Contamination of aromatic herbs and medicinal plants by fungi and associated mycotoxins

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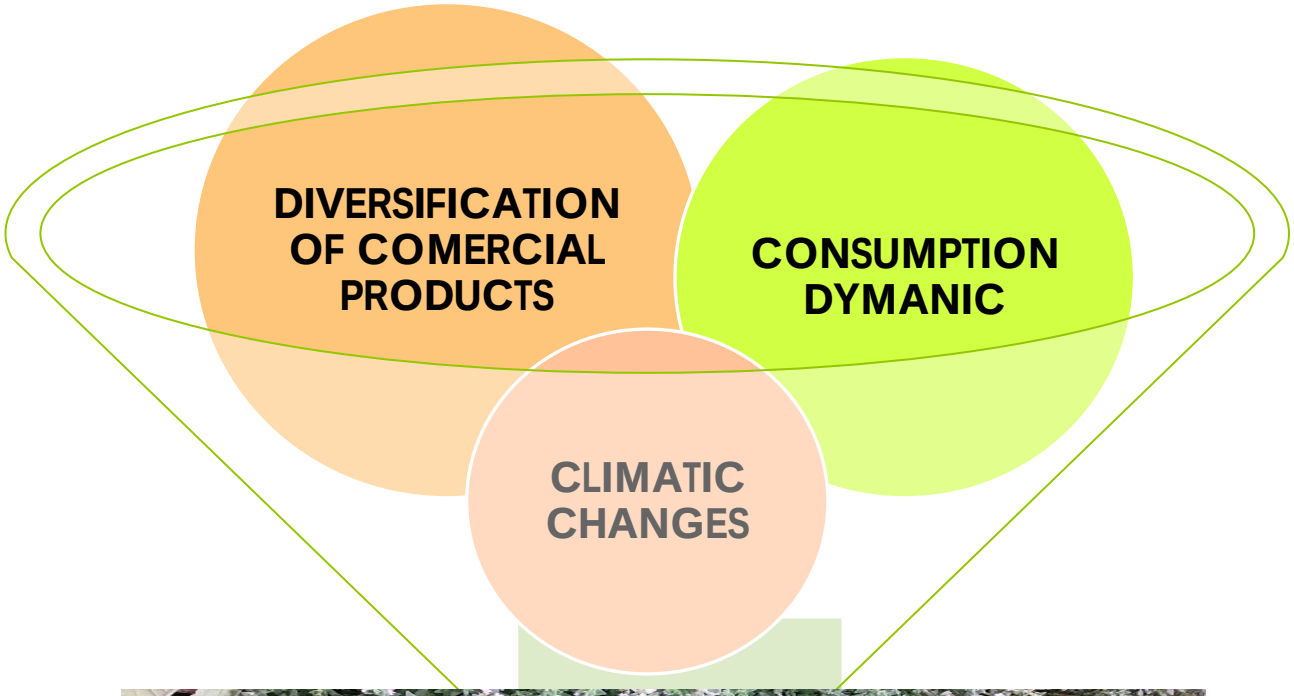
Approaches regarding aromatic herbs



Consumption dymanic in european countries

- social changes
- food diversity
- seeking for new flavors
- increased interest in "ethnic" cuisine
- processed foods that require spices and herbs for cooking
- tourism
- traditional restaurants of various ethnic groups
- immigrants involved in supply chain stores and food markets
- catering system
- increased interest in a healthy lifestyle and, consequently, in the consumption of healthy food.

Media influence

Media have stimulated demand by:

- a great variety of culinary programs
- dedicated magazines
- culinary contests
- radio programs

Producers and consumers in EU

- Traditional producers: France, Italy and Greece
- The largest EU producers: Germany, Austria, Bulgaria, Spain, Poland and Hungary
- Consumers: UK, Germany, Romania, Hungary

CBI Market Survey: The Spices And Herbs Market In The Eu, march 2010, http://www.crecemype.pe/portal/images/stories/files/pdf/estudioespeciasyhierbas.pdf

Diversification of comercial products

- Comercialization:
  - Individually
  - Spices mix bags for specific recipes
  - Sauce mix
  - Food supplements
  - **Food products**

Herbs are currently used to manufacture a very wide range of food products:

- meat
- cheese
- juices
- spirits
- balsamic vinegar
- flavored oils
- bakery products
- canned food
- confectionery, ice-cream, candy and chocolate

