal and foreseeable conditions for fruit bags. Furthermore, it is of interest to investigate the effect of digestion on organic pollutants and the effect of these contaminants on soils.

Keywords: *Anaerobic digestion, Food waste, SPCR 120, Fruit bag, Helsingborg municipality, Waste Management*

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Terminology

Anaerobic Digestion: Degradation of organic matter in the absence of oxygen.

Collection bag: Used to refer to all types of food waste bags, not only the ones in paper, but also those in bioplastic and plastic.

Digestate: The "by-product" (effluent) from anaerobic digestion that can be used as a fertiliser.

Feedstock: The combination of substrates that are digested in the anaerobic digestion plant.

Food waste bag: In this paper this term is used to refer to food waste bags in paper provided by the local waste company.

Fruit bag: The paper bags provided in the vegetable and fruit section in grocery stores to collect e.g. apples, potatoes, and onions.

Source separation: This means that the food waste is segregated from the other generated waste streams for separate collection at the source, e.g. by the households (Swedish Waste Management Association, 2022a).

SPCR 120: The certification system in Sweden for digestates. The certified digestates are in Sweden referred to as a "biofertiliser". In this study, "digestate" is used as this is the common term used in research.

Substrate: The different types of organic matter that can be digested in the anaerobic digestion plant.

Retailers: Axfood, Coop, City Gross, ICA and Lidl.

1 Introduction

The composition of waste varies globally. Depending on geographical region, 25–65% of municipal waste is comprised of food waste (Banks et al., 2018). In Sweden, it is estimated that each person annually generates 61 kg of food waste, only including the part thrown in the waste bin (Hultén et al., 2022). For all food waste in Sweden, some kind of collection bag is used. Collection bags can be made of bioplastic, plastic, or the most common, paper (Swedish Waste Management Association, 2022b); so, this term includes all types of food waste bags. The number of collection bags that are annually used depends on the amount of generated food waste. Thus, the more food waste, the more resources to produce collection bags.

Paper is a renewable resource originating from forests. Besides paper, forests offer a range of benefits including the provision of products such as raw materials and fuels, as well as ecosystem services, such as, carbon sequestration, air purification, erosion prevention, biodiversity, recreation, and temperature regulation. As the world tries to move towards a biobased economy, the demand of products and services derived from forests is increasing, putting pressure on these ecosystems. Based on the ongoing global forest cover decline, they are already under high pressure (FAO, 2020). Even in ecosystems where the wood volume is increasing, as in Swedish boreal forests (Swedish Environmental Protection Agency, 2020), the forest is still under pressure as the old trees are continuously cut down and projected to be gone by 2070 if current rates continue (Ahlström et al., 2022). It is therefore also important to consider the negative impacts of using a renewable resource like forests.

The production of paper bags is unavoidably contributing to increasing the pressure on forests as they are made out of wood fibre (Ekstrand 2019). Since May 1st, 2020, the number of paper bags used in Sweden has increased due to a tax on small and thin plastic bags (Swedish Environmental Protection Agency, 2022). The plastic bags were typically used by consumers for fruits and vegetables in grocery stores. However, since the new tax was introduced, many stores have replaced them with paper bags. Prints on these paper bags sometimes encourage consumers to reuse them specifically for food waste (Axfood 2019). Reusing fruit bags for food waste would reduce the waste of bags and consequently, fewer food waste bags would need to be manufactured. However, this action may not be consistent with local waste management policies as nutrients and energy in the food waste is recovered through anaerobic digestion (Nordvästra Skånes Renhållning, n.d.; Swedish Waste Management Association, 2022a). The local waste company is afraid that the fruit bags contain contaminants which then becomes a part of the digestate.

Anaerobic digestion is the decomposition of organic matter in the absence of oxygen (Mata-Alvarez et al., 2000). One of the products of anaerobic digestion is a nutrient-rich digest referred to as digestate, which can be used as a fertiliser (O'Connor et al., 2022). Digestates produced in Sweden can as a quality label be certified according to SPCR 120. This certification scheme sets certain requirements to reduce the risk of spreading impurities on arable land, including the collection bags (Swedish Waste Management Association, 2023). The local waste company therefore provides the collection bag to the municipality's households. However, if fruit bags fulfil these requirements, they could be used for food waste, replacing some of the local waste company's food waste bag, conserving renewable resources.

Since waste management varies across municipalities, this study focuses on the municipality of Helsingborg, which is one of those where food waste is treated through anaerobic digestion. Furthermore, the digestate is certified according to SPCR 120 (Nordvästra Skånes Renhållning, n.d.; Swedish Waste Management Association, 2023). Since the local waste company in the municipality cannot control the quality of the fruit bags in each of the municipality's grocery stores, Helsingborg's inhabitants are directed to only use the local waste company's collection bag (Nordvästra Skånes Renhållning, n.d.). This is a measure to safeguard the quality of the digestate, but it may also hinder the use of fruit bags for food waste. If fruit bags can be used for food waste, they can replace some of the food waste resulting in less waste of fruit bags.

1.1 Aim and Objectives

This study will through interviews and a mapping of fruit bags provided in grocery stores investigate the current use of fruit bags and analyse the possibilities of using fruit bags for food waste in the municipality of Helsingborg.

To further specify the aim, the following questions are to be answered:

1. How many food waste bags can be saved by using fruit bags?
2. What are the fruit bags used for after they have been brought home?
3. How many of the grocery stores' bags qualify for the certification scheme?
4. What are Biond’s concerns regarding the use of collection bags?

2 Background and Theory

2.1 The Consumer’s Possible Actions

The way consumers in Helsingborg's municipality actually use waste bags is currently unknown. This means it is unknown to what extent inhabitants follow the local waste company's directive and only use their food waste bag, or if they use the fruit bag for food waste. There are mainly two paths of action the consumer can take that have different outcomes (see Fig. 1). In the conventional path, consumers use the waste bags provided by the local waste company. This is considered the dominating way of acting today and safeguards the quality of the digestate. However, this implies that many grocery stores' fruit bags are thrown in the garbage for recycling after only being used once, which is considered against the EU’s waste hierarchy which states that waste is primarily to be prevented (Swedish Environmental Protection Agency, n.d.). The alternative path is that consumers use the grocery stores' fruit bags for food waste. These bags can either fulfil the requirements in the certification scheme or not. Helsingborg's inhabitants then reduce the waste of paper bags and decrease the number of manufactured food waste bags (which can be represented as trees). However, this action can reduce the quality of the digestate if the grocery stores' paper bags do not fulfil the requirements of the certification scheme.

