

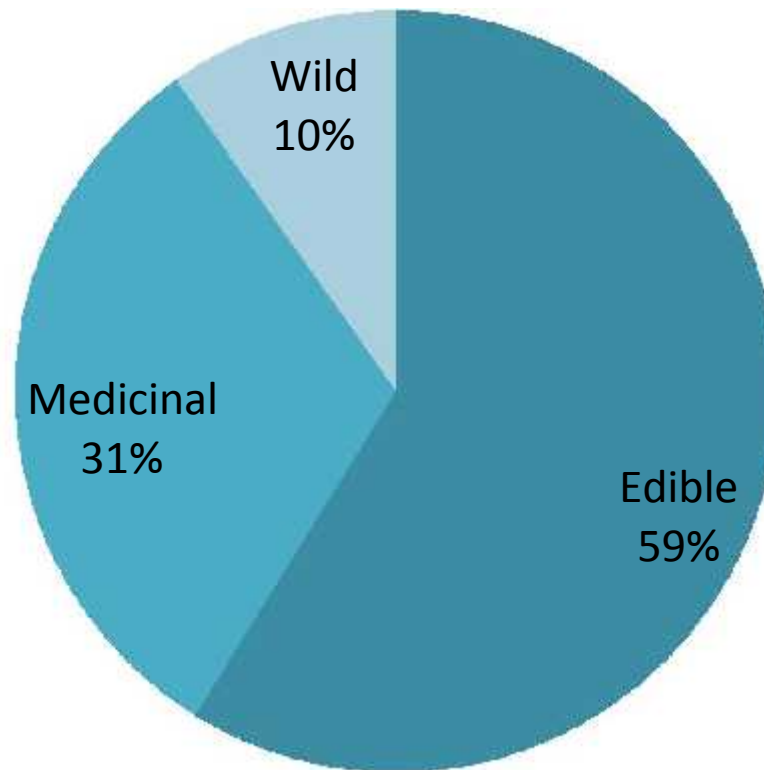
A Global Perspective of the High  
Five: *Agaricus*, *Pleurotus*, *Len* ,  
*Auricularia*, & *Flammulina*

