

# Safety and commercial issues in fresh mushrooms and mushroom-based products sold at retail in Tuscany region

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## Abstract

The compliance to European and National safety and labelling requirements relating to the sale of spontaneous and cultivated mushrooms and mushroom-based products in Tuscany was assessed. The evidence was collected by the Mycological Inspectorate of North-West Tuscany Local Health Authority during 90 inspections (from 2016 to 2020) at large-scale distribution stores, wholesalers, and restaurants in 10 cities belonging to 3 provinces, and on the labelling analysis of 98 commercial products collected at retail in 2021. Despite a substantial compliance of the inspected activities and products with the regulatory requirements, critical issues were highlighted: 1) EU legislative gap in the definition of specific measures for the safe sale of spontaneous mushrooms; 2) improper shelf storage temperatures of fresh-cut products; 3) incorrect condition of use on the labels of pre-packaged products; 4) lack of country-of-origin declaration in pre-packaged products. Furthermore, the labelling analysis highlighted that 18.4% and 15.3% of the products presented issues in the validity and correctness of the scientific names respect to national requirements in. A revision of the current EU legislation is needed to guarantee consumers safety, also considering the relevant number of poisoning cases related to false mycetisms (ingestion of edible mushrooms improperly stored or used). Also, a specific revision and harmonization of the EU labelling of mushrooms would be desirable to protect consumers.

## Introduction

Commercial mushrooms, typically consisting of fresh and variously processed including fresh-cut products, are valuable and popular food appreciated worldwide due to their nutritional and nutraceutical properties (Tung *et al.*, 2020; Valverde *et al.*, 2015). The overall mushroom consumption has risen over the last 50 years, also in response to the growing demand for alternative sources and, at present, the European Union (EU) absorbs a large part of the global mushroom market (<http://www.fao.org/faostat/en/#data/QC/visualize>). To date, more than 2000 edible species are harvested and consumed worldwide, more than 200 of which of commercial importance in 27 European countries (Li *et al.*, 2021; Peintner *et al.*, 2013).

Mushrooms are also known for producing toxic compounds which are responsible for mild to severe acute and chronic syndromes including gastrointestinal or neurological self-limiting manifestations to liver and kidney failure or neurological sequelae (Govorushko *et al.*, 2019). They are mostly due to the thermo-resistance of toxic compounds characterized by a specific target mechanism of action such as ribosome inactivating proteins, cytolytins, lectins and cyclic peptides (Wenning *et al.*, 2020). Additionally, several intoxication phenomena have been recollected to the improper collection, transportation, storage, and cooking of edible mushroom species (Nieminen & Mustonen, 2020).

Given the risks related to the trade in non-edible species, since 1981 the Codex Alimentarius has published a specific standard for edible fresh or processed mushrooms marketing, quality, hygiene, and labelling (CX38-1981). In this respect, to exclude non-edible and poisonous products from the market, the need of the species identification by an expert is underlined.

In EU, health and hygiene aspects from mushroom cultivation or harvesting and processing to the final purchase and the related control activities by the competent authorities are based on the Regulation EC No. 178/2002, EC No. 852/2004, and EU No. 2017/625. Mushroom products labelling fall within the scope of the Regulation EU No. 1169/2011 and further implementing regulations, integrated with the Regulation EU No. 1308/2013 on the market of agricultural products and the Implementing Regulation EU no. 543/2011 laying down marketing standards in the sectors of fresh fruit and vegetables. However the Implementing Regulation EU No. 543/2011 explicitly exclude non-cultivated mushrooms from its scope. The EU regula-

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tory framework has integrated previous national regulations specifically addressing harvesting and marketing rules on both fresh and preserved epigeal mushrooms defining criteria for the identification, labelling and trade of edible species (Peintner *et al.*, 2013). In Italy, the Presidential Decree (PD) No. 95/376, on the collection and marketing of fresh and preserved epigeal mushrooms, imposes the identification of the products by the combination of the commercial and the scientific name of the mushroom (Article 10). The same PD include a positive list of the commercial species, currently including around 150 mushrooms (Giusti *et al.*, 2021). In addition, the PD imposes for all the Food Business Operators (FBOs) the acquisition of certificate of suitability for the identification of fungal species acquired on completion of specific training courses organized

by the local Health Authority (LHA). This certificate is essential to obtain the authorization for selling mushrooms avoiding the commercialization of non-edible species.