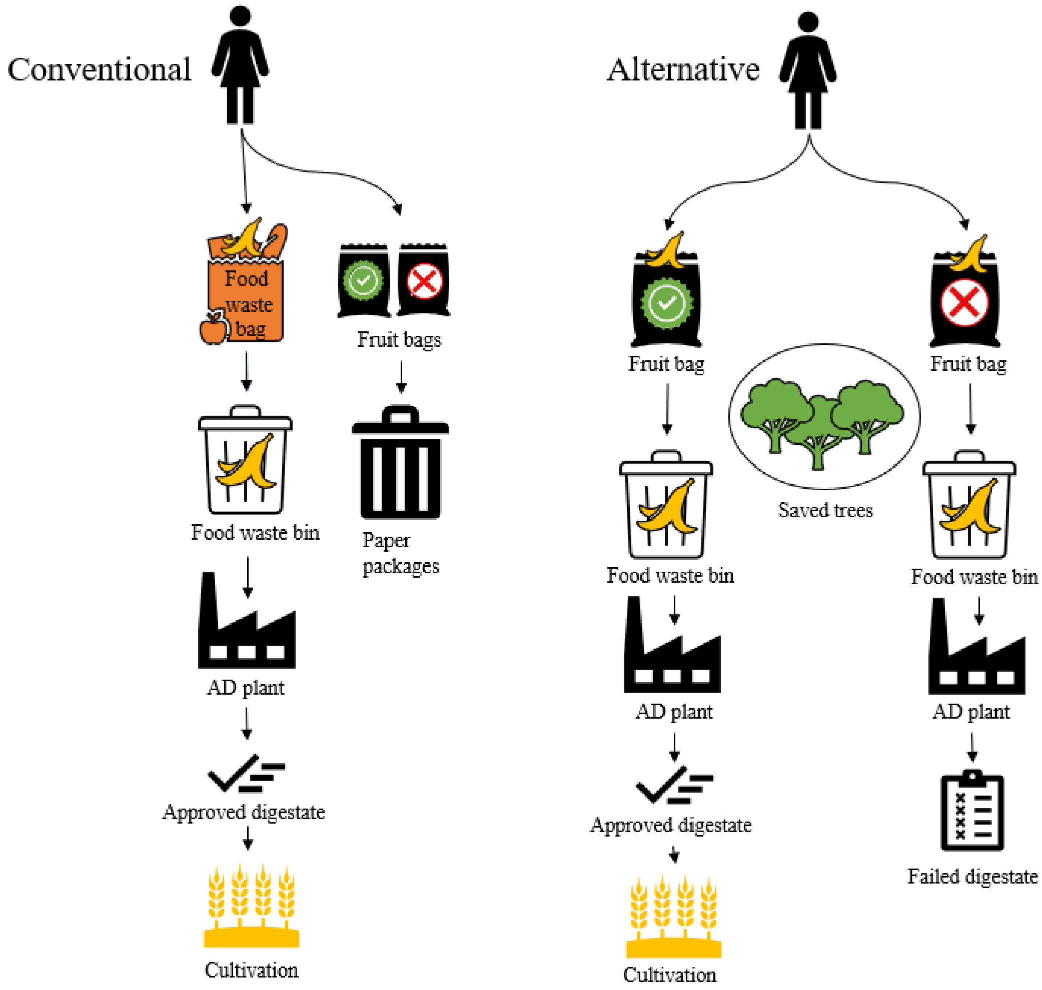

Fig. 1: Illustration of the conventional (left) and alternative (right) action paths made by consumers. In the conventional path consumers safeguard the quality of the digestate by using the local waste company's food waste bag. However, this implies that many fruit bags are thrown in the garbage. In the alternative path, consumers reduce the waste of fruit bags, but if the fruit bag does not fulfil the requirements in the certification scheme, it can reduce the quality of the digestate. AD stands for anaerobic digestion.

If each of the 68,711 households in Helsingborg (Statistics Sweden, 2023) goes grocery shopping once a week and they all use two paper bags for fruit and vegetables, this corresponds to a total of 7.15 million paper bags annually. Therefore, an equal amount of paper bags does not have to be manufactured if grocery shopping bags can be used for the food waste. It is worth mentioning here that this estimation is based on many assumptions and will be further investigated in this study (section 4.2).

2.2 Anaerobic digestion

Anaerobic digestion is the decomposition of organic matter in the absence of oxygen. This occurs naturally in e.g., wetlands and marshes, but also in ruminants' stomachs (Vasco-Correa et al., 2018). Anaerobic digestion provides two products, biogas which can replace fossil fuels, and a digestate consisting of partially degraded matter, microorganisms, and inorganic compounds in forms of nutrients and minerals. The digestate can therefore be used to replace synthetic fertilisers (Manu et al., 2021; O'Connor et al., 2022).

In the digester, the biochemical decomposition goes through four steps that take place more or less simultaneously (see Fig. 3) (O'Connor et al., 2022; Vasco-Correa et al., 2018; Vögeli et al., 2014):

1. Hydrolysis: Decomposition of larger and more complex organic molecules of proteins, carbohydrates, and lipids into more basic organic molecules (monomers) in the form of sugar and amino acids. The complex organic molecules are too large for microorganisms to use as food.
2. Acidogenesis: Bacteria convert the monomers of sugars and amino acids into volatile fatty acids, such as acetate and other products, one of which is ammonia.
3. Acetogenesis: The volatile fatty acids are broken down into hydrogen, carbon dioxide and acetic acid.
4. Methanogenesis: The methanogens convert acetic acid and some of the hydrogen into methane gas and carbon dioxide.

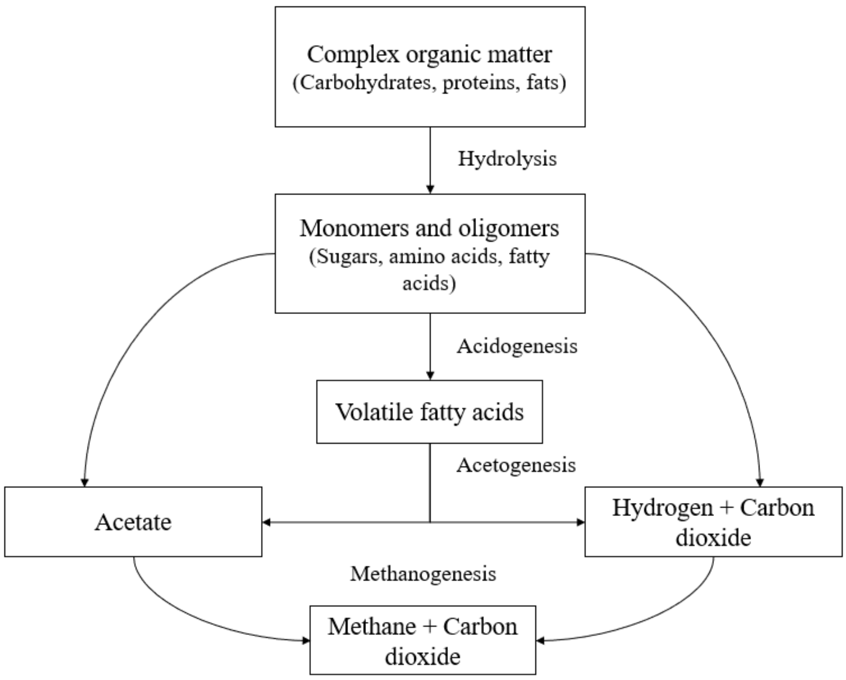

Fig. 2: The stages taking place in the anaerobic digestion process. Modified based on Ekstrand (2019) and Moraes et al. (2022).

There are different technologies for anaerobic digestion plants. These technologies can be categorised based on the solid content in the digester, feeding mode, temperature and number of stages in the digestion process (Fig. 2). Dry digestion plants treat substrates with a solid content of 20-40%, whereas solids in wet digestion plants are <16% (Vögeli et al., 2014). Dry plants have advantages such as a reduced need for water addition and higher organic loading rate potentials. Wet plants are the most common system in Europe (Vögeli et al., 2014). The substrate can be fed into the digester either continuously or batch-wise and operates either at mesophilic (30-40°C) or thermophilic temperatures (50-60 °C) (Weinrich & Nelles, 2021). The single-stage systems differ from multi-stage digesters in the sense the whole anaerobic digestion process is finished in a single tank. In the latter, there is either a physical separation of the process stages or a separation by controlling the anaerobic digestion process by separating the stages in time (U.S EPA, 2006).

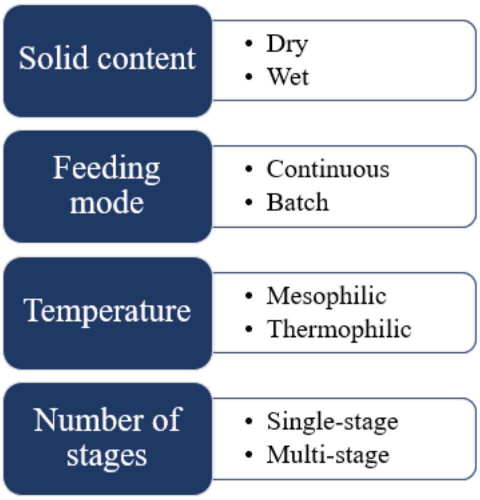

Fig. 3: The operating parameters in anaerobic digestion plants. Modified based on Vögeli et al. (2014).

The operating factors such as temperature, pH, carbon-to-nitrogen (C/N) ratio, organic loading rate and retention time in the digester are described below. The description is based on Vögeli et al. (2014) and Weinrich & Nelles (2021) if nothing else is stated.