Climate changes

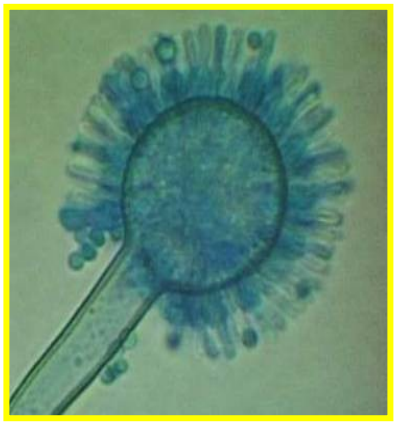
- Climate changes and their intensity depends on their action alone or simultaneously

- Major climate changes:
  - temperature regime
  - rainfalls
  - increased frequency and intensity of storms (including hurricanes)
  - dry years
  - increased UV-B, CO2 and NOx pollution

Climate changes affects: - biodiversity of fungi
- host-pathogen relationship

Fungi contamination

- Aromatic hebs and medicinal plants are dried and powdered herbal blends that include different parts of the plant: leaves, stems, roots, flowers and seeds. All these parts of the plant can be degraded by bacteria and fungi.
- Some of the microbial contaminants may produce toxins
- Mycotoxigenic fungi belong maily to genera: *Aspergillus sp*., *Penicillium* sp. and *Fusarium* sp.



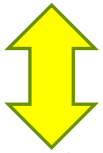
What are mycotoxins?

- MYCOTOXINS are fungal metabolites that, when ingested, inhaled, or absorbed through the skin, may cause lowered performance, sickness or death in man or animals
- They are not required for the growth of the producing fungus and, therefore, are considered secondary metabolites
- Presumably they play some role in the ecology of the fungus, but their function has not been clearly defined
- Mycotoxins are low molecular weight, nonproteinaceous compounds, with different chemical structure and with thermal stability
- They have bad effects on human and animals even when they are present in small amounts (ppm, ppb)

Who can produce mycotoxin?

MYCOTOXIN	PRODUCING FUNGI
Aflatoxins (B1, B2, G1, G2)	*Aspergillus flavus*, *Aspergillus parasiticus*
Aflatoxin M1	
Ochratoxin A	*A. ochraceus*, *A. carbonarius*, *A. niger*, *Penicillium verucosum*
Deoxynivalenol	*Fusarium graminearum*, *Fusarium culmorum*
Zearelenone	*Fusarium graminearum*, *F. culmorum F. cerealis*
Fumonisins	*Fusarium verticillioides*, *Fusarium proliferatum*

The presence of a toxin-producing fungus does not automatically imply **the presence of the associated toxin** as many factors are involved in its formation



The absence of any visible mould does not guarantee **freedom from toxins** as the mould may have already died out while leaving the toxin intact

Health effects of mtcotoxins

For their diversity of chemical structures and physical properties, mycotoxins exhibit a wide range of biological effects and can be:

- GENOTOXIC
- MUTAGENIC
- CARCINOGENIC
- EMBRYOTOXIC
- TERATOGENIC
- OESTROGENIC

Factors affecting the occurance of toxigenic fungi and mycotoxins

- **Biological factors**
  - susceptible crop, compatible toxigenic fungus
- **Planting**
  - crop rotation, soil preparation, fertilization, irrigation, plant-spacing, weed control
- **Environmental factors**
  - temperature, moisture, mechanical damage, insect damage
- **Harvesting**
  - crop maturity, temperature, moisture, mechanical damage
- **Storage**
  - temperature, moisture, CO2 / O2, mechanical damage, insect damage
- **Distribution and processing**
  - temperature, moisture, spore load, microbial interactions

Fungi contamination of aromatic herbs

Aromatic herb	Identified fungi	References
Origanum vulgare **(Oregano)**	*Alt. alternata, Aspergillus spp., A. niger, A. versicolor, Chaetomium spp., Mucor spp., Nigrospora spp., Penicillium spp., Phoma spp., Rhizopus spp., Trichoderma spp.*	Guglielminetti et al., 1996; García et al., 2001
Mentha piperita **(Peppermint)**	*Alternaria spp., A. flavus, A. niger, A. ochraceus, A. terreus, Fusarium spp., F. equiseti, Penicillium spp., R. nigricans, Trichoderma spp*	Pepeljnjak and Cvetnić, 1998; Abou-Arab et al., 1999; Rizzo et al., 2004
Salvia officinalis **(Garden sage)**	*A. candidus, A. flavipes, A. fumigatus, A. glaucus, Cladosporium spp., Fusarium spp., Penicillium spp., R. nigricans*	Pepeljnjak and Cvetnić, 1998; Martins et al., 2001
Thymus vulgaris **(Thyme)**	*R. nigricans*	Pepeljnjak and Cvetnić, 1998
Coriandrum sativum **(Coriander)**	A. flavus, A. glaucus, A. niger	Guglielminetti et al., 1996; Rizzo et al., 2004