The Mycological Inspectorates operate in accordance with specific guidelines and regional laws. In Tuscany they operate in accordance with the Regional Law (RL) No. 16/1999 and subsequent amendments. Aside from the FBOs training, their activities consist of the morphological identification of mushroom species, to prevent poisoning phenomena, and of the verification of the products compliance to the hygiene and commercial requirements imposed by EU and national legislation to guarantee consumers health and interests. In this context, the compliance to food safety and traceability requirements relating to the sale of fresh, spontaneous and cultivated mushrooms, and mushroom-based products, was investigated in this study, through the evaluation of the evidence collected in inspections carried out by the Mycological Inspectorate of North-West Tuscany LHA (Tuscany region) and through the evaluation of the labelling of commercial products purchased at retail level.

## Materials and methods

### Analysis of the results of official control activities

Results of 90 inspections in the contest of the official control activities from 2016 to 2020 performed by the Mycological Inspectorate of North-West Tuscany LHA were analysed. The inspections were carried out at large-scale distribution stores, wholesalers and restaurants distributed in 10 cities belonging to Pisa, Lucca, Livorno, and Massa Carrara provinces with an average of three controls per type of activity per city included in the control activities planning. During the inspections, the compliance to PD No. 376/1995- and RL n. 16/1999 were checked with respect to the holding by the FBO of: a) certificates of suitability for the identification of mushroom species, b) authorization for the sale of mushrooms in bulk, c) lists of authorized suppliers for the distribution of epigeal mushrooms. The control activities were also addressed at the verification of the state of conservation of whole mushrooms (wild and cultivated), and of fresh-cut cultivated mushrooms according to the EU provisions on food safety and hygiene (Regulation EC No. 178/2002, Regulation EC No. 852/2004) and the marketing standards according to the Implementing Regulation (EU) no.

543/2011 and national guidelines on methods of preserving fresh-cut products (Ministerial Decree n. 3746 of July 2014). The evidence was analysed to verify the effective application of national and EU requirements and to highlight the frequency and type of any non-conformities.

### Assessment of labelling compliance of commercial products to EU and national requirements

A total of 98 mushroom products (dried n=26, frozen n=36, canned n=23, others n=13) were directly purchased at retail from several major large distribution supermarkets located within Pisa province from October 2020 to March 2021. All the labelling information were tabulated in an excel file and labels compliance to the EU and national requirements was assessed. In detail, the presence of mandatory information pursuant to the Regulation EU No. 1169/2011 (chapter IV) was checked. The presence of the declaration of country of origin, pursuant to the article 26 dispositions and the Implementing EU Regulation No. 775/2018 specifically addressing this topic, was also included in the analysis. Food name and condition of use were also checked in accordance with the requirement of the PD No. 376/1995 to verify the presence and compliance of both commercial and scientific name to the official list of the authorised edible mushrooms species and the presence of a statement informing the consumers on the need of cooking the product for a safe consumption. The validity of the scientific names declared was checked against the taxonomic databases "Index fungorum" (<http://www.indexfungorum.org/names/Names.asp>).

Finally, all the products included in the category "others" (lyophilized, ready to cook first course dishes and bakery products) were checked for the presence of the Italian wording "*ai funghi*" (with mushrooms).

## Results

### Analysis of results of official control activities

The analysis showed a substantial compliance of the inspected activities with EU and national requirements on product traceability and possession of the specific authorizations required for the products commercialization. All the inspected large-scale distribution, wholesalers and restaurateurs were confirmed in possession of the certificate of suitability for the identification of mushroom species necessary both for the

labelling of the products in the packaging phase and for the administration of harvested epigeal mushrooms. Nevertheless, hygiene issues relating to the presence of spontaneous epigeal mushrooms and fresh-cut cultivated mushrooms exposed at purchase at room temperature and not under refrigeration conditions were highlighted.

### Labelling compliance of commercial products to EU and national requirements

The overall results of the analysis are summarized in Table 1.

