Representing Food Waste in Ontologies: A Role-Based Account

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Abstract

Food waste attracts growing research interest because it has a significant impact on our society and the environment. There is nonetheless no general consensus about the meanings of the terms "food loss" and "food waste". To address this issue, this paper aims to provide an ontological analysis of food waste with a focus on FoodOn: an ontology of food and food production that is developed in compliance with the upper ontology Basic Formal Ontology (BFO). We propose the notion of "food material waste" and characterize it in terms of bearing a realized "food waste role". The basic idea is that food waste has a relevant sociotechnical dimension and its relational nature can be analyzed in terms of roles in BFO because they are inherently relational. We also discuss this role-based account of food waste in connection with role-based approaches to food (material) and food products as well as with a list of eight criteria for defining food waste proposed recently by A. Borghini and N. Piras.

Keywords

food waste, food loss, food, food material, food product, role, FoodOn, Basic Formal Ontology (BFO)

1. Introduction

There is a burgeoning demand for an in-depth study of food waste in many domains of inquiry [1]. This is not least because, given that a considerable amount of food is nowadays wasted through an industrialized system of food production, food waste as a contributor to climate change [2] (through GHG emissions from agricultural over-production and disposal of food) is detrimental to the environment; and it can also raise some serious ethical concerns, e.g., as to environmental sustainability [3, 4]. Minimizing food waste is a global problem that must be tackled to achieve food sustainability and security, and this calls for interdisciplinary collaborations [5].

Such interdisciplinary research is hampered by the lack of broad agreement about what food waste is like. As we will see below, there are many different definitions of the terms "food waste" and "food loss" in the literature that it may be notoriously difficult to create a general framework for the conceptualization and measurement of food loss and waste. In some contexts the term "food waste" is used synonymously with "food loss", as food loss and waste may be sometimes lumped together under the abbreviation "FLW". In other contexts, "food waste" is defined as distinct from "food loss". In others, food loss is understood as a kind of food waste.

To address this issue, we will provide an ontological analysis of food waste which will serve to theoretically underpin a general ontology of food and to facilitate a cross-domain study of food waste. For this purpose, we will consider the treatment of food waste that can be integrated into FoodOn [6], namely an existing ontology of food and food production that is developed in accordance with the upper

Proceedings of the Joint Ontology Workshops (JOWO) - Episode XI: The Sicilian Summer under the Etna, co-located with the 15th International Conference on Formal Ontology in Information Systems (FOIS 2025), September 8–9, 2025, Catania, Italy

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published 2026-03-02

ontology Basic Formal Ontology (BFO) [7, 8]. This is partly because the notion of food waste remains underexplored in FoodOn and its ontological scrutiny will be useful in fulfilling the goal of FoodOn to give a comprehensive representation of the food-related reality, ranging from food production to food consumption and disposal.

The paper is organized as follows. Section 2 adumbrates preceding works on food waste and food loss, in particular on their definitions. Section 3 investigates the notion of food waste within the framework of FoodOn and BFO. Section 4 discusses our account of food waste in connection with some recent foundational approaches to food material and food product in FoodOn, as well as with a list of eight criteria for a theory of food waste — which have been recently proposed by Borghini & Piras [9]. Section 5 concludes the paper with some remarks on future work.

2. Related work on food waste

There is a wide diversity of definitions of the terms "food waste" and "food loss" in the literature (see [10, 11] for a general overview). For instance, one of the most widespread definitions of these terms is given by the Food and Agriculture Organization of the United Nations as follows:

> Food loss is the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retail, food service providers and consumers.
>
> Food waste is the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food services and consumers. [12, p. 5]

These FAO definitions have at least two key features. Firstly, both food loss and food waste are defined from the standpoint of the food supply chain (see [13] for a literature review of many similar conceptual characterizations in this supply domain). Secondly, food loss and food waste may be indistinguishable in outcome — a decrease in food quantity/quality — but are distinguished from each other by the actor and stage involved. As FAO says, this distinction is "highly relevant" from a "policy point of view", "as the types of interventions that can affect consumer behaviour (food demand) are different from those that encourage suppliers to reduce food losses (food supply)" [12, p. 5].

