BREADCRUMB

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DELIVERABLE 1.2

Conceptual model of links between food marketing categories and FW

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BREADCRUMB

Project title	**BR**inging Evidence-b**A**se**D** food **C**hain solutions to prevent and **R**ed**U**ce food waste related to **M**arketing standards, and deliver climate and circularity co **B**enefits		
Project acronym	BREADCRUMB		
Call topic	HORIZON-CL6-2023-FARM2FORK-01		
Type of action	HORIZON-RIA		
Coordinator	EIGEN VERMOGEN VAN HET INSTITUUT VOOR LANDBOUW- EN VISSERIJONDERZOEK - EV ILVO		
Project number	101136701		
Project start date	01/01/2024	Duration	36 months
URL			

D1. 2 - Conceptual model of links between food marketing categories and FW

Due date	**31/03/2024**	**Delivery date**	**29/03/2024**
Work package	WP1		
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Version	v 3.0		
Dissemination level	Public		

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VERSION AND AMENDMENTS HISTORY

Version	Date (MM/DD/YYYY)	Created /Amended by	Changes
0.1	03/06/2024		
0.2	03/15/2024	Paulina Szwed and Nika Palaguta	1. The structure of the deliverable 2. In-depth analysis of desk research 3. Final model visualization and its description
0.3	28.03.2024	Nika Palaguta and Paulina Szwed	4. Implementation of internal recommendations after the internal review.

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LIST OF ABBREVIATIONS

Abbreviations	Full Name
B2B	Business to Business
B2C	Business to Consumers
COOL	The country-of-origin labelling
CMO	The common market organisation
CLD	Causal Loop Diagram
EC	The European Commission
EFSA	The European Food Safety Authority
EU	The European Union
FAO	Food and Agriculture Organization
FW	Food Waste
FMS	Food Marketing Standards
F&V	Fruits and Vegetables
GMOs	Genetically Modified Organisms
HACCP	Hazard Analysis and Critical Control Point
PO	Producers Organization
PDO	Protected Designation of Origin
PGI	Protected Geographical Indication
TSG	Traditional Specialty Guaranteed

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2 EXECUTIVE SUMMARY

This report is the second deliverable of WP1 of the BREADCRUMB project. In this report, we aim to provide **a preliminary conceptual model depicting the potential influence of each one of the categories of marketing standards included in Regulation (EU) 1308/2013 on Food Waste (FW) generation.** This conceptual model considers categories of marketing standards rather than specific standards within each category. The research on specific standards will follow in the next stages of the project.

The conceptual model is crucial in analysing prior research findings and guiding interactions in upcoming tasks of the project, namely T1.3, T1.4, T2.1, T2.2, T2.3, and T3.1. While the preliminary conceptual model focuses on marketing standards categories rather than specific standards within each category, T1.3 and T1.4 will explore the latter, contributing to an enhanced and deeper conceptual model. T1.3, T1.4, T2.1, T2.2, T2.3 will focus on empirical research on food marketing standards (FMS) including further desktop research, fieldwork, creation of the inventory of FMS and further consultations with the experts. The conceptual model will also be considered during the pre-modelling and modelling stages (T3.1 & T3.2), encompassing problem definition and the development of a modelling framework.

The report starts with the explanation of the goals of the BREADCRUMB project and outlines its scope providing definitions of FW and delimiting the boundaries of FMS investigated in this project. Next, the report addresses FW per selected food commodity: fruits and vegetables, meat, eggs, cereals, and fish. The report continues with the detailed desktop research establishing the scientifically proved links between FMS and FW at general level. The report concludes by providing a preliminary conceptual model outlining the potential impact of various categories of FMS specified in Regulation (EU) 1308/2013 on FW generation, offering a perspective to comprehend and tackle the issue effectively and serve as a starting point for task 1.3 and 1.4 in BREADCRUMB.

A preliminary conceptual model outlines the potential impact of the categories of FMS on FW generation supported by previous research. These connections are represented with continuous lines, while those not thoroughly studied and of a more speculative nature are indicated with dashed lines. The casual connection between the categories of FMS and FW and the direction of the connection are indicated by the arrows (->); positive relationship (increase of FW) is marked with the plus sign (+) and negatives (decrease of FW) ones with the minus sign (-).

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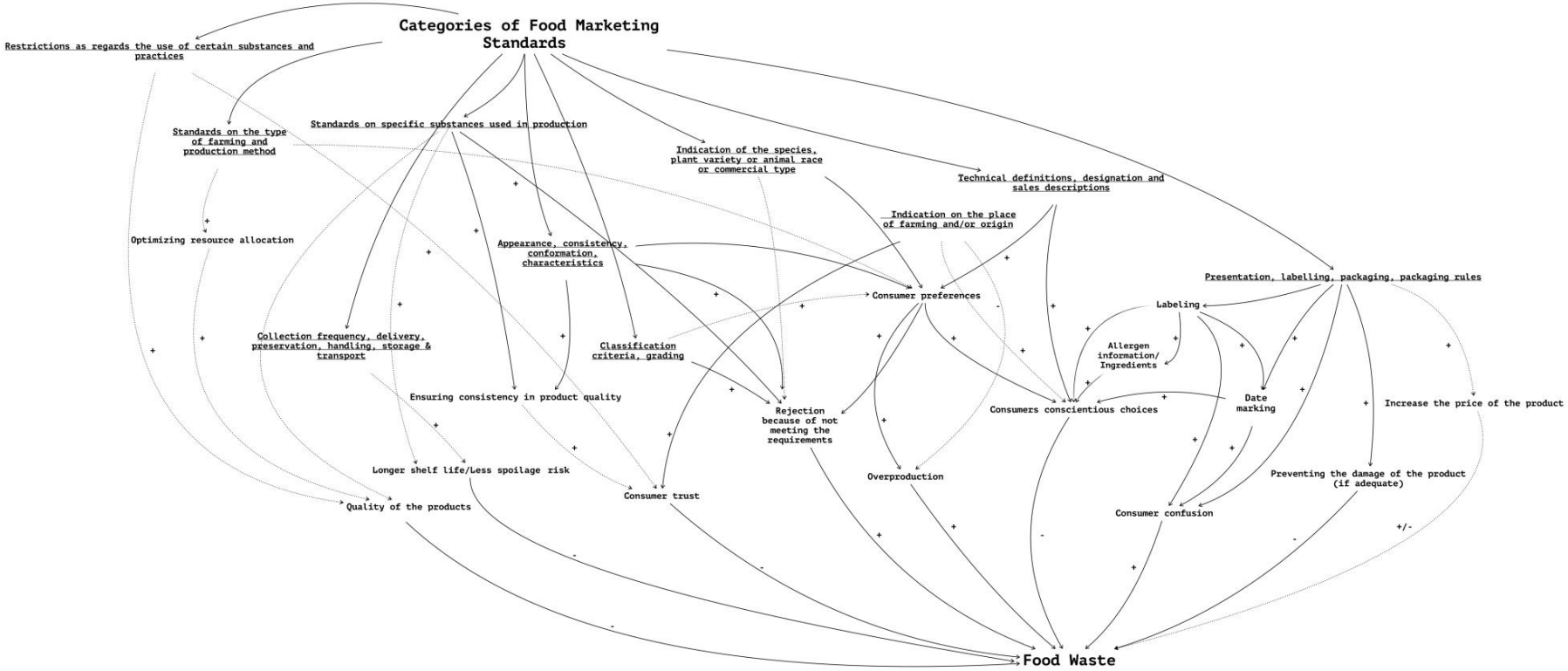
A preliminary conceptual model outlining the potential impact of various categories of food marketing standards on FW presented as a causal Loop Diagram (CLD)



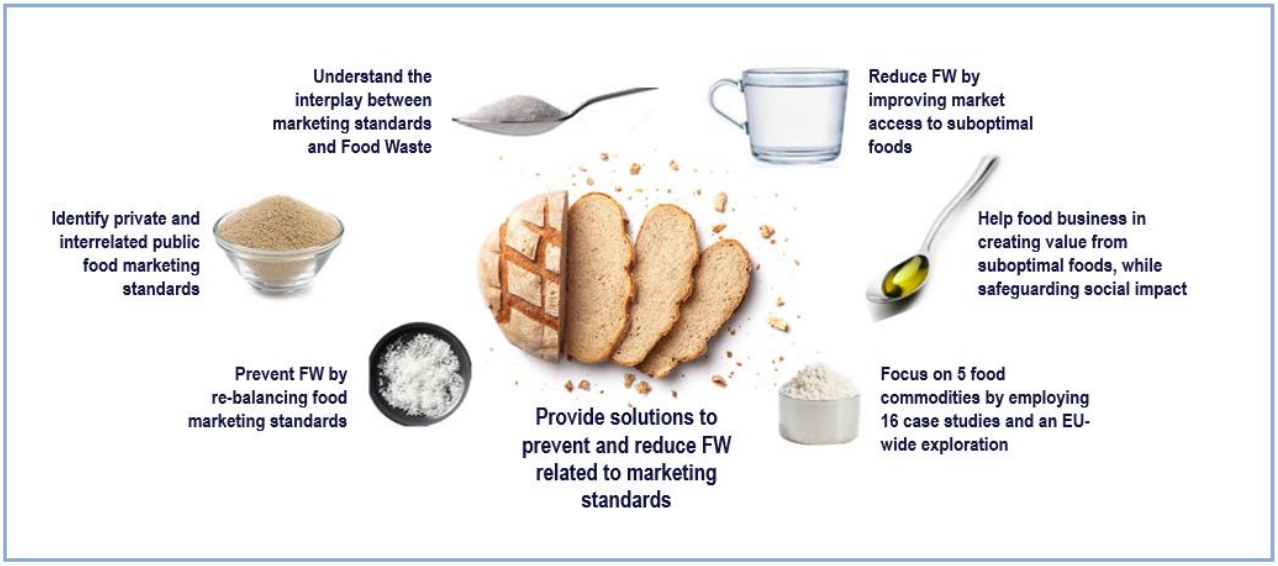
2 INTRODUCTION

2.1 BREADCRUMB Project Summary

The **goals** of the BREADCRUMB project, as outlined in the Grant Agreement, are as follows: **"BREADCRUMB** aims to provide an **empirical evidence-based understanding of the purpose and nature of food marketing standards** and **their impact on FW** *[Food Waste, hereinafter FW]* **generation**, to propose **interventions that balance the objectives of reducing FW and other objectives of standards, and to help food chain actors increase the business potential of suboptimal foods".** (Grant Agreement, Part B, p.3/41)

The Grant Agreement defines the following **procedure** for the project: "(i) establish a holistic view of marketing standards and identify those with key relevance to FW generation; (ii) create evidence-based estimates of FW generated as a consequence of marketing standards; (iii) provide solutions that alleviate the negative impacts of marketing standards to FW, based on a valid understanding of the underlying mechanisms of FW generation and trade-offs with other objectives (re-balancing marketing standards); (iv) enhance the business potential of "sub-optimal" foods; (v) inform and guide food businesses, consumers, owners of standards and policy regulators on how to prevent/reduce FW related to marketing standards" (Grant Agreement, Part B, p.7/41).

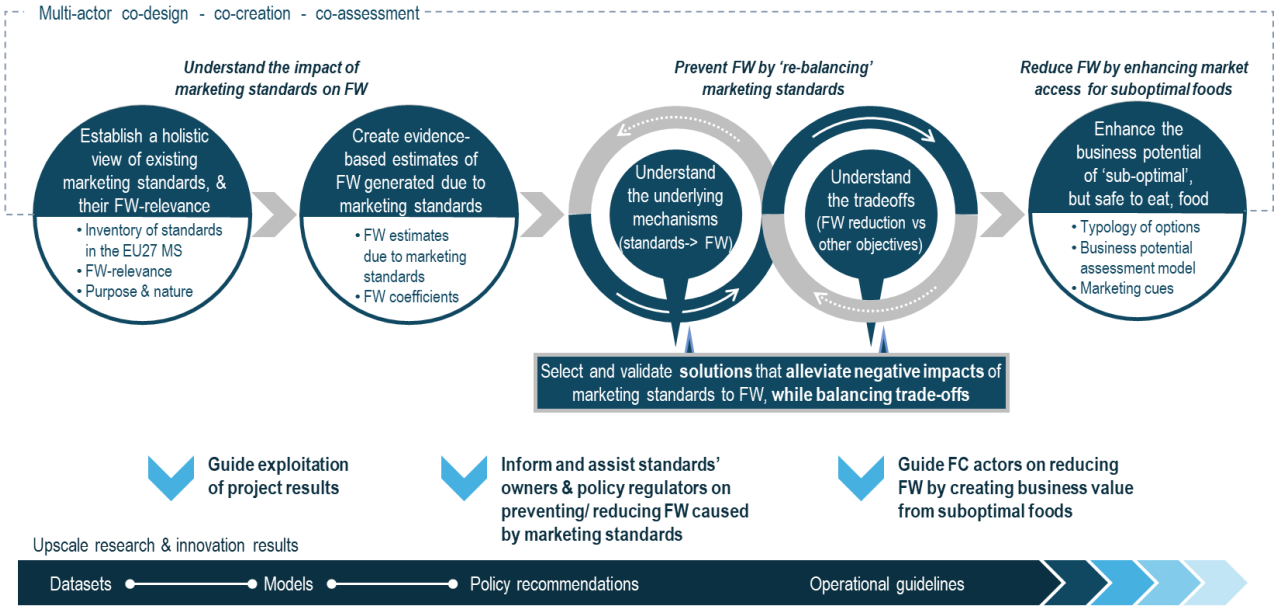
Figure 1: BREADCRUMB project at a glance



Source: Grant Agreement, Part B, p.5/41

To achieve the goals and adhere to the project's methodological approach, BREADCRUMB will **utilise existing research** connecting marketing standards and food waste, **create new evidence** on the impact of marketing standards on food waste, **employ advanced modelling methods** to develop solutions that integrate behavioural and economic theories, **use research findings to assess the business potential of non-optimal but still edible food**, and incorporate research outcomes into **innovative products** (Grant Agreement, Part B, p.7/41).

Figure 2: The concept of BREADCRUMB



Source: Grant Agreement, Part B, p.8/41

Moreover, the project intends to incorporate a **gender perspective** and **intersectional analysis** across the project. Both are pertinent to better understand the design and response to marketing standards affecting food choices, usage, and waste (Grant Agreement, Part B, p.).