#### Mandatory information

Pursuant to EU Regulation No. 1169/2011, all products reported: the description of the food name, net and drained weight, company name, minimum durability date, nutritional facts (except of 1 dried and 1 canned product) and the condition of use. In this regard, the validity and correctness of the condition of use reported in 12 frozen products were subject to a further evaluation whose final considerations are reported in section 4.3. A clear mention of the storage conditions was highlighted in 92.8% of the products (91/98), not present exclusively in 7 lyophilized ready to eat products stable at room temperature. The list of ingredients was found in 86.7% (85/98) of the products. The 13 products (11 dried and 2 frozen products) for which no ingredients list was included in the labels were still compliant under the Regulation (Article 19) allowing the list omission for all products consisting of a single ingredient. Allergens were declared in 44.9 % (44/98) of the products as follow: sulphites and sulphur dioxide residues in 6 dried products, sulphites and celery in 19 canned products, glutinous ingredients in 6 frozen products and celery, eggs, wheat and milk and wheat or milk derivatives also in the form of residues in 13 other products.

The country of origin was declared in 34 products corresponding to the 40% (34/85) of the products in which mushrooms constituted the primary ingredient. This information was available for dried (18/26; 69.2% within the category), frozen (9/23; 39 % within the category), and canned (7/36; 19.4% within the category) products. Specific data on product composition (mono or multispecies) and about the reference to the geographic origin declared on the label are summarized in Table 2. To be noted that 50% (17/34) of the products for which the country of origin was reported were declared as made in Italy.

All products were also compliant with PD No. 376/1995 (Article 10): 1) all products were clearly identified by trade and sci-

entific name, 2) the labelling of all uncooked pre-packaged mushrooms in the various commercial categories (dried, frozen), was suitably integrated with the indication of the obligation to cook; 3) all ready-to-eat products containing mushrooms were presented for sale with a food name containing the words “*ai funghi*” (with mushrooms) or similar expressions.

On the contrary, several incorrect scien-

tific names associated with the commercial names were found. The use of invalid obsolete scientific names (*Lentinus edodes* currently *Lentinula edodes*; *Psalliota bispora* currently *Agaricus bisporus*, *Xeroconus badius* or *Boletus badius* currently *Imleria badia*, *Boletus pinicola* currently *Fomitopsis pinicola*) or the use of non-existent scientific names produced by the blending of two different species names

(*Pholiota nameko mutabilis* produced by blending of *Pholiota nameko* and *Kueheromyces mutabilis*) were found in 18 products analysed (18.4%). Furthermore, typos were highlighted in 15 products (15.3%) mainly consisting of the use of a capital letter to indicate the species attribute (e.i *Agaricus Bisporus*) or in the misspelling of valid scientific name (e.i *Lentinula edodes*).

**Table 1. Assessment of the labelling compliance to the European and national Regulatory requirements.**

Reference	Labelling info	Presence	Commercial category				Total (%)	
			Dried (n=26)	Canned (n=36)	Frozen (n=23)	Others (n=13)		
Reg. EU No.1169/2011	Food name	Y	26	36	23	13	98 (100)	
	Ingredients list	N	0	0	0	0	0	
		Y	15	36	21	13	85 (86.7)	
	Net/drained weight	N	11	0	2	0	13 (13.3)	
		Y	26	36	23	13	98 (100)	
	Company name	N	0	0	0	0	0	
		Y	26	36	23	13	98 (100)	
	Storage condition	N	0	0	0	0	0	
		Y	26	36	23	6	91 (92.9)	
	Condition of use	N	0	0	0	7	7 (7.1)	
		Y	26	36	23	13	98 (100)	
	Minimum durability	N	0	0	0	0	0	
		Y	26	36	23	13	98 (100)	
	Nutritional facts	N	0	0	0	0	0	
Y		25	35	23	13	96 (97.9)		
Allergens highlights	N	1	1	0	0	2 (2.0)		
	Y	6	19	6	13	44 (44.9)		
Reg. EU No. 1169/2011 (Art. 26) Impl.Reg. (EU) No. 2018/775 Reg EU No. 543/2011	Country of origin	Y	18	7	9	0	34 (34.7)	
		N	8	29	14	0	51 (52.0)	
		NA	0	0	0	13	13 (13.3)	
	PD No. 376/95 R L No. 16/1999	Commercial name	Y	26	36	23	13	98 (100)
		Scientific name	Y	26	36	23	13	98 (100)
	Scientific name validity	N	0	0	0	0	0	
		Y	23	28	16	13	80 (81.6)	
	Scientific name correctness	N	3	8	7	0	18 (18.4)	
		Y	20	33	18	11	83 (84.7)	
		N	6	3	5	1	15 (15.3)	

Y= yes, N=no, NA= Not Applicable.

