



## Research Paper

# Policy instruments to reduce food loss prior to retail – Perspectives of fruit and vegetable supply chain actors in Europe

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## ABSTRACT

Food loss and waste burdens the food system with an unnecessary use of natural resources such as soil, land and water as well as with the avoidable generation of further climate-relevant emissions. These negative externalities may provide a rationale for public sector intervention where feasible and efficient.

Semi-structured interviews with 22 experts (farmers, producer organisations and retailers) in Germany and a questionnaire survey with 215 suppliers of a retailing company from Germany, Spain and Italy were conducted. The material reveals the perspectives and claims of relevant actors in upstream fruit and vegetable supply chains on political intervention.

Stakeholders identified policy instruments from four overarching thematic categories: (I) communicative and cooperative policies, (II) subsidisation and food prices, (III) regulation and political framework conditions and (IV) questioning of necessity and effectiveness of food loss interventions. Four further categories of private sector measures were identified: (I) mechanisation, innovation and process optimisation, (II) communication and cooperation, (III) reconditioning and repackaging and (IV) processing, alternative marketing and redistribution.

Issues that should be addressed by policy include consumer education and awareness, supply chain cooperation and power relations, food prices, marketing standards, alternative marketing and processing and promotion of technologies, infrastructure and agronomic practices to reduce food loss. The study shows that additional leverage points for policy action are still unrecognised and that stakeholders should be more involved in tackling the root causes of food loss. These policies should be holistically embedded in the sustainability transformation of the food system.

## 1. Introduction

Wasting food implies the depletion of natural resources utilised for its production (Garske et al., 2020b), such as phosphorus, land and freshwater, as well as environmental degradation in the form of eutrophication and contamination of waterbodies and soil, greenhouse gas emissions and effects on biodiversity (WWF, 2021). According to Springmann et al. (2018) halving food loss and waste by 2050 could contribute largely towards keeping the food system within the planetary boundaries. Such negative externalities are often not incorporated in the economic assessments of the supply chain stakeholders but carried by society as a whole. Hence, losing or wasting food may deliberately be accepted by supply chain stakeholders as their optimal market outcome while standing in contradiction to the best interest of society (FAO, 2019; Koester, 2014). Negative externalities are one kind of market failure that may provide a rationale for public sector intervention

(Döring and Töller, 2018; FAO, 2019).

Policies and legislation play a crucial role in driving choices towards reducing food loss and waste by all actors along the food supply chain (Segrè et al., 2014). Flanagan et al. (2019) and the UN (2020) underline the need for governmental action towards more sustainable consumption and production patterns established in the Sustainable Development Goal (SDG) 12 of the Agenda 2030. SDG 12.3 explicitly aims at halving food waste amounts on consumption and retail stages and merely reducing the food loss amount within the remaining stages of the food supply chain. A large variety of national policies exists to directly or indirectly counteract the emergence of food loss and waste. The examples range from food loss and waste measurement over investments into infrastructure and manufacturing processes, changes of standards, tackling of so-called Unfair Trading Practices (UTP), tax-incentives and fees and voluntary agreements to behaviour change campaigns (Reynolds, 2023). International strategies, such as the Circular Economy

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Action Plan (European Commission, 2020) and the European Green Deal (European Commission, 2019b), also suggest that food loss and waste should be ranked high on the political agenda. However, scientific evidence regarding policy actions remains scarce (Cattaneo et al., 2020b; Reynolds, 2023). In recent scientific literature, a focus is laid on two main topics. On the one hand, food loss and waste prevention measures targeting consumers at the household level are investigated (Eičaitė et al., 2021; Giordano and Franco, 2021; Herzberg et al., 2020; Karunasena et al., 2021). On the other hand, legislation targeting the redistribution and reuse of surplus food as well as recycling of food loss and waste is being evaluated to a large extent (Giordano et al., 2020; Soma et al., 2021). However, redistribution and reuse represent minor priorities of the food waste hierarchy compared to prevention (Papargyropoulou et al., 2014).

We identified two research gaps to be addressed in this paper. First, evidence on policy measures in the upstream supply chain (primary production to retail) remains scarce, although large reduction potentials exist at the production stage and in industrialised regions such as Europe and North America (FAO, 2019; WWF, 2021). Kuiper and Cui (2021) showed in their modelling approach, that policy measures focussing on primary stages of the food supply chain, as well as on the product groups of fruit and vegetables, promise positive effects on food security and environmental sustainability on a global scale.

Second, the perspectives of supply chain actors with regard to food loss and waste prevention policies are often neglected (Johnson et al., 2019). This can result in policies failing to address the underlying causes of food loss and waste (Herzberg et al., 2022; Johnson et al., 2019; Kinach et al., 2020). From this, we derive the following research questions:

I. Which policy instruments have so far dominated in tackling food loss in the early supply chain and which approaches have been neglected?

II. What are the demands of relevant stakeholders of the food supply chain on policy interventions to reduce food loss in the early supply chain?

III. How can policies be designed to meet these demands and to address the underlying causes of food loss in the early supply chain?

The proposed research questions will be answered on the basis of qualitative expert interviews and a quantitative supplier survey. These reflect the subjective views of stakeholders on the question of what can and should be done in order to reduce food loss. The empirical findings are exemplary for fruit and vegetable supply chains fully or partially situated in Germany, although some findings are translatable to other geographic regions and product groups.

## 2. Political intervention from a sustainability governance perspective

In environmental policy, or sustainability governance, distinct political instruments are at hand to tackle the respective environmental or resource-related problem. Within this paper, we largely follow the categorisation of policy instruments in accordance with Döring and Töller (2018) and use it as a theoretical foundation for our expert interviews. Table 1 provides a summary of existing classifications of environmental policy instruments, including a selection of arguments in favour of and against their implementation as well as selected examples of application fields in sustainability governance.

### 2.1. Direct regulation or command-and-control instruments

Direct regulation, also referred to as “command-and-control regulation”, works by “imposing mandatory obligations or restrictions on the behaviour of firms or individuals” (Perman et al., 2011, p. 217). Traditional regulation, according to Driesen (2006), implies performance standards and work practice standards. While performance standards set a certain target, which needs to be reached by any means, work practice standards refer to the regulation of means or techniques in connection with a certain aim. It is argued that this kind of environmental policy may not foster innovation as it might not provide incentives for technical progress (Döring and Töller, 2018, p. 421; Johnstone et al., 2010). However, it is debated whether regulation in fact inhibits innovation as some studies have shown that particularly flexible performance standards enhance innovation by giving an incentive to minimise control costs (Driesen, 2006; Lanoie et al., 2011, p. 837). Further, financial resources for the executive enforcement of the regulation must be available and carried by the governing entity (Döring and Töller, 2018, p. 421). Moreover, governance problems such as rebound and shifting effects and lack of rigour could weaken the desired positive environmental effects (Ekardt, 2016; Garske et al., 2020a). Nonetheless, Taylor et al. (2012, p. 274) claim that direct regulation proved to be an effective instrument to prevent environmental degradation in many cases. Döring and Töller (2018, p. 421) specify, that particularly in the event of a low number of damage causers with similar abatement costs, regulation can be the instrument of choice in reducing environmental damage.

### 2.2. Market-based or monetary incentive instruments

The second of the two most frequently cited sets of environmental policy instruments encompasses market-based instruments or economic incentive programs which are described by Driesen (2006) as an alternative between liberalisation and regulation. This set of policy measures

**Table 1**  
Instruments of environmental policy, respective advantages and disadvantages as well as examples of application.

policy instrument	specifications	advantages	disadvantages	examples from sustainability governance
<b>direct regulation / command-and-control</b>	performance standards, work practice standards	potentially high effectiveness	do not foster innovation, resources for executive enforcement	ambient (water, air) pollution requirements and targets, restrictions in pesticide use, mandatory use of catalytic converters
<b>market-based instruments / economic incentive programs</b>	taxes, subsidies, certificates, liability law, tradable rights and permits	positive effect on innovation, potentially high effectiveness	unclear adjustment behaviour in market, undesirable avoidance behaviour and distributional effects, market distortions	Emissions Trading Schemes (ETS), landfill tax, agri-environment payments and conservation payments
<b>cooperative instruments / self-co-regulation</b>	voluntary/ environmental agreements, disclosure of information	less costly than regulatory and market-based approaches, businesses can make own contributions	risk of low effectiveness, cooperation hampered by power imbalances	sector-wide voluntary agreements on food waste reduction, corporate social responsibility programs
<b>information-based instruments</b>	targeted information provision, naming and shaming/faming, labelling and certification	low costs, low degree of intervention	rely on consumer sovereignty and morality, limited to processable amount of information	“right-to-know-programs”, emission inventories, eco-labelling of food

Note: based on Döring and Töller (2018), Taylor et al. (2012), Driesen (2006), Perman et al. (2011) and Gouldson et al. (2008).

operates by influencing incentives to encourage firms or individuals towards a behaviour change on a voluntary basis (Perman et al., 2011, p. 217). Döring and Töller (2018, p. 421) divide environmental policy instruments into taxes, subsidies, certificates and liability laws. Taylor et al. (2012, p. 274) list tradable rights and payments besides taxes and subsidies. Price-based instruments imply negative incentives such as taxes on environmentally destructive activities while positive incentives, such as subsidies, encourage environmentally beneficial activities (Driesen, 2006). An argument raised against market-based instruments is the limited knowledge of political entities on the adjustment behaviour of private entities facing taxes, subsidies or other economic incentives (Döring and Töller, 2018, p. 421). Hence, it cannot be reliably estimated whether or to which extent actors react to the incentive and whether the targeted environmental effect will be reached (Taylor et al., 2012, p. 274). Furthermore, market incentives may entail harmful avoidance behaviour, create socially undesirable distributional effects and lead to market distortions and rising prices (Taylor et al., 2012, p. 280). An advantage of economic instruments is the positive effect on innovation (Johnstone et al., 2010) as any further abatement of negative environmental effects leads to further monetary advantages (Döring and Töller, 2018, p. 421). This set of instruments moreover provides an incentive for an individual cost-efficient abatement of environmental degradation (ibid.).