However, the distinction (as embraced by FAO) between food loss and food waste may require caution from an ontological viewpoint. For instance, Borghini et al. [2] state:

> This distinction [between food loss and food waste] is typically drawn in terms of the early stages (food loss) and final stages (food waste) of the food chain. But, what counts as early or final is often underdetermined too. Should we regard a food with a short shelf life, which goes unsold and hence expired in a supermarket, as a food loss (emphasizing the responsibility of the producers) or a food waste (focusing on the choices of the consumers)? [2, p. 858]

For another example, Boiteau & Pingali [14] argue that a definition of food loss and waste given by FAO in 2014 can serve as a comprehensive and globally applicable framework for defining them. They summarize that FAO 2014 definition as follows:

> Food loss and waste is a reduction in the quantity or quality of the edible portion of food intended for human consumption when food is redirected to non-food uses or when there is a decrease in the nutritional value, food safety, or other quality aspect from the time food is ready for harvest or slaughter to consumption. [14, p. 7]

Generally speaking, existing perspectives on food loss and waste (as introduced above) tend to focus on its processual aspect, whereas we will investigate the material aspect — the former and latter being understood in terms of the general ontological distinction between continuants and occurrents.

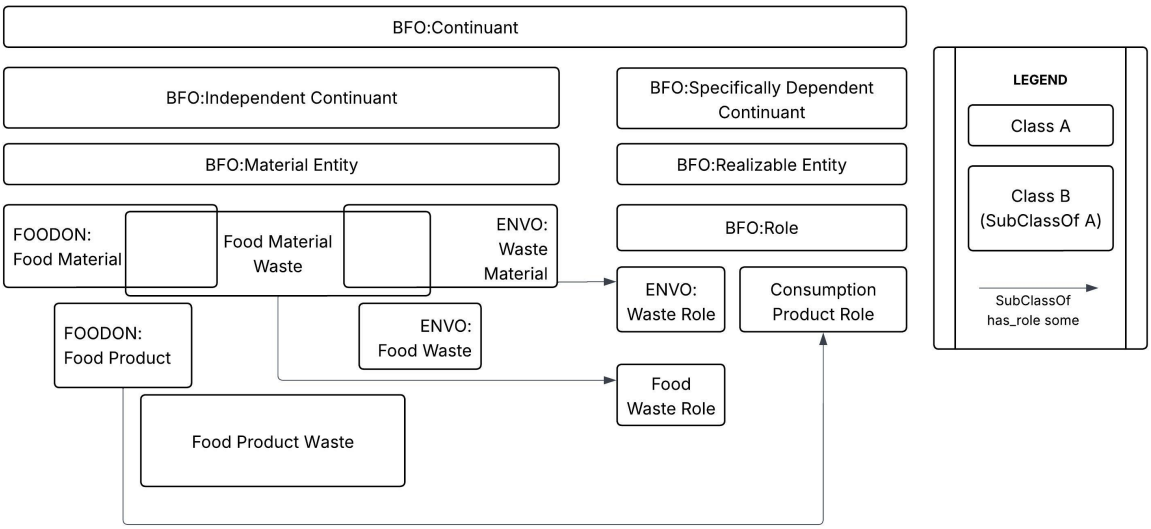

Figure 1: An ontology comprising terms for the classes discussed in this paper

Finally, there is nowadays a heightened awareness of the utility of the ontology of food waste, as it can enhance data integration and knowledge discovery that relate to food waste [15], and the combination of food ontologies with artificial intelligence has the potential to foster sustainable food systems [16]. Based on Boiteau & Pingali's [14] work, an ontological analysis of food consumption, loss and waste has been provided [17]. In a more theoretical direction, Borghini & Piras [18] argue that the issue of defining food waste can be addressed through a study of what they call the "duration question": "when it is that the predicate-schema 'Is an *X*-Food,' where '*X*-Food' stands for a certain type of food (e.g., Champagne, yoghurt) ceases to apply to an entity?" (ibid., p. 444). Borgini & Piras [9] provide a list of eight criteria that a theory of food waste should meet to comply with the demands of different scientific and agential fields (see Section 4.3 for detailed discussion).