Temperature: The anaerobic digestion process is hindered at low mean temperatures as well as large temperature fluctuations. There are two temperature intervals at which anaerobic digestion plants operate. These two intervals benefit different types of bacteria. The mesophilic plants operate at 30-40℃ and the dominant bacteria culture in this environment is more tolerant to changes of pH and temperature. This bacterial culture also consumes less energy than the bacteria culture in the thermophilic conditions. Thermophilic plants require more energy (to reach temperatures of 45-60℃) but increase the process rate (50%), reducing the time required for digestion.

pH: The pH influences the growth and composition of the bacteria culture within the digester. Consequently, pH affects the metabolism of the substrate, stimulating or inhibiting decomposition. The pH is therefore commonly between 6.5-7.5 in the anaerobic digestion plant (Khanal et al., 2019). Different bacteria strains have different optimal pH ranges for their growth, also affecting the degradation of waste materials. Proteins are more efficiently degraded at neutral pH of around 7, while carbohydrates degradation is enhanced in slightly acidic environments of 5.8-6.2. Changes of pH (e.g., when there is a strong acid load into the reactor) can lead to process inhibition.

C/N ratio: The anaerobic digestion process is sensitive to the carbon-to-nitrogen ratio (C/N). High C/N can decrease the biogas yield and therefore reduce the anaerobic digestion plant's financial sustainability. However, C/N decreases during digestion as organic matter is degraded. Degradation of carbon is also 20-30 times faster than the degradation of nitrogen. A too low C/N can lead to an accumulation of ammonia resulting in an increase of pH (even exceeding pH 8.5). To obtain an appropriate C/N, substrates are co-digested (Vasco-Correa et al., 2018).

Retention time and organic loading rate: The retention time in digesters varies typically between 30-55 days but it depends on the temperature both inside and outside the digester (Khanal et al., 2019). Faster degradation enables higher loading rates.

The microbial community that converts the substrate in the digester is sourced from an inoculum. It can be obtained from previous digestion, other anaerobic digestion plants, manure or from the residual stream that is to be treated. However, it is only when the digester is first initiated inoculation is necessary. Thereafter, some digested material is maintained within the digester to be used as inoculum for the next cycle (Moraes et al., 2022). It is only if the digester is stopped an inoculum is necessary to start operating the digester again.

Before the feedstock enters the reactor, it is in most cases pre-treated (Vasco-Correa et al., 2018). This can include separation to remove impurities such as metal and plastic pieces, mincing to reduce the particle size to provide more surface area to enhance degradation, and possibly the addition of water for dilution. The feedstock can consist of a wide range of different organic matter: food waste, slaughterhouse waste, manure, crop residues, sewage sludge, industrial wastewater etc. (Vasco-Correa et al., 2018). It is recommended that the substrates are co-digested, i.e., the feedstock consists of a mixture of different substrates (Manu et al., 2021). There are two main reasons for this. First, substrates rich in nitrogen (such as food waste) can inhibit the activity of microorganisms and consequently the whole anaerobic digestion process (Wan et al., 2013). Second, co-digestion allows the customisation of characteristics such as the concentration of nutrients. Depending on the substrates accepted by the anaerobic digestion plant, pasteurisation can be mandatory to eliminate possible pathogens (O'Connor et al., 2022). This can be done by heating the substrate or digestate to 70℃ for an hour or 55℃ for 6 hours (Swedish Waste Management Association, 2023).

2.3 The Digestate as a Fertiliser

The digestate from anaerobic digestion is considered to have good fertilising and soil amendment properties improving soil structure and decrease water evaporation (O'Connor et al., 2022). Digestates contain macronutrients (nitrogen, phosphorus and potassium), micronutrients (e.g. iron, nickel, selenium and zinc) and carbon. However, the presence is highly dependent on the feedstock (O'Connor et al., 2022).

In a review done by O'Connor et al. (2022), the concentrations of macronutrients in digestates based on solid organic waste were listed. Common nitrogen contents range from 1.1-7.0%, phosphorous 0.5-5.0% and potassium 0.2-11.9%. For carbon, the concentrations vary between 12.8-48.9%. The accessibility of nutrients is also important for the digestates suitability as a fertiliser. While ammonium and nitrate are readily accessible to plants, organic compounds need further mineralisation before they can be taken up. This is why the fertilising effect of the digestate can be delayed compared to synthetic fertilisers. While the organic nitrogen is mineralised, it accumulates in the soil (Odlare et al., 2011). The accessibility of the nitrogen is influenced by operating parameters such as temperature and retention. However, this is not the case for phosphorus (Vögeli et al., 2014).

There are also concerns related to digestates including contaminants in food waste, emissions of greenhouse gases, leaching and odours (O'Connor et al., 2022). Contaminants include contaminants such as plastic and metal pieces, as well as heavy metals, pesticides, PFAS and pathogens (O'Connor et al., 2022; Vasco-Correa et al., 2018). However, there are strategies to reduce some of these. For example, pasteurisation can be used to eliminate pathogens. Leaching is affected by factors such as soil type, rate of application, plant type, climate, and nutrient concentration. Digestates solely based on food waste can have ammonium accounting for 60-80% of total nitrogen. This causes a large risk of nitrogen being lost through volatilisation (i.e. gaseous emissions) and nitrate and ammonium leaching. It can also cause a phytotoxic environment for plants (Manu et al., 2021). However, through co-digestion, these high amounts of ammonium can be reduced, also utilisation strategies can reduce this loss (O'Connor et al., 2022). According to O'Connor et al. (2022), there is little knowledge about how contaminants in food waste impact soil health.

Synthetic fertilisers require large amounts of energy to be produced (Vaneeckhaute et al., 2013), increasing the interest for replacing them by digestate. Moreover, unlike digestates, synthetic fertilisers offer no or very limited soil-amendment properties (O'Connor et al., 2022). Concerns as associated with the presence of heavy metals or eutrophication risks are applicable to both synthetic fertilizers and digestates. Regulations to avoid excessive contamination and eutrophication rely on responsible use and are often enforced through national certification systems.

In a Swedish study conducted on a barley field, Odlare et al. (2011) compared the yield and soil properties between digestate, compost, and synthetic fertilisers, and found that the digestate gave almost 88% of the synthetic fertiliser yield. This difference could be explained by the difference in inorganic nitrogen between the two fertilisers. The nitrogen in the synthetic fertiliser was 100% inorganic, while the digestate's was at 61%. Furthermore, they also found that the digestate had a good effect on soil health, increasing microbial biomass, soil organic carbon and microbial activity. In contrast, a short-term study by Vaneeckhaute et al. (2013) reported no significant improvement in crop yield, soil fertility and soil quality by digestate treatments compared to manure and synthetic fertilisers. However, it is worth mentioning that comparing the effects of digestate are complex since they present a variability associated with its production characteristics and utilisation on different soil and plant types.

2.4 National Conditions

Source-separation of food waste will be mandatory in the EU from 2024 (Swedish Waste Management Association, 2022a). Consequently, the same goes for Sweden, which furthermore has a goal to reach 75% of food waste being both source-separated and treated through anaerobic digestion by the end of 2023 (Sveriges Miljömål, 2023). Treatment of food waste through anaerobic digestion has increased successively in Sweden over the last 10 years and reached 40% in 2020 (Hultén et al., 2022). To source-separate food waste, the most frequently used collection bag is of paper, but both bioplastic and plastic bags do also occur in municipalities. Anaerobic digestion plants can choose to certify their digestate as a quality label according to the certification scheme SPCR 120 (Swedish Waste Management Association, 2023). Only certified digestates are allowed to by actors such as KRAV, Svenska Kvarnföreningen and Lantmännen (Swedish Waste Management Association, 2022a). Of the 27 anaerobic digestion plants accepting food waste in Sweden 2019, 21 were certified (Swedish Waste Management Association, 2022a). In the same year, food waste was the third largest substrate in Sweden (11%) after sewage (35%) and manure (20%) (Feiz et al., 2022).

Many European countries have regulatory guidelines and policy guidelines for digestates from anaerobic digestion, e.g., UK (PAS110), Germany (RAL GZ 245) and Denmark (EC No 834) (O'Connor et al., 2022). In Sweden, there is no legislation controlling the quality of digestates (RISE Research Institutes of Sweden, 2017), but instead is the certification system SPCR 120 used. Among others, SPCR 120 sets requirements on the collection bag either that either have to be approved according to EN 13432 or evaluated for contact with foods according to (EC) No 1935/2004 (Swedish Waste Management Association, 2023).