### 2.3. Cooperative instruments or co-/self-regulation

Besides the described rather traditional instruments, Döring and Töller (2018) list cooperative policy instruments, defined as cooperation between the state and private actors. Examples of cooperative instruments are voluntary agreements, environmental agreements and voluntary disclosure of information (ibid.). Taylor et al. (2012, p. 281) describe this equivalently as self-regulation or co-regulation. Voluntary agreements (VAs) in this context are commitments of private entities or stakeholders to reach certain qualitative or quantitative objectives (Burgos et al., 2019). These agreements may be supported by governments, businesses or other actors and implemented besides prevalent legislation or individually (ibid.). A major advantage of voluntary action is that additional costly regulation and legislation might be avoided. It moreover gives businesses the opportunity to make their own contributions and engage in the action as ambitiously as desirable or feasible (UNEP, 2014). Especially if key organisations commit to voluntary engagement, this can trigger wider implications within the whole sector (ibid.). Taylor et al. (2012, p. 281) nevertheless argue that the flexibility and voluntary nature of cooperative action carries the risk of businesses not engaging much more than they would have done without the instrument, as they weigh implementation costs against potential effects. The participation in the voluntary agreement then gives the illusion of positive environmental behaviour without leading to significant environmental outcomes, also referred to as “green-washing” (Taylor et al., 2012, p. 281). Döring and Töller (2018, p. 417) further argue that in case of power imbalances the mutual will of cooperative action may be hampered.

### 2.4. Information-based instruments

Taylor et al. (2012) and Gouldson et al. (2008) understand information-based instruments as a fourth category of environmental policy instruments. Information-based instruments will, in accordance with Döring and Töller (2018), be united with cooperative instruments and self-/co-regulation in the frame of this paper. The lines between cooperative instruments or self-/co-regulation and information-based instruments are blurred as illustrated by the similar examples of “disclosure of information” and “targeted information-provision” (Table 1). Information-based instruments function by providing knowledge based on which businesses and individuals make decisions towards better environmental performance (Taylor et al., 2012, p. 280).

According to Gouldson et al. (2008), three types of information-based instruments exist: targeted information provision, naming and shaming/faming and labelling and certification schemes. Naming and shaming or right-to-know programs and eco-labelling are frequently used tools in several European countries to inform consumers on the environmental traits of different products which might influence their respective purchase decisions (Driesen, 2006). Information and education campaigns also represent a frequently applied tool in food waste prevention and reduction (Priefer et al., 2016). Nonetheless, this kind of policy relies completely on consumer sovereignty and morality and is limited to the amount of information that consumers can process (ibid.), thereby creating a tension between comprehensive information provision and simplification (Driesen, 2006).

Overall, there are different types of instruments in sustainability governance, each with its own set of advantages and disadvantages. In this paper, we examine whether some of these instruments are being used in the context of food loss prevention, and what challenges may arise if they are used in the future. We draw on the categorisation of environmental policy instruments as a theoretical background for the conduct, analysis and interpretation of our interviews.

## 3. Data and methods

The objective of the applied methodology is to intersect demands and claims of relevant supply chain stakeholders on food loss measures with potentially applicable policy instruments in sustainability governance.

By “food loss and waste” we refer to the entire supply chain, while “food loss” describes losses from primary production to the retail gate (FAO, 2019). Although the respective European legislation (European Commission, 2019a) does not consider produce left in the field as food loss and waste, we also consider this fraction as do other researchers (Hartikainen et al., 2018; Parfitt et al., 2021; Stenmarck et al., 2016).

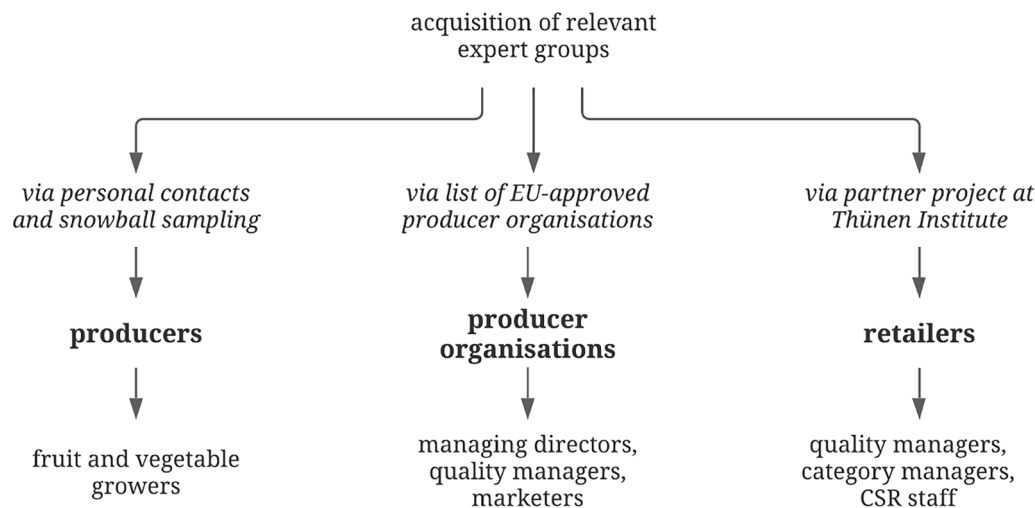
Qualitative expert interviews and questionnaire data serve to explore the demands and claims of supply chain actors regarding food loss policies. Information on policy instruments for sustainability governance are derived from scientific findings and theoretical literature from the field of economic and environmental policies (Section 2).

### 3.1. Semi-structured expert interviews in fruit and vegetable supply chains

The acquisition of participants as well as the implementation of the expert interviews is described in detail by Herzberg et al. (2022). Parts of the interviews specified therein also form the basis of the present study. We identified the following stakeholders as the most relevant in fresh fruit and vegetable supply chains (Garming et al., 2018; Schmidt and Orr, 2019; Strohm et al., 2016): first, producers (fruit and vegetable growers), second, fruit and vegetable producer organisations and third, food retailers. The inclusion of interviewees from both the production and retail side allows the diversity of potentially controversial and self-interested claims about policy measures to be captured.

All in all, we conducted 22 expert interviews between September 2020 and January 2021. Geographically, producers and producer organisations are located in distinct federal states of Germany and the main fruit and vegetable growing areas are included. Grown and marketed fruit and vegetables comprise carrots, potatoes, salads, onions, blue berries, pomaceous fruit (e.g., apples) and others. The interviewed retailers range from regionally through to internationally represented companies and enterprises. Purely organic as well as full range providers and discounters are included in the sample. Some interviews were conducted face-to-face at the interviewees’ premises, while the majority were held online or by telephone due to the COVID19-pandemic. Further details on the conduct and analysis of the interviews can be found in Herzberg et al. (2022). Fig. 1 provides an overview of the acquisition method and the respondents’ position within the respective enterprise or organisation.

The initial aim of the expert interviews was to improve the



**Fig. 1.** Expert acquisition procedure from Herzberg et al. (2022) (means of selection and acquisition, expert group, and position of interviewees within the enterprise).

comprehension of the supply chain stakeholders' interactions and relationships that either result in or prevent the emergence of food loss and waste. We developed an interview guideline consisting of the following thematic priorities:

- (1) Structure of value chain and business relationship
- (2) Perception of food loss
- (3) Contracts, agreements, orders, and quantities
- (4) Quality management and quality standards
- (5) Trading practices and bargaining power
- (6) Options for action (policy and private sector)

The focus of the present study lies on priority six “options for action (policy and private sector)” (see above). Interviews were audio-recorded, transcribed and pseudonymised. Then, the software MAXQDA was used to perform a structuring content analysis to the textual material guided by Kuckartz (2018) and following Mayring (2015). In a first step, all approaches and measures to reduce food loss and waste along the supply chain mentioned by the experts were coded using the superordinate codes “policy intervention” or “private sector measures”. In a second step, we derived sub-codes of “policy interventions” mainly deductively, informed by the theoretical basis on environmental policy and sustainability governance presented in Section 2. We drew the sub-codes of the superordinate code “private sector measures” from the interview data in an inductive manner. This was due to the lack of a theoretical foundation on private sector interventions as compared to policy interventions.