**Table 2. Analysis of the products labels for the assessment of the country-of-origin declaration.**

Category	Product composition (n. mushroom species)	N.	Declaration of country of origin		References to the geographic area				
			Absence	Presence	Italy	Specific EU and Extra EU Countries	EU	Extra-EU	EU and Extra-EU
Dried (N=26)	Monospecies	22	8	14	6	4*	1	0	3
	Multispecies	4	0	4	0	0	2	0	2
Canned (N=36)	Monospecies	29	23	6	6	0	0	0	0
	Multispecies	7	6	1	1	0	0	0	0
Frozen (N=23)	Monospecies	14	8	6	2	4*	0	0	0
	Multispecies	9	6	3	2	0	0	0	1
<b>Total</b>	<b>85</b>	<b>51</b>	<b>34</b>	<b>17</b>	<b>8</b>	<b>3</b>	<b>0</b>	<b>6</b>	

\*Romania, Hungary, Bulgaria, Holland, Macedonia, Turkey, PRC

### Voluntary information

Additional information included on voluntary basis were highlighted in the following products: a) 13 (13.3%) products included in the “other” category (lyophilized and ready to eat) presented an indication of allergens residues deriving from other processes carried out within the same processing plant ; b) 9 (9.2%) products (8 canned and 1 frozen) reported the absence of gluten stated in agreement with the Implementing Regulation EU No. (EU) No 828/2014; c) 3 products (3.1%) (2 canned and 1 lyophilized) were reported as glutamate free.

## Discussion

Some critical issues that will be briefly discussed were highlighted in the study relating to: 1) a regulatory gap at EU level in the definition of specific measure for the safe commercialization of spontaneous mushrooms; 2) the improper shelf storage temperatures of fresh-cut products offered for sale; 3) incorrect condition of use reported on the labels of pre-packaged products; 4) lack of declaration of the mushrooms' country of origin in pre-packaged products.

### Definition of specific measures for the safe commercialization of spontaneous mushrooms

The issue that emerged during official controls was related to the state of conservation of spontaneous mushrooms exposed at room temperature on the shelf. To frame the issue, it is necessary to recall some regulatory references. Without prejudice to the food safety and hygienic requirements imposed by Regulation EC No. 178/2002 and Regulation EC No. 852/2004 (Annex II), mushrooms follow quality requirements defined by Regulation EU No. 543/2011, although all wild harvested mushrooms (NC070959) are excluded from the application of general marketing rules stated for vegetables in the Annex A of the Regulation. This fact creates a gap in the homogeneous definition of mushrooms quality standards. The regulatory gap is bridged by the PD and RL which impose specific marketing standards, analogous to EU requirements for cultivated mushrooms, describing the products at purchase as: clean, free of parasites and off-odours and sufficiently developed. Nevertheless, both EU and national legislation do not specify mandatory temperatures for the storage of the products, apparently not considering the mushrooms' limited shelf-life at room temperature (1-3 days). Mushrooms shelf-life is indeed directly related to their high respiration rate and physical-

chemical composition, (high water activity, neutral pH, high dehydration and oxidation rate) which significantly contribute to the early microbial spoilage (Fernandes *et al.*, 2013, Venturini *et al.*, 2011). In this regard, storage at refrigeration temperatures (<7°C), has been proven effective in prolonging the overall product quality, shelf-life and safety (Mahajan *et al.*, 2008; Santana *et al.*, 2008). Thus, a proposal for the integration and revision of the current legislation on the management of the cold chain during the transport and display for sale of the products would be desirable.