To verify the results, the project will employ various **validation methods** involving participants external to the project:

- External Advisory Board (4-5 individuals: researchers, practitioners with complementary expertise);
- Marketing Standards Interest Group (20-30 individuals: food businesses, civil society organisations, FW entrepreneurs, policy actors, and Joint Research Centre representatives);
- Specified consultation events, such as workshops, to widen the validation process with a larger group of diverse actors.

BREADCRUMB is divided into 6 WPs with different goals, tasks, and deliverables to reach its goals.

Deliverable 1.2: Goals and Report Structure

This report is the second deliverable of WP1 of the BREADCRUMB project. In this report, we aim to provide a **preliminary conceptual model** depicting the **potential influence** of each one of the **categories of marketing standards included in Regulation (EU) 1308/2013** on FW generation. The conceptual model considers categories of marketing standards rather than specific standards within each category. **The research on specific standards will follow in the next stages of the project.**

The categories of food marketing standards outlined in Regulation (EU) 1308/2013 within the scope of the BREADCRUMB project include the following:

a) the technical definitions

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b) classification criteria
c) the species, plant variety or animal race or the commercial type
d) the presentation, labelling linked to obligatory marketing standards, packaging, rules to be applied in relation to packing centres
e) criteria such as appearance, consistency, conformation, product characteristics and the percentage of water content
f) substances used in production
g) the type of farming and production method
i) the frequency of collection, delivery, preservation and handling, the conservation method and
j) temperature, storage and transport
k) the place of farming and/or origin
l) restrictions as regards the use of certain substances and practices
m) specific use
n) the conditions governing the disposal, the holding, circulation and use of products.

While the aforementioned categories combine requirements related to product quality, provision of food information to consumers, and safety aspects, **BREADCRUMB focuses on the first two requirements reflected in marketing standards, i.e. food quality and the provision of food information to consumers**, as these are the ones that can have a direct impact on FW generated, and **only for those two FW prevention/reduction actions can be employed to address them**. Moreover, unsafe food is not intended to, nor reasonably expected to be ingested by humans.

2.2 Links with other BREADCRUMB deliverables

This report centres on Task 1.2, which presents **a preliminary conceptual model outlining the *potential* impact of the categories of FMS specified in Regulation (EU) 1308/2013 on FW generation.** Referred to as the "A Conceptual Model of Links Between the Categories of FMS and FW", it plays a crucial role in analysing prior research findings and guiding interactions in future tasks of the project (T1.3, T1.4, T2.1, T2.2, T2.3, T3.1).

While the conceptual model focuses on marketing standards *categories* rather than specific standards within each category, T1.3 and T1.4 will explore the latter, contributing to an enhanced and deeper conceptual model. Task1.3, T1.4, T2.1, T2.2, T2.3 will focus on empirical research on FMS including further desktop research, fieldwork, creation of the inventory of food marketing standards and further consultations with the experts. The conceptual model will also be considered during the pre-modelling and modelling stages (T3.1 & T3.2), encompassing problem definition and the development of a modelling framework.

More specifically, to create models illustrating the connection between specific marketing standards and FW generation, the initial step is identifying the categories of standards for consideration in modelling tasks. This involves **understanding the mechanisms through which these categories influence FW, including identifying issues arising at various stages of food supply chains for various food commodities.** Next, the project's focus will shift to modelling interactions between FMS and FW generation. This entails the creation of a foundational agent-based model to depict various interactions among individuals and organisations, which stem from the implementation of FMS and their impact on FW generation.

2.4 The content of this deliverable

This report explores **the relationship between the categories of FMS and FW, covering several areas**. More specifically, the report starts with **the definitions of FW** and **delimits the scope of FMS** investigated within the BREADCRUMB project. Moving forward, the report presents **a comprehensive examination of key food commodities within the project scope**: fruits and vegetables, meat (poultry and bovine), cereals,

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fish, and eggs. This part of the report aims to elucidate the understanding of the aforementioned food commodities' production processes, identify relevant marketing standard categories, and analyse factors contributing to FW. In addition, the chapters dedicated to the exploration of food commodities, attempt to reveal the areas in the literature requiring further exploration and underscore the significance of FMS for the specific food commodities from a business industrial standpoint. Next, the report addresses **the connections between the categories of FMS outlined in Regulation 1308/2013 and FW** delving into a literature review of scientific studies regarding their interplay. Since there has been a growing interest in understanding how gender influences consumer behaviour, particularly food choices and waste, the report briefly addresses the intricate relationship between gender differences in the perception of marketing standards categories and their connection to food waste. Finally, the report presents **a preliminary conceptual framework model that connects the categories of FMS with FW** based on the available scientific studies. In conclusion, the report juxtaposes the two perspectives: a view on FW from the perspective of food commodities and a view from the perspective of the categories of FMS outlined in Regulation 1308/2013 and concludes on the nature of further investigation required and planned within the BREADCRUMB project.

3 BREADCRUMB PROJECT: KEY DEFINITIONS AND CONCEPTS

3.1 Food Waste

FAO defines **food waste**[1] as "food appropriate for human consumption being discarded, whether or not after it is kept beyond its expiry date or left to spoil. Often this is because food has spoiled, but it can be for other reasons such as oversupply due to markets or individual consumer shopping/eating habits" (FAO, 2013).

According to the definition above, food waste is distinct from food loss that typically occurs at the production, postharvest, and processing stages due to insufficient systems requiring infrastructure investment. In contrast, food waste can happen due to customs and preferences.

The EU-funded project FUSIONS expands the definition by adding "inedible parts" and defines **food waste** as "any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed of (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea)" (FUSIONS, 2014).

The European Commission adopts an even broader definition of food waste, including all supply chain stages. Directive 2008/98/EC[2] stipulates that **food waste** is "All food as defined in Article 2 of Regulation (EC) No 178/2002[3] of the European Parliament and of the Council that has become waste" (page 4, point 4a). In its turn, Regulation (EC) No 178/2002 defines food or foodstuff as "**Any substance or product**, whether processed, partially processed or unprocessed, intended to be, or **reasonably expected to be ingested by humans**" (art.2, p.10). Food or foodstuff can include drink (as well as water), chewing gum, and any substance "intentionally incorporated into the food during its manufacture, preparation or treatment" (art.2, p.10). It does

[1] Food Waste is distinct from Food Loss that "refers to a decrease in mass (dry matter) or nutritional value (quality) of food that was originally intended for human consumption. These losses are mainly caused by inefficiencies in the food supply chains, such as poor infrastructure and logistics, lack of technology, insufficient skills, knowledge and management capacity of supply chain actors, and lack of access to markets. In addition, natural disasters play a role." (FAO, 2013) Another term Food Wastage refers to both food loss and food waste and refers to "any food lost by deterioration or waste." (FAO 2013)

[2] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (OJ L 312, 22.11.2008)

[3] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety (OJ L 31, 1.2.2002).

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not include feed, live animals (unless prepared for placing on the market for human consumption), plants before harvesting, medicinal products, cosmetics, tobacco, and tobacco products, narcotic or psychotropic substances, residues, and contaminants. Commission Delegated Decision (EU) 2019/1597.[4] **The definition of food "encompasses food as a whole, along the entire food supply chain from production until consumption".** Food also includes inedible parts, which were not separated from the edible parts when the food was produced, such as bones attached to meat destined for human consumption.

Directive 2008/98/EC2[2] defines waste as "Any substance or object which the holder discards or intends to, or is required to discard" (page 3). Commission Delegated Decision (EU) 2019/1597[4] highlights that since food has been defined in Article 2 of Regulation (EC) No 178/2002 to include "inedible parts, **where those were not separated from the edible parts when the food was produced** - such as bones attached to meat destined for human consumption", for example - **FW** can thus also be comprised of "items which include **parts of food intended to be ingested** and parts of **food not intended to be ingested"** (Decision (EU) 2019/1597).

The BREADCRUMB project abides by the EU definition of FW. It regards FW as any food or inedible parts reasonably intended for human consumption that became waste along the entire food supply chain.

3.2 Food Marketing Standards

Marketing standards are "**a set of rules aimed to ensure that the single market is supplied with standardised quality agricultural products that meet consumer expectations**" (European Commission, 2020). They aim to improve economic conditions for production, enhance product quality, provide transparent product information, and enable easy access to standardised and satisfactory quality products (Nes & Ciaian, 2021).

3.2.1 Distinction Between Private and Public Food Marketing Standards

Food Marketing Standards can be either **public or private**. **Public standards are regulations enforced by government agencies or international bodies that establish baseline criteria for product quality, labelling, and performance.** These standards **protect public health, welfare, and the environment while promoting fair trade** (Mancini, 2019).

For example, within the European Union, the European Commission can propose legislation on food marketing standards, which may be adopted as mandatory regulations across all member states. Examples include the EU Regulation (EU) 1308/2013 (CMO Regulation) and the so-called "breakfast directives" laying down the rules on the composition, naming, and labelling of certain products.

In contrast, **"private" refers to standards developed, owned, and operated by entities other than public government bodies.** This can include **companies, food manufacturers, non-governmental organisations, industry associations, farmers, and retailers** (Henson & Humphrey, 2009, 2010). Private standards are often considered more adaptable and flexible when meeting changing consumer trends. For example, Tesco Nurture is a standard created by the supermarket chain Tesco to ensure that fruits and vegetables meet responsible cultivation criteria.

Private standards emerged due to the need to **manage risks related to regulatory compliance** and **meet consumer expectations** regarding the safety and quality of food products. In addition, the globalisation of trade, changing social trends, and food scares have created a demand for more reliable mechanisms to ensure

[4] Commission Delegated Decision (EU) 2019/1597 supplementing Directive 2008/98/EC as regards a common methodology and minimum quality requirements for the uniform measurement of levels of food waste.

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trust in food safety. **Traditional public authorities have struggled to keep up with rapid changes in agri-food systems,** which **allowed private stakeholders to develop their own set of private standards** (Henson & Humphrey, 2009, 2010). Private standards may also be used to enhance a company's brand, or even manage suppliers.

Public and private standards can be distinguished based on various factors:

- **Origin of Standards:** Public standards are typically established by public authorities to ensure social welfare, including the interests of producers, consumers, and society. On the other hand, private-sector entities set private standards reflecting their specific interests.

- **Nature of Compliance and Level of Enforcement:** When imposed by public authorities, standards can be mandatory or voluntary. While private standards are inherently voluntary, they may become de facto mandatory due to market pressures or retailer requirements. For example, when private standards are incorporated into public regulatory frameworks or adopted by government agencies as part of regulatory compliance, they become mandatory standards that must be followed, with legal implications for non-compliance.

- **Conformity Assessment:** This refers to verifying adherence to standards and may involve first, second, or third-party assessments. Public standards may rely on governmental spot checks, while private ones often use direct supplier checks or independent third-party certifications.

- **Content and Focus:** Standards may focus on product characteristics (product-focused) or production processes (production process-focused). They also differ in whether they aim to ensure food safety as a government concern tied to public health or food quality that caters to a broader array of attributes such as ethical concerns, product differentiation or creating competitive advantage.

- **User Category:** The distinction here lies between business-to-consumer (B2C) and business-to-business (B2B) standards. B2C private standards signal quality attributes to consumers through labels/certification marks, while B2B ones are used within the supply chain mainly for risk management and ensuring reliability among businesses (Mancini, 2019).

While public standards can adversely affect the quantity of FW, substituting the public with more diverse private standards can also have drawbacks. Private standards are costlier for some companies due to their heterogeneity across products and sectors. In this case, if public standards provide clear guidance, they will be more effective than private standards and can reduce food waste.

3.2.2 Interconnection between private and public standards

Private and public standards are interconnected primarily due to private standards always operating within the overarching legal framework provided by the law. **Both types of standards are enabled and constrained by this legal context.** Nonetheless, public and private standards can be complementary as well: **private standards often build upon public standards by providing more specific and detailed instructions for compliance**. In other words, private standards complement public regulation by translating statutory requirements into practical, operational criteria for industry players. **Private standards can be directly driven by legal requirements** as well. The imposition of legal requirements, such as the EU General Food Law requiring food business operators to have procedures based on Hazard Analysis and Critical Control Point (HACCP) principles, has bolstered the development of private certification schemes. **Compliance with private standards can facilitate adherence to these legal mandates.** Private standards may also emerge in response to perceived inadequacies in government regulation or attempts to restore consumer confidence after food safety incidents. They sometimes **fill gaps in public regulations** by addressing consumer demands swiftly. Finally, in some instances, **public actors may get involved in creating private standards**. For

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example, governmental experts may be involved in developing certain private standards, or retail-driven private standards initiated without state involvement can become de facto requirements due to market forces (Havinga, 2017).

The BREADCRUMB project aims to explore the role of both public and private FMS in FW generation. A detailed exploration of individual standards will be conducted in the upcoming tasks, T1.3, T1.4, T2.1, T2.3. Within this context, **D1.2** aims to create a preliminary conceptual model of the potential impact of the categories of FMS on FW and therefore the **preliminary conceptual model focuses on the standards within categories of FMS, within which, both public and private standards are included.**

Given that the BREADCRUMB project focuses on five food commodities: fruits and vegetables, meat (poultry and bovine), cereals, fish, and eggs, the following chapter of the report delves into the context within which FW is generated for each food commodity.

3 FOOD COMMODITIES AND THE CONTEXT WITHIN WHICH FW IS GENERATED

3.1 Fruits & Vegetables

3.1.1 Fruits & Vegetables Production Processes

The EU employs a variety of agricultural practices for fruit and vegetable cultivation, including conventional, organic, and integrated farming methods. These practices determine factors such as seed selection, irrigation, fertilization, pest management, and harvesting techniques (Eurostat, 2020).

Fruits and vegetable (hereinafter F&V) production involves several phases and requires the participation of various parties. According to Bartezzaghi et al. (2022), the process starts with the initial agricultural production phase, which exclusively involves farmers. Subsequently, the product undergoes storage, handling, processing, or packaging with multiple stakeholders, including traders, producers, processors, manufacturers, transporters, service providers, cooperatives, and consortia. As it progresses to distribution, transportation and eventually to retail, other players, such as retailers, markets, small shops, etc., join in aside from those involved in post-harvesting activities.

The F&V industry in the EU is diverse, with each country within the EU growing a variety of F&V with certain regions specialising in certain crops due to favourable weather conditions and soil quality. Many farms in the EU are small-scale and require a significant amount of manual labour. The value of the gross output of vegetables and horticultural products produced by the EU's agricultural industry is €65.9 billion, 12.3% of the total gross output of agricultural products (Eurostat, 2023).