### 3.2. Quantitative survey with suppliers of a retailing company

As a second component of this paper, we analysed parts of a quantitative survey conducted at Thünen Institute with 215 fruit and vegetable suppliers (producers, producer organisations and private traders) of a retailing company. These deliver fruits and vegetables from Germany, Spain and Italy via so-called agencies to the retailer's stores in Germany. The survey was conducted between April and July 2022 as part of a project aiming to analyse the influence of the retailing company's quality standards and business practices on food loss in 12 crops. The questionnaire was distributed online via the communication channels of the retailing company and its upstream fruit and vegetable agencies in the respective countries. It collects data on the following aspects:

- (1) Quantities and trading partners

- (2) Product specifications: existence, types and manner of passing on specifications
- (3) Non-compliance with product specifications: shares and marketing channels of sub-standards produce
- (4) Food loss drivers with a focus on product specifications and business practices
- (5) Crop specific food loss drivers: comparison of retail standards with specific EU and UNECE standards
- (6) Options for action: own options, retailer's options, policy options
- (7) Supplier characteristics: size, fruit and vegetable volumes produced or traded, organisational structure, crop management

Further details on how the questionnaire was administered and how it was analysed can be found in Herzberg et al. (2023). In the following, only results on aspect six will be presented descriptively. The analysis of the questionnaire data of the items presented was performed using IBM SPSS 23 and Microsoft Excel 2019. The development of the respective Likert-scaled questionnaire items was inspired by the results of the expert interviews (Section 3.1). Between 134 and 143 respondents provided answers to these optional questionnaire items assessed within this paper.

## 4. Results

The content analysis of the expert interviews resulted in two overarching codes, namely potential policy interventions (1) and private sector measures (2) that contain four sub-codes each. In the case of policy measures, these are:

- (1a) Communicative and cooperative measures
- (1b) Subsidisation and food price related measures
- (1c) Regulatory measures and political framework conditions
- (1d) Political intervention not necessary or wanted

And in the case of private sector measures:

- (2a) Mechanisation, innovation and process optimisation
- (2b) Communication and cooperation of supply chain actors
- (2c) Reconditioning and repackaging
- (2d) Alternative marketing, processing and redistribution

The following sections will elaborate on and provide examples of these categories.

Overall, the participants more frequently mentioned private sector

**Table 2**  
Superordinate and subordinate codings of structured content analysis per expert group indicated as absolute numbers and percentages per line.

	retail		producer organisations		producers		total	
	no. of codings	percentage per line	no. of codings	percentage per line	no. of codings	percentage per line	no. of codings	percentage per line
<b>(1) policy interventions</b>	<b>23</b>	<b>43 %</b>	<b>19</b>	<b>36 %</b>	<b>11</b>	<b>21 %</b>	<b>53</b>	<b>100 %</b>
(1a) communicative and cooperative measures	5	42 %	5	42 %	2	17 %	12	100 %
(1b) subsidisation and food price related measures	7	54 %	4	31 %	2	15 %	13	100 %
(1c) regulatory measures and political framework conditions	11	48 %	6	26 %	6	26 %	23	100 %
(1d) political intervention not necessary or wanted	0	0 %	4	80 %	1	20 %	5	100 %
<b>(2) private sector measures</b>	<b>59</b>	<b>52 %</b>	<b>19</b>	<b>17 %</b>	<b>35</b>	<b>31 %</b>	<b>113</b>	<b>100 %</b>
(2a) technologies, innovation and process optimisation	14	56 %	3	12 %	8	32 %	25	100 %
(2b) communication and cooperation of supply chain actors	11	37 %	8	27 %	11	37 %	30	100 %
(2c) reconditioning and repackaging	7	64 %	2	18 %	2	18 %	11	100 %
(2d) alternative marketing, processing and redistribution	27	57 %	6	13 %	14	30 %	47	100 %
<b>total</b>	<b>82</b>		<b>38</b>		<b>46</b>		<b>166</b>	

measures than policy interventions, in particular the retailers (Table 2). They highlight alternative marketing and processing options but also regulatory policies. Interviewees from producer organisations seem to bank on an improved cooperation within the value chain and state more often that politics should not interfere at all to bring about a food loss reduction. As compared to other interviewees, producers speak least on political interventions. Alternative marketing, processing and redistribution as well as communication and cooperation are the private sector measures that most often came to their mind (Table 2).

#### 4.1. Policy interventions suggested by the interviewed experts

This section summarises recommendations and claims the interviewed stakeholders expressed with regard to political intervention for food loss reduction (see also Table 3). In the following, these potential policy interventions are structured according to the corresponding codes of the interview material.

##### 4.1.1. Communicative and cooperative measures

Most of the proposed communicative and cooperative measures relate to communicating the environmental burden of food loss to consumers. In this sense, it is argued that a respective policy should influence the consumers' choice, promote their appreciation of agriculture at large (B03:89; B13:105–110), address their food preparation skills (B15:117–120) and increase their awareness of the potential internal quality of “ugly” or “misshapen” produce (B20:99–103). With respect to consumer education, interviewees from retail and a producer organisation stress the responsibility of policy-makers to communicate, but not necessarily price in, the “true cost of food” to consumers (B06:147; B03:89). The quality manager of an organic retailing company explains the “true” or environmental costs of food waste as follows: “Well, we have many goods that don't even show the true price, because now you don't see the costs that the sewage treatment plant or the water industry has to pay to get all the glyphosate back out of the groundwater. [...] but society has paid the price in another form. And I think that would also be a topic that politics could take up” (B06: 147).

As a second line of thought and apart from consumer education, communicative and cooperative approaches directed at the cooperation between governments and retail, and between governments and producers were mentioned. Accordingly, politicians should approach large retailers and urge them to offer more regional products at “fair” prices (B19:148–150). Participants further expect political decision makers to communicate changes in provisions on agronomic practices (e.g., on pesticide use) early enough to enable farmers to adapt accordingly. The train of thought is to prevent farmers from incurring losses through pest infestations or due to products exceeding the acceptable pesticide residue limits (B20:99–103).

##### 4.1.2. Subsidisation and food price related measures

Some interviewees highlight the relation between low food prices and food loss due to lacking lucrativeness of harvesting or processing fruits and vegetables. They consider it the politicians' responsibility to work towards “fair” prices and reflecting the “true” costs of food and food loss. The argument is to modify food prices in a way that they contain environmental costs, notwithstanding the associated difficulties of political enforceability (B06:147; B11:99–104).

Particularly, the representatives of producer organisations emphasise the macro-perspective of food price developments and food loss. It is argued that differences in framework conditions between Germany and other European and non-European countries, such as minimum wages, put pressure on domestic production (B02:116–119; B03:89; B09:101–103). Accordingly, strong competition occasionally leads to harvesting and processing of produce becoming non-lucrative and thereby promotes food loss. An employee of a producer organisation in this regard suggests the “Swiss system”, in which imports are only allowed if domestic produce does not suffice (B02:122–131).

**Table 3**

Summary of suggestions risen by the interviewed experts concerning present and potential policy interventions to reduce food loss.

<b>(1a) communicative and cooperative measures</b>	<ul style="list-style-type: none"> <li>• communicate true (environmental) costs of food to consumers</li> <li>• enhance food preparation skills through educational offers</li> <li>• work towards a higher appreciation of the agricultural sector within the population</li> <li>• communicate to consumers that the appearance of products is not a quality indicator</li> </ul>
<b>(1b) subsidisation and food price related measures</b>	<ul style="list-style-type: none"> <li>• communicate adjustments to agronomic provisions (e.g., concerning the application of pesticides) reasonably early</li> <li>• subsidisation of packaging machinery and related trainings so that producers can adhere to retailers' packaging requirements</li> <li>• subsidisation of infrastructure and modern agronomic techniques (crop protection, irrigation, storage, cooling, sorting)</li> <li>• financial compensation for harvest of unprofitable products (e.g., small products)</li> <li>• bonus-malus-regulation: subsidisation of participation in food loss reduction activity and charging of non-participation</li> <li>• policies should address labour costs and framework conditions resulting in low competitiveness of domestic products</li> </ul>
<b>(1c) regulatory measures and political framework conditions</b>	<ul style="list-style-type: none"> <li>• “Swiss system” to protect domestic market: imports are only allowed if domestic supply does not suffice</li> <li>• establish legal framework conditions for innovations to prolong shelf-life (e.g., coating technologies)</li> <li>• ensure legal protection for selling products with labelling mistakes</li> <li>• acknowledge legal pesticide residue limits and quality requirements as sole binding provisions</li> <li>• critically assess the necessity of EU marketing standards for certain fruits and vegetables</li> <li>• curb private product requirements and Unfair Trading Practices of retailers, e.g., through independent ombudsperson</li> <li>• make it mandatory for retailers to redistribute, sell or process lower quality produce</li> <li>• acknowledge conflicting goals and set priorities (e.g., food waste reduction vs. packaging reduction)</li> <li>• create framework conditions that ensure reasonable producer prices in European Economic Community</li> </ul>
<b>(1d) political intervention not necessary or wanted</b>	<ul style="list-style-type: none"> <li>• the food loss problem must be solved by market participants, politics should not and cannot intervene</li> <li>• market and price interventions are per se critical</li> <li>• politics can only set framework conditions, market actors themselves must intervene</li> </ul>

Nonetheless, the experts find themselves in the dilemma of import bans and tariffs contradicting the principles of the free intra-European market (B03:89; B09:101–103) and protectionist measures are also seen critical: “[...] If you compare a Polish apple with a German apple, then you are no longer on an equal footing, because there are also other framework conditions in the background, and we should at least (...) try to make a difference. [...] Yes, that is always difficult, then one would talk about compulsory tariffs, which is not possible within Europe [...]” (B09:101–103).