3. Food waste in FoodOn

3.1. Preliminaries: BFO and FoodOn

FoodOn is an ontology for representing multifarious food-related entities, ranging from natural materials (e.g., plants and animals) that can be consumed by humans and domesticated animals, as well as food products (e.g., apple pies), to processes of food preparation (e.g., planning) and food production. It has been formalized in the Web Ontology Language (OWL) and developed in compliance with the Open Biological and Biomedical Ontology (OBO) Foundry [19, 20], the upper ontology Basic Formal Ontology (BFO) [7, 8] and many other OBO- and BFO-compatible domain ontologies such as the Ontology for Biomedical Investigation (OBI) [21] and the Environmental Ontology (ENVO) [22, 23].

Figure 1 represents an ontology comprising terms for the classes discussed in this paper. This ontology consists of terms denoting classes that are extracted from FoodOn, BFO, ENVO and the existing work [24] as well as terms denoting new classes to be proposed in what follows. To forestall terminological confusion, we write terms for classes and relations in italic, where class terms begin with uppercases (e.g., *Plant piece* and *has_role*) and terms for instances in bold (e.g., **plant piece$_1$**), respectively. We occasionally add an ontology name to a term used in that ontology (e.g., FoodOn:*Plant piece*). We adhere partially to the Manchester Syntax for OWL (e.g., "*Plant piece* SubClassOf *Material entity*").

BFO includes the top-level distinction between continuants and occurrents. Regarding continuants, independent continuants include material entities such as plants. A specifically dependent continuant is a continuant that depends (existentially) on at least one independent continuant. Subtypes of *Specifically*

dependent continuant include *Quality* (e.g., the shape of a plant) and *Realizable entity* (e.g., edibility; cf. [25] for food-relevant realizable entities).

Among realizable entities in BFO, a role is a realizable entity that (1) exists because the bearer is in some special physical, social, or institutional set of circumstances in which the bearer does not have to be (optionality), and (2) is not such that, if this realizable entity ceases to exist, then the physical make-up of the bearer is changed (external grounding). Examples of roles in BFO include the role of being a student and the role by a stone of marking a boundary.

Regarding occurrents, a process in an occurrent that exists in time by occurring, i.e., by having (proper) temporal parts, and which depends on at least one independent continuant as participant. Examples of processes in BFO include a process of discarding a plant or a process of mold growing on a yoghurt.

Of paramount importance in FoodOn are the classes *Food material* and *Food product*. These two terms are defined in FoodOn as follows:

> food material (FOODON_00002403) $=_{\text{def.}}$ Any substance that can be consumed by an organism to satisfy nutritional or other health needs, or to provide a social or organoleptic food experience.

> food product (FOODON_00001002) $=_{\text{def.}}$ Food material for humans and animals which is processed with the intention that it be consumable as a whole or added to other food products.

The FoodOn classes *Food material* and *Food product* have been recently scrutinized by Barton et al. [25] and Toyoshima et al. [24], respectively (see Sections 4.1 and 4.2 for details).

3.2. Food waste in the ENVO

Although it is not exported to FoodOn, the class *Food waste* is included in the ENVO. In the ENVO, *Food waste* is a subclass of *Waste material* (which is in turn a subclass of BFO:*Material entity*) and *Waste material* is characterized in terms of *Waste role*. The definitions of these three terms and one relevant axiom (based on *has_role*; RO_0000087) in the ENVO are presented as follows:

> waste material (ENVO_00002264) $=_{\text{def.}}$ A material which is not the desired output of a process and which is typically the input of a process which removes it from its producer (e.g., a disposal process).

> waste role (ENVO_01000665) $=_{\text{def.}}$ A role that is realized in some process wherein the bearer is discarded or not utilized further.

> (1) *Waste material* SubClassOf (*has_role* some *Waste role*)

> food waste (ENVO_03600006) $=_{\text{def.}}$ A waste material which is primarily composed of uneaten food and removed from the food supply chain.