The EU supports its F&V industry through policies that encourage consumption. The EU focuses on regulatory interventions to address market pressures or seasonal fluctuations. Additionally, **reducing agricultural practices' environmental impact is essential for shaping the sector**'s future. Therefore, **the EU promotes eco-production methods and encourages investments in technological advancements** (Rossi, 2019).

The EU F&V market is influenced by factors such as consumer preferences, seasonal variations, trade policies, and market trends. Understanding market dynamics is crucial for producers to make informed decisions regarding crop selection, pricing, and distribution channels (Eurofruit, 2020).

3.1.2 Food Waste of Fruits & Vegetables

FW during agricultural production of F&V can occur due to various interconnected factors. For instance, **overproduction**, often driven by forecasting errors and the unpredictability of market demand, is a significant

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issue. Furthermore, **strict cosmetic standards** may[5] result in perfectly edible produce discarded because it does not meet the appearance criteria.

Production wastage of F&V in the EU occur at various stages of the supply chain, from cultivation to consumption. F&V may be lost or wasted during cultivation, harvesting, and post-harvest handling due to factors such as weather-related damage, pests and diseases, inadequate storage facilities, and labour shortages (FAO, 2019).

During processing and distribution, additional waste occurs due to quality standards, overproduction, transportation inefficiencies, and market fluctuations. This can lead to discarding of F&V at packing centres, wholesale markets, and retail outlets (Papargyropoulou et al., 2014).

At the retail and consumer levels, F&V are frequently wasted due to various factors, including aesthetic preferences, over-purchasing, improper storage, and misunderstanding of date labels (Stenmarck et al., 2016).

During the **packaging and processing** phases, FW is generated due to **F&V needing to meet retailers' quality standards**. Additionally, **consumer attitudes toward imperfect-looking F&V** contribute to this issue by leading to trimming or outright discarding parts of the produce before reaching consumers, despite being edible.

FW occurs during **handling, storage, wholesale, and retail distribution** due to operational inefficiencies and infrastructure shortcomings. **Inappropriate maintenance of the cold chain, insufficient cold-chain equipment, and inadequate storage facilities** can lead to perishable items not being kept at optimal temperatures, hastening their degradation. These factors contribute to mechanical damage and biochemical deterioration, ultimately increasing waste. Furthermore, **defective, or unsuitable packaging** can also result in heightened spoilage and waste. Naturally, consumers' opinions about appearance become more prominent in retail (Augustin et al., 2020, Bartezzaghi et al., 2022).

3.1.3 The EU Regulations and FMS Related to F&V

One of the key regulations for F&V production in the EU is Regulation (EU) No 1151/2012, which sets the guidelines to **define quality rules and schemes for specific products to promote their unique characteristics linked to their geographical origin** and traditional know-how. It sets criteria and procedures for the recognition and registration of agricultural product quality schemes such as Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), and Traditional Specialty Guaranteed (TSG). **Quality schemes** for agricultural products may indirectly affect the variety of species: products with geographical indications must often comply with standards concerning the plant species and the allowed varieties of raw materials used in production. In 2017, 117 PDO, PGI and TSG products were counted at the European level.[6] Often, geographical indications of products have a link to Producers Organization (PO) for the success and management of production schemes. Each PO applies EU Regulation No 1151/2012 to the production of geographical indication goods by potentially setting additional standards regarding the origin of plant production.

Regulation (EU) No 848/2018 defines **production standards for organic products**. **Organic production excludes synthetic inputs**, including plant protection products, exposing crops to a higher risk of attack by insects and pathogens such as fungi and bacteria. The regulation also includes provisions on certification and the recognition of certification. However, some organic certification bodies may add additional private standards or requirements beyond the minimum requirements established at the European level. These

[5] Some F&V not meeting the FMS criteria can be sold for processing thereby avoiding being waste.
[6] ISTAT http://dati.istat.it/Index.aspx?QueryId=35169&lang=en

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additional standards may be developed to meet specific market needs or consumer demands, and they can be related to specific farming practices, environmental protection, and social responsibility (e.g., Demeter, Ecocert, Naturland)[7].

Marketing standards related to the type of **farming and production method** of F&V are often put in place to distinguish between different farming practices and production methods, particularly in organic and conventional agriculture. This category of standards is based on **certifications** provided to farmers by national and international certification bodies. The organic production control system and the recognition of certification are regulated by **Regulation (EU) No 848/2018** on organic farming, which states that national bodies issue certifications following inspections concerning compliance with regulations.

Following Regulation (EU) No 1333/2008, food additives are authorised and used to maintain consumer safety and transparency of food labelling. This legislation applies **strict criteria to fruits and vegetables to maintain their quality, freshness, and nutritional content throughout the processing and packing value chain.** The European Food Safety Authority (EFSA) conducts thorough safety assessments on additives and adherence to Hazard Analysis and Critical Control Points (HACCP)[8] enforced by prohibiting or restricting specific additives in specific fruit and vegetable applications.

Regulation (EU) No 543/2011 sets requirements concerning the **appearance, consistency, conformation, maturity, and product characteristics** of fruit and vegetable products, specifying the **"class" a product falls into, depending on specific criteria. It also sets specific standards for marking**, depending on the products. Some common requirements regarding the marking of the products are: identification of **the origin, identification of the packer and/or dispatcher, nature of produce, and commercial specifications (e.g., class and size).** Additionally, **Regulation (EU) No 1169/2011** adds other requirements in terms of **information to be provided to consumers**: *"a) information on the identity and composition, properties or other characteristics of the food; b) information on the protection of consumers' health and the safe use of a food, in particular on: (i) compositional attributes that may be harmful to the health of certain groups of consumers; (ii) durability, storage and safe use; (iii) the health impact, including the risks and consequences related to harmful and hazardous consumption of a food; (c) information on nutritional characteristics to enable consumers, including those with special dietary requirements, to make informed choices"* (Article 4).

3.2 Meat (Poultry & Bovine)

3.2.1 Meat production processes

Poultry

Poultry meat plays a crucial role in the meat sector of the EU; it is the second most widely produced and consumed type of meat after pork. The EU is one of the largest poultry producers. In 2022, 13 million metric tons of poultry meat were produced, with Poland, Spain, and Germany emerging as the leading producers[9]. The most common type of poultry meat produced and consumed in Europe is chicken (broiler), followed by

[7] It is important to note that some organic certification bodies may add additional private standards or requirements beyond the minimum requirements established at the European level. These additional standards may be developed to meet specific market needs or consumer demands, and they can be related to specific farming practices, environmental protection, and social responsibility (e.g., Demeter, Ecocert, Naturland). Retailers can require other certifications that can and can be private marketing standards are those related to the sustainability of agricultural practices like Rainforest Alliance, which ensures that fruits and vegetables are produced according to rigorous environmental, social, and economic sustainability standards, GlobalGAP (Good Agricultural Practices), which focuses on food safety, environmental sustainability, and social welfare, or LEAF (Linking Environment And Farming) brand which promotes integrated farm management practices that enhance biodiversity, soil health, and resource efficiency in fruit and vegetable production.

[8] https://haccp-international.com/

[9] https://www.statista.com/

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turkey, duck, and other poultry varieties. Chicken is the most consumed poultry meat, with chicken breasts, legs, and whole chickens being the most popular cuts. Consumers especially appreciate them due to their affordability and versatility. Poultry meat production in the EU is highly diverse and characterised by a variation between large-scale industrial production and small, family-based farms. Although the **indoor farming system is the most common, there is a growing demand for free-range and organic methods that prioritise animal welfare, sustainability, and ethical aspects of meat production** (Augère-Granier, 2019).

The poultry meat sector is the one with the highest number of intensive farming systems in the EU. It is estimated that 90% of meat chickens are raised in such systems. The intensive system is characterised by high stocking densities (33 kg/m2) and vast holdings of indoor rearing (at least 5000 broilers in the EU). In this type of production, fast-growing strains aim to reach a live weight of 2-2.5kg in 35 to 45 days, with extremely high breast yield (Augère-Granier, 2019).

On the other hand, extensive rearing systems (ERS) of poultry (organic, free-range, and low-input) contribute to around 5% of poultry production and are gaining interest. In this type of farming, mainly slow-growing boilers that need 70 to 81 days to reach the targeted weight are used. In ERS, broilers have access to outdoor areas with low indoor density. Organic farming also has some specific requirements related to feed. Some countries such as France, the UK, the Netherlands, and Germany also have certified boiler production where boilers are kept inside till they are at least 56 days old (Dal Bosco et al., 2021).

The poultry meat supply chain covers all the stages of producing, processing, distributing, and selling poultry meat products. It comprises **breeders, hatcheries, farms, slaughterhouses, wholesalers, and retailers**. For meat production (and poultry in particular) the FW appears at the slaughterhouse stage, where the chickens are slaughtered and bled out. Further, the carcasses are submerged in hot water to ease the elimination of feathers (scalding step). The following steps include gutting and washing processes. Carcasses are classified according to weight and quality (Esnaola-Gonzalez et al., 2020). **In slaughterhouses, one of the main requirements is uniformity in bird size and weight, which minimises the need for production line adjustments.** Also, **food service actors value consistent chicken products, resulting in a demand for uniformity throughout the supply chain. As a result, farms monitor the weight gain of birds to ensure they align with market standards.** Ultimately, farms prefer to send chicken lots to slaughterhouses with minimal deviations from the target market weight (Solano-Blanco et al., 2023).

Later, the carcasses and entrails are chilled. The last step includes a cutting stage where different pieces or products of poultry meat (e.g., wings and breasts) are produced and packaged. Therefore, the overall quality of the slaughterhouse phase is based on the quality of the final poultry meat (Esnaola-Gonzalez et al., 2020). After the slaughterhouse process, chicken meat products are distributed to wholesalers, retailers and food services before reaching the consumer.

Various entities participate in poultry supply and subsequent slaughter and processing within the poultry meat supply chain. Slaughterhouses are responsible for poultry processing while processing companies refine the meat into consumer-ready products (van Horne & Bondt, 2013).

Production in the poultry sector can be either integrated or non-integrated. In the integrated model, a single company oversees the entire production process. Non-integrated production involves independent companies operating in the market. (Augère-Granier, 2019).

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Bovine

The bovine sector in the EU is a vital component of the region's agricultural landscape, contributing significantly to food security, rural economies, and cultural heritage[10]. **Beef is the 3rd most consumed meat in the EU.** Around 50% of beef produced in the EU is from France (20.8%), Germany (16.5%), and Italy (11.6%), while the Netherlands (26.9%), Spain (22.9%), and France (18.9%) contributed to 70% of veal meat production. Beef is the meat from the slaughter of bovine animals of at least 1 year of age. Certain cattle breeds are explicitly reared for their beef, although beef can also come from dairy cattle. Veal is considered as the meat from bovine animals younger than 1 year (usually male calves and young cattle)[11].

Beef production in the EU is characterised by a **diverse range of production systems, including extensive grazing systems** prevalent in countries like Ireland, France, and Spain and **intensive feedlot systems** found in parts of the Netherlands and Germany. The suckler herd, which primarily consists of beef cows and their offspring, plays a crucial role in beef production, particularly in regions with suitable grazing conditions. **Bovine meat production can involve various farming systems, each with its characteristics, management practices, and impacts on animal welfare, environmental sustainability, and product quality** (Hocquette & Lherm, 2018).

In **grass-fed or pasture-based farming**, cattle are raised on pasture and graze on grass and forage throughout their lives. Grass-fed beef production emphasises natural feeding behaviours, environmental sustainability, and potential health benefits associated with grass-fed diets. This system may involve rotational grazing, where cattle are moved to different pasture areas to optimise forage utilisation and pasture health. On the other hand, **feedlot or intensive farming systems** involve confining cattle in enclosed pens or barns and feeding them a high-energy diet consisting of grains, such as corn and soybeans, supplemented with protein sources and feed additives. Intensive farming allows for rapid weight gain and efficient production but may raise concerns about animal welfare, environmental impacts, and the use of feed additives, hormones, and antibiotics. **Mixed farming systems** combine pasture-based and intensive farming elements with cattle raised on pasture and feedlot settings. These systems may involve seasonal grazing on pasture and confinement during periods of low forage availability or when cattle are being finished for market. Mixed farming allows for flexibility in production and may provide opportunities to optimise resource use and animal welfare (Greenwood, 2021).

The beef meat supply chain encompasses various stages, from cattle rearing, transportation, slaughterhouses or industry, and retailers and food services to consumers. According to Karwowska et al. (2021), **the most significant loss in the meat food chain occurs at the consumption level, followed by manufacturing, distribution, and primary production.**

The supply chain begins with cattle rearing, raising beef cattle from different farming types. This stage involves breeding, feeding, and managing the health and welfare of the animals (Hocquette & Lherm, 2018). Cattle are transported from farms to livestock markets or processing facilities, often via specialised livestock transport vehicles. **Proper handling and transportation practices are essential to ensure the animals' welfare and the meat's quality, including tenderness, colour, amount of intramuscular fat (marbling), and water holding capacity.** However, preslaughter handling, including transportation, is the primary source of animal stress that ultimately also has an impact on meat quality. The main stressful factors are loading and unloading,

[10] https://www.farm-europe.eu/
[11] https://ec.europa.eu/eurostat/

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transportation time, uncomfortable conditions, lairage at the slaughterhouse, and no water and feed access (Hultgren et al., 2022).

Further, cattle are slaughtered and processed at processing facilities into various cuts of beef and beef products. Before the cattle are slaughtered, the worker from the slaughterhouse checks if the animal is suitable for human consumption. After that, the approved animal is adequately stunned, bled out, and deskinned, and the carcass is opened to remove internal organs and cut in half. This stage involves carcass inspection, meat cutting, and packaging. Improper techniques during the slaughtering process, including inadequate stunning, bleeding, skinning, evisceration, and carcass splitting, can result in damage to carcass parts and inevitable by-products, rendering them unfit for further human consumption. Later, beef is tagged and hung in a cooler for about one week for ageing. The following step in beef processing is cutting. The carcasses can be cut according to the specifications of the end products (roasts, short ribs, steak). Cut can be processed differently in the processing stage, including salting, pickling, or ground. The processing of beef cuts includes various processes, such as chopping, seasoning, smoking, etc. Processed beef products are then distributed to various destinations, including wholesale markets, retail outlets, restaurants, and food service establishments. **The main reason for FW creation in the processing stage is related to inappropriate transport conditions, human error, product defects and non-compliance with the standards** (Dora et al., 2020).