When it comes to subsidisations, a retailer highlighted the potential of financing packaging machines and corresponding operational trainings to adhere to corporate design packaging requirements (B07:75–76). Other participants mentioned the subsidisation of modern crop protection and irrigation techniques, warehouses, cooling and sorting facilities as well as the staff-intensive product management or direct treatment of food products as food loss reduction approaches (B14:126–128; B18:92–93). One interviewee suggests a financial compensation for harvesting of non-lucrative produce, such as small products and surplus produce during peak season. He moreover proposes a bonus-malus-regulation in which entities would be subsidised for participation and charged for non-participation in food loss reduction activities.

#### 4.1.3. Regulatory measures and political framework conditions

Regulation includes not only “classical” instruments such as prohibitions and provisions, but also the design of legislative framework conditions. In the eyes of the experts (particularly producers, but also one retailer), loss-preventing framework conditions should largely focus on the power relations between the producing and the retailing side of the supply chain. Accordingly, regulatory law should ensure the surveillance and control of trading practices, e.g., through an ombudsperson (B12:94–95; B16:125–139; B06:146–147).

Improved legislative framework conditions should, in the eyes of the interviewees, aim at the marketing of sub-optimal, mislabelled or incorrectly packed produce. Hereby, legal protection for marketing or donation should be provided and guaranteed (B05:51). Further, politics should urge retailers to market or process products not fulfilling their specific requirements (B05:49; B07:73; B22:77) and even prohibit retailers from setting private norms, if in line with the competition law (B10:125–127; B1:218–222): “What would really be a concrete

recommendation, to say that the laws that are set must be sufficient. If a maximum residue limit was 0.1 mg, then a [retailing] chain would not be allowed to say, ‘But I only want 0.001.’ or so. That’s nonsense, you know.”.

One of the experts additionally highlighted the importance of policy coherence pointing out that policy-makers also need to recognise conflicting goals (e.g., packaging material and pesticide residue reduction vs. food loss and waste reduction) and work towards a coherent data base for priority setting (B05:53).

#### 4.1.4. Political intervention not necessary or wanted

Although they recognise the existence and problematic nature of food loss within the early supply chain, some producers and producer organisations believe that politics cannot or should not intervene to reduce food loss levels. Therefore, markets should regulate themselves and it would be wrong in itself to undermine market mechanisms (B03:89; B21:123): “But it is always bad when politics intervene in markets, also in market price regulating mechanisms, that is always dangerous. It’s best to stay away from such things. Maybe it will somehow regulate itself” (B03:89). Two interviewees further argue that lawmakers are not able to change the situation, and therefore the responsibility should be left to market actors (B10:120–123; B13:99–100).

#### 4.2. Views on policy interventions based on supplier survey

The quantitative assessment within the supplier survey of the retailer’s value chain provides insights into the magnitude of the perceived importance of various policy measures (Fig. 2). Overall, all potential policy measures available received quite high approval. About half of the respondents strongly agreed with the view that policy should engage in consumer education, work towards a balance of power and foster technologies and infrastructure to reduce food loss amounts. Suppliers also consented to the support of alternative marketing and processing, examining product specifications set by law or by the UNECE, counteracting retailers’ specific product standards and providing legal certainty for loss-reducing measures (e.g., liability issues or shelf life-prolonging technologies). With 42 % approval, the political support for reprocessing and repackaging was slightly less popular among suppliers. A noticeably smaller, but still non-negligible share of 29 %

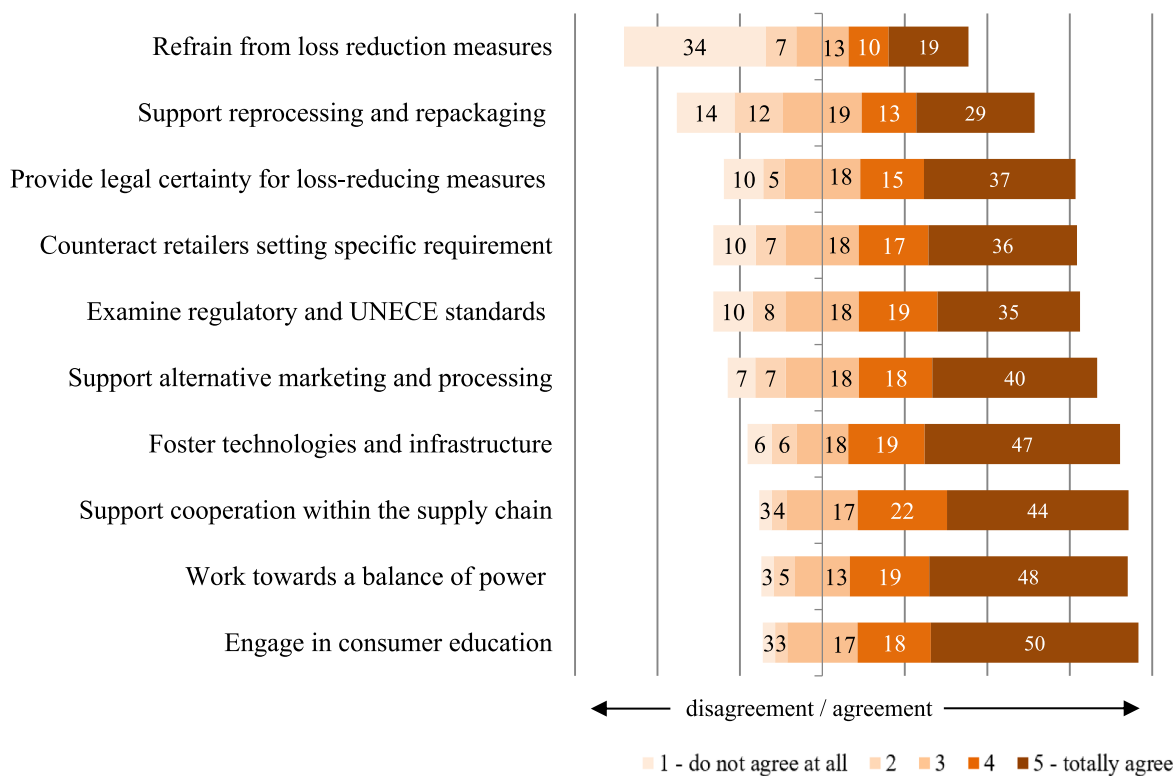


Fig. 2. Suppliers views on what politics should do to reduce food loss in upstream fruit and vegetable supply chains as percentages of respondents (measured on a 5-point Likert scale, n = 134 to 136, percentages do not sum up to 100 % due to omitting NAs).

suggested that policy-makers should fully refrain from implementing food loss reduction measures.

### 4.3. Private sector measures suggested by the interviewed experts

Although this paper primarily deals with political intervention, the potential options for action of supply chain stakeholders are presented as well (see also Table 4). These may provide further leverage points for policy recommendations to support activities of private entities.

#### 4.3.1. Technologies, innovation and process optimisation

Experts raised the argument that enhanced precision in horticultural practice and storage as well as optimised processes will substantially lower food loss levels. With respect to technologies, producers mentioned the modernisation of cold systems and CO<sub>2</sub>-storage-facilities (B12:27; B18:35), greenhouses (B10:45), crop protection sprayers, fertiliser spreaders and irrigation systems (B18:92–93). Retailers highlighted the adoption of shelf life-prolonging coating technologies, picking robots and drones with ripeness detection (B08:163–167; B14:122). Shifting towards new robust and storable, but still tasty, varieties was mentioned by both retailers and producers (B08:163; B12:27; B18:35;89–91). However, there is the concern that new technologies and modernisation require large investments. A blueberry producer, for instance, explains, that the replanting of this perennial crop will only pay off after decades and therefore after his retirement (B18: 89–91). Apart from purely technical solutions, enhanced forecasting systems for purchasing (B06:135), an improved planning reliability and better coordination of advertising periods (B13:94) are process optimisations that minimise the risk buffer in agricultural production as well as overproduction (B10:101): “Maybe (...) sometimes short-term promotions in retail would help to pass production peaks [...]. It would have to be really short-term within a few days. Not all of our buyers are willing or able to do that” (B13: 94).