The European standard EN 13432 (European Standards, 2000) tests the biodegradation of packaging materials through composting (Zhang et al., 2018). However, the standard only covers aerobic degradability tests and therefore, further tests under anaerobic conditions are not necessary (Dolci et al., 2022). However, the Swedish Waste Management Association (Swedish Waste Management Association, 2022b) motivates the use of EN 13432 as it includes ecotoxicity tests. The second alternative is that the collection bag is evaluated for contact with foods according to Regulation (EC) No 1935/2004. This regulation is a framework to ensure that materials and articles intended for or placed in contact with food are safe to use under normal and foreseeable conditions (Swedish Food Agency, 2022b). However, normal and foreseeable conditions for fruit bags are not the same as for food waste bags. In the latest version of SPCR 120, these conditions have been specified to "contact with acid food at room temperature under a maximum of 30 days" (Swedish Waste Management Association, 2023, p. 12). The conditions are said to have been requested by the manufacturers of food waste bags since the requirement of (EC) No 1935/2004 was implemented (Swedish Waste Management Association, 2022b).

Contact materials (e.g. a fruit bag) that fulfil (EC) No 1935/2004 are indicated using a wine glass and fork symbol (Fig. 4), a print stating "for contact with food" or a print stating the use (e.g. "use this bag to collect your fruit in") (Swedish Food Agency, 2022b). However, it is not mandatory to have a print on the fruit bag since it can also be available in documentation following the fruit bag (Swedish Food Agency, 2022b). The requirements on the collection bag are set to minimise the risk of metals and unwanted chemicals in digestates and to maintain confidence in its quality (Swedish Waste Management Association, 2022b).

Fig. 4: The wine glass and fork symbol (Swedish Food Agency, 2022a).

SPCR 120 also states the method analysis used as well as the testing frequency, operation parameters, nutrients, pathogens, metals (e.g. lead, mercury, cupper, cadmium), visible contaminants, pasteurisation and substrate (Swedish Waste Management Association, 2023).
The digestate producers are to annually evaluate the substrate providers to ensure approved collection bags are used (Swedish Waste Management Association, 2023).

2.5 Study site: Helsingborg’s Municipality

Helsingborg's municipality is located in the northwest of Skåne and has 149,280 inhabitants in 68,711 households (Statistics Sweden, 2023). The local waste company is responsible for the collection and transportation of food waste as well as communication with consumers. The food waste is source-separated and collected in paper bags. It is then transported to the anaerobic digestion plant in the periphery of Helsingborg city producing a digestate certified according to SPCR 120 (RISE Research Institutes of Sweden, n.d.). The local waste company owns the digestate facility, but the company Biond runs it (Biond, n.d.). To control the quality of the food waste bags, the local waste company encourages all consumers to use the specific food waste bag provided by them. When it comes to the usage of fruit bags from grocery stores for food waste, the local waste company writes the following on their website:

> *"The food waste that NSR collects is transported to Biond, which recycle it into biogas and biofertilizer. Biond has many different requirements to reach an*

approved standard for several types of certificates, including the quality of the biofertilizer that is spread on fields to grow new food. In order to obtain these certificates, there are, among other things, classifications of which bags are approved to be treated together with the food waste, without the risk of any inappropriate substance being spread on the fields.

Unfortunately, you cannot use grocery store paper bags for fruit and vegetables for your food waste. This is because there are many different bags on the market today that are distributed and sold in several different chain stores. Therefore, it is important that you only use the food waste bags provided by NSR." (Nordvästra Skånes Renhållning, n.d., sec. Only use bags approved by NSR, para. 1-2)

The average person in Helsingborg's municipality threw away 18 kg of edible food 2021 (Nordvästra Skånes Renhållning, 2021). This is not to be confused with the total food waste of 61 kg of the average Swede. The 18 kg only includes edible food (excluding e.g. shells and bones). The total food waste per person in Helsingborg has not been found. However, the 18 kg is 1 kg more than the national average (Hultén et al., 2022). Still, a large portion of the food waste (i.e. both the non-edible and edible food) ends up in the unsorted fraction in the garbage bin, representing a 59% for apartments and 21% for houses (Nordvästra Skånes Renhållning, 2021). The unsorted fraction in the municipality goes to incineration for district heating and thus, the nutrients are never recovered.

3 Method

3.1 Delimitations

This study is spatially limited to Helsingborg's municipality. The retailers included in the study are Axfood, City Gross, Coop, ICA and Lidl. Individual grocery stores that are not connected to any of the large retailers acting in the Swedish market are excluded. Whether the grocery stores' bags qualify for SPCR 120, or not, is based on information provided on the actual bag.

3.2 Structured Interviews of Consumers and Web-based Survey

Structured interviews were done with grocery stores' consumers in two ways, (1) face-to-face and (2) a web-based survey published on a social media platform. The two methods complement each other by getting a more representative and larger sample size. The purpose of the interviews and the web-based survey was to quantify how many fruit bags are brought home from the grocery stores and what they were used for afterwards.

Structured interviews were used which are characterised by following a clear script prepared beforehand and leaving little room for conversation (Mann, 2016). This makes the interviews less dependent on the interviewer as it leaves little room for interpretation and the responses are comparable, providing a quantitative result. This type of interview can be considered a questionnaire.

Cochran's modified formula (Eq. 2) for finite populations (Cochran, 1991) was used to determine the minimum number of respondents to 96. Still, the larger the sample size, the better the representation.

$$n_0 = \frac{z^2 * p * (1-p)}{e^2} \qquad Eq. 1$$

$$n = \frac{n_0}{1 + \frac{n_0 - 1}{N}} \qquad Eq. 2$$

Where n_0 is the sample size for an unknown population size, *n* is the sample size for a known population size, *z* is the z-score which is a table value based on a confidence interval, *p* is the population proportion, *e* is the margin of error, and *N* is the total population.

The values of the variables are found in Table 1. The population proportion was set to 50% since the accurate value was unknown. This is the most conservative and gives the largest sample size calculation (The Pennsylvania State University, 2023).

Table 1: Input parameters to the web-based statistical calculators and the used inputs.

z[1]	e	p	N
1.96	0.10	0.50	68,711

[1] Z-score for a 95% confidence interval.

To see if there was a significant difference in the results between the face-to-face interviews and the web-based survey for Question 1 and 3, the Pearson's chi-square test of independence was used.

$$\chi^2 = \sum \frac{(O - E)^2}{E} \qquad Eq. 3$$

where χ^2 is the chi-square test statistic, *O* is the observed frequency, and *E* is the expected frequency.

For the critical value, the degrees of freedom were calculated to 2 and a significance level of 95% was chosen. This gives a critical value of 5.99 which χ^2 was compared to. If χ^2 < critical value, the null hypothesis is accepted stating that there is no difference between the two groups. If χ^2 > critical value, the null hypothesis is rejected and there is therefore a significant difference between the two groups.

To estimate the number of fruit bags that are annually thrown in the garbage (corresponding to an equal amount of food waste bags that can be saved), Eq. 4 was used.

$$x = y * w * q * N * 52 \qquad Eq. 4$$

where *x* is the estimated number of fruit bags thrown for recycling, *y* is the fraction of households using fruit bags in paper, *w* is the average number of fruit bags each household take home per week, *q* is the fraction of households that throw the fruit bag, and *N* is the total population.

The estimation on the corresponding number of trees is based on Ribble Packaging Ltd. (2018). For simply estimation purposes, they say one pine tree about 14 m high and 20 cm in diameter, produce 10,000 office sheets. Various fruit bags have different weights and fruit bags generally also weigh less than original food waste bags. Since the aim is to find the number of food waste bags that can be saved and consequently how many trees this represents, the local waste company's food waste bags were used. The food waste bag was weighted (18 g) to determine that one food waste bag corresponds to 4 office sheets of A4 (210*297 mm). With this information the corresponding number of trees could be estimated. Based on the number of households in municipalities using food waste bags made of paper, the number of conserved trees was scaled to a national level.

3.2.1 Face-to-Face interviews

The structured interviews consisted of three questions:

1. What type of bag do you use to pack your fruits and vegetables in grocery stores?
2. How many paper bags for fruit and vegetables do you estimate that your household get home from grocery stores on average each week?
3. What do you use the paper bags for after you have brought home the food:
    a. They are thrown in the garbage.
    b. They are used for the food waste.
    c. Other.