Food product distribution channels may vary depending on market demand, geographic location, and customer preferences. Beef products are sold to consumers through retail channels such as supermarkets and butcher shops. **Food waste in this part of the food chain is mainly related to incorrect storage conditions, a short shelf-life, and mechanical damage to the package, which can affect the quality of the product** (Karwowska et al., 2021).

3.2.2 Food Waste of Meat (Poultry and Bovine)

During the production of poultry meat, factors such as disease outbreaks among poultry flocks, inadequate farm management practices, and suboptimal conditions in poultry houses can lead to production losses. Disease outbreaks, such as avian influenza, can result in the culling of entire flocks to prevent the spread of the disease, leading to significant losses of poultry meat (Eurostat, 2020). In the processing and distribution phase, poultry meat can be wasted due to factors such as inefficient processing practices, overproduction, transportation inefficiencies, and market fluctuations. For instance, poultry meat that does not meet the desired quality standards or is not sold within the expected timeframe may be discarded during processing or at retail outlets (FAO, 2019).

At the retail and consumer levels, poultry meat wastage can occur due to various reasons, including over-purchasing, improper storage, aesthetic preferences, and misunderstanding of date labels. **Consumers may discard poultry meat based on best-before expiration dates, even if the meat is still safe for consumption**, contributing to avoidable food waste (Stenmarck et al., 2016).

3.2.3 The EU Regulations and FMS Related to Meat (Poultry and Bovine)

Poultry

Poultry meat falls under the common market organisation (CMO) regulation, which is governed by EU **Regulation 1308/2013**[12]. Although the regulation does not explicitly focus on poultry meat, it provides a framework to support and regulate the broader agricultural sector within the EU, which indirectly affects poultry

[12] Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007

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producers through its provisions on market support, quality schemes, trade policy, promotion, and rural development. For instance, Regulation (EU) No 1308/2013 **includes definitions and provisions related to live poultry and chickens. It provides definitions and classifications for different types of poultry, including chickens, which are relevant for various aspects of agricultural policy, market support measures, and quality schemes.**

Regulation (EC) No 543/200[13] **establishes marketing standards for poultry meat** in the EU, encompassing various aspects of the poultry industry such as **production, processing, and marketing.** This regulation **covers different types of poultry, including domestic fowl, ducks, geese, turkeys, and Guinea fowl.**

According to the regulation, **poultry meat must be marketed as fresh, frozen, or quick-frozen and meet grading and quality standards.** Fresh poultry meat must not undergo any stiffening through cooling processes and must be maintained within the temperature range of -2°C to +4°C. Frozen poultry meat or preparations cannot be thawed and must be offered to consumers in a frozen state. **Poultry meat marketed in the EU must comply with packaging, labelling, transportation, and presentation requirements.**

Pre-packaged poultry meat intended for consumers must include specific details on the packaging or label, such as the **class (Class A or B), total price, price per weight unit, "use by" date, storage conditions, slaughterhouse or cutting plant registration number, and country of origin**. **The country-of-origin labelling (COOL) is obligatory in the EU by legislation** (Regulation (EU) No 1169/2011, Art. 9)[14].

Specific terms may be used in labelling poultry meat if the conditions outlined in Regulation (EC) No 543/2008 are fulfilled. These terms include "Fed with ___ % of___," "Extensive indoor" ("Barn reared"), "Free range," "Traditional free range," and "Free range - total freedom." Due to complaints from the sector, the updated regulations regarding optional labelling provide greater flexibility to promote various farming practices, including sustainable methods. In addition to standard terms such as "fed with," "extensive indoor," and "free range," the new regulations allow free-range poultry to be labelled as such even if the birds have been housed to prevent the spread of avian flu. This eliminates the previous 12-week housing restriction.

Bovine

Bovines, similarly, to other kinds of meat types, need to follow the requirements of **Regulation (EU) No1308/2013**,[15] which establishes the **common market organization (CMO)**. The regulation covers multiple aspects relevant to the sector, such as market management measures, producer organisations, quality schemes, and trade policy. **Regulation (EU) No 1308/2013** set the requirements for **quality schemes and certification systems for beef products, including Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), and Traditional Specialty Guaranteed (TSG), organic certification, quality labels, and logos.** These quality schemes and certification systems aim to provide consumers with transparent and reliable information about the quality, origin, and production methods of beef products.

[13] Commission Regulation (EC) No 543/2008 of 16 June 2008 laying down detailed rules for the application of Council Regulation (EC) No 1234/2007 as regards the marketing standards for poultry meat

[14] REGULATION (EU) No 1169/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004

[15] Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007

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Labelling regulations concerning the country of origin of beef in the present form mandate mandatory **traceability and origin labelling** for beef from slaughterhouses to the point of sale to consumers.

The labelling system for beef consists of two components: compulsory and voluntary. The aim is to ensure transparency during beef marketing. Compulsory labelling necessitates operators or organisations to provide specific information on beef at all marketing stages up to and including the point of sale. These requirements **apply to all forms of fresh or frozen beef marketed in the EU**, including carcasses, de-boned meat, cut meat, or minced meat. Information required under the labelling regulations must be applied to individual meat pieces or their packaging. If beef is not packaged, the information should be provided visibly to consumers at the point of sale. The following details must be labelled:

1) Reference number or code of the animal or group of animals from which the beef originated.

2) Country of the slaughterhouse and its approval number indicated as 'Slaughtered in (name of country) (approval number)'.

3) The country of the cutting hall and its approval number are indicated as 'Cutting in (name of country) (approval number)'.

4) Furthermore, the origin of the beef needs to be clearly indicated. If beef comes from animals born, raised, and slaughtered in the same country, it can be labelled as "Origin: (name of country)". However, suppose beef comes from animals from different countries. In that case, the label must indicate the country of birth, country (or countries) of fattening, and country of slaughter (e.g., 'Born in Italy' 'Reared in France' 'Slaughtered in Ireland').

Voluntary labelling follows **Regulation (EU) No 653/2014**, which aligns beef labelling requirements for including any food information beyond mandatory labelling with horizontal legislation, including **Regulation (EU) No 1169/2011** on food information provision to consumers.

The marketing standards for the beef sector are regulated by the common market organisation (“single CMO”) established by **Regulation (EU) No 1308/2013** (described above) and other Regulations (“secondary CMO legislation”) setting up specific marketing standards (Areté & Agra CEAS Consulting Ltd, 2019). **Commission Regulation (EC) No 566/2008** sets out the rules for implementing Council **Regulation (EC) No 1234/2007** concerning the classification of carcasses of adult bovine animals. **Regulation (EC) No 566/2008** provides detailed guidelines for the **classification of carcasses of adult bovine animals**, where detailed factors such as conformation (shape and muscular development of the carcass), fat cover (thickness and distribution of fat over the carcass, are included. The regulation **defines several conformation classes**, typically denoted by letters from E to P, with E representing the highest level of conformation and P the lowest. The specific criteria for each conformation class are based on visual and palpation assessments of the carcass. Like conformation classes, fat cover classes are designated by numbers, typically ranging from 1 to 5, with 1 representing the leanest carcasses and 5 being the fattest. The fat cover is assessed visually and by palpation, focusing on the ribeye and kidney regions. The overall classification of the bovine carcass combines the conformation and fat cover classes. For example, a carcass may be classified as "UE" (Excellent conformation with lean fat cover) or "R4" (Good conformation with average fat cover).

The regulation's aim is to standardise the classification process across the EU, which provides consistency and uniformity in assessing the quality and characteristics of bovine carcasses.

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3.3 Eggs

3.3.1 Egg Production Processes

The EU is a significant player in the global egg market, with over half of the international egg trade involving EU member countries. The Netherlands and Poland are key exporters, while Germany is a leading importer. Following the 2012 ban on conventional cages, the EU stabilised its number of laying hens and egg production volumes. Enriched cages became the predominant housing system at 55.6%, with barn, free-range, and organic systems following closely. The utilisation of housing systems varies across individual EU member countries. **From 2012 to 2017, egg production in the EU increased by 6.1%, reaching 7.5 million tons.** The production is highly concentrated regionally, with the five leading member states accounting for 57.7% of the EU's total egg production. Between 2017 and 2025, egg production in the EU is expected to outpace consumption. This could lead to an egg surplus, necessitating increased exports or potentially causing prolonged periods of low egg prices (Windhorst, 2017).

3.3.2 Food Waste of Eggs

There are two leading causes of FW in egg production: (1) egg breakage and (2) egg spoilage. Egg breakage and spoilage can happen during laying, collection, packaging, transportation, storage, retail, and consumption. Additional waste can occur at the stage of candling, where some eggs can be rejected due to defects, such as cracks or internal blood spots, and at the sorting stage, where eggs are graded by size and sorted based on quality standards. Some eggs can be downgraded at this stage due to size, shape, or minor flaws.

Given clear sources of FW in the egg industry, **the scholarly and policy debates frequently revolve around animal rights and welfare, preservation of eggs, protection of eggshells and eggshell recycling.**

For instance, the debate on **washing versus not washing and refrigerating versus not refrigerating eggs is generally centred on food safety practices and varies depending on regional regulations and consumer habits.** In many European countries, eggs are not washed because washing can remove the protective cuticle on the eggshell, potentially making it easier for bacteria to contaminate the egg. In these countries, eggs are often kept at room temperature and not refrigerated. In contrast, the USDA (the United States Department of Agriculture) requires that commercially sold eggs be washed and sanitised in the United States. Because the washing process strips the natural protective barrier from the shell, it is required that eggs are refrigerated to prevent bacterial growth (da Silva Pires et al., 2020).

Eggshell protection is a subject of considerable research: **extra (synthetic) egg coatings may improve shelf-life by delaying the rate of internal quality deterioration, control the transfer of moisture and oxygen, which are factors in the spoilage process, reduce eggshell breakage, thereby decreasing the number of cracked eggs and FW.** The types of coatings include protein, polysaccharide, and lipid coatings (da Silva Pires et al., 2020).

Eggshell waste is a significant by-product of the increased global egg consumption. Global egg production in 2018 resulted in about 8.58 million metric tons of eggshells, most commonly disposed of in landfills (Waheed et al., 2020). This disposal practice leads to environmental issues due to the calcium content of eggshells. However, eggshells, representing approximately 10% of eggs, can be better managed; they can be used as a calcium source in animal feed, as an eco-friendly fertiliser that can enrich the soil with calcium, maintain pH levels, and help prevent plant diseases like blossom end rot in tomatoes and berries, the eggshell powder can replace a portion of cement in the manufacturing of eco-friendly bricks and pavers, as an absorbent for heavy metals from wastewater and as a catalyst for biodiesel production, making the biodiesel process more ecological and cost-effective (Laca etc al., 2017, Waheed et al., 2020). The eggshell membrane is also

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valuable for uses such as the production of cosmetics and medical and dental preparations (Oliveira et al., 2013).

An issue of animal rights also becomes more prominent: **consumers increasingly consider sustainability attributes, such as production systems' environmental and animal welfare impacts, when choosing food items.** Doyon et al.'s 2023 study found that in the context of egg production, consumers preferred eggs from more sustainable production systems, and this preference was even stronger when the eggs were included in prepared meals rather than in unprocessed form. Additionally, providing information about animal welfare, nutrition, or environmental impact led to respondents updating their beliefs and revising their initial choices, particularly concerning animal welfare attributes (Doyon et al., 2023).

3.3.3 The EU Regulations and FMS Related to Eggs

In the European Union, the production and marketing of eggs are regulated by a set of standards and Regulations designed to ensure quality, protect consumers, and maintain consistency across the EU market.

The marketing standards related to eggs within the EU are primarily governed by **Regulation (EU) No 1308/2013** of the European Parliament and of the Council of 17 December 2013 establishing a common organization of the markets in agricultural products. This regulation lays down rules concerning the classification, packaging, and marketing of eggs within the EU market.[16]

The Commission Delegated Regulation (EU) 2023/2465[17] that substituted (EC) No 589/2008 lays down detailed rules for implementing marketing standards for eggs.[18] **This regulation** enacted on 17 August 2023, **supplements Regulation (EU) No 1308/2013** concerning marketing standards for eggs, aiming to ensure a fair, healthy, and environmentally friendly food system. This Regulation addresses various aspects of **egg marketing to ensure product quality, safety, and transparency, aligning with technical developments and consumer demands.** For example, regarding technical definitions, the Regulation emphasises the importance of maintaining high-quality standards for Class A eggs, drawing on the UNECE Standard No 42[19] for marketing and commercial quality controls. **Eggs must be graded by weight, with clear weight grades and labelling requirements set.** Only packing centres meeting specific conditions are authorised to grade eggs by quality and weight.

Regarding storage and handling, the Regulation 2023/2465 specifies that **eggs should not generally be washed or cleaned to avoid damaging the eggshell and ensuring a natural barrier against bacteria.** In some exceptional cases, specific guidelines allow for controlled egg washing. The rules also establish time **limits for grading, marking, and packing eggs to maintain their freshness. It also details the conditions for egg treatment, including UV rays that are not considered a cleaning method**. **The Regulation refers**

[16] Other EU legislation and directives may also impact the marketing standards related to eggs. For example, Regulation (EU) 2017/1185 outlines criteria for practices in market monitoring and Regulation (EC) No 589/2008 that lays down detailed rules for implementing Council Regulation (EEC) No 1907/90 on certain marketing standards for eggs.

[17] Commission Delegated Regulation (EU) 2023/2465 of 17 August 2023 supplementing Regulation (EU) No 1308/2013 of the European Parliament and of the Council as regards marketing standards for eggs, and repealing Commission Regulation (EC) No 589/2008

[18] Commission Delegated Regulation (EU) 2023/2465 integrates sustainability criteria into egg marketing standards to promote environmentally friendly food systems, aligning with the EU's Farm to Fork Strategy. This approach aims to reduce food loss and waste by encouraging the uptake of sustainable agricultural products and incorporating the role of sustainability into production and marketing standards. The Regulation ensures that egg production aligns with modern consumer demands and addresses risk factors such as avian influenza, potentially reducing waste through improved production practices.

[19] UNECE STANDARD NO. 42 concerning the marketing and commercial quality control of EGGS-IN-SHELL moving in international trade between and to UN/ECE member countries.

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to Council Directive 1999/74/EC regarding animal welfare and farming practices[20] for guidelines on keeping hens in farming systems highlighting the connection between egg marketing standards and hen welfare. Additionally, it mentions **(EC) No 178/2002[21], emphasising the need for traceability and labelling on transport packaging and accompanying documents**, especially when products are transported to another Member State.