To illustrate them, consider two instances (**plant piece$_1$** and **plant piece$_2$**) of the class *Plant piece* (FOODON_00004333; $=_{\text{def.}}$ An anatomical or other piece derived from a plant.) such that they are pieces of the same particular plant. Suppose that both plant pieces are harvested, packaged for consumption, transported to the same supermarket, and given the same best-before date: January 2, 2025. Suppose further that **plant piece$_1$** is sold on January 1, 2025 and is consumed the following day, whereas **plant piece$_2$** remains unsold on January 3, 2025 and has been discarded by the food supplier. Then, **plant piece$_1$** on January 1 and **plant piece$_2$** on January 3 are food materials (more specifically: food products), and **plant piece$_2$** on January 3 (but not **plant piece$_1$** on January 1) is food waste and bears some waste role.

3.3. Food material waste and food waste role

We will examine the ENVO characterization of food waste. On the one hand, the definition of the ENVO term "food waste" may be problematic in at least two respects. Firstly, the second part of the differentia of the definition, "removed from the food supply chain", would imply that food waste stems from some process(es) in the food supply chain. Although many existing definitions of food loss and waste may appeal to the food supply chain (see Section 2), we suggest that the notion of food waste in a general ontology of food and food production should be broad enough — beyond the scope of the food supply chain — to deal with e.g., the case in which I consume a piece of a naturally grown plant in my garden and discard the rest — which would not be ENVO:food waste.

Secondly and more importantly, the first part of the differentia of the definition, "primarily composed of uneaten food", would seem to imply that food waste is primarily food. In effect, **plant piece$_2$** on January 3 can be considered both as ENVO:food waste and FoodOn:food material. This consequence may be controversial. According to Coles & Hallett [26], for instance, salmon heads are valued as foodstuffs in some market places but are food waste in others. Based on their observation, Van Bemmel & Parizeau [27] argue that "food waste is relationally defined in the food value chain" and "socio-cultural norms and other systematic factors are central to determinations of when food has transformed into waste" (ibid., p. 217). This relational view of food waste can motivate us to embrace the moderate view that some food waste may be food in some contexts but not in others, instead of thinking (in the ENVO's spirit) that food waste is food in (almost) all contexts (see Section 4.1 for more thoughts in connection with the relational character of food).

On the other hand, the relational nature of food waste in question may well be accommodated along with the ENVO's role-based characterization (as formulated by axiom (1)) of *Waste material* in terms of *Waste role*. This is because roles in BFO have an inherently relational nature in virtue of their external grounded-ness (see [28, 29] for details). Taking a cue from the definitions of ENVO:*Waste role* and "appropriate food role" [25] (see Section 4.1 for details), we propose the terms "food waste role" and "food material waste" and an associated axiom, using the *has_role* (introduced in Section 3.2) and *realized_in* (BFO_0000054) relations, as follows:

> food waste role $=_{\text{def.}}$ A role (i) whose bearer was or is a food material and (ii) that exists because the bearer is now considered by some agent as inappropriate for consumption by ingestion in order to fulfill nutritional needs or to provide organoleptic experiences and (iii) that can be realized in a process in which the bearer is not consumed accordingly over time.

(That is, the realizations of a food waste role are its bearer not being consumed in order to fulfill nutritional needs or to provide organoleptic experiences over a certain period of time. Further exploration will require a rigorous ontological analysis of processes in BFO [30, 31].)

> food material waste $=_{\text{def.}}$ A material entity (i) that was or is a food material and (ii) that is considered as inappropriate by some agent for consumption by ingestion in order to fulfill nutritional needs or to provide organoleptic experiences and (iii) that is not consumed accordingly.

> (2) *Food material waste* SubClassOf (*has_role* some [*Food waste role* and (*realized_in* some *Process*)])

For example, **plant piece$_2$** on January 3 (but not **plant piece$_1$** on January 1) is food material waste because it bears a food waste role (**food waste role$_2$**) that is realized — in other words, it bears realized **food waste role$_2$**.