#### 4.3.2. Communication and cooperation of supply chain actors

Communication and cooperation to reduce food loss does not only take place between governments and the private sector (Section 4.1.1) but also on a voluntary basis within the supply chain. In this regard, retailers themselves highlight their own potential to influence consumers’ purchase decisions (B05:7; B06:141; B07:73; B10:45–47). Producers claimed that particularly consumer information with respect to diverging product appearance (“ugly produce”) is essential and should be fostered by retailers as well as by the media (B16:125; B19:110–112; B20:97; B21:111). Furthermore, an improved cooperation in the form of long-term arrangements, personal contact and a respectful interaction with each other may lower overproduction, grade out losses and rejections (B06:135–137; B10:123; B12:91–93). A producer believes that particularly expertise and comprehension at the product reception as well as internal communication between purchasers and product reception of retailing companies are lacking: “They [product reception] should have the possibility to call the purchaser or an intermediary. Someone who really has expertise, who has an overview of the weather situation in the field, and that on that day the raspberries might be a bit softer, but with cooling they will be a bit better again” (B16:131–133).

#### 4.3.3. Reconditioning and repackaging

A frequent problem causing food loss within the supply chain is the spoilage of parts or single pieces of fruits and vegetables within one packaging unit. In these cases, resorting, repackaging and reconditioning enables to market the unspoiled fraction. The experts added for consideration that this approach is usually not economically bearable by any of the supply chain participants (B07:78; B08:86; B14:130; B17:58–61). A retailer explains: “The topic of repackaging is perhaps interesting in general. Because we can’t afford that. If a truck full of lemons came, I couldn’t say, ‘okay, now we have two people here to unpack lemons all day and repack them and deliver them.’ That is not viable” (B22:130–136). In the event of spoilage or a quality defect, usually the whole product unit is discarded or returned to the supplier. The supplier

Table 4

Summary of suggestions risen by the interviewed experts concerning present and potential private sector measures to reduce food loss.

(2a) mechanisation, innovation and process optimisation	<ul style="list-style-type: none"> <li>• improve forecasting systems and product management in store</li> <li>• introduce modern technologies, such as coatings, harvesting robots and drones with ripeness detection</li> <li>• grow resistant and storable cultivars under consideration of relevant product traits (e.g., taste)</li> <li>• organise advertising campaigns to offer surplus produce at short notice</li> <li>• use modernised greenhouses to control growing conditions</li> <li>• further improve plannability on purchasing side to minimise risk buffers in primary production</li> <li>• improve storage facilities, e.g., to prevent from germination and to shift surplus produce into periods of low supply</li> </ul>
(2b) communication and cooperation of supply chain actors	<ul style="list-style-type: none"> <li>• improve crop protection sprayers, fertiliser spreaders, irrigation systems, storage and sorting facilities</li> <li>• retail should make use of point of sale to influence consumers' purchase decisions</li> <li>• foster stakeholder dialogue, cooperation and idea generation regarding food loss and waste along the supply chain</li> <li>• foster long-term arrangements and improve business relationship between retailers, suppliers and producers</li> <li>• purchasers of retail should grant short-term flexibility of product requirements in case of short supply</li> <li>• retail should act more reliably and foster personal communication with business partners</li> <li>• retail and media should educate consumers towards acceptance of irregular appearance of produce</li> </ul>
(2c) reconditioning and repackaging	<ul style="list-style-type: none"> <li>• increase comprehension at product reception as well as direct communication between producers and purchasers</li> <li>• repacking if parts of a packaging unit are spoiled or in case of rejection</li> <li>• reconditioning of stored vegetables, e.g., removal of the outer leaf of stored cabbage</li> <li>• relabelling of products with labelling mistakes</li> </ul>
(2d) alternative marketing, processing and redistribution	<ul style="list-style-type: none"> <li>• extension of best-before date</li> <li>• establish product-lines and brands creating added value from marketing or processing of suboptimal produce (e.g., jams and frozen foods)</li> <li>• promote sales of suboptimal and mixed products as well as products without trade category</li> <li>• process products not fulfilling standards and surplus produce</li> <li>• utilise products not fulfilling standards and surplus produce as animal feed, biogas or compost</li> <li>• donate to food banks or staff</li> <li>• sell substandard products to food service or cutting businesses</li> <li>• in field cultivation, crops can be ploughed back; protected crops must be harvested and brought to biogas plant</li> </ul>

only repacks, if he/she would otherwise lack products to fulfil a delivery obligation and therefore accepts the non-lucrative reconditioning (B02:95–97).

#### 4.3.4. Alternative marketing, processing and redistribution

In case products are not spoiled, but other traits impede the initially intended outlet as fresh fruit or vegetable (e.g., irregular calibre, shape or internal traits), the alternative marketing, processing and redistribution (donation) of food was mentioned as a food loss reducing strategy. Retailers highlighted already existing product lines that enable value creation by selling suboptimal produce directly at the supermarket in the form of “party tomatoes”, “gourmet onions”, “weather apples”, ready-to-eat salads, dips, soups, etc. (B07:65–68 and 89–91; B11:90–94; B14:23–24). Producers and producer organisations associate themselves largely with the retailers' positive views on such campaigns (B04:109; B09:87–97; B16:113–115; B19:84–90; B20:39–43). Misshapen or broken produce may also be marketed to the food service industry or be donated to employees, food banks or other recipients (B05:9; B07:73; B15:83–84; B17:95–102). Some interviewees endorsed the processing of fruits and vegetables to food articles such as juices, jams and frozen foods (B16:65) as well as its utilisation as animal feed, agricultural material, biogas and compost. Although the latter two are legally defined as waste treatment procedures, some participants perceive them as reasonable food loss reduction strategies (B05:9; B22:29; B17:52–55; B18:50–51). All alternative marketing, processing and redistribution options have in common that they are, for the most part, not economically viable: “So if a juice apple is only paid five cents for at the factory and the production costs for the apple are nine cents, then it is clear that this apple was never put on the market. Because why throw money out the window, so it's just left on the ground” (B09:105–107). Moreover, some alternative marketing channels may simply not be accessible by producers due to a limited network (B15:82; B19:39–44; B17:63; B21:37).

#### 4.4. Views on private sector measures from supplier survey

The online-survey further breaks down which private-sector courses of action suppliers expect from retail companies with respect to lowering food loss levels along the supply chain (Fig. 3). All in all, the respondents' approval of items available for selection was lower than for

political options for action (Fig. 2). With more than 50 % of all respondents, the endorsement of better coordinating promotion campaigns with seasonal peaks, tolerating deviations from the private calibre standard and establishing alternative marketing and processing networks was rather high. Almost half of all suppliers moreover expect retailers to ensure long-term and neutral packaging designs and tolerate deviations in terms of product appearance. There was less support among suppliers for the statement that retailers should improve their planning of orders, tolerate deviations in terms of pesticide residue limits and ensure higher reliability of their own product requirements.

## 5. Discussion

Our analysis indicates that there is a potential for the implementation of further kinds of policy instruments in food loss reduction. In line with Schanes et al. (2018) and Giordano et al. (2020) it becomes apparent, that transnational and national food loss and waste policies rely largely on cooperative and information-based policy approaches and mainly target consumption and retail stages. Such voluntary action and corporate social responsibility programs can indeed form an integral part of a sustainability transformation (Croci, 2005) and already do so in the case of food loss and waste reduction (Burgos et al., 2019). However, they cannot fully replace supplementary regulatory approaches (Ekardt, 2020; Sinclair Taylor et al., 2019). Engagement of involved parties towards a sustainability transformation is often insufficient (Ekardt, 2020) as supply chain stakeholders are not willing to voluntarily reduce inter-stage drivers or root causes that provoke losses on other supply chain stages (e.g., product requirements and business practices) (Herzberg et al., 2022; Mena et al., 2014). Messner et al. (2021) apply the concept of lock-ins in the food loss reduction debate, meaning established ways of seeing and doing things that resist transformation. They argue that different types of lock-ins, such as legislation and policies, accepted views and paradigms and existing infrastructures, result in food surplus becoming waste. Messner et al. (2021) and Messner et al. (2022) suggest focusing more on this systems-based understanding and the inter-connected processes of overproduction and food loss when designing food loss policies, rather than focusing on ‘end-of-pipe’ solutions. Garske et al. (2020a) suggest that in the case of food loss and waste reduction the application of economic instruments, such as the subsidisation and