### Improper shelf storage temperatures of fresh-cut products

The issue arose after the discovery of prepacked cultivated mushroom fresh-cut products exposed at room temperature in shops belonging to an international distribution chain. In this specific contest, mushroom fresh-cut products falling within the scope of the Regulation EU No. 543/2011 should also fall under the scope of national provisions concerning the preparation, packaging and distribution of fourth range fruit and vegetable and, specifically, under the Ministerial Decree no. 3746 issued by the Ministry of Economic Development in June 2014. Thus, the issue is configured as a non-compliance with the current legislation imposing a mandatory storage temperature below 8° C for all fourth range fruit and vegetables (Ministerial Decree-Article 6).

### Incorrect conditions of use reported on the labels of pre-packaged products

Pursuant to Regulation EC No. 178/2002, EU No. 1169/2011 and specifically to PD No. 396/1995, the FBOs are obliged to report the indication of use on each package of fresh mushrooms. That said, the indications “to be consumed after cooking” or “cook the frozen products for 5-10 minutes or at will” reported in 12 raw frozen products consisting of *Agaricus bisporus*, *Boletus edulis* or mixed mushrooms containing *B. edulis*, albeit compliant with legislation, were evaluated negatively by expert mycologists as not sufficient to protect the consumer from any forms of accidental intoxication. Indeed, the presence of numerous molecules isolated from commonly recognized edible mushrooms such as *B. edulis* responsible for adverse effects and capable of causing intoxication phenomena and hospitalization has been clearly underlined (Landi *et al.*, 2021; Cervellin *et al.*, 2018). Specifically, numerous molecules, including Edulitin 1 and 2 isolated from *B. edulis*, proved to be resistant both to peptic proteolysis in an acid environment and to tryptic proteolysis while they

appeared sensitive to heat treatment at a temperature of 90 ° C for at least 10 minutes (Landi *et al.*, 2021). Thus, the information evaluated in the present study appeared ineffective in reducing the risk related to the intake of these molecules. This evidence reinforced the recommendation that major caution should be paid in the communication of the conditions of use as already pointed out by previous authors (Landi *et al.*, 2021, Cervellin *et al.*, 2018).

### Lack of declaration of the mushroom's country of origin in pre-packaged products

Pursuant to the EU Regulation 1169/2011, the country of origin of a food product and of its primary ingredient are required where the omission could mislead the consumer as to their true country of origin. This aspect has been further clarified following the issue of the Regulation EU No. 775/2018, in application since the 1<sup>st</sup> April, 2020, which specifically regulates information to consumers on the indication of the country of origin of the primary ingredient of a food and establish the declaration of the country of origin with reference to one of the following geographical areas: “EU”, “non-EU” or “EU and non-EU” or a region or any other geographical area within from different Member States or from third countries. Additionally, in fruit and vegetables category the declaration of the country of origin is included among the general marketing standard listed in the Regulation EU no. 543/2011 and directly applicable to cultivated mushrooms but also to fresh spontaneous mushroom pursuant to the Regulation EU No. 1308/2013 which extended the obligation to all the fruit and vegetable sector intended for sale as fresh products, regardless of the applicability of marketing standards. This said, the omission of declaration highlighted in most of the products was partially justified on the fact that the absence of origin declaration didn't mislead the consumer as to their true country (Regulation EU No. 1169/2011- Article 26). Nevertheless, most of the dried products showed a clear indication of the country of origin of the primary ingredients expressed according to Regulation EU No. 775/2018 (Table 2, section 3.4), even in batches prior to the date of application of the Regulation. This information appears relevant in terms of transparency towards the final consumer given the high mushroom volumes and varieties imported from East-EU and Extra-EU countries to satisfy the national demand (<https://www.cbi.eu/market-information/processed-fruit-vegetables-edible-nuts/dried-mushrooms/market-potential>).

## Conclusions

Despite a substantial compliance to the legislative requirements of both the commercial activities and products at purchase some relevant issues, such as the shelf storage condition at purchase and proper information on the use of mushroom clearly emerged from the present study. This considered, a draw up of a proposal for the integration and revision of the current legislation would be needed also by virtue of mushroom poisoning data at national level. In fact, in addition to cases due to the consumption of toxic fungal species, occasional episodes described as false mycetisms are documented, due to the ingestion of edible mushrooms improperly stored and used. Finally, in line with the existing regulatory framework, a further labelling harmonization of mushroom products at European level to promote a more informed and transparent choice should be considered.

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