We make some clarifications on these two new terms and their definitions. First, the term "agent" figuring in these definitions can refer to collective agents [32] as well as individual ones. Second, some instances of *Food material waste* are also instances of *Food material* ("*is* food material"); but other instances thereof are not, even if they must have been so in the past ("*was* [...] food material") (see Section 4.1 for details).

Third, items (ii) and (iii) of the definition of the term "food material waste" correspond to the OWL class (*has_role* some [*Food waste role* and (*realized_in* some *Process*)]) figuring in axiom (2). For that matter, the definition of "food waste role" and axiom (2) may appear somewhat complex, but they result from the refinement of the ENVO notion of waste role and axiom (1), as the definition of the ENVO term "waste role" might be taken to entail the status of the bearer not *having been* utilized further ("A role that *is realized* in some process [...]"). Relatedly, we remain agnostic as to whether *Food waste role* is a subclass of ENVO:*Waste role* or not. We also note that BFO:*Process* in axiom (2) could be further articulated in terms of a disjunction of specific kinds of processes, such as *Discarding* (OBIB_0000011) from the BFO- and OBO-compliant Ontology for Biobanking ($=_{\text{def.}}$ A planned process that gets rid of a material that is no longer useful or desirable).

Fourth, although inedibility may be sometimes closely associated with food waste (e.g., [14]), our definition of food material waste does not imply that all inedible material entities are food material waste. In particular, some inedible material entities — such as animal bones, fruit cores and pieces of plastic — would not be food material waste because they may never have been regarded as food material altogether. We find this consequence desirable, as the distinction between food components that were inedible from the beginning and food waste has been used in empirical studies on food waste (see e.g., [33]).

Fifth and finally, our proposal might seem to imply that food waste is not a *bona fide* entity because food waste role is a *fiat* entity introduced by us. Although it may be uncustomary and even counterintuitive to consider food waste as a role-based entity, we think that this kind of revisionary perspective will be helpful in theoretically underpinning an ontology of food waste. For instance, Borgini & Piras [9] argue that "adverbialism" about food waste will serve to provide a unified theoretical framework for food waste. In particular, they suggest using the *ad hoc* word "wastingly" in studies on food waste, as "substantivalism" about food waste — which treats the term "food waste" as a noun — would undesirably subscribe to the "uniqueness" ("if something is food waste, then it cannot be food") and "irreversibility" ("food that has become waste cannot be turned into food again") of food waste. From Borgini & Piras's perspective, our approach may be interpreted as accommodating the non-uniqueness and reversibility of food waste (as analyzed and illustrated above) in terms of food waste role, while retaining the usage of the noun phrase "food waste material" — see also Section 4.3 for discussion about Borgini & Piras's list of eight criteria (including reversibility) for defining food waste.

4. Discussion

4.1. Food waste and food (material)

We proposed to illuminate the relational character of food waste by means of the notion of food waste role. This proposal can be combined with the view [25] that the general notion of food (e.g., FoodOn:*Food material*) can be analyzed in terms of the notion of "appropriate food role":

> appropriate food role $=_{\text{def.}}$ A role of a material entity of a type that is generally considered by some agent as appropriate for consumption by ingestion in order to fulfill nutritional needs or to provide organoleptic experiences. [25, p. 7, with slight modifications]

The underlying idea here is that food has a relational nature. In more detail, being food and being of a specific food kind (e.g., *Yogurt*) can have some substantive social dimension, as is supported by Borghini & Piras [18] contention that "fixing the application conditions of an *X*-food depends upon a social structure" (ibid., p. 447) in relation with their "duration question" (see Section 2).

We suggest that the interrelationship between food waste and food can be analyzed in terms of the combination of food waste roles and appropriate food roles. Recall that, on January 3, 2025, **plant piece$_2$** is food material waste and it bears realized **food waste role$_2$**, as it is regarded as inappropriate for food consumption and thereby has been discarded by the food supplier. Suppose that **plant piece$_2$** is considered by somebody else as appropriate for consumption, as it has only just passed the best-before day, and it comes to bear an appropriate food role (**appropriate food role$_2$**).