When respondents replied with intervals regarding how many fruit bags their household got home each week, the average was used. The number of questions was kept low and simple to get more respondents and avoid misunderstandings. The interviews were done outside three large grocery stores belonging to the largest retailers in Sweden: Axfood, Coop and ICA which account for 89% of the market shares (Axfood, n.d.). The stores were “Stora Coop", "Maxi Supermarket" and "Willys". The specific grocery stores were selected based on size and geographical distribution. Interviews were done on weekdays at times between 10:00 AM and 4:00 PM and amounted totally to 6.5 hours.

The above-mentioned retailers and grocery stores were selected to reach a representative group of consumers. Only large stores were selected because they are more accessible by car and the study wants to represent the households in Helsingborg's municipality, not just Helsingborg city. Moreover, there are typically more planned weekly purchases made at these large stores. Different retailers were used to capture variability in acquisition power and shopping preferences.

3.2.2 Web-based Survey

Google Forms was used for the web-based survey since it is free of charge, easy to use, and has no limiting restrictions on the number of respondents. The survey was posted on the social media platform Facebook as a link in two groups targeting people living in Helsingborg's municipality. To further ensure that the results only represent the target group, this question was added as required to the original three questions in the face-to-face interviews. Otherwise, the survey was made to correspond as much as possible to the face-to-face questionnaire to combine the results from the two methods. The two Facebook groups had together 26819 members and the survey was posted on 2 April 2023 and closed on 5 April 2023.

The responses were quality-checked to ensure that they were reasonable and answered the question. If the response was unusable, e.g. it said "many" and not an interval or specific number in Question 2, the reply for that question was excluded from the results, but not the respondent's answers for the remaining questions. As for the face-to-face interviews, the average was used when respondents replied with intervals in Question 2. Only the two first questions (Question 0 and Question 1) in the web-based survey were mandatory, i.e. if the respondent was living in Helsingborg's municipality and what type of bag they used. The other two could not be set to mandatory since if the respondent used plastic bags or their own bag brought from home, the last two questions were irrelevant.

3.3 Semi-Structured Interviews

To better understand how the anaerobic digestion plant in Helsingborg works and the perspectives of the digestate producer, a semi-structured interview was done with Biond Production AB (Biond, n.d.). Semi-structured interviews have open-ended, predetermined questions acting as a guide for the interview and the respondent can elaborate on their answers. The interviewer is also given greater freedom compared to structured interviews which gives room for follow-up questions and reduces the risk of misunderstandings (Mann, 2016).

The interview took place at Biond's facility in Helsingborg the 8th of May and was booked with Johanna Witt. The interview started with a presentation of the company and interview questions was then asked. A tour around the facility was thereafter carried out guided by Johanna Witt.

3.4 Mapping of Fruit bags

Both large and small grocery stores in the municipality belonging to any of the retailers on the Swedish market (Axfood, Coop, City Gross, ICA and Lidl) were mapped to document what type of fruit bag the grocery store offered. Of these, 76% were visited after a random selection using Excel's. A suitable sample size was estimated using Eq. 2. The documentation included information on whether the fruit bag was labelled with EN 13432, printed/labelled indicating that it had been evaluated for contact with food according to (EC) No 1935/2004 or encouraged to be reused for food waste. If the grocery store only offered plastic bag, it was documented, but it was not checked if it had any of the labels. Furthermore, it is to be noted that it is not possible to tell under what conditions (EC) No 1935/2004 was tested and approved based on the label on the fruit bag. The stores were visited between the 28th of March and the 8th of April.

4 Results

4.1 Biond's Digestion Plant in Helsingborg

The plant treats ~150,000 tonnes per year of organic waste and produces ~145,000 tonnes of digestate per year. In the last years (2019-2022), the feedstock has consisted of residuals from food industry (47±1%), food waste (34±1%) and manure (18±2%). The concentration of heavy metals and visible impurities measured in the digestate are shown in Table 2. It is worth noting that visible impurities have decreased over the last three years and all heavy metals in the digestate are >50% of the concentration margin established in the certification scheme SPCR 120.

Table 2: Heavy metals and visible impurities in Biond's digestate the last three years. The values show yearly averages. The SPCR 120 thresholds are from the latest version (2023). The tables are based on Biond (n.d.).

Substance	SPCR 120 Threshold	2022	2021	2020	Unit[1]
Cadmium	1	0.3	0.3	0.3	mg/kg TS
Copper	600	94	68.8	74.3	mg/kg TS
Chromium	100	9.7	9	9.3	mg/kg TS
Lead	100	2	2	2.4	mg/kg TS
Mercury	1	0	0	0	mg/kg TS
Nickel	50	11	10.6	11.2	mg/kg TS
Zink	800	364.2	337	341	mg/kg TS
Visible impurities	10	0.1	0.5	3.1	cm^2/kg

[1] TS = Total solids

Average concentrations of macro- and micronutrients the last three years are shown in Table 3. It is worth noting that that the annual averages are rather constant. Of the digestate is ~3.9% solid content while the rest is liquid.

Table 3: The concentrations of macro- and micronutrients measured in Biond's digestate the last three years. The values show yearly averages. The tables are based on Biond (n.d.).

Substance	2022	2021	2020	Unit
Nitrogen	4.7	4.9	5.2	kg/ton
Phosphorous	0.5	0.6	0.6	kg/ton
Potassium	1.5	1.4	1.4	kg/ton
Ammonium nitrogen	3.2	3.3	3.4	kg/ton
Calcium	0.9	1.0	1.1	kg/ton
Magnesium	0.1	0.1	0.1	kg/ton
Sulphur	0.4	0.4	0.4	kg/ton

If nothing else is stated, the remaining information in this section is based on the interview booked with Johanna Witt and carried out May 4, 2023.

Given the low solid contents the digestion plant is categorised as wet. Furthermore, it is a single stage plant, continuously feed with substrate and operates at 37°C (mesophilic temperature). In the pre-treatment, the particle size of the substrate is reduced as it passes through a hammer mill. Separation is also done to purify the substrate from contaminants. The separation consists of three steps where impurities consisting of plastic, bioplastic, glass and metal pieces are removed. Some organic matter is inevitably discarded along with the impurities and sent to incineration at the local district heating system. The pre-treatment has a success rate of about 96%. After the reduction in particle size and separation, the food waste is mixed with the co-digesting substrates to create a favourable environment for the microbial culture. Before the mixture enters the digester, it is pasteurised at 70°C for an hour to eliminate pathogens. After pasteurisation, the mixture enters the digestate where it stays between 30-38 days. Since some digested material is constantly maintained in the digester, no inoculation is necessary. The aftertreatment consists of one more purifying step to further reduce the existence of impurities. The digestate is then transported to the cultivation field where it can either be stored some time or utilised directly on the fields.

Biond and the farmers using their digestate have the vision of zero of plastic in the substrate. One of Biond's main priority, and major challenge, is therefore to efficiently detect and discard plastics and bioplastics. Plastic and bioplastic are very difficult to separate from organic matter. For this reason, additional purification steps have been added to the pre-treatment the last years. The enhanced pre-treatment was introduced in connection with stricter requirements in SPCR 120 as the threshold of visible impurities was halved to 2020.

The use of bioplastics is a problem for Biond since biodegradable and compostable does not mean the bag can be broken down in anaerobic digestion conditions. One of the reasons that increases the complexity of the problems is that the term "bioplastic" is often misleading (Renee, 2017). Consumers may think bioplastic are equivalent to paper bags since they are bio-based. However, bioplastics are not necessarily biodegradable and degradation depends on the environment (Bátori et al., 2018). That companies in Helsingborg's municipality are allowed to use bioplastic bags for their food unlike household, might further complicate distinction for the consumer. In contrast, both households and companies in the Höganäs municipality (also sending their food waste to Biond) are allowed to use bioplastic bags for their food waste. If the local waste company would change their directives regarding food waste bags, allowing consumers to use fruit bags labelled EN 13432 or fruit bags encouraging reuse of it for food waste, Biond see a risk that it might make consumers more confused, resulting in an even larger variety of food waste bags of various unwanted materials.

4.2 Consumer Survey

A total of 233 responses were collected, where 116 were from the face-to-face interviews and 117 from the web-based survey (see Appendix). The results provided in this section are based on 228 respondents since 5 of the respondents in the web-based survey were excluded for not living in Helsingborg's municipality. The result from the two methods have been put together and are presented in Fig. 5. The total adds up to more than 100% in the left figure since respondents could answer more than one alternative. The sum in the right figure is less than 100% since this question was not mandatory.