Fungi contamination of medicinal plants

Medicinal plant	Identified fungi	References
Matricaria chamomilla, Chamomilla recutita **(Chamomile)**	*Absidia spp., A. candidus, A. flavipes, A. flavus, A. fumigatus, A. glaucus, A. niger, A. terreus, Cladosporium spp., Fusarium spp., F. compactum, Mucor spp., Paecilomyces spp., Penicillium spp., R. nigricans*	Pepeljnjak and Cvetnić, 1998 ; Martins et al., 2001, Rizzo et al., 2004
Tilia spp. **(Linden)**	*Alternaria spp., A. candidus, A. flavus, A. fumigatus, A. glaucus, A. niger, A. ochraceus, A. terreus, Cladosporium spp., Fusarium spp., F. equiseti, F. verticillioides, Mucor spp., Penicillium spp., R. nigricans*	Pepeljnjak and Cvetnić, 1998; Abou-Arab et al., 1999 1999; Martins et al., 2001; Rizzo et al., 2004,
Urtica dioica, Urtica urens **(Nettle leaves)**	*R. nigricans, A. niger*	Pepeljnjak si Cvetnić, 1998 Stevic T. et al. 2012
Equisetum arvense **(Horsetail)**	*R. nigricans, Fusarium spp., Penicillium spp., A. flavus, A. niger*	Pepeljnjak si Cvetnić, 1998 Stevic T. et al. 2012

Santos et al., 2013 Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas 12 (2): 119 - 142

Mycotoxin contamination (produced by *Aspergillus* sp. and *Penicillium* sp.

Aromatic herb	AFt (µg/kg)	OTA (µg/kg)	Citrinin (µg/kg)	Referinte
Origanum vulgare **(Oregano)**	ND	-	-	Romagnoli et al., 2007
Mentha sp. **(Spearmint)**	16.6-29.7	1.1-1.4	41.0-43.3	Santos et al., 2009
Rosmarinus officinalis **(Rosemary)**	ND	-	-	Romagnoli et al., 2007
Salvia fructicosa	23.8-25.2	1.1-17.3	51.6-273.2	Santos et al., 2009
Salvia officinalis (Sage)	ND	ND	-	Romagnoli et al., 2007
Zingiber officinale **(Ginger)**	0.4-3.6 4.2-13.5	2.1-7.5	-	Arranz et al., 2006 Patel et al., 1996
Ocimum basilicum **(Basil)**	ND	-	-	Romagnoli et al., 2007
Coriandrum sativum (Coriander)	0.7	4.0	ND	Roy et al., 1988 Lino et al., 2006

Mycotoxin contamination (produced by *Fusarium* sp.)

Aromatic herb	Fumonizine (µg/kg)	ZEA (µg/kg)	Trichothecenes (µg/kg)	References
***Origanum vulgare* (Marjoram)**	FB1 ND-<LD FB2 ND	-	-	Omurtag and Yazicioğlu, 2004
***Mentha sp.* (Spearmint)**	<LD	2.1-9.3	DON 46.9-91.1 T2 3.9-4.9	Santos et al., 2009
***Mentha piperita* (Peppermint)**	FB1 160, FB2 ND	-	-	Omurtag si Yazicioğlu, 2004
***Salvia officinalis* (Sage)**	130.0-133.3	4.7-5.2	DON 83.6-102.2, T2 0.6-2.5	Santos et al., 2009
***Coriandrum sativum* (Coriander)**	ND	3.6-6.7	DON 21	Patel et al., 1996
Ginkgo biloba (Ginkgo leaves)	<LD	9.1-9.4	DON 63.4-134.1 T2 19.1-29.4	Santos et al., 2009
***Matricaria chamomilla Anthemis sp.* (Chamomile)**	<LD	7.3-12.5	DON 123.4-191.5 T2 3.5-8.3	Santos et al., 2009

Santos et al., 2013 Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas 12 (2): 119 - 142

Things to take home

- Aromatic plants and medicinal plants are susceptible to toxigenic fungi contamination;
- Even the filamentous fungi can't be seen, the mycotoxin may be present;
- When intended to be used in food processing, aromatic plants need to be analyzed for toxigenic fungi contamination and for mycotoxin content.

Thank you