If the food supplier still finds **plant piece$_2$** to be inappropriate for food consumption and leaves it discarded accordingly, then **plant piece$_2$** would continue to bear realized **food waste role$_2$** and, given the supposition, it also bears **appropriate food role$_2$**. Moreover, **plant piece$_2$** would be both food material and food material waste. By contrast, if the food supplier no longer intends to discard **plant piece$_2$** or views it as appropriate for food consumption, then **plant piece$_2$** would cease to bear **food waste role$_2$** and, by axiom (2), it would cease to be food material waste. Furthermore, **plant piece$_2$** would be food material and, based on the supposition, it bears **appropriate food role$_2$**.

We can also formally link food waste roles and appropriate food roles. For example, it is reasonable to think that any realization of a food waste role is not a realization of any appropriate food roles. We can formalize this statement in OWL, using the *realized_in* (introduced in Section 3.3) and *realizes* (BFO_0000055) relations, as follows:

(3) *Food waste role* SubClassOf [*realized_in* not (*realizes* some *Appropriate food role*)]

We leave open the question of whether (3) should be considered as an axiom or a theorem derived from axioms, to be explored in future work.

4.2. Food waste and food product

Toyoshima et al. [24] develop two ontological approaches to food products with the aim of enriching the axiomatization of FoodOn:*Food product*. According to their "role-based approach" among them, food products can be characterized in terms of the notion of "consumption product role". The definition of this term (relying on the OBI term "planned process"; OBI_0000011) and an associated axiom are presented as follows:

consumption product role $=_{\text{def.}}$ A role to be realized in a planned process in which the bearer is consumed.

(4) FoodOn:*Food product* SubClassOf (*has_role* some *Consumption product role*)

On January 1, 2025, for example, **plant piece$_2$** bears a consumption product role (**consumption product role$_2$**). But on January 3, **plant piece$_2$** would cease to bear **consumption product role$_2$**, as it is not planned to be consumed after the before-best date.

This role-based approach to food products may be useful in understanding the definitions of food waste (and food loss) that appeal to the food supply chain. Let us introduce the term "food product waste" as follows:

food product waste $=_{\text{def.}}$ A food material waste that was or is a food product.

Note that *Food product waste* can be considered as a subclass of *Food material waste*, as *Food product* is a subclass of *Food material*. For instance, **plant piece$_2$** on January 3 would be a food product waste, as it was a food product; and it is considered as inappropriate as food material and thus has been discarded by the food supplier. Seen from the viewpoint of the ontology of food-relevant roles, **plant piece$_2$** on January 3 ceases to bear **consumption product role$_2$** and, by contrast, it bears **food waste role$_2$**, which is realized.

We can also formally associate food waste roles with consumption product roles. For example, it is plausible to think that any realization of a food waste role is not a realization of any consumption product roles. This assertion can be formalized in OWL as follows:

(5) *Food waste role* SubClassOf [*realized_in* not (*realizes* some *Consumption product role*)]

As with (3), we leave open the question of whether (5) should be considered as an axiom or a theorem derived from axioms, to be explored in future work.

4.3. A list of eight criteria for defining food waste by Borghini & Piras

Borgini & Piras [9] provide a list of eight criteria that a theory of food waste should meet to comply with the demands of different scientific and agential fields (p. 3, Table 2):

- Reversibility: A food-waste definition should account for items that may later be reclassified as non-waste.
- Relationality: A food-waste definition should account for the specific relations that render any item food waste.
- Possibility: A food-waste definition should account for the specific likelihood that each item has to become waste.
- Vagueness: A food-waste definition should account for items whose status as food waste is sometimes undetermined.
- Value-sensitivity: A food-waste definition should account for the values involved in regarding something as food waste.
- Agentivity: A food-waste definition should account for the different kinds of agents involved in the production of food waste. Those agents can be aware or unaware, identifiable or unidentifiable, human or non-human; they can have different beliefs, perspectives and ends in regard to food waste.
- Exceptionality: A food-waste definition should account for exceptional cases in which the term takes on a different meaning and does not apply to commonly wasted items.
- Luck: A food-waste definition should account for factors beyond human control that are not predictable and thus unavoidable.