When asked what type of fruit bag used the household used, most respondents replied that they use paper bags (81%), while the least amount said they use plastic bags (11%), or a bag brought from home (25%). After bringing the groceries home, most respondents throw their fruit bags into the garbage (43%) or use it for food waste (32%), while the least use the fruit bag for other things (18%). These other uses include collecting and throwing waste other than food. In general, their usage afterwards depends on the quality of the bag, e.g., some fruit bags are considered too thin to be used for food waste. Other less common usages are for storage, collection of mushrooms, burning and cultivation.

Based on question 2, it was found that the average household bring home 3.4±2.2 (SD) fruit bags per week. This information was used to estimate that 4.3 million fruit bags are annually thrown into the garbage for recycling after been brought home. If each fruit bag would replace a food waste bag, a corresponding of 1,700 trees could be conserved annually. On a national level that corresponds to 98,000 trees.

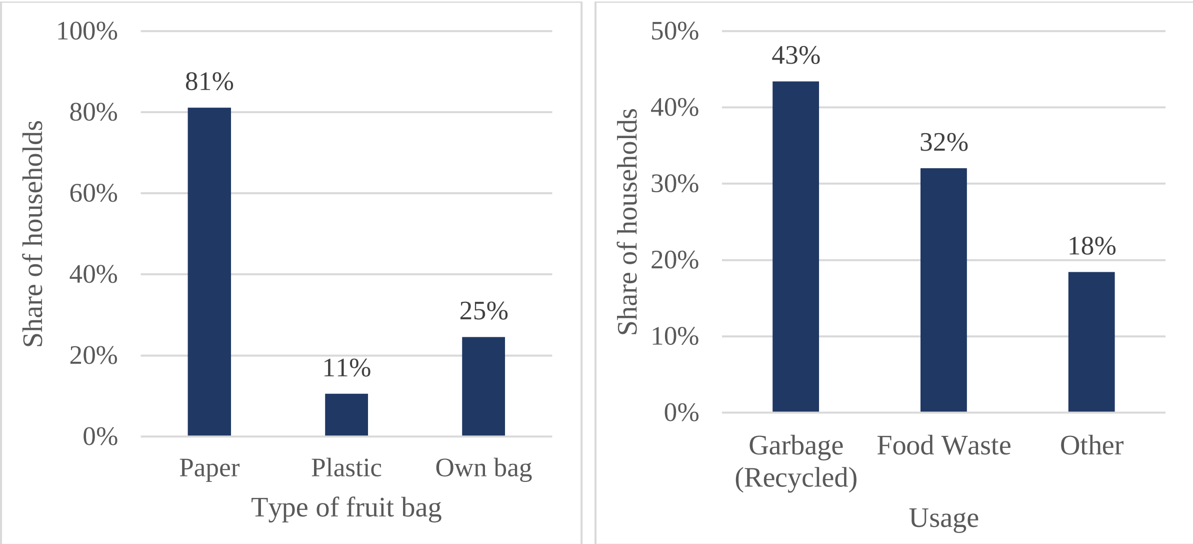

Fig. 5: Type of fruit bag the respondents use (left) and what the bag is used for after the food has been brought home (right). The totals deviate from 100% since more than one alternative could be chosen and as the other question was not mandatory.

When testing if the response between the two groups (respondents from the face-to-face interview and respondents from the web-based survey) significantly differed, it was found that there was no difference for the type of bag used. However, there is for the usage after the groceries have been brought home. When comparing the results for this question, the largest difference is that 16 percentage points more of the respondents in the web-based survey answer they use the fruit bag for food waste, while 13 percentage points less of them answer "other usage".

4.3 Mapping of Fruit bags

Out of the 33 identified grocery stores in Helsingborg's municipality connected to any of the large retailers, 25 were visited for this project. 94% of the identified grocery stores offered fruit bags made of paper. The two stores that did not offer paper bags, only provided plastic bags to the consumers (Fig. 6) and consequently, the controlled attributes i.e. EN 13432-marked, (EC) No 1935/2004 approved, and encourage reuse for food waste, are not applicable.

It was also found that 64% of the grocery stores offered a fruit bag approved according to (EC) No 1935/2004. All fruit bags EN 13432-labelled or encouraging reuse for food waste were also shown to be (EC) No 1935/2004 approved. This means 64% of the grocery stores offered a fruit bag that fulfilled at least one of the controlled attributes. Of the grocery stores, 28% offered a fruit bag labelled either EN 13432 or encouraging reuse for food waste. Two of these encouraged to be reused for food waste without being EN 13432-labelled, while one was EN 13432-labelled, but did not encourage reuse for food waste. Basically all Coop (excluding Coop X:-tra) are included in the 28% along with the both visited Maxi stores and one Hemköp (out of the two visited). Two grocery stores offered more than one type of fruit bag, two respectively three kinds. None of these bags were labelled to show that they fulfilled any of the standards.

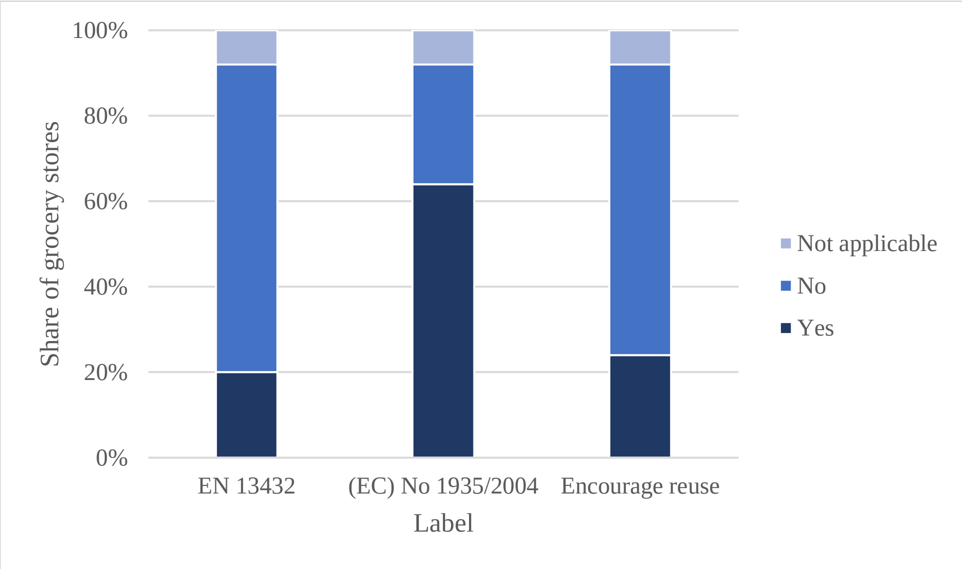

Fig. 6: Illustration of how the fruit bags in the grocery stores are labelled. A fruit bag can have multiple labels. "Yes" means that the bag had the specific label, "No" that the fruit bag did not have the specific label, "Not applicable" means that the grocery store only offered plastic bags.

5 Discussion

5.1 Discussion of Results

The results show that the majority of households use fruit bags of paper and that most are thrown in the garbage for recycling directly they after been brought home. These fruit bags have been estimated to be able to conserve about 1,700 trees annually on a municipal level. If consumers behave similarly in the other Swedish municipalities using paper food waste bags, 98,000 trees can be estimated to annually be conserved nationally. Given the local waste company's current policy of only using their specific food waste bag, it can be considered a surprise that 32% of the households use the fruit bag for food waste. This means that some households either are not aware of the local waste company's directives or, they are aware, but still use the fruit bag since they do not think it makes any difference what paper bag is used. Through the mapping of fruit bags, it is apparent that there is a large variation of fruit bags available on the market today. Some of these fruit bags are not suitable for food waste only based on their thickness as they risk breaking when using them for moist food waste.