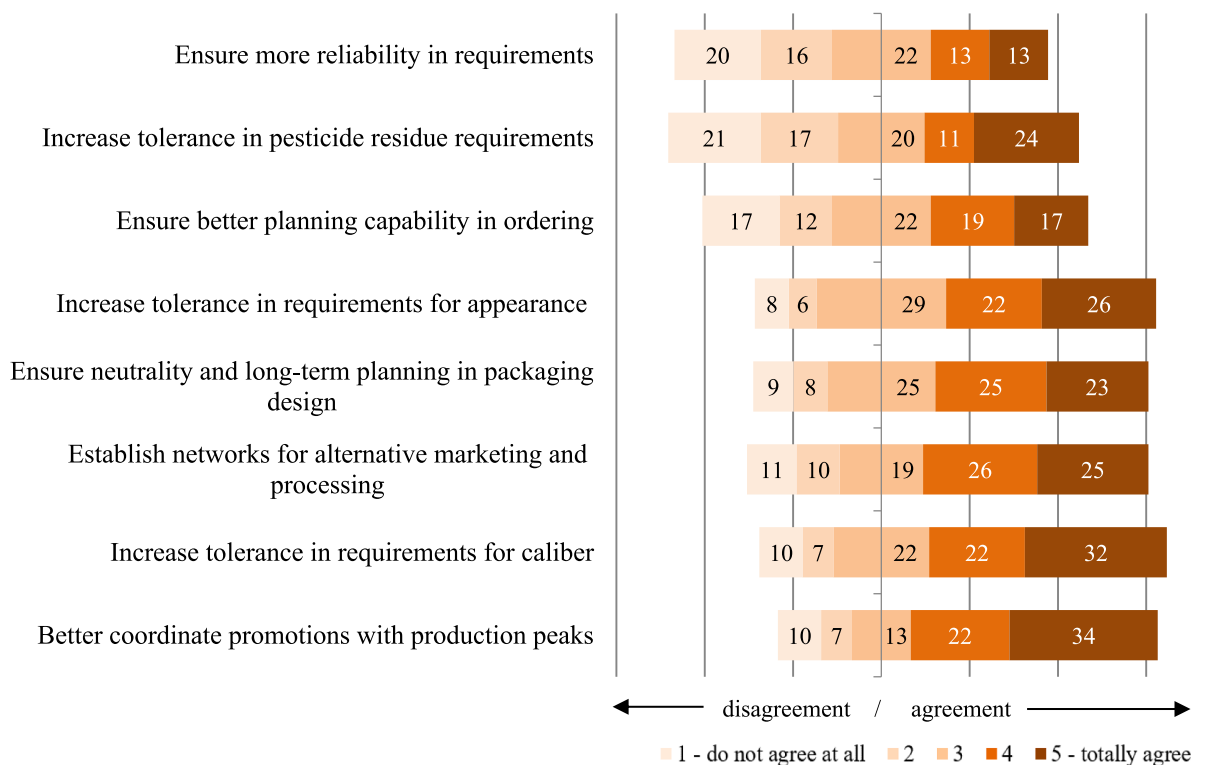


Fig. 3. Suppliers views on what retailing companies should do to reduce food loss in upstream fruit and vegetable supply chains as percentages of respondents (measured on a 5-point Likert scale, n = 143, percentages do not sum up to 100 % due to omitting NAs).

food price related measures presented within this paper, might be a comprehensive solution to address multiple interlinked challenges in a more comprehensive manner.

It also becomes clear that the supply chain actors' demands partially diverge from current political interventions. Supply chain actors agree with current policies in that they emphasise the need for instruments that encourage consumers to change their behaviour and increase their appreciation of agricultural practices. Nonetheless, de Gorter et al. (2021) and Kuiper and Cui (2021) challenge such a narrow focus on consumers' food waste behaviour. Similar to the findings of Johnson et al. (2019), our study reveals that recent policies partially bypass other claims of supply chain actors. Examples of further policies are the subsidisation of loss reducing agricultural and food-related practices, the containment of private standards and power imbalances, the design of political framework conditions that favour domestic produce at acceptable prices and the fostering of alternative processing, marketing and redistribution channels. All of these measures may however present major challenges. To name an example, the suggested redistribution of surplus to employees might not be feasible from a legal point of view as it is considered a benefit of employment for tax purposes, similar to a company mobile phone or car. Hence, such a measure would due to the great effort required probably be discontinued immediately.

Thyberg and Tonjes (2016) argue that policies to prevent food loss and waste should increasingly address the actual causes and motivations for loss and waste generation. A focus on "strong" prevention measures addressing root causes, such as reduced production and consumption and alternative business models, is needed when aiming at more sustainable food systems and circular economy but is neglected in the public debate and actual policy making (Mourad, 2016).

Therefore, a holistic agri-food systems approach can assist in designing coherent food loss and waste policies. Many of the solutions promoted tend actually to manage surplus than prevent food loss in a systemic way and in line with the food waste hierarchy (Giordano et al., 2020; Mourad, 2016). Such a holistic view on food loss and waste is

required from a circular economy perspective (Vilarinho et al., 2017). A concrete example is that food loss and waste measures could be introduced again into the Common Agricultural Policy (CAP) (Garske et al., 2020a). In the past, redistribution policies of surplus produce had formed a part of the CAP (Caraher, 2015). Measures to tackle food loss and waste within the CAP should this time also be aimed at prevention, not just redistribution. Moreover, in Pillar Two of the CAP, investments in rural development programs and infrastructures that prioritise food loss reduction should be focused on more intensely.

Food loss reduction targets in the upstream supply chain could also be synchronised with the Directive on so-called Unfair Trading Practices (European Parliament, 2019) and its implementations into national laws. The framework set by the directive is a starting point. However, it currently fails to explicitly state food loss reduction as a secondary objective and does not capture short-notice ordering and the informal nature of agreements upon quantity and quality of produce in the fruit and vegetable sector (Herzberg et al., 2022). The leeway that the directive grants national member states should be used to prevent such food loss inducing practices. To provide an example, the Agricultural Organisations and Supply Chains Act (Deutscher Bundestag, 2021), which translates the UTP-Directive into German law, regulates unilateral contract changes upon the quantity and quality of produce and forbids short-term cancellations. However, if neither such contract clauses nor short-term cancellations exist within the sector, the law bypasses the actual problems related to imbalanced trade relations and food loss.

Sorrentino et al. (2018) moreover suggest that the entanglement of food loss with marketing channels and power constellations could be captured in existing legislation on producer organisations. The European regulation of the Common Organisation of the Markets in agricultural products (COM) defines among others the following aims of producer organisations: ensuring quantity planning, management of by-products and waste and contribution to a sustainable use of natural resources. However, to embed food loss reduction targets, the regulation

should even more explicitly motivate producer organisations to support alternative marketing and processing of their members' surplus produce.

Arising governance problems and advantages and disadvantages of distinct instruments must be considered in the design of food loss and waste preventing policies. Many synergies and trade-offs exist between food loss and waste reduction and further demands on the food system (Reynolds, 2023). Cattaneo et al. (2020a) and de Gorter et al. (2021) stress trade-offs between reducing natural resource use and for instance increasing farm welfare and potential greenhouse gas emissions through further cold-chains and processing. Therefore, “win–win–win” solutions are in many cases not achievable, as actors with different interests in commodity chains likely suggest competing solutions (Mourad, 2016). Rebound, shifting and cascading effects must also in the case of food loss and waste policies be considered. A technical or behavioural improvement may have a positive effect on the level of food loss. However, this effect may be outweighed or even exceeded by spending monetary savings on other environmentally damaging goods or processes and hence simply shifted to other sectors, products, regions, resources or stages of the supply chain (Albizzati et al., 2022; de Gorter et al., 2021; Ekardt, 2020; Kuiper and Cui, 2021; Vilarinho et al., 2017).

Limitations of our study emerge, which also provide direction for future research. The interviews and questionnaires primarily aimed at topics other than options for action, namely power imbalances, product specifications and business practices. This setting might influence the views of participants on options for action. Additionally, the interviewees and survey respondents are the norm addressees of potential policies. It is likely that their suggestions are driven by potentially self-interested motives besides food loss and waste prevention and might therefore not consider overall benefits to society. Hence, the results can provide insights into different stakeholders' demands and claims but do not reflect on the actual effectiveness or even efficiency of policies. Future research could look more closely at the effectiveness and efficiency of some of the proposed policies, such as subsidising reworking and repackaging, or introducing various forms of process optimisation and mechanisation. It could use ex-ante and ex-post analysis to assess the expected outcomes and welfare effects of the policies proposed in this paper.