It will be beneficial to evaluate our role-based account of food waste according to this list of eight criteria. First of all, as we argued in Section 3.3, it can meet Reversibility and Relationality — not least because roles in BFO are inherently relational. It may also fulfill Agentivity, as the definition of food material waste is based on the notion of agent that is general enough to accommodate different (e.g., non-human) agents with different views of food waste ("is now considered by *some agent* as inappropriate for consumption").

Next, our proposal may not directly satisfy Possibility or Exceptionality, but it may be capable of capturing the basic ideas behind these criteria. Certainly, the definition *per se* of food material waste does not (and arguably should not, since this is an empirical matter rather than a definitional one) account for "the specific likelihood that each item has to become waste", nor for "exceptional cases in which the term takes on a different meaning". But regarding Possibility, this definition implies the modal character of food waste, because food material waste is characterized in terms of food waste roles and roles in BFO are inherently modal. As for Exceptionality, Borghini & Piras illustrate this criterion with an example of "ideological mismatch" [9, p. 2]. Our definition of food waste material, by emphasizing that it is considered as "inappropriate for consumption" by some agent, accounts for differing viewpoints based on ideologies — in line with Relationality and Agentivity above discussed.

Finally, while Vagueness, Value-sensitivity and Luck may go beyond the scope of our role-based account of food waste, they could still be associated with it. Concerning Vagueness and Value-sensitivity, the underdetermination and value-laden dimension of food waste can result from the cognitive element

of the notion of food waste role ("is now *considered* by some agent as *inappropriate* for consumption"). Concerning Luck, "factors beyond human control" relevant to food waste may be considered as part of some special — unpredictable and unavoidable in particular — set of circumstances in which food waste exists (cf. the elucidation of roles in BFO; see Section 3.1).

5. Conclusion

We provided an ontological analysis of food waste in the context of FoodOn, so as to take the first steps towards an interdisciplinary framework for considering and minimizing food waste. More specifically, we proposed that the notion of "food material waste" can be characterized in terms of the notion of "food waste role", to wit, in terms of bearing a realized food waste role. This role-based account of food waste is buttressed by the idea that food waste has a relevant social dimension and its relational character can be analyzed in terms of the BFO notion of role because roles in BFO are by nature relational. We also discussed the linkage between the role-based view of food waste, on the one hand, and role-based approaches to food (material) and food products as well as a list of eight criteria for defining food waste by Borghini & Piras, on the other hand.

There are several directions of inquiry in which we will be able to further pursue our role-based account of food waste. For instance, it warrants investigation whether "is considered as appropriate" in the definitions of *Food waste role* and *Food material waste* should be reformulated as "would be considered as appropriate, given all relevant information" (this "given" condition implies the perspective of an all-knowing observer). This reformulation is motivated in order to accommodate cases where, for example, a glass of milk left on a kitchen table that has gone bad, unnoticed by any agent, might still be considered as food waste, even if no one actually considers it inappropriate for consumption.

As another example of future work, it will be valuable to strengthen and extend this account with a well-established theory of roles in BFO (see [28, 29] for pointers to this line of study). Coping with this task can be expected to elaborate a role-centered unifying perspective on food (material), food products and food waste, and to solidify a foundational basis for a general ontology of food and food production, such as FoodOn.

Acknowledgments

For FT, this work is part of the project "An Ontology of Production, Products, and By-Products" (2023-2027; grant number #212493) funded by the Swiss National Science Foundation (SNSF). FT is financially supported by SNSF. FT's participation in the relevant workshop is made possible by funding from the Swiss Academy of Humanities and Social Sciences (SAHSS). The research has been conducted in cooperation with the Swiss Center for Ontological Research (SCOR).

For DD, this work is primarily supported by the USDA Non-Assistance Cooperative Agreement 8040-10700-004-023-S.

Declaration on Generative AI

During the preparation of this work, the authors used ChatGPT in order to: Grammar and spelling check, Paraphrase and reword. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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