The discrepancy in the message communicated to the households is another possible explanation to the relatively high number of households using fruit bags for food waste nowadays. Accessible and consistent communication to consumers is therefore considered important. Especially considering that grocery shopping is likely to occur across municipality boarders, i.e. consumers can live in one municipality and buy groceries in another municipality. While the local waste company encourages consumers to only use their food waste bag, the prints on some fruit bags encourages consumers to reuse the fruit bag for food waste. In the municipality of Helsingborg, it was found that 24% of the grocery stores offer fruit bags encouraging reuse for food waste. This originates from actions taken by retailers to minimise waste and environmental impact as the fruit bags can be used twice (Axfood, 2020; Coop, 2019). The discrepancy in communication is therefore derived from a wish to minimise environmental impact from both parties, even though it results in a conflicting communication. If a fruit bag does encourage to be reused for food waste, even though they are not labelled with

EN 13432, the consumer can rely on that it fulfils the SPCR 120 standard. For instance, this is the case for the fruit bag Axfood offers in some Hemköp stores. In personal communication with Axfood's sustainability strategist, K. Bildsten (April 25, 2023), she says that before Axfood launched their fruit bag, they mapped what collection bag each municipality in Sweden used and informed the municipalities about their new bag. By the fruit bag producer Axfood was ensured that the bag was allowed to be used for food waste. The fruit bags were also only launched in the municipalities where the collection bag is of paper, in accordance with the Swedish Waste Management Association's recommendations. In personal communication with the purchasing manager of consumables ICA Sweden (April 24, 2023), she states that they instead reason that the fruit bags they offer their grocery stores, should be able to be used in all Swedish municipalities. Thus, they are be thrown away for paper recycling after the groceries been brought home. This means that local and national differences in management cause barriers. Even though Helsingborg's local waste company directs consumers to not use fruit bags, this is not consistent among all waste companies. For example, Dala Vatten och Avfall (2022) and Uppsala Vatten (2023) inform that some fruit bags are approved to use for food waste. In line with the results from this study. Regarding the approval according to (EC) No 1935/2004, it is not possible to tell if they were approved according to the conditions in SPCR 120, i.e. in contact with acid food in room temperature for a maximum of 30 days. The relevance of this label on fruit bags is therefore reduced. Still, without considering this label, 28% of the grocery stores are offering a fruit bag fulfilling the requirements in SPCR 120, which can be told only based on the print on the fruit bag.

Waste management is run locally while SPCR 120 is national. The requirements in SPCR 120 therefore intend to enable all municipalities to treat their food waste through certified anaerobic digestion, independently of choice of collection bag. Since non-degradable plastic cannot fulfil the requirements of EN 13432 (Swedish Waste Management Association, 2022b), these bags can instead be approved through (EC) No 1935/2004. Thus, the Swedish Waste Management Association wants to allow also non-degradable food waste bags. The purpose of the requirements is therefore not to ensure that degradable bags are used. Instead, for the Swedish Waste Management Association's point of view, the importance is the ecotoxicological tests and the forbidden and limited substances that are included in these tests, this is clarified through personal communication with the chairman of Certified Recycling G. Rogstrand (May 2, 2023). Biond on the other hand emphasises the importance of limiting the amount of plastic, including bioplastic, in the food waste. Since none of the tests, either EN 13432 or (EC) No 1935/2004, aims to ensure degradability in anaerobic digestion, SPCR 120 rely on good pre-treatment to reach below the threshold value of visible impurities in the certification scheme. On the other hand, from Biond's perspective, the most important is that paper bags are used. This is because they degrade in the digester and do not contribute to either plastic on arable land or organic matter going to incineration. This is also in line with their vision of zero plastic in the digestate.

In personal communication with J. Witt and her colleagues at Biond (May 8, 2023), they mention that when they are comparing the number of impurities in the food waste they receive with the local waste company Sysav, Biond find that Sysav's food waste has less impurities. Biond suspects that the main reason for this is that Sysav only offer food waste bags of paper for both households and companies in all municipalities. Consistency can therefore be a key factor. In a personal communication with M. Mårtensson, Waste advisor at Sysav (April 3, 2023), she states that their main concern regarding fruit bags for food waste is that the consumers might get disappointed as the fruit bags might not keep the same standard as the food waste bags. One way to reduce discrepancy in communication and reduce the waste of fruit bags would be that the local waste company approve fruit bags labelled EN 13432 or fruit bags that through prints on them encourage reuse of the fruit bag for food waste. However, J. Witt and her colleagues at Biond (May 8, 2023) sees a risk that it might confuse consumers resulting in a larger variety of bags used for the food waste. Nevertheless, the discrepancy already sent to consumers is likely to also cause confusion. This is also indicated by the 32% already using fruit bags for food waste. To enable consumers to understand which fruit bags that fulfil SPCR 120, retailers, grocery stores as well as local waste companies plays important roles.

There is a wide range of fruit bags on the market today with various additives. This should be the background behind national guidelines such as BfR 36 (German Federal Institute for Risk Assessment, n.d.) that e.g. include threshold values for various substances. The requirements on fruit bags are motivated by ecotoxicological and chemical tests to avoid organic pollutants. Organic pollutants include PFAS, PCBs and dioxins and there is a rising concern about these compounds internationally (O’Connor et al., 2022). PFAS has been detected to contaminate food through direct contact. It has been found in the range of 0.11-1 µg/kg in food waste, while concentrations have ranged up to 485 µg/kg in contact materials (U.S. EPA, 2021). The fact that migration of these organic pollutants is dependent on temperature and contact time (U.S. EPA, 2021), motivates the specification of the conditions for testing (EC) No 1935/2004 and verifies the concerns from the Swedish Waste Management Association. However, migration is only relevant for collection bags of non-paper. Data suggest it is foremost contact material for greasier foods that tend to have higher concentrations of PFAS. However, there is not enough studies to confirm that digestates should have higher or lower concentrations of PFAS compared to digestates made of other substrates (U.S. EPA, 2021).

5.2 Future Research

It is of interest to investigate the concentrations and origins of possible organic pollutants in food waste and digestates, as well as what impact these might have on soil. Furthermore, food waste bags of paper are treated very differently from food waste bags in plastic or bioplastic. Since the whole fruit bag enters the digestate, the aim of the requirements on food waste bags in paper are that they do not include inappropriate substances diverting from guidelines such as BfR 36, independently of migration. However, for non-paper food waste bags, the aim of SPCR 120 is to ensure that there is no migration of contaminants from the food waste bag to the food waste during storage, transport or as the food waste is treated (Swedish Waste Management Association, 2022b). It is therefore of interest to carry out tests on fruit bags labelled according to (EC) No 1935/2004, independently of the conditions the test is carried out in, to investigate occurrence of contaminants. Furthermore, it is of interest to explore the effect on organic pollutants as they are digested and how the contaminants affect soil properties.

5.3 Limitations of the current study

There are some considerations to bear in mind when studying the results. First, the type of fruit bag that was offered by the grocery store was not taken into consideration when designing the survey. In the face-to-face interviews, there is unavoidably a certain subjective selection of respondents. Regarding the web-based survey, the same person was able to submit more than one response. This was not optimal, but the alternative was to require the respondents to log into their Google account to fill in the form. This was suspected to reduce the number of respondents and therefore dismissed. Last, the mapping of the type of fruit bag (i.e. if they are e.g. EN 13432-labelled or not) in grocery stores is quickly outdated since they are easily interchanged.

6 Conclusions

The food waste in Helsingborg's municipality is sent to certified anaerobic digestion. The certification scheme sets requirements on the food waste bags that should be utilised. This study investigates the current use of fruit bags and analyse the possibilities of utilising these fruit bags for food waste in Helsingborg's municipality.

The data collected through this study indicates that about 4.3 million fruit bags are annually thrown in the garbage after been used for groceries. If these bags could be used a second time for food waste, the municipality could conserve an estimated number of 1,700 trees each year, which on a national scale corresponds to 98,000 trees. Currently, 32% of the municipality's households already use fruit bags for food waste, deviating from the directives of the local waste company. Additionally, it was found that 28% of the municipality's grocery stores offer fruit bags that are approved according to the digestate's certification scheme.

From the perspective of Biond, the digestate producer, their primary focus is on reducing plastic and bioplastic in the food waste as these do not degrade in the digester. They see a risk that consumers might start using food waste bags of a wider variety of materials if the local waste company change its directives to approve paper fruit bags labelled EN 13432 and fruit bags that encourages to be reused for food waste. However, there are currently local waste companies that approve the use of fruit bags by consumers. Some retailers have also launched fruit bags approved for food waste to minimise their environmental impact. Nevertheless, the fact that waste management is run locally while retailers operate nationally create difficulties.

Future studies should concentrate on testing contaminants in fruit bags approved according to the EU regulation (EC) No 1935/2004, regardless of the testing conditions. Depending on results, the percentage of grocery stores offering fruit bags safe to use for food waste could go from 28% to 64%. Alternatively, it might be discovered that this criterion is not suited for paper bags since they enter the digester, making migration testing irrelevant.