In essence, the standards mentioned above **may reduce FW in egg production: they promote proper handling and packaging of eggs to ensure the product reaches consumers in good condition**, thus decreasing the chances of edible goods becoming FW. The transparent grading and labelling guidelines also **assist customers in making informed decisions**, which could lower discarding eggs that are still edible but do not meet the Class A quality standards. Nonetheless, **rigorous criteria might result in more eggs being rejected for failing to meet requirements, potentially leading to an increase in FW.**

Under Regulation (EU) No 1308/2013, eggs must meet specific quality standards to be marketed within the EU. These standards encompass criteria such as size, weight, cleanliness, shell integrity, freshness, and grading. Eggs that meet the established quality standards are categorized into different classes, including Class A, which represents eggs intended for direct human consumption, and Class B, which includes eggs not meeting the requirements for Class A but suitable for industrial processing or egg products.

Furthermore, the regulation mandates that eggs must be appropriately labelled to provide consumers with essential information about their quality and characteristics. This labelling includes details such as the category of the egg (e.g., Class A or Class B), the method of production (e.g., organic, free-range, barn), the country of origin, the packing date, and any relevant safety instructions.

3.4 Cereals

3.4.1 Cereals Production Processes

Cereal production in the European Union varies considerably among its Member States. The differences can be seen in the areas dedicated to cereal crops and their evolution between 2007 and 2016, and the share in the value of cereal production. For instance, while France and Spain produced almost 40% of the total cereal production in 2016, Poland contributed 6% of the EU's grain production value.

Different cereals also dominate in terms of production value in different countries. For example, wheat and spelt have the largest share of production in Belgium, Germany, Latvia, Lithuania, and the Netherlands. In Poland, the share of wheat and spelt increased from 33.6% in 2007 to 39.9% in 2016. On average, wheat and spelt accounted for 48.5% of the cereal production value in the EU. Barley is vital in Ireland and Finland, while oats and spring cereal mixtures represent a smaller portion of the total cereal production value (Nowak, 2020).

Cereal crops have distinct characteristics in terms of water and climate requirements, soil preferences, planting methods, growth cycles, harvesting processes, and nutritional content. For instance, rice is typically grown in flooded fields with warm and humid climates, wheat thrives in well-drained loamy soils with varying planting seasons, and maise requires less water than rice but prefers fertile soils and warmer weather conditions for optimal growth (Nowak, 2020).

3.4.2 Food waste of Cereals

[20] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety

[21] Council Directive 1999/74/EC of 19 July 1999 laid down minimum standards for the protection of laying hens

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The exact causes of food waste in cereals can vary depending on their type and the regional conditions. Nonetheless, there are **common causes of food waste for all cereals such** as **inappropriate storage** methods or **production processes**. For example, rice is often susceptible to insect infestation and spoilage due to high humidity; on the other hand, wheat and other cereals can be negatively affected by the high humidity level in storage facilities. The waste can also spur from poor by-product handling. Cereals, for instance, are processed through **dry** or **wet milling** to obtain edible grains. The difference between wet milling and dry milling is primarily in the presence of water and the end products, while **dry milling.**[22] is focused on separating the edible parts of the grain with minimal moisture content, **wet milling**[23] involves soaking the grain, which allows for the separation of its chemical components.

The application of various dry milling methods, like pearling, reduction, grinding, impact milling, and hammer milling, contribute to **the generation of by-products when cereal components such as bran and germ are removed from the endosperm; these by-products are considered waste** (Dumitru et al., 2020, Hassan et al., 2021).

The third way of cereal processing is **malting**, which is specifically used in manufacturing beer and similar alcoholic drinks. During this process, the grain is prepared to have its fermentable sugars and starch consumed by enzymes (Papageorgiou & Skendi, 2018). The malting process allows grains to germinate to produce malt. In the production of malt for alcoholic beverages, malt extracts, and vinegar, malting induces grain germination, which is then halted by dry air. **This process leaves spent grain as a waste product.**

Finally, during processing and distribution, cereals may also be wasted due to inefficiencies in processing plants, transportation delays, and fluctuations in market demand. Processing plants may discard cereals that do not meet quality standards or are damaged during handling. Transportation delays or improper storage conditions can lead to spoilage before cereals reach consumers (Buzby et al., 2014)

3.4.3 The EU Regulations and FMS Related to Cereals

The EU has established a comprehensive regulatory foundation to ensure food products' safety, quality, and sustainability, including cereals. This framework covers aspects such as the collection, delivery, preservation, handling, conservation methods, temperature control, storage, and transport of cereals.

Except for the **EU Regulation No 1308/2013**[24] laying down the rules on the common organisation of the markets in agricultural products, several legislative acts influence cereal production directly or indirectly.

For instance, **Regulation (EU) No 1169/2011**[25] outlines principles, **requirements and responsibilities concerning food information and labelling standards within the EU**. For cereals and other food items, it

[22] More specifically, the dry milling process aims to produce milled fractions of cereal grains that can be used for various food products, from flour for baking to bran for added fibre in foods. Before milling, grains are cleaned to remove impurities. Conditioning or tempering involves adding moisture, so the bran becomes harder and the inner endosperm softer, which helps separate them during milling. The actual milling includes grinding the grain and then sifting the resulting material into different fractions, such as flour and bran. In the case of corn, there is an extra step called degermination, which separates the germ and pericarp to produce low-fat, high-purity products (Papageorgiou & Skendi, 2018).

[23] Wet milling is a process that involves grinding soaked grain and then separating the grain's chemical compounds. Wet milling primarily aims to extract as much native or undamaged starch granules as possible. The resulting starch can then be utilised to produce various products like syrups, modified starches, thickeners, and products for the food industry, as well as applications in pharmaceuticals, textiles, and other non-food industries (Papageorgiou & Skendi, 2018).

[24] Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007

[25] Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European

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mandates information on packaging such as the product name, ingredient list (highlighting allergens like gluten-containing cereals), weight, expiration date or best-before date, storage instructions or recommended usage conditions, contact details of the food business operator, country of origin or source location (if applicable), as well as nutritional information (mandatory, for most pre-packaged foods). These rules provide information on the labelling guidelines that indirectly define terms like identifying grains with gluten and putting it on food packages. **Regulation (EC) No 1935/2004**[26] guarantees that **packaging materials do not transfer these elements to food in quantities that may endanger health, change the food's composition, or negatively impact the taste and scent of food** (art.3). This is especially crucial for grains, where packaging has a role in maintaining quality and preventing contamination. **Regulation (EU) 2018/848**[27] sets out **rules for producing, verifying, and recognising organic food items.** It includes using the EU organic logo on products that meet the criteria and information on the organic production method. The Regulation affects cereal species grown under organic farming methods, specifying how they should be produced, processed, and labelled, impacting their holding and circulation. Regarding product origins, **Regulation (EU) No 1151/2012**[28] **establishes frameworks for products with characteristics linked to their origin,** including cereal production.

3.5 Fish

3.5.1 Fishing Industry

The European Union is the world's top trader in fishery and aquaculture products, with a trade value of approximately EUR 30.3 billion in 2017. During that period, the EU exceeded China's trade by more than EUR 2.3 billion (Cantillo et al., 2017). The production involves harvesting finfish, shellfish, and other aquatic organisms. Different methods are practised, ranging from extensive aquaculture, which has a minimal environmental impact, to intensive systems that may require artificial feeds and medication, potentially leading to more significant environmental impacts (Arvanitoyannis & Kassaveti, 2008).

The EU has two main types of fish production systems: **capture fishing and aquaculture**. **Capture fisheries** is harvesting naturally occurring fish in marine and freshwater environments. The sustainability of capture fisheries is essential; hence we assume that fish landings are limited to the maximum sustainable yield set by EU legislation to prevent overexploitation of fish stocks. **Aquaculture** includes the breeding, rearing, and harvesting of fish in a controlled environment. Farmed fish can convert low-opportunity-cost feed, such as by-products and wastes from processing, into high-quality animal-source foods with essential nutrients such as protein, vitamin B12, and omega-3 fatty acids (van Hal et al., 2023).

Fishery and aquaculture products are vital for human nutrition, contributing to about 17% of global animal protein consumption while supplying essential nutrients such as fatty acids, iodine, vitamin D, and calcium. Currently, **the residents of Europe demonstrate higher average per capita seafood consumption than the global average** (Cantillo et al., 2017).

While the demand for fishery and aquaculture products is growing, the concern over the environmental impact of fish farming is also increasing. The concerns include issues such as the release of organic wastes that can

Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004 Text with EEA relevance

[26] Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC

[27] Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007

[28] Regulation (EU) No 1151/2012 of the European Parliament and of the Council of 21 November 2012 on quality schemes for agricultural products and foodstuffs

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alter the ecosystem of coastal zones, including impacts on the benthos, plankton, and nekton, as well as potential changes in community structure and biodiversity.

3.5.2 FW in the Fishing Industry

Food waste in the fishing industry begins at the landing site wholesale markets, where fishermen bring their catch for its first sale within the supply chain. It's crucial to recognize that quality, traceability, and food safety are paramount in fish products, all of which must be considered when assessing the causes of food waste. Moreover, factors such as the origin and method of extraction or production can influence the occurrence of food waste in fish and seafood products, as consumer preferences often favor certain attributes.

During the production phase, fish food waste can occur due to various factors such as overfishing, bycatch, and discards. Overfishing of certain species can lead to the depletion of fish stocks, resulting in waste as fish are caught but not utilized (FAO, 2018). Bycatch, the unintentional capture of non-target species, contributes to waste when discarded at sea.

In the processing and distribution stages, inefficiencies in processing facilities, transportation delays, and market fluctuations contribute to fish food waste. Processing facilities may discard fish that do not meet quality standards or are damaged during handling (Bogard et al., 2017). Transportation delays and improper handling can also lead to spoilage of fish before reaching consumers.

At the retail and consumer levels, food waste of fish can occur due to over-purchasing, improper storage practices, aesthetic preferences for certain fish species, and misunderstanding of date labels. Consumers may discard fish based on expiration dates or visual cues of spoilage, even if the fish is still safe for consumption (Stenmarck et al., 2016).

Regulatory frameworks and policies play a significant role in reducing fish food waste. Measures such as quotas, size limits, and seasonal restrictions aim to prevent overfishing and reduce discards (European Commission, 2020). Additionally, labeling requirements and traceability standards ensure transparency and accountability throughout the fish supply chain.

3.5.3 The EU Regulations and FMS Related to Fish

While EU Regulation No 1308/2013 applies to certain products, there is a distinct regulation for fishery and aquaculture products as they are excluded from EU Regulation No 1308/2013. This distinction allows for a more comprehensive analysis and evaluation of marketing standards, addressing the specific needs and characteristics of fishery/aquaculture.

The EU Regulation No 1379/2013[29] includes fish and seafood products, excluding those produced as non-human edible products but for animal or industrial purposes.

Article 33.2.a of the Regulation establishes that to meet consumer expectations and improve the economic benefits of production and product quality, the EC may formulate some requirements, which in the case of fish include **size classification criteria** and **species excluded from commercialisation**. As for the fish size, there is a legal minimum size for many species to be marketed. Catches below the minimum size (measured

[29] Regulation (EU) No 1379/2013 of the European Parliament and of the Council of 11 December 2013 on the common organisation of the markets in fishery and aquaculture products, amending Council Regulations (EC) No 1184/2006 and (EC) No 1224/2009 and repealing Council Regulation (EC) No 104/2000

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in length) must be discarded and cannot be commercialised. Species excluded from commercialisation cannot enter the market for conservation reasons or because of a food safety risk[30].

Regulation No 1379/2013 offers information on labelling as well. Labelling is crucial to ensure the product's traceability, and it directly impacts the product's quality.

Labels must include the origin (FAO catchment area), the expiry date, the fishing gear or production method (aquaculture), the species name (commercial and scientific) and the net weight for its commercialisation in all stages of the supply chain and if the product has been defrosted (art. 35, Regulation No 1379/2013).

Regulation (EC) No 2406/96[31] is the most critical Regulation regarding fish quality. While it came into force in 1997, it remains valid today and comprehensively outlines the standards for fish quality in the market. It defines categories and factors integral to the private FMS, which are elaborated upon below.

This Regulation provides criteria for qualifying freshness and calibre of most marketed species, distinguishing between oily, lean fish, elasmobranchii (sharks and rays), cephalopods and crustaceans. **The calibre** establishes the minimum length and weight classification. Different regions of Europe may have different minimum sizes and different calibres as these parameters depend on the population status and other factors such as physical, chemical, and biological characteristics that may affect them. For example, some species such as Hake (Merluccius merluccius) can be classified considering their weight: more weight means higher quality and, therefore, higher price per kg.

Different fish parts can be used as a reference to measure freshness. The skin (colour, brightness, mucosa), the eye, the gills, the operculum, the smell, and the texture of the flesh are indicators. This parameter has four possible levels: Extra (higher quality), A, B (bad but still edible), and “Not allowed” (not edible). For instance, for oily and lean fish, a grey eye with a concave shape in the centre means loss of freshness, and the product must be discarded.

Article 5 of this Regulation (2406/96) also notes that **the batches** (defined as a certain quantity of products of the same species, which have undergone the same treatment, and which may come from the same fishing area and the same vessel) **must be homogeneous in freshness,** except for small batches where the lower quality state is considered as classification. Article 8 notes the same, but for calibre: the lots must be homogeneous in calibre, except for small lots.

Despite this exact classification, **some decisions can be influenced by the subjective perception of the qualifications**. In some cases, previous experience in the fish sector is needed to correctly place the product quality.

Within demand, the origin and method of production/extraction are significant. While these factors directly affect price (fishery products have higher prices than aquaculture products), food waste can also be affected by these product characteristics. Some origins are considered better than others, the products value in quality and price of such products is higher, hence such products are unlikely to be wasted at any stage of the supply chain. Also, aquaculture products have more careful handling since their production methods allow more control and less food safety risk, which reduces the probability of food waste due to parasites or loss of integrity. These reasons will be further explained in this document.

[30]The prohibited species and size classification information is available in the EU Regulation 1380/2013 Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC.

[31] Council Regulation (EC) No 2406/96 of 26 November 1996 laying down common marketing standards for certain fishery products

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The calibre and quality homogeneity of the batch are crucial for establishing its overall quality and price. In this case, public and private requirements are in line; a mismatch between the homogeneity requirement could lead to a reduction in price and, in the worst case, food waste. These requirements are essential along the entire supply chain. However, their importance is most prominent at the first sale stage, where fishermen should prepare the batches for sale, considering the homogeneity.