## 6. Conclusions

This paper analyses expert interviews with retailers, producer organisations and producers and a quantitative survey with suppliers of a German retailing company to grasp policy and private sector options for action to tackle food loss in upstream fruit and vegetable supply chains. We found that the focus of a majority of policies in Germany and other industrialised countries lies on downstream supply chain stages and applies voluntary and communicative approaches. Actors in the field agree upon the need for a change in consumer behaviour to lower food loss levels but also suggest interventions addressing the broader context of the food system beyond already existing ones. Accordingly, market-based approaches could assist by fostering the adoption of robust cultivars, alternative marketing channels as well as processing, reworking and repackaging facilities. Regulatory framework conditions could prevent food loss by adjusting legal framework conditions to facilitate donation as well as the adoption of innovative food loss reducing technologies. Regulatory laws should moreover address power relations and setting of private quality standards within supply chains. In order to take account of policy coherence, these policies should be aligned with leverage points of existing laws and communications such as the Circular Economy Action Plan, the Farm-to-Fork Strategy, the Directive on Unfair Trading Practices, the Common Agricultural Policy of the European Union and legislation on producer organisations. We suggest that translations of the UTP-Directive into national law should be implemented in a way that takes food loss into account, e.g., by restricting short-notice orders rather than cancellations and by a containment of

private quality standards. Already existing legislation on producer organisations could in the future comprise incentives for the creation of supplier and processor networks as well as processing facilities. A policy mix from the field of cooperation and communication, regulatory law and market-based instruments seems appropriate to address the manifold drivers of food loss on upstream supply chain stages. The exact effects of these policies are still to be determined by further research. Horizontal alignment of policies between ministries and departments as well as vertical alignment between different governance levels is essential to reach this aim. This should take into account potential trade-offs between policy objectives within and outside the food system, as well as governance problems, and give greater priority to the wider context in which reducing food loss and waste is embedded.

## CRedit authorship contribution statement

**Ronja Herzberg:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft. **Felicitas Schneider:** Conceptualization, Validation, Writing – review & editing, Supervision. **Martin Banse:** Writing – review & editing, Supervision.

## Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: The mentioned retailing company supported the supplier survey, which serves as an additional data source of this paper besides the expert interviews, financially. At the time of the preparation of the paper draft, the respective project had already expired. The contents of the paper do not form part of the respective project and are unknown to the retailing company. The retailer is kept anonymous in this paper. No salaries of co-authors or other expenses related to the paper were funded by the retailer. All authors certify that the funding source had no influence on the contents of the paper.

## Data availability

The data that has been used is confidential.

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## References

- Albizzati, P.F., Rocchi, P., Cai, M., Tonini, D., Astrup, T.F., 2022. Rebound effects of food waste prevention: Environmental impacts. *Waste Manage* 153, 138–146. <https://doi.org/10.1016/j.wasman.2022.08.020>.
- Deutscher Bundestag, 2021. Gesetz zur Stärkung der Organisationen und Lieferketten im Agrarbereich (Agrarorganisationen-und-Lieferketten-Gesetz): AgrarOLkG.
- Burgos, S., Colin, Flavien, Graf, V., Mahon, P., 2019. REFRESH Policy Brief: Voluntary Agreements as a collaborative solution for food waste reduction. <https://eu-refresh.org/voluntary-agreements-food-waste.html>.
- Caraher, M., 2015. The european union food distribution programme for the most deprived persons of the community, 1987–2013: From agricultural policy to social inclusion policy? *Health Policy* 119, 932–940. <https://doi.org/10.1016/j.healthpol.2015.05.001>.
- Cattaneo, A., Federighi, G., Vaz, S., 2020a. The environmental impact of reducing food loss and waste: A critical assessment. *Food Policy* 101890. <https://doi.org/10.1016/j.foodpol.2020.101890>.