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8 Appendix: Consumer Survey

Consumer survey: responses from the face-to-face interviews. These are the questions answered:

1. What do you use to pack your fruits and vegetables in grocery stores?
2. How many paper bags for fruit and vegetables does your household get home from grocery stores on average each week?
3. What do you use the paper bags for after you have brought home the food:
    a. They are thrown in the garbage.
    b. They are used for the food waste.
    c. Other.

Table A1: The result from the face-to-face interviews. Q1 = Question 1 etc., pp = paper, a = garbage/recycling, b = food waste, c = other. Empty cells mean the question was not relevant based on the answer to previous question.

Respondent	Q1	Q2	Q3
1	pp	3.5	a, c
2	own bag		
3	pp	2	b
4	pp	6	a
5	pp	1	a
6	pp	5	a
7	own bag		
8	pp	1	c
9	pp	10	a
10	pp	6.5	b
11	pp	2	b
12	pp	1.5	a, b
13	pp	2	a
14	pp	1	a
15	own bag		
16	pp	1	a
17	pp	4.5	a
18	pp, own bag	2	b
19	pp	1	a
20	plastic		
21	pp	4.5	a
22	own bag		
23	own bag		
24	pp	10	a, c
25	pp, own bag	2	c
26	pp	4	a
27	pp	5	a
28	pp	2.5	b
29	pp	2	a
30	own bag		
31	pp	4.5	b

32	pp	10	b, c
33	pp	5.5	c
34	pp	3.5	c
35	plastic		
36	pp	1	c
37	pp	2	b
38	pp	3.5	a
39	pp	2.5	a, c
40	pp	3	b
41	pp	8.5	b
42	own bag		
43	pp	2	a, b
44	own bag		
45	pp	3	b
46	pp	2	a
47	pp	0.25	a
48	pp	1	a
49	own bag		
50	pp	1.5	a
51	pp	2	a, c
52	pp	5	a
53	pp, own bag	4	b
54	pp	4	a
55	pp	6	a, b
56	pp, own bag	2	b, c
57	pp	1	b
58	pp	5	a
59	pp	2.5	b
60	pp	3.5	a
61	pp	7	a
62	pp, plastic	1.5	c
63	pp	3.5	c
64	pp	2	c
65	pp, plastic	3.5	b
66	pp	4.5	a
67	pp	5	c
68	pp	5	c
69	pp	6	a
70	pp	2	a
71	own bag		
72	own bag		
73	pp	10	a, c
74	pp	-	a
75	pp	4	b
76	pp	5	c
77	pp	3.5	a

78	pp	3	a
79	plastic		
80	pp	3	b
81	pp	3	c
82	pp	10	a, c
83	pp	3.5	a
84	pp	1	c
85	pp	2	c
86	pp	7.5	a
87	pp	6.5	a
88	own bag		
89	pp, plastic	5	c
90	pp	4	a
91	pp	1	a
92	plastic		
93	pp, plastic	5.5	c
94	pp, own bag	8	b
95	own bag		
96	pp	1	c
97	own bag		
98	pp, plastic	8	a
99	own bag		
100	pp	5.5	c
101	pp	3	b
102	own bag		
103	pp, plastic	2.5	c
104	pp	5.5	a
105	pp, own bag	3	a, b
106	pp, own bag	1	c
107	pp, plastic	0.25	c
108	pp	1.5	a, b
109	pp	10	a
110	pp	1.5	b
111	pp	1.5	b
112	own bag		
113	plastic		
114	own bag		
115	pp	3	b
116	own bag		

Consumer survey: responses from the web-based survey. These are the questions answered:

0. Are you living in Helsingborg's municipality?
    a. Yes
    b. No
1. What do you use to pack your fruits and vegetables in grocery stores?
2. How many paper bags for fruit and vegetables does your household get home from grocery stores on average each week?
3. What do you use the paper bags for after you have brought home the food:
    a. They are thrown in the garbage.
    b. They are used for the food waste.
    c. Other.

Table A2: The result from the face-to-face interviews. Q0 = Question 0 etc., pp = paper, a = garbage/recycling, b = food waste, c = other. Empty cells either mean that the question was not relevant based on the answer to previous question, or the respondent chose to not respond.

Respondent	**Q0[1]**	**Q1[1]**	**Q2**	**Q3**
1	Yes	own bag		
2	Yes	pp	2	b
3	Yes	pp, own bag	0.25	c
4	Yes	plastic		
5	Yes	pp	2	a
6	Yes	plastic, pp	6	a
7	Yes	pp	2.5	a
8	Yes	pp	2	b
9	Yes	pp	2.5	a, b
10	Yes	pp, own bag	1.5	b
11	Yes	pp	2	b
12	Yes	pp	2	b
13	Yes	own bag		
14	Yes	pp	2	b
15	Yes	plastic, pp	3.5	a, c
16	Yes	plastic, pp	3	a, b
17	Yes	pp	0.75	a
18	Yes	pp	2	a
19	Yes	pp, own bag	1	b
20	No	own bag		
21	Yes	pp	3	a
22	Yes	pp	4	a
23	Yes	pp	4	b
24	Yes	own bag		
25	Yes	own bag		
26	Yes	pp	3	a
27	Yes	pp	3	a
28	Yes	pp	5	b
29	Yes	pp, own bag	1	b

30	Yes	pp	3	b
31	Yes	pp, own bag	5	b
32	Yes	pp, own bag	2	b
33	Yes	pp		b
34	Yes	pp, own bag		c
35	Yes	pp	3	b, c
36	Yes	own bag		
37	Yes	pp, own bag	4	a
38	Yes	pp	5	a
39	Yes	pp		b
40	No	pp		
41	Yes	pp	5	a
42	Yes	plastic, pp	1	a
43	Yes	pp	5	a
44	Yes	plastic		a
45	Yes	pp	8	a
46	Yes	pp		a
47	Yes	pp		a
48	Yes	pp, own bag		a, c
49	Yes	pp	6	a, b
50	Yes	pp	2	a
51	Yes	pp	2.5	a, b
52	Yes	pp	2	b
53	Yes	pp	4	b
54	Yes	pp	3	a
55	Yes	pp	2	b
56	Yes	pp	3	b
57	Yes	plastic, pp	2	a
58	Yes	pp	2	a
59	Yes	own bag		
60	Yes	own bag		
61	Yes	pp	3	a
62	Yes	own bag		
63	Yes	pp	5	b
64	Yes	pp	4	b
65	Yes	pp	1.5	a
66	No	pp		
67	Yes	pp	7	a
68	Yes	pp	3	a
69	Yes	pp	5	b
70	Yes	own bag		
71	Yes	pp	0.5	c
72	Yes	own bag		
73	Yes	plastic, pp, own bag	2	c
74	Yes	pp	3	b, c
75	Yes	plastic, pp	10	a
76	Yes	pp	3	b
77	Yes	own bag		a

78	Yes	pp	5	a
79	Yes	pp	1	a
80	Yes	pp	2	a
81	Yes	pp	2	a
82	Yes	pp	5	c
83	Yes	own bag		c
84	Yes	plastic		
85	Yes	pp, own bag	5	a, b
86	Yes	pp	3	a
87	Yes	pp	4	a
88	Yes	pp, own bag	1	b
89	Yes	pp	5	a
90	Yes	pp	1	b
91	Yes	pp, own bag	2	b
92	Yes	pp	3	b
93	Yes	pp	5	b
94	Yes	pp	3	a
95	Yes	pp	5	a
96	Yes	pp	4	b
97	Yes	pp	2	a
98	Yes	pp	1	b
99	Yes	own bag		a
100	Yes	pp	1	b
101	Yes	pp	4	b
102	Yes	pp	1	c
103	Yes	pp	1	a
104	Yes	pp	2	a
105	Yes	pp	7	b
106	Yes	plastic, pp	2	b, c
107	Yes	pp	4.5	c
108	No	own bag		
109	Yes	own bag		b
110	No	plastic		
111	Yes	own bag		
112	Yes	pp	5	b
113	Yes	plastic, pp	2.5	a
114	Yes	own bag		
115	Yes	pp	3	a, b
116	Yes	pp, own bag	2	b
117	Yes	pp	2	a

[1] Mandatory questions.