It is also vital for all stages of the food supply chain to **maintain cold storage conditions** from harvesting to consumption. For fresh products, which are not frozen at any stage, it is crucial to keep them at 0ºC, and certainly not exceeding 4ºC. This includes **refrigeration** and **the quantity of ice in the boxes** where the product is transported. The amount of ice on a product is directly related to its quality at all stages, especially during sale and distribution. For frozen products requiring shelf-life extension, the ideal temperature is -20ºC. A low temperature stops or delays the post-mortem degradation of the product, extending the shelf life and improving the quality over time (Huss, 1998). **A stable temperature is as critical as a low one**. Temperature changes may lead to breaks of microorganisms and damage the product.

Rigour mortis is another indicator considered by the food chain actors. The rigour mortis depends on the species and handling and is an indicator of not only the harvesting date but also the slavery process and cold chain management (Huss, 1998). At first sale, usually, if the product is from daily fisheries, freshness is required where the rigour mortis is not under development, so the fish meat must be soft. For the rest of the food supply chain stages, hard meat, a synonym of rigour mortis development, is essential to indicate freshness. **The best time to consume fish is just after the end of rigour mortis**. Hence, a fresh fish that has ended rigour mortis and is not in the retail or consumer stage is more likely to be discarded by the retailer or consumer.

Product integrity is also critical, especially if the fish is to be marketed as a whole rather than in filets or other manipulated forms. The absence of any part of the fish, such as eyes, or their breakage during its management at any stage of the chain can cause a devaluation in the price of some species or a direct discard (waste) of the product.

The last important private food marketing standard to consider is the **quantity of products in the box.** This standard is related to the distribution and retail stages. To save temperature-controlled or refrigerated space, the boxes are filled with the product to the brim. Consequently, the integrity of the product can be compromised as heavily loaded cartons may damage it. Sometimes, these overloaded crates cause food waste due to the destruction of the bottom part of the crate (loss of integrity and quality of the bottom products). Many retailers mandate a maximum of kg per box to avoid this, thus using it as a quality feature.

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4 FOOD MARKETING STANDARDS AND FOOD WASTE: CONNECTIONS

To explain the connections outlined in the preliminary conceptual model this section focuses on each category of FMS outlined in Regulation (EU) 1308/2013[32] and presents a cohesive **summary based on current scientific knowledge regarding the impact of marketing standards on FW. It is also a basis for the preliminary conceptual model of this deliverable.**

4.1 Technical definitions, designation, and sales descriptions

Technical definitions related to FW including terms "organic", "locally sourced", "fair trade", or "zero waste packaging" signal the values and sustainability principles associated with a product to consumers. When actively selecting products with these designations, consumers play a role in driving market demand for more sustainable and waste-conscious practices throughout the supply chain. This demand, in turn, encourages producers, retailers, and other stakeholders to implement measures aimed at reducing food waste and promoting sustainability at every stage of the supply chain. Therefore, **consumer choices have the potential to catalyse positive changes in the food system toward more efficient resource utilization and reduced environmental impact** (Marsden & Morley, 2014). Also, opting for "imperfect produce" or "rescued food" helps divert items that would otherwise be discarded due to cosmetic imperfections or surplus, thereby reducing overall food waste (Marsden & Morley, 2014). Studies have also examined how **marketing messages and product descriptions influence consumer perceptions and purchasing decisions**. For example, research by Grunert et al. (2011) investigates consumers' motivation, understanding, and use of sustainability labels on food products, shedding light on the potential impact of marketing strategies on sustainable consumption practices.

4.2 Classification criteria such as grading into classes, weight, sizing, age and category

Grading food products into different classes based on quality standards can lead to increased food waste as perfectly edible produce that doesn't meet strict cosmetic standards set by retailers or consumers may be discarded or left unharvested, contributing to FW (FAO, 2011). **Strict weight and sizing requirements imposed by retailers and consumers can result in the rejection of produce that deviates slightly from predetermined standards, leading to significant quantities of perfectly edible food being discarded solely based on cosmetic appearance or size** (Parfitt et al., 2010). There is a correlation between fruit and vegetable grading standards and waste (Jaeger et al., 2018; Waarts et al., 2011; Porter, Reay, Bomberg, & Higgins, 2018). This research suggests that grading practices could result in non-compliant products being discarded as food waste, consequently impacting the environment negatively.

Perceptions of freshness and expiration dates often lead to the premature disposal of food items that are still safe to consume, contributing to FW despite the items being perfectly edible (Stuart, 2009). **Categorizing food products based on factors such as type, variety, or specialty can influence consumer preferences and purchasing behaviour, leading to overproduction or underutilization of certain categories, resulting in food waste** (WRAP, 2020).

[32] With the exception of “coupage of must and wine” since wine is not on the list of commodities addressed by the BREADCRUMB project.

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4.3 Indication of the species, plant variety or animal race or commercial type

Different species, plant varieties, or animal races may have varying market demands and consumer preferences. **If certain types of species, varieties, or races are favoured over others, it can lead to overproduction or underutilization of specific food products, contributing to FW** (Galanakis, 2020).

Commercial types of food products, such as branded versus unbranded items, or specialty versus conventional varieties, **can influence consumer purchasing decisions and market dynamics**. Mismatch between consumer preferences and available commercial types may result in excess inventory or product disposal, contributing to FW (Thyberg & Tonjes, 2016).

4.4 Presentation, labelling linked to obligatory marketing standards, packaging, rules to be applied in relation to packing centres, marking, year of harvesting and use of specific terms

Some marketing standards require specific packaging materials and designs, which can contribute to additional costs and waste if not efficiently managed. For instance, Herzberg et al. (2022) investigated food marketing standards set by retailers. One of the identified standard categories is related to packaging. Packaging varies between retailers, each characterised by customised packaging, representing an essential part of product differentiation. According to the producers interviewed by the authors, the increasing supply chain integration, and the fact that product is often packed right after the harvest, **producers are more and more restricted to specific marketing channels, increasing the dependency on retailers' demand and business practices**.

Packaging plays a vital role in safeguarding food during transportation, storage, and display, and allows to avoid product damage and thus FW. However, inadequate, or excessive packaging can have adverse consequences, such as product damage, spoilage, or overhandling, all of which contribute to food waste (Stuart, 2009). Eggs are typically packaged into cartons or trays for transportation and retail sale. However, inadequate packaging or improper stacking can result in breakage during transit (Wideman et al., 2016). Inefficient or improper handling at packing centres can result in product deterioration or contamination, leading to FW. Also, excessive packaging not only leads to environmental concerns but also increases the likelihood of product damage or spoilage due to improper ventilation or handling practices, as discussed in various studies on packaging and FW prevention (Food and Agriculture Organization, 2011). Processing and packaging and inadequate storage conditions or packaging failures can lead to spoilage of meat and fish (Karwowska et al., 2021; Peñarubia et al., 2020), like the sell-by date for eggs, influence waste volumes depending on how they are managed in retail (eggs are broken in transit or the store) and by consumers. For cereals, waste at the retail level might occur when the packaging is damaged, exposing the product to air and moisture, which causes spoilage (Belc, 2019).

The presentation and labelling of food products play a crucial role in shaping consumer perceptions regarding the quality, freshness, and value of the items. When labels are misleading or unclear, it can result in consumer confusion or dissatisfaction, leading to the rejection or premature disposal of products, thereby contributing to food waste (Papargyropoulou et al., 2014). For instance, if a label fails to accurately convey important information such as expiration dates or ingredients, consumers may discard perfectly edible items out of uncertainty. Clear marking and indication of the year of harvesting on food products provide transparency and information to consumers about product freshness and shelf life. Lack of proper marking or inaccurate labelling may lead to consumer uncertainty or distrust, resulting in FW (Parfitt et al., 2010). Labelling and packaging standards provide consumers with information about the contents, nutritional value, allergens, and expiration dates of cereal products. Transparent labelling helps consumers make informed choices, reducing the likelihood of purchasing products that may go to waste due to incorrect storage, allergen concerns, or expiration. Additionally, packaging innovations such as resealable containers or portion-controlled packaging can help extend the shelf life of cereal products and minimize waste (Aschemann-Witzel et al., 2019).

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Standards requiring accurate identification of components and constituents help prevent mislabelling or misrepresentation of food products. Incorrect or inadequate identification may result in consumer confusion, regulatory non-compliance, and product recalls, leading to FW (Galanakis, 2020).

The impact of date marking on food waste has been extensively investigated in the scientific literature (Badiger et al., 2023; Lebersorger & Schneider, 2014; Samotyja & Sielicka-Różyńska, 2021; Van Boxstael et al., 2014). **Numerous studies have concluded that date labels, especially "best before" dates, significantly contribute to food waste at retail and consumption stages.** One of the primary reasons is consumer misunderstanding and confusion regarding the meaning of these labels, often leading to prematurely discarding perfectly edible food. Additionally, retailers and manufacturers tend to adopt conservative date labelling practices to mitigate liability risks, resulting in the disposal of products that are still safe for consumption (European Commission, n.d.). The study suggests that approximately 10% of the 88 million tonnes of FW produced annually in the EU can be attributed to date marking practices. Among the main contributors to this food waste are fruit and vegetables, bakery products, meat (including fish and poultry), and dairy products (Lyndhurst, 2018). Terms such as "expiration date," "sell-by date," "best before date," "use-by date," and "food waste hierarchy" provide consumers with important information about the lifespan of food products and guide their decisions on consumption and disposal (Evans & Campbell, 2014). Clear and accurate definitions help consumers differentiate between dates that indicate quality and those that denote safety, thereby reducing the likelihood of premature disposal of perfectly edible items (Evans & Campbell, 2014).

For instance, understanding the distinction between "best before" dates, which signify the peak quality of a product, and "use-by" dates, which indicate safety, enables consumers to make informed decisions about whether a product is still suitable for consumption (Evans & Campbell, 2014). This knowledge empowers consumers to minimize food waste by avoiding unnecessary discards based solely on date labels.

The overarching conclusion drawn from analysing EU food waste data is that efforts to reduce food waste through improved date marking practices should prioritize food product types where consumers are likely to make disposal decisions based on on-pack labels and where their contribution to EU food waste is significant. In terms of market research, the greatest opportunities for reducing food waste related to date marking are identified for milk and yoghurts, fresh juices, and chilled meat and fish. However, for other product types, consumer decisions to discard are more likely to be influenced by visual cues (how given product looks like) indicating a decline in product quality and palatability. While opportunities for waste reduction related to date marking exist for certain products like milk, yoghurts, fresh juices, and chilled meat and fish, for other types, consumer decisions to discard are more likely to be influenced by visual cues indicating a decline in product quality and palatability.

4.5 Criteria such as appearance, consistency, conformation, product characteristics and the percentage of water content

Strict appearance standards enforced by many retailers for fruits and vegetables, with **a preference for visually pleasing products**. Retailers enforce **shape, size, and colour requirements**, which results in rejecting products that do not meet these standards even though they are perfectly edible. As a result, large amounts of **"imperfect" products are discarded** at the farm level only because they do not look good enough. For instance, Herzberg et al. (2023) studied private marketing standards enforced by a large retailing company in Germany, Spain, and Italy. Many of the interviewed suppliers indicated calibre, shape and curvature, sorting, and peel retailers' specifications to increase the amount of product sorted out and later becoming food waste, with differences depending on the specific crops. Among the reasons for these private requirements are the fulfilment of consumers' preferences, the cost-efficient transportation and handling of uniform products, maintaining retailers' firm reputation, avoiding additional labour at the retail stage to sort marketable products,

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and in order not to introduce a price differentiation and avoid competition among actors' products. Consumer preference for visually appealing food products is a significant driver of food waste, as consumers tend to reject items that do not meet certain aesthetic standards, even if they are perfectly edible. This emphasis on appearance can lead to the discarding of significant quantities of food, contributing to food waste at various stages of the supply chain (Gössling et al., 2016). Research by Gössling et al. (2016) underscores the role of consumer behaviour in contributing to FW through the rejection of visually imperfect produce. The study highlights how consumers' desire for aesthetically pleasing food items influences their purchasing decisions and consumption patterns. Such consumer desire is further reinforced through the existing marketing standards. Items that do not meet specific visual criteria, such as size, shape, colour, or surface blemishes, are often discarded by retailers contributing to food waste. Similarly, studies showed that inconsistent texture or undesirable consistency may lead to consumer dissatisfaction and disposal of food items, contributing to FW (Papargyropoulou et al., 2014). Quality standards outlined in FMS for cereals ensuring consistency in product quality, producers can build consumer trust and satisfaction, leading to reduced FW at the retail and consumer levels (Loureiro & Umberger, 2007).

4.6 Standards on specific substances used in production, or components or constituents, including their quantitative content, purity and identification

Standards on substances, components, and constituents ensure that food products meet quality and safety requirements. Non-compliance with these standards may result in the rejection or disposal of products **due to concerns** about contamination, adulteration, or inferior quality, contributing to FW (Thyberg & Tonjes, 2016).

Standards specifying the quantitative content and purity of substances used in food production ensure consistency and integrity in product formulation. Variability or deviations from these standards may lead to product rejection or withdrawal from the market, contributing to FW (European Commission, 2020).

4.7 Standards on the type of farming and production method, including advanced systems of sustainable production

Standards promoting sustainable farming and production methods encourage efficient use of resources such as water, energy, and land. By optimizing resource allocation and minimizing waste throughout the production process, these standards help reduce FW (FAO, 2019). Godfray et al (2010) emphasize the importance of sustainable food production practices in addressing the challenge of feeding a growing population. This includes promoting agricultural innovation, such as improved crop varieties, precision farming techniques, and sustainable land management practices, to increase productivity while minimizing environmental impact. Advanced systems of sustainable production prioritize quality over quantity, emphasizing factors such as flavour, nutrition, and freshness. By enhancing product attributes and reducing defects or spoilage, these methods contribute to FW reduction (Thyberg & Tonjes, 2016)

Doyon et al.'s 2023 study found that in the context of egg production, consumers preferred eggs from more sustainable production systems, and this preference was even stronger when the eggs were included in prepared meals rather than in unprocessed form. Additionally, providing information about animal welfare, nutrition, or environmental impact led to respondents updating their beliefs and revising their initial choices, particularly concerning animal welfare attributes (Doyon et al., 2023).

4.8 Standards on the frequency of collection, delivery, preservation and handling, the conservation method and temperature, storage and transport

Standards specifying the frequency of collection, delivery, preservation, and handling of food products ensure timely processing and distribution, reducing the risk of spoilage and waste. **Efficient handling practices minimize product damage and deterioration, thereby contributing to FW reduction** (Stuart, 2009).