- Cattaneo, A., Sánchez, M.V., Torero, M., Vos, R., 2020b. Reducing food loss and waste: Five challenges for policy and research. *Food Policy* 101974. <https://doi.org/10.1016/j.foodpol.2020.101974>.
- Croci, E., 2005. *The handbook of environmental voluntary agreements: Design, Implementation and Evaluation Issues*. Springer, Dordrecht.
- de Gorter, H., Drabik, D., Just, D.R., Reynolds, C., Sethi, G., 2021. Analyzing the economics of food loss and waste reductions in a food supply chain. *Food Policy* 101953. <https://doi.org/10.1016/j.foodpol.2020.101953>.
- Döring, T., Töller, A.E., 2018. *Umweltpolitik*. In: Mause, K., Müller, C., Schubert, K. (Eds.), *Politik Und Wirtschaft: Ein Integratives Kompendium*. Springer Fachmedien, Wiesbaden, pp. 401–430.
- Driesen, D., 2006. Economic Instruments for Sustainable Development. In: Richardson, B. J. (Ed.), *Environmental Law for Sustainability: A Reader*. Hart Publishing, Oxford, pp. 277–308.
- Eičaitė, O., Alenčikienė, G., Pauliukaitytė, I., Salaševičienė, A., 2021. Eat or throw away? factors differentiating high food wasters from low food wasters. *Sustainability* 13, 10741. <https://doi.org/10.3390/su131910741>.
- Ekardt, F., 2016. *Zur Verteidigung umweltökonomischer Politikinstrumente gegen ihre Freunde und ihre Kritiker: Analysen des Hauptinstrumentes der Transformation zur Nachhaltigkeit*. *Momentum Quarterly* 5, 224–242.
- Ekardt, F., 2020. *Sustainability: Transformation, Governance, Ethics, Law*. Springer International Publishing, Cham.
- European Commission, 2019a. Commission Delegated Decision (EU) 2019/1597 of 3 May 2019 supplementing Directive 2008/98/EC of the European Parliament and of the Council as regards a common methodology and minimum quality requirements for the uniform measurement of levels of food waste: (EU) 2019/1597.
- European Commission, 2019b. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions - The European Green Deal: (COM) 2019/640.
- European Commission, 2020. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A new Circular Economy Action Plan for a cleaner and more competitive Europe: (COM) 2020/98.
- European Parliament, 2019. Directive (EU) 2019/633 of the European Parliament and of the Council - of 17 April 2019 - on Unfair Trading Practices in business-to-business relationships in the agricultural and food supply chain.
- FAO, 2019. The state of food and agriculture: Moving forward on food loss and waste reduction. Food and Agriculture Organization of the United Nations. <https://www.fao.org/3/ca6030en/ca6030en.pdf>.
- Flanagan, K., Lipinski, B., Goodwin, L., 2019. SDG Target 12.3 on Food Loss and Waste: 2019 Progress Report: An annual update on behalf of Champions 12.3. *Champions 12 (3)*. <https://champions123.org/sites/default/files/2020-09/champions-12-3-2019-progress-report.pdf>.
- Garming, H., Dirksmeyer, W., Bork, L., 2018. Entwicklungen des Obstbaus in Deutschland von 2005 bis 2017: Obstarten, Anbauregionen, Betriebsstrukturen und Handel. *Thünen Working Paper 100*. Johann Heinrich von Thünen-Institut, Braunschweig. <https://doi.org/10.3220/WP1531805739000>.
- Garske, B., Heyl, K., Ekardt, F., Weber, L.M., Gradzka, W., 2020a. Challenges of Food Waste Governance: An Assessment of European Legislation on Food Waste and Recommendations for Improvement by Economic Instruments. *Land* 9, 231. <https://doi.org/10.3390/land9070231>.
- Garske, B., Stubenrauch, J., Ekardt, F., 2020b. Sustainable phosphorus management in European agricultural and environmental law. *RECIEL* 29, 107–117. <https://doi.org/10.1111/reel.12318>.
- Giordano, C., Franco, S., 2021. Household Food Waste from an International Perspective. *Sustainability* 13, 5122. <https://doi.org/10.3390/su13095122>.
- Giordano, C., Falasconi, L., Cicatiello, C., Pancino, B., 2020. The role of food waste hierarchy in addressing policy and research: A comparative analysis. *J Clean Prod* 252, 119617. <https://doi.org/10.1016/j.jclepro.2019.119617>.
- Gouldson, A., Lopez-Gunn, E., van Alstine, J., Rees, Y., Davies, M., Krishnarayan, V., 2008. New alternative and complementary environmental policy instruments and the implementation of the Water Framework Directive. *Eur. Environ.* 18, 359–370. <https://doi.org/10.1002/eet.491>.
- Hartikainen, H., Mogensen, L., Svanes, E., Franke, U., 2018. Food waste quantification in primary production - The Nordic countries as a case study. *Waste Manage* 71, 502–511. <https://doi.org/10.1016/j.wasman.2017.10.026>.
- Herzberg, R., Schmidt, T.G., Schneider, F., 2020. Characteristics and determinants of domestic food waste: A representative diary study across Germany. *Sustainability* 12, 4702. <https://doi.org/10.3390/su12114702>.
- Herzberg, R., Schmidt, T., Keck, M., 2022. Market power and food loss at the producer-retailer interface of fruit and vegetable supply chains in Germany. *Sustain Sci* 17, 2253–2267. <https://doi.org/10.1007/s11625-021-01083-x>.
- Herzberg, R., Trebbin, A., Schneider, F., 2023. Product specifications and business practices as food loss drivers – A case study of a retailer's upstream fruit and vegetable supply chains. *J Clean Prod* 417, 137940. <https://doi.org/10.1016/j.jclepro.2023.137940>.
- Johnson, L.K., Bloom, J.D., Dunning, R.D., Gunter, C.C., Boyette, M.D., Creamer, N.G., 2019. Farmer harvest decisions and vegetable loss in primary production. *Agric Syst* 176, 102672. <https://doi.org/10.1016/j.agsy.2019.102672>.
- Johnstone, N., Haščić, I., Kalamova, M., 2010. *Environmental Policy Design Characteristics and Technological Innovation: Evidence from Patent Data*. OECD Environment Working Papers No. 16. OECD.
- Karunasena, G.G., Ananda, J., Pearson, D., 2021. Generational differences in food management skills and their impact on food waste in households. *Resour Conserv Recycl* 175, 105890. <https://doi.org/10.1016/j.resconrec.2021.105890>.
- Kinach, L., Parizeau, K., Fraser, E.D.G., 2020. Do food donation tax credits for farmers address food loss/waste and food insecurity? A case study from Ontario. *Agric Human Values* 37, 383–396. <https://doi.org/10.1007/s10460-019-09995-2>.
- Koester, U., 2014. Food loss and waste as an economic and policy problem. *Inter Econ* 49, 348–354. <https://doi.org/10.1007/s10272-014-0518-7>.
- Kuckartz, U., 2018. *Qualitative Inhaltsanalyse. Methoden, Praxis, Computerunterstützung*, 4th ed. Beltz Juventa, Weinheim, Basel.
- Kuiper, M., Cui, H.D., 2021. Using food loss reduction to reach food security and environmental objectives – A search for promising leverage points. *Food Policy* 98, 101915. <https://doi.org/10.1016/j.foodpol.2020.101915>.
- Lanoie, P., Laurent-Lucchetti, J., Johnstone, N., Ambec, S., 2011. Environmental Policy, Innovation and Performance: New Insights on the Porter Hypothesis. *J Econ Manag Strategy* 20, 803–842.
- Mayring, P., 2015. *Qualitative Inhaltsanalyse: Grundlagen und Techniken*, 12th ed. Beltz, Weinheim.
- Mena, C., Terry, L.A., Williams, A., Ellram, L., 2014. Causes of waste across multi-tier supply networks: Cases in the UK food sector. *Int J Prod Econ* 152, 144–158. <https://doi.org/10.1016/j.ijpe.2014.03.012>.
- Messner, R., Johnson, H., Richards, C., 2021. From surplus-to-waste: A study of systemic overproduction, surplus and food waste in horticultural supply chains. *J Clean Prod* 278, 123952. <https://doi.org/10.1016/j.jclepro.2020.123952>.
- Messner, R., Johnson, H., Richards, C., 2022. Towards systemic solutions to food waste: Creative destabilisation and escaping food waste lock-in. *J Rural Stud* 92, 180–188. <https://doi.org/10.1016/j.jrurstud.2022.03.023>.
- Mourad, M., 2016. Recycling, recovering and preventing “food waste”: competing solutions for food systems sustainability in the United States and France. *J Clean Prod* 126, 461–477. <https://doi.org/10.1016/j.jclepro.2016.03.084>.
- Papargyropoulou, E., Lozano, R., K Steinberger, J., Wright, N., Ujang, Z.b., 2014. The food waste hierarchy as a framework for the management of food surplus and food waste. *J Clean Prod* 76, 106–115. <https://doi.org/10.1016/j.jclepro.2014.04.020>.
- Parfitt, J., Croker, T., Brockhaus, A., 2021. Global food loss and waste in primary production: A reassessment of its scale and significance. *Sustainability* 13, 12087. <https://doi.org/10.3390/su132112087>.
- Perman, R., Ma, Y., Common, M.S., Maddison, D., McGilvray, J., 2011. *Natural resource and environmental economics*. Addison Wesley (Pearson), Harlow, England.
- Priefer, C., Jörissen, J., Bräutigam, K.-R., 2016. Food waste prevention in Europe – A cause-driven approach to identify the most relevant leverage points for action. *Resour Conserv Recycl* 109, 155–165. <https://doi.org/10.1016/j.resconrec.2016.03.004>.
- Reynolds, C., 2023. Tackling food loss and waste: An overview of policy actions. In: Busetti, S., Pace, N. (Eds.), *Food Loss and Waste Policy: From Theory to Practice*. Routledge, Oxon, pp. 42–60.
- Schanes, K., Dobernick, K., Gözet, B., 2018. Food waste matters - A systematic review of household food waste practices and their policy implications. *J Clean Prod* 182, 978–991. <https://doi.org/10.1016/j.jclepro.2018.02.030>.
- Schmidt, T.G., Orr, L., 2019. Monitoring food waste in the wholesale and retail sector in Germany 2019: Food retail data. *Thünen Working Paper 168a*. Johann Heinrich von Thünen-Institut, Braunschweig. <https://doi.org/10.3220/WP161355002000>.
- Segrè, A., Falasconi, L., Politano, A., Vittuari, M., 2014. *SAVE FOOD: Global Initiative on Food Loss and Waste Reduction: Background paper on the economics of food loss and waste (unedited working paper)*. Food and Agriculture Organization of the United Nations.
- Sinclair Taylor, J., Parfitt, J., Jarosz, D., 2019. REFRESH Policy Brief: Regulating the role of Unfair Trading Practices in food waste generation. [https://eu-refresh.org/sites/default/files/REFRESH%20Policy%20Brief%20on%20UTPs%202019\\_FINAL.pdf](https://eu-refresh.org/sites/default/files/REFRESH%20Policy%20Brief%20on%20UTPs%202019_FINAL.pdf).
- Soma, T., Kozhikode, R., Krishnan, R., 2021. Tilling food under: Barriers and opportunities to address the loss of edible food at the farm-level in British Columbia. *Canada. Resour Conserv Recycl* 170, 105571. <https://doi.org/10.1016/j.resconrec.2021.105571>.
- Sorrentino, A., Russo, C., Cacchiarelli, L., 2018. Market power and bargaining power in the EU food supply chain: the role of producer organisations. *New Medit* 17, 21–31. <https://doi.org/10.30682/nm1804b>.
- Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B.L., Lassaletta, L., de Vries, W., Vermeulen, S.J., Herrero, M., Carlson, K.M., Jonell, M., Troell, M., DeClerck, F., Gordon, L.J., Zurayk, R., Scarborough, P., Rayner, M., Loken, B., Fanzo, J., Godfray, H.C.J., Tilman, D., Rockström, J., Willett, W., 2018. Options for keeping the food system within environmental limits. *Nature* 562, 519–525. <https://doi.org/10.1038/s41586-018-0594-0>.
- Stenmarck, Å., Jensen, C., Quedsted, T., Moates, Graham, 2016. Estimates of European food waste levels. FUSIONS, Stockholm. <https://www.eu-fusions.org/phocadownload/Publications/Estimates%20of%20European%20food%20waste%20levels.pdf>.
- Stroh, K., Garming, H., Dirksmeyer, W., 2016. *Entwicklung des Gemüsebaus in Deutschland von 2000 bis 2015: Anbauregionen, Betriebsstrukturen, Gemüsearten und Handel*. *Thünen Working Paper 56*. Johann Heinrich von Thünen-Institut, Braunschweig. <https://doi.org/10.3220/WP1461137491000>.
- Taylor, C., Pollard, S., Rocks, S., Angus, A., 2012. Selecting policy instruments for better environmental regulation: a Critique and future research agenda. *Env Pol Gov* 22, 268–292. <https://doi.org/10.1002/eet.1584>.
- Thyberg, K.L., Tonjes, D.J., 2016. Drivers of food waste and their implications for sustainable policy development. *Resour Conserv Recycl* 106, 110–123. <https://doi.org/10.1016/j.resconrec.2015.11.016>.
- UN, 2020. *Goal 12: Sustainable Development Knowledge Platform*. <https://sustainabledevelopment.un.org/sdg12> (accessed 27 February 2020).
- UNEP, 2014. *Prevention and reduction of food and drink waste in businesses and households: Guidance for governments, local authorities, businesses and other*

- organisations. United Nations Environment Programme. <https://wedocs.unep.org/20.500.11822/25194>.
- Vilariño, M.V., Franco, C., Quarrington, C., 2017. Food loss and waste reduction as an integral part of a circular economy. *Front Environ Sci* 5, 21. <https://doi.org/10.3389/fenvs.2017.00021>.
- WWF, 2021. Driven to Waste: The Global Impact of Food Loss and Waste on Farms. [https://wwfint.awsassets.panda.org/downloads/wwf\\_uk\\_driven\\_to\\_waste\\_the\\_global\\_impact\\_of\\_food\\_loss\\_and\\_waste\\_on\\_farms.pdf](https://wwfint.awsassets.panda.org/downloads/wwf_uk_driven_to_waste_the_global_impact_of_food_loss_and_waste_on_farms.pdf) (accessed 22 July 2021).