A Global Perspective of the High Five: *Agaricus, Pleurotus, Lentinus, Auricularia, & Flammulina*

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The Pennsylvania State University
World Mushroom Industry
$51 Billion (USD)

- Edible 59%
- Medicinal 31%
- Wild 10%

Chang 1996 & 2013, Li 2012
Cultivated edible mushrooms $30 B

Wild mushrooms $5 B

Medicinal mushrooms $16 B

Chang 2006, 2013
World Population vs. Mushroom Production

- Billion
- kg

World population vs. mushroom production over time from 1978 to 2012.
Mushroom Production in Selected Countries (2010)

- China
- Japan
- USA
- Netherlands
- India
- Poland
- Spain
- Others EU

Production (x 1,000 t)

Yamanaka 2011, Li 2012, FAOSTAT 2013
Cultivated Edible Mushrooms

Chang 2006, ISMS 2007, Li 2012
Mushroom Production in China by Genus (2010, CEFA)

- **Pleurotus**
- **Auricularia**
- **Len**
- **Agaricus**
- **Flammulina**
- **Coprinus**
- **Agrocybe**
- **Volvariella**

Production (x 1,000 t)

Li 2012
Mushroom Production in China
Chinese Edible Fungi Association vs. FAOSTAT

![Bar chart showing mushroom production in China from 2002 to 2010. The chart compares data from the Chinese Edible Fungi Association (CEFA) and the Food and Agriculture Organization (FAO). The chart indicates a significant increase in production from 2002 to 2010, with a peak of 22.5% in 2010. The percentage of production data from FAOSTAT is also shown, with a notable increase from 2004 to 2006.](chart.png)
Agaricus

- 30% of world production
- Primarily *A. bisporus* (some *A. brasilensis*)
- White (90%)
- Brown (10%)
  - Crimini
  - Portabilla
Agaricus Production in Selected Countries (2010)

China
USA
Canada
Mexico
India
Netherlands
Poland
Spain
Others EU

Li 2012, FAOSTAT 2013
**Agaricus producon - China**

- Began in 1925 – introduced from Europe
- 1966, Fujian province - large scale producon
- 1996, 75% of producon in China
- 1996, producon began to spread north to Shandong, Henan and Xinjiang
Agaricus spawn - China

• Spawn industry yet to fully develop
  – Few suppliers
  – Many farmers produce own spawn
• Demand for commercial spawn increasing
• 100 million kg/year
• $200-$300 million/year

h// www.sylvaninc.com/produconProcess.html
Agaricus - United States

Producn

Pleurotus spp.

Agaricus 98%

Len 1%

White 81%

Brown 17%

Brown value = 22%
Specialty value = 6%

USDA 2014
Agaricus - United States

- Value $1.05 billion (2013)
- 2nd largest producer in world – 400,820 T
  - 0% increase from 2011
- Agaricus – New Dutch style farms
Agaricus - United States

- 65% in Pennsylvania
- 12% California
- 3% organic sales
- 87% sold fresh
- 13% processed
- 19% of growers certified organic

Source: Phillips Mushroom Farms
Agaricus - United States

- Number growers decreasing
  - -57% in 22 y
- 31 growers produced 77% of total (> 4.50 million kg each)
- Price per kg
  - 2004 = $2.51
  - 2013 = $2.77
Agaricus - Netherlands

- 95% *Agaricus bisporus*
- World’s 3rd largest producer (260 M kg)
- 140 M kg into canned and frozen mushrooms
  - Germany, France, Greece
- Most fresh exported to UK, Germany, France
- Three main compost producers
- Mostly fully colonized (phase III compost)
Agaricus - Netherlands

- Three companies supply casing soil
- Number of growers decreasing
- 75% of growers hand harvest; 25% mechanical
- Overall industry is highly mechanized
Agaricus - Poland, Ukraine and Russia

• Producon connues to move eastward
• Poland now equals output of Netherlands
• 80% Poland’s producon for fresh market
• Poland exports to Russia and Ukraine
• 90% of Russian market supplied by Poland
Agaricus - Poland, Ukraine and Russia

- Ukraine well positioned to increase share of Russian market
- Ukraine wages lower (1/2) than Poland
- Raw materials less expensive in Ukraine
- Ukraine mushrooms likely to replace Polish mushrooms to Russia
Agaricus - Biotechnology

• 50 years of genetic research
• First hybrids – 1980s
• Breeding difficult
• Brown mushrooms increasingly popular
• Brown hybrid developed at Amycel
• 20% increase in yield
**Agaricus - Speed Spawn**

- Alternative to grain spawn
- Less susceptible to green mold disease
  - Less starch, more protein
- Greater parcels per unit weight
  - Faster colonization of compost
Pleurotus Production in Selected Countries and Regions

1997
87%
875,000 t

2010
86%
6.2 million t
+618%

- China
- Japan
- Rest of Asia
- N. America
- C & S America
- EU
- Rest of E
- Africa
China – *Pleurotus* spp.

- Primarily from 2 species:
  - *P. ostreatus*, *P. cornucopiae*
- Administrative agencies guide farmers:
  - Regions, and resources
- Northeast of China (cool climate & sawdust avail):
  - *P. ostreatus*, *P. eryngii*,
    *P. nebrodensis*
Japan – *Pleurotus* spp.

- *Pleurotus eryngii* fastest growth since 2000 +453%
- 8.1% of total production
- Considered “best taste”
- Hokuto & Yukiguni – 65% of production

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<tr>
<th>Year</th>
<th>2000</th>
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![Image of Pleurotus eryngii mushroom]
Growth in World Shiitake Production

Million t

Year


Others
Japan
China
Shiitake - China

- 4 million tons
- 90% of total world production
- *Ene communis* helped from poverty
- Excellent quality
- Logs exported to USA
- Harvest one flush – discard (550 g)
Shiitake - Japan

**Grifola**
- Hypsizygus: 24%
- Others: 9%
- Len: 22%
- Flammulina: 30%

**Others**
- 15%

**Fresh**
- 16%

**Dried**
- 6%

Total: 461,107 T

Yamanaka 2009
Auricularia sp. – China

- Major producer
  - 3.6 million tons
- Earliest cultivated mushroom
- Two species
  - A. auricula, A. polytricha
- Domescaon of wild type strains selected for season, locaon
Auricularia sp. - China
Auricularia sp. - China
Growth in World Production of *Flammulina velutina* (1980-2010)
Flammulina - Japan

- 50% increase 1990-2009
- On sawdust or corncobs
- Boes
Flammulina - China

- 1995 to 2010
- +1,208%
- Many new farms in last 5 y
  - Bole technology
- One farm produces 60 t/d
  - Equivalent to 6% of Japan total producon
  - 80% for domesse
  - 20% export
  - Southeast Asia and Europe
Outlook

• Mushroom consumption/production increasing worldwide – industry connue to expand
• Increasing trend toward mechanization and bulk handling of materials
• Consumers look to mushrooms to help satisfy their need for a healthy diet – while enjoying the culinary characteristics