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Conservation methods and temperature control during storage and handling influence FW by preserving product freshness and extending shelf life. Proper temperature management prevents microbial growth, enzymatic reactions, and physical degradation, reducing the likelihood of spoilage and waste (Galanakis, 2020).

Standards governing storage and transport practices address factors such as packaging, humidity, ventilation, and sanitation to maintain product quality and safety. Compliance with standards in this category ensures that food products are stored and transported under optimal conditions, minimizing losses and waste (Thyberg & Tonjes, 2016).

During egg collection, mishandling or rough handling by workers can increase the risk of breakage. Eggs that are dropped or mishandled may develop cracks, making them unsuitable for sale (Wideman et al., 2016).

Transporting eggs from farms to distribution centres or retail outlets involves vibration and movement, which can exacerbate existing cracks or cause additional breakage. Temperature fluctuations during transportation can also contribute to spoilage (Jones, 2011). Eggs must be stored under controlled conditions to maintain their freshness and quality. Improper storage temperatures or humidity levels can accelerate spoilage, leading to reduced shelf life (European Food Safety Authority, 2014).

Efficient collection and delivery schedules, mandated by EU regulations, **facilitate the movement of cereals, but also other products from farms to processing facilities or markets, thus reducing spoilage risks. Preservation guidelines and hygiene protocols work towards minimising contamination risks** during handling practices, which is crucial for maintaining cereal quality and safety during storage and transportation. Regulations governing the storage of food items like cereals ensure that **facilities are constructed and maintained to prevent contamination and spoilage, ultimately reducing waste.**

4.9 Indication on the place of farming and/or origin

Indications on the place of farming and origin provide consumers with information about the source of their food products. Consumers may perceive certain origins or regions as having higher quality, safety, or environmental standards, leading them to prefer products from specific locations. **This perception of quality and trust in the origin can influence purchasing decisions and reduce the likelihood of product rejection or waste** (Loureiro & Hine, 2002).

Indications on the place of farming and origin contribute to supply chain transparency by providing traceability and accountability for food products. **Consumers increasingly seek information about the origin and production methods of their food to make informed choices aligned with their values and preferences.** Clear indications on farming location and origin enhance transparency, build consumer trust, and reduce the likelihood of food waste due to uncertainty or distrust (Brunso et al., 2017).

Indications on the place of farming and origin can be used for market differentiation and premiumization strategies. Products with specific geographical indications or origin labels may command higher prices and attract consumers seeking unique, specialty, or artisanal items. By highlighting the uniqueness and authenticity of products from specific regions, **producers can reduce the risk of waste by catering to niche markets and meeting consumer demand for distinctive offerings** (Gellynck et al., 2012). In one study investigates consumers' willingness to pay for local food products, including produce, based on country-of-origin labelling. It suggests that clear indications of the origin of food products can influence consumer perceptions of quality, safety, and authenticity, ultimately impacting purchasing decisions. **Establishing trust through transparent labelling, as implied in the statement, can lead to a steadier demand for cereal products and potentially reduce overproduction**. (Mak et al.,2016).

4.10 Restrictions as regards the use of certain substances and practices

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Restrictions on harmful substances and practices aim, among others, to ensure food quality. By **prohibiting the use of certain chemicals, additives, or production methods these restrictions help maintain product integrity and consumer trust.** Compliance with quality and safety standards reduces the likelihood of product rejection or disposal due to contamination or quality concerns, thus minimizing FW (Food and Agriculture Organization, 2018). **Restrictions on certain substances and practices reflect consumer preferences for natural, organic, or sustainably produced food.** Consumers increasingly seek products that are free from synthetic chemicals, genetically modified organisms (GMOs), or other undesirable inputs. **Food labels indicating compliance with restrictions on specific substances or practices build consumer trust and confidence, influencing purchasing decisions and reducing FW by aligning with consumer preferences (Brunso et al., 2017).**

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5 A PRELIMINARY CONCEPTUAL MODEL OF LINKS BETWEEN CATEGORIES OF FMS AND FW

The following section summarises the insights from the preliminary research put forth in the previous sections and discusses Task 1.2 contribution to the BREADCRUMB project (i.e. a preliminary conceptual model of links between categories of FMS and FW).[33] Given that the project is still in its initial stage, **certain elements of the conceptual model might be subject to changes in the future**.

The evidence shows that the influence of FMS on FW is contradictory. In some cases, marketing standards can reduce FW, while in others, they exacerbate the issue. The preliminary conceptual model (Figure 3) outlines key factors influencing FW outlined in the scientific literature.

The preliminary conceptual model is presented in a form of a causal loop diagram (CLD) and **incorporates only those categories and standards for which a link to food waste (FW) was identified through literature review.** Connections supported by previous research are represented with continuous lines, while those not thoroughly studied and of a more speculative nature are indicated with dashed lines. The causal connection between the categories of FMS and FW and the direction of the connection are indicated by the arrows (->); positive relationship (increase of FW) is marked with the plus sign (+) and negatives (decrease in FW) ones with the minus sign (-). Given that the CLD format shall be used for the final conceptual model in T1.4, the preliminary model in T1.2 is also expressed as a CLD.

The results summarized and pictured as a preliminary conceptual model show the following:

- **Technical definitions, designation and sales descriptions** can impact consumer preference, and thus mitigate the food waste via consumers more conscientious choices.
- **Classification criteria** can inadvertently contribute to food waste by necessitating the rejection of perfectly acceptable products that fail to meet specific requirements. Additionally, they can influence consumer preferences, potentially leading to overproduction and subsequent waste.
- **Indicating specific species, plant varieties, or animal races as** preferred can result in overproduction or underutilization of other varieties, contributing to food waste. When consumer preferences do not align with the types of products available, it can lead to excess inventory or disposal of unwanted items, further exacerbating food waste.
- **The packaging** of the product can mitigate the FW by preventing the damaging of the product or allowing better labelling of the product, however when it is inadequate it can also increase the FW. It can also increase FW by increasing the price of the products. **At the same time high-value food is more difficult to be wasted. In sum, the effect of packing on a FW can be mixed.**
- **The labeling of food products** plays a critical role in shaping consumer perceptions of quality and freshness. Misleading or unclear labels can lead to confusion or dissatisfaction, resulting in product rejection and food waste. However, accurate labeling can empower consumers to make informed choices, potentially reducing waste, especially regarding allergies and ingredient awareness.
- **Strict appearance criteria** aimed at meeting aesthetic preferences may lead to retailers rejecting otherwise edible products, increasing food waste. However, **Consistent product quality** builds consumer trust and satisfaction, reducing waste at the retail and consumer levels.

[33] For more details, see part 1-4 of this report.

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- **Standards on specific substances used in production** fostering consumer trust via ensuring the consistency of a given product (taste the same every time) and thus limiting waste. They can also prolong the shelf life of a product, and this limits the FW. Failure to meet these standards can result in waste at an early stage in the supply chain.
- **Standards on the type of farming and production method** enhance product quality, potentially reducing waste via optimizing the recourse allocation. They can also be in line with consumer preferences, leading to more conscientious choices and thus lower waste.
- **Standards specifying handling frequency and preservation methods** reduce spoilage and prolong shelf life, mitigating waste at various stages of the supply chain.
- **Consumer perceptions of quality, safety, and environmental standards** associated with specific origins or regions may influence their purchasing decisions, potentially reducing food waste, also via lesser overproduction.
- **Restrictions as regards the use of certain substances and practices** can enhance the quality of the food and this mitigates the FW. They can also minimize FW by enhancing the consumer trust about the safety (e.g. GMO or pesticides free) of a given product.

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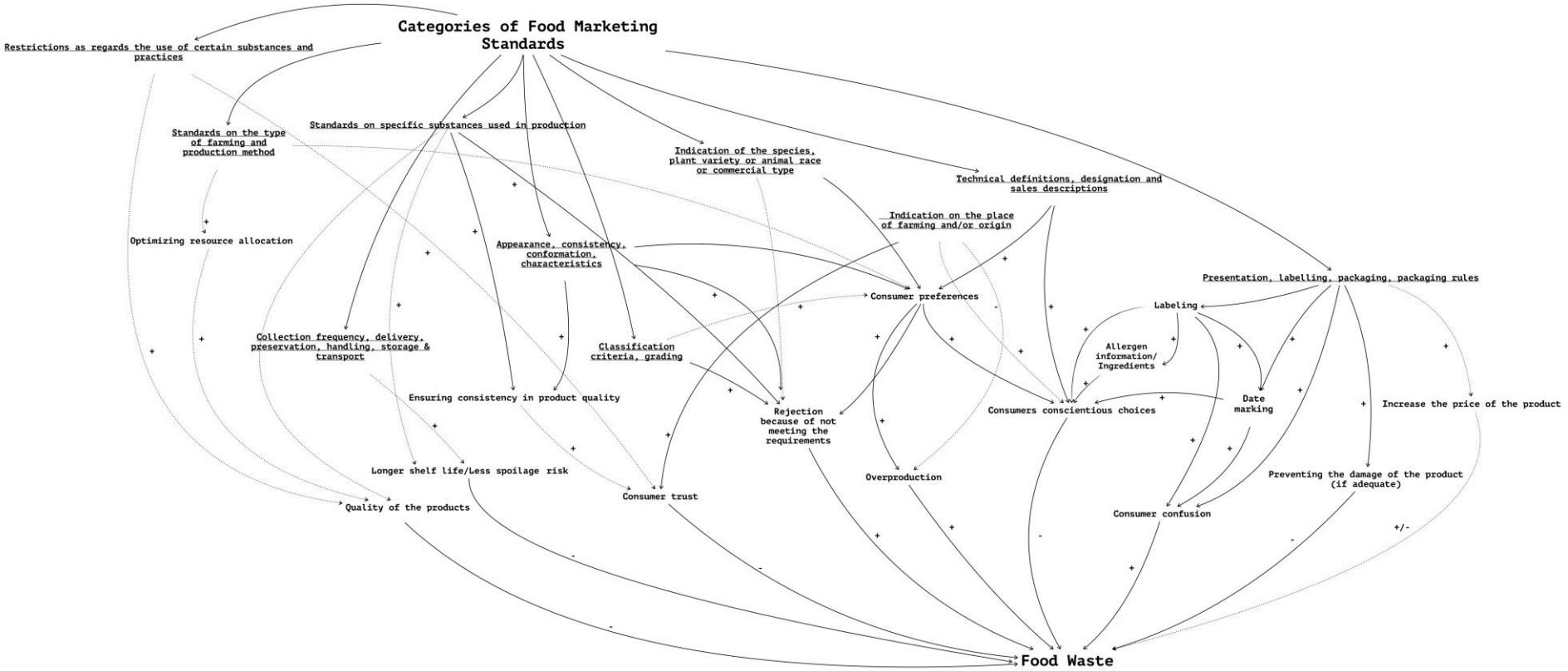
Figure 3**: A preliminary conceptual model** outlining **the potential impact of various categories of food marketing standards on FW presented as a causal loop diagram (CLD)**



6 INVESTIGATING GENDER DIFFERENCES IN PERCEPTION OF FOOD MARKETING STANDARDS CATEGORIES AND PLAUSIBLE CONNECTIONS TO FOOD WASTE

There has been growing interest in understanding how gender influences consumer behaviour, particularly food choices and waste. In BREADCRUMB, among others, we aim to explore the intricate relationship between gender differences in the perception of marketing standards categories and their connection to food waste. We can gain valuable insights into the underlying factors driving these dynamics by delving into existing literature and empirical evidence.

Research has consistently shown that **gender plays a significant role in shaping consumer behaviour** (Buzby & Hyman, 2012; Gutierrez-Barba & Ortega-Rubio). Kanwal et al. (2022) in their studies have highlighted how gender roles influence individuals' preferences, decision-making processes, and purchasing habits. These differences are in perceptions of marketing standards categories, such as product appearance, branding, and labelling. Regarding product appearance, **research suggests that women tend to prioritize visual aesthetics and packaging design** (Gruber & Schlegelmilch, 2014). In contrast, **men may emphasize other factors, such as brand reputation or product features** (Lee & Lee, 2018). Similarly, studies on expiration dates and risk perception indicate that **women are more cautious and risk-averse than men** (Jerven, 2019). However, in a study when respondents (Danish consumers) were provided with textual descriptions of the four products,[34] women were more likely to buy a suboptimal (i.e. aesthetically not appealing) product. An interaction was observed between sticker communication emphasizing FW avoidance and gender. Women were more likely than men to express a likelihood of choice when presented with such stickers (Aschemann-Witzel, 2018), suggesting that **women are more cautious with suboptimal food and are more open to buying it when environmental gain is stressed out.** This aligns with many results showing that women tend to behave more pro-environmental than men (e.g., Zelezny et al., 2000).

Understanding how gender differences in perception of marketing standards categories intersect with food waste behaviours is crucial for addressing the global challenge of FW. Research by Nemat (2020) and Zafar et al. (2022) suggests that **consumer attitudes towards food packaging significantly impact purchasing decisions and FW**. By recognizing gender-specific preferences and concerns, marketers and policymakers can develop targeted interventions to reduce FW and promote sustainable consumption practices.

[34] "Suboptimal" product nearing expiration as shown below, including expiration date-based pricing stickers and, where relevant, the organic logo for the respective experimental groups.

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7 CONCLUSION

The preliminary research created in Task 1.2 of the BREADCRUMB project has provided insights into the complex relationship between the categories of FMS and FW. While the project is still in its early stages and subject to potential adjustments, the findings shed light on various factors influencing FW across different stages of the supply chain.

The analysis reveals that **marketing standards can have both positive and negative effects on food waste. Restrictions on certain substances and practices, as well as standards related to farming methods and production processes, can enhance product quality, build consumer trust, and minimize waste.** Conversely, **strict classification criteria and appearance standards may inadvertently contribute to FW** by necessitating the rejection of edible products or influencing consumer preferences towards overproduction.

The labelling of food products plays a crucial role in shaping consumer perceptions, with accurate labelling empowering consumers to make informed choices and potentially reducing waste. Similarly, **packaging can mitigate FW by protecting products** and providing clear information, although excessive packaging may lead to environmental concerns and increased waste.

Standards specifying handling frequency and preservation methods are essential for reducing spoilage and prolonging shelf life, thus mitigating waste throughout the supply chain. Additionally, **consumer perceptions of quality, safety, and environmental standards associated with specific origins or regions can influence purchasing decisions and reduce FW.**

As already mentioned, certain categories of marketing standards can lead to both positive and negative effects on food waste. This seemingly contradiction might be resolved when the conceptual model is enriched with information on specific FMS within each category. It might be the case that standards within the same FMS category have the opposite influence on FW generation.

The following categories of FMS demonstrate fewer direct links to FW:

- Indication of the species, plant variety or animal race or commercial type;
- Standards on specific substances used in production, or components or constituents, including their quantitative content, purity, and identification;
- Standards on the type of farming and production method, including advanced systems of sustainable production.

These links will be examined in the next steps of the BREADCRUMB project.

Overall, while marketing standards can both mitigate and exacerbate food waste, **careful consideration and alignment with consumer preferences and sustainability goals are crucial for minimizing waste and promoting a more efficient and sustainable food system**. Further research and refinement of the conceptual model will be essential for developing effective strategies to address food waste within the BREADCRUMB project and beyond.

While the preliminary conceptual model lays a foundation for the following stages of the project, guiding interactions among tasks within the project, and with external stakeholders it has its **limitations**:

- There is a **lack of literature** providing indications of **causal links** in relation to the **specific categories of standards to FW** (for example, aesthetic requirements are addressed by many studies, while the standards related to sorting and grading, or the utilization of resources are not).

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- Furthermore, the information on the **directions of the links** between the categories of standards to FW is not always exhaustive. For instance, while the existing rules of best-before date marking might increase the amount of FW, the directions of the links between quality standards overall and FW are not so clear-cut.
- Different categories of standards and individual standards can have varying effects on different food commodities: **some standards may hold more influence than others**. However, the **literature does not necessarily provide information on the magnitude (the weight) of those effects**.
- **The interconnection between categories and individual FMS on each level** (EU, Member States and private) on selected food commodities is understudied as well.
- The results of the desktop research on food commodities and the literature review on the categories of FMS show asymmetries in subjective literature. Literature on specific food commodities focuses more on product safety, hygiene or waste management regulations and less on specific FMS.

More specifically, both groups of sources highlight the importance of standards and regulations in food production to mitigate FW, both discuss the impact of standards on consumer preferences, emphasize the significance of consumer trust and awareness in reducing FW, and mention the importance of transparent labelling and adequate packaging in reducing FW. However, the literature on food commodities focuses more on the regulatory aspects such as hygiene, certification, and waste management regulations, while the analysis of the categories of FMS sets emphasis on the impact of specific farming practices, production methods, and product standards. The literature on the categories of FMS discusses the influence of technical definitions and classification criteria on consumer behaviour, which are not addressed in the first set. The second set highlights the potential downside of strict appearance criteria and packaging, which could increase waste, whereas the first set does not delve into this aspect. The second set emphasizes the impact of restrictions on certain substances and practices, particularly in relation to consumer trust and preference, while the first set touches upon this but not as extensively.

The following stages of the project will build on the results of D1.2. More specifically, while the preliminary conceptual model focuses on marketing standards categories rather than specific standards within each category, T1.3 and T1.4 will explore the latter, contributing to an enhanced and deeper conceptual model. T1.3 will include an in-depth exploration of information on food marketing standards including further desktop research and fieldwork (200 in-depth interviews/surveys with relevant stakeholders across the 27 EU countries). During T1.4, the hypotheses developed by the project team, will be subjected into a co-assessment and co-creation process by employing the members of the Marketing Standards Interest Group and by undertaking an open workshop with a balanced mix of external stakeholders from the operations, policy, and research domains. The results of the workshops will be used to revise and finalise the preliminary conceptual model, and will be reported in D1.4. The outcomes of the research within WP1 and WP2 will contribute to the creation of the inventory of private and inter-related public marketing standards in the EU27 countries. The conceptual model will also be considered during the pre-modelling and modelling stages (T3.1 & T3.2), encompassing problem definition and the development of a modelling framework.

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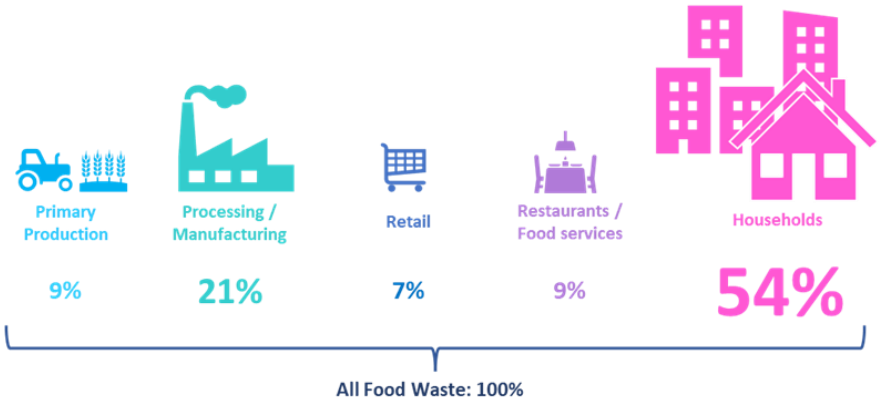
9 ANNEX 1: FOOD WASTE IN THE EU

European Commission highlights that "wasting food is not only an ethical and economic issue, but it also depletes the environment of limited natural resources." (European Commission, Official Website). Nevertheless, the EU produces more than 58 million tonnes of food waste annually (131 kg per capita), with an estimated market value of 132 billion euros. Eurostat's approximation suggests that about 10% of food available to EU consumers may go to waste. In the meantime, over 37 million individuals in the EU cannot afford a nutritious meal regularly. According to Eurostat, around 70% arise from households, food services, and retail sources (European Commission, Official Website).

Figure 4: Percentage of FW along the supply chain (% of Total FW)



Source: Adapted from Eurostat, Food waste and food waste prevention – estimates, 2023.

While only **9% of total FW in the EU occurs during the primary production** stage, according to Eurostat data, the **land and water footprints are affected the most at this stage**. In particurlar, **strict cosmetic standards set by retailers or regulatory agencies for size, shape, and appearance, which may result in perfectly edible crops being discarded if they do not meet these criteria.**

Processing and manufacturing are responsible for 21% of total FW in the EU. FW during the processing stage occurs due to **quality and specification requirements and safety standards; lack or improper storage facilities also have a significant effect on FW volumes**. Food manufacturers often adhere to strict quality criteria, meaning foods not matching the required size, colour, or shape are considered suboptimal and discarded. Similarly, perfectly consumable foods that deviate from sensory norms or have uncertain safety are frequently deemed FW (Raak et al., 2017).

Retail produces 7% of total FW in the EU. Product-related factors such as **quality standards, appearance, taste, type** (e.g., perishable products), and short **shelf-life** of certain products significantly impact food waste generation at the retail stage. At this stage, the weight of consumer preferences increases as well. **Consumer expectations of food quality, reluctance to purchase suboptimal products, and refraining from buying products with imminent expiry dates** contribute significantly to FW. **Eating habits, appetite, dietary needs, excessive ordering or purchasing of food, and demographics such as age, gender and ethnicity also play a role in generating food waste. Lack of awareness about FW and varying demand patterns further exacerbate the issue.** Furthermore, retailers' **sales and promotions** affect consumer purchasing behaviour, leading to excessive purchases, **packaging, and labelling** issues, causing confusion among consumers (Yetkin et al., 2020).

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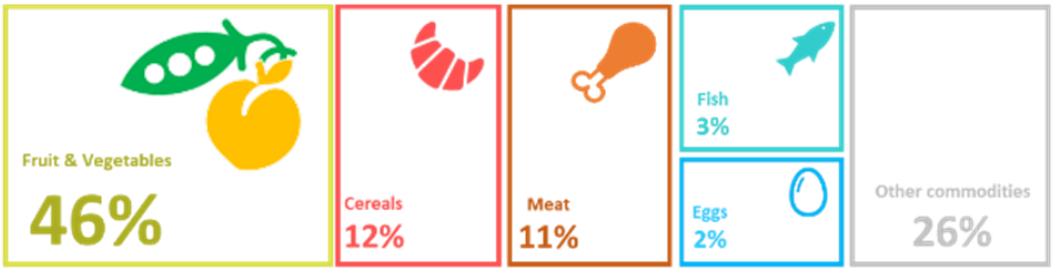
The huge magnitude of food at the level of the households it is explained by factors as **poor meal planning, purchasing an excessive amount of food, misunderstanding of date labels (such as "best before" and "use by" dates), improper cooking and storage, overcooking**, and the tendency to discard edible food based on preferences or perceived quality standards contribute significantly to food waste in households. L**ack of awareness regarding the quantity of food wasted** and the perception of food availability also impact household FW (Aschemann-Witzel et al., 2015; Nicastro & Carillo, 2021; Principato et al., 2021). Additionally, the **demographic composition of households and household income level** influence the volume of FW across households (Ilakovac et al., 2020; Falasconi et al., 2019). Furthermore, while **consumers recognise the importance of reducing FW, they find it challenging to do so in their daily lives.** This struggle is mainly due to **competing goals** affecting both the intentions to reduce FW and the implementation of those intentions. For instance, consumers often aim to provide ample and diverse food options for their families, leading to purchasing more food than is needed, which can result in waste. Out of concern for themselves and their family's health, consumers may dispose of food near or past the expiration date, potentially discarding food that is still safe to consume. The attraction to promotional offers and discounts can lead to buying food in bulk, some of which may not be used before it expires. Finally, the desire for pleasurable eating experiences may lead to purchasing or preparing more food than can be consumed before it spoils (Geffen et al., 2020). These drivers are interrelated and may compete with one another, creating a complex picture of why consumers waste food (Vittuari et al., 2023).

The quantity and the type of FW varies depending on the supply chain stage, food commodity and countries. Fruits and vegetables are food commodities susceptible to the most wastage: these commodities constitute over 20% of total food waste in the EU each. Cereals and meat are in second place with 12% and 11% respectively. Fish FW takes up to 3%, and eggs 2% of total FW.

Figure 5: Percentage of FW by food commodities (% of Total FW)



Source: Brief on food waste in the European Union, 2020.

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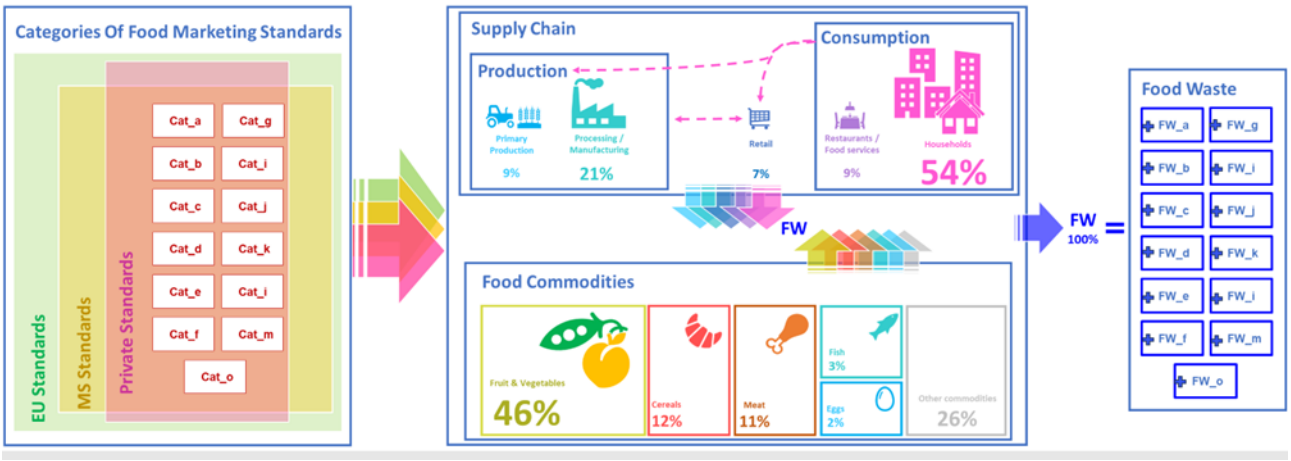
10 ANNEX 2: VISUAL SUMMARY: THE CONNECTIONS BETWEEN THE CATEGORIES OF FMS, THE SUPPLY CHAIN AND THE FOOD COMMODITIES, AND THE FW

The following figure visually summarises the connections between the categories of FMS, the supply chain and the food commodities, and the FW considering:

- ✓ the categories of food marketing standards (FMS);
- ✓ the levels on which standards operate (EU, Member States, private) and their intersections.
- ✓ five selected food commodities (fruit & vegetables, meat, cereals, fish and eggs) + the amount of food waste produced with each of them;
- ✓ the stages of the supply chain + the amount of food waste produced with each of them;
- ✓ the relationship between the actors within the supply chain;
- ✓ possible food waste creation due to the categories of food marketing standards specified in Regulation (EU) 1308/2013 + 1 optional category.

Figure 6: The connections between the categories of FMS, the supply chain and the food commodities, and the FW: a visual summary



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11 ANNEX 3: FOOD WASTE IN THE EU

Different categories of standards might influence food commodities differently. For some food commodities, there is a set of more and less influential standards. The preliminary research, supported by the expertise of the BREADCRUMB project members, identified the following crucial categories of food marketing standards for the food commodities featured in the project (Figure 8). Despite the promising results, this information requires further verification, including analysis of the categories of food marketing standards on 3 levels: EU, Member States, and Private. The in-depth research on the topic will take place during the following stages (particularly within WP1 and WP2).

Figure 8: A preliminary analysis of the categories listed in Regulation (EU) 1308/2013 regarding their importance for producing food commodities (based on the expertise and subjective assessment of the BREADCRUMB project partners)

Fruits & Vegetables	Meat	Cereals	Fish	Eggs	Categories of FMS according to the Regulation 1308/2013
	YES	YES		YES	*technical definitions*
YES	YES	YES	YES	YES	*classification criteria*
YES	YES	YES	YES	YES	*indication of species, plant variety, animal race, the commercial type*
YES	YES	YES	YES	YES	*presentation, labelling, packaging, packaging rules*
YES	YES	YES	YES	YES	*appearance, consistency, conformation, characteristics*
	YES	YES			*specific substances, components, constituents*
YES	YES	YES	YES	YES	*standards on the type of farming and production method*
YES	YES	YES	YES	YES	*collection frequency, delivery, preservation, handling, storage & transport*
YES	YES	YES	YES	YES	*indication of the place of farming and/or origin*
YES	YES	YES	YES	YES	*restrictions as regards substances and practices*
	YES	YES			*specific use*
YES	YES	YES		YES	*disposal conditions, holding, circulation and use of products*

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