Daniel J. Royse

The Pennsylvania State University



# World Mushroom Industry \$51 Billion (USD)



Chang 1996 & 2013, Li 2012



Cultivated edible mushrooms

\$30 B

Wild mushrooms

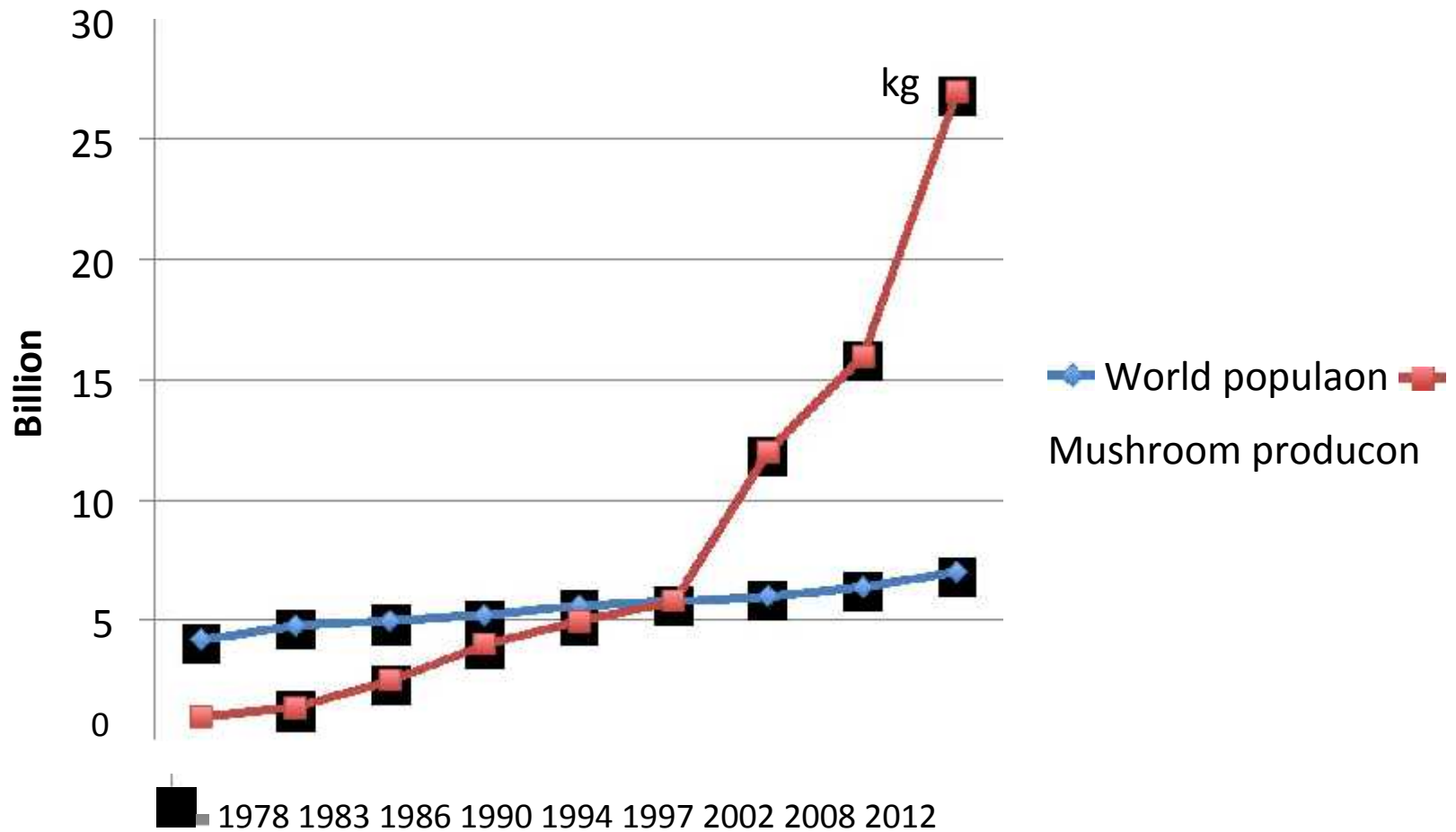
\$5 B

Medicinal mushrooms

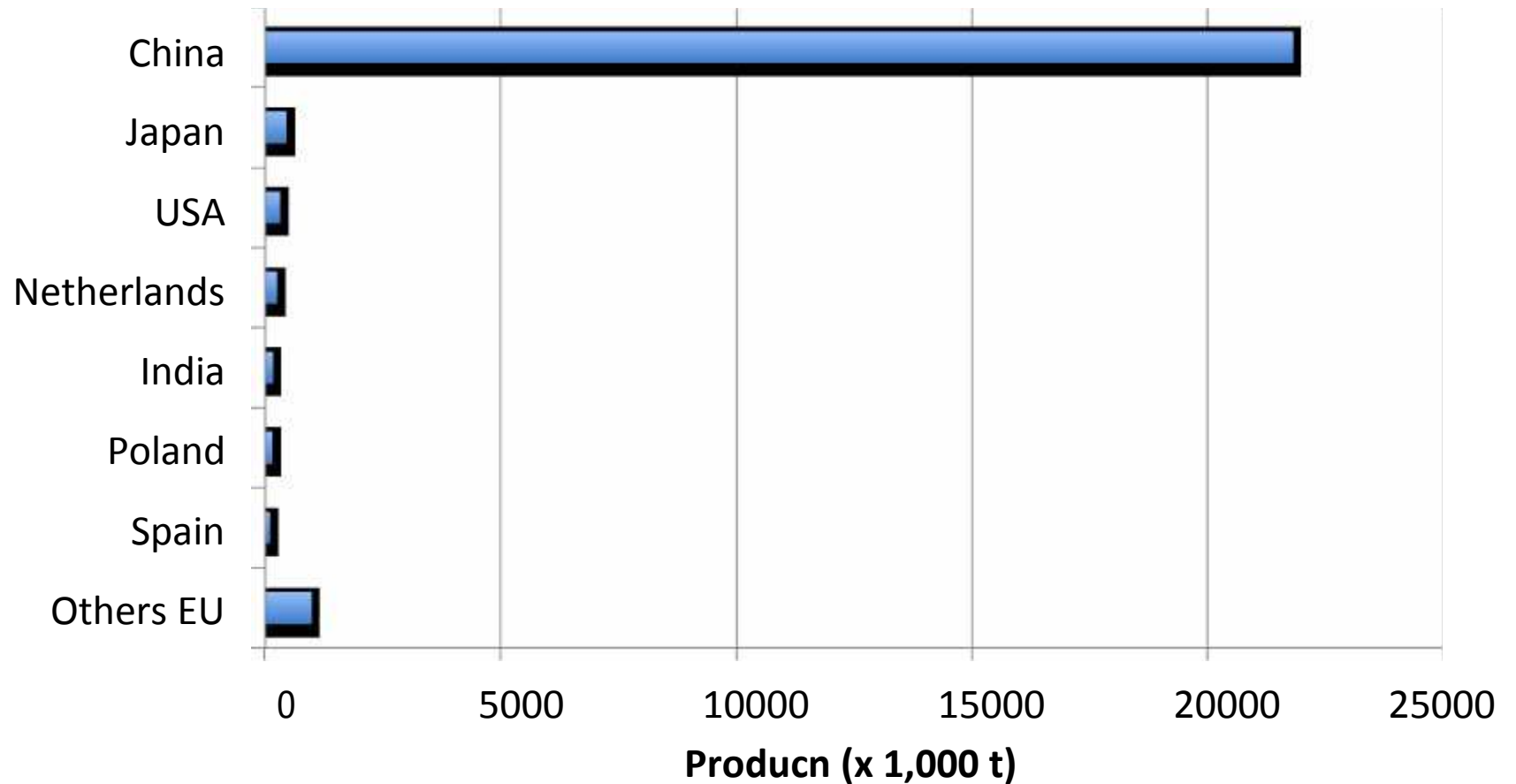
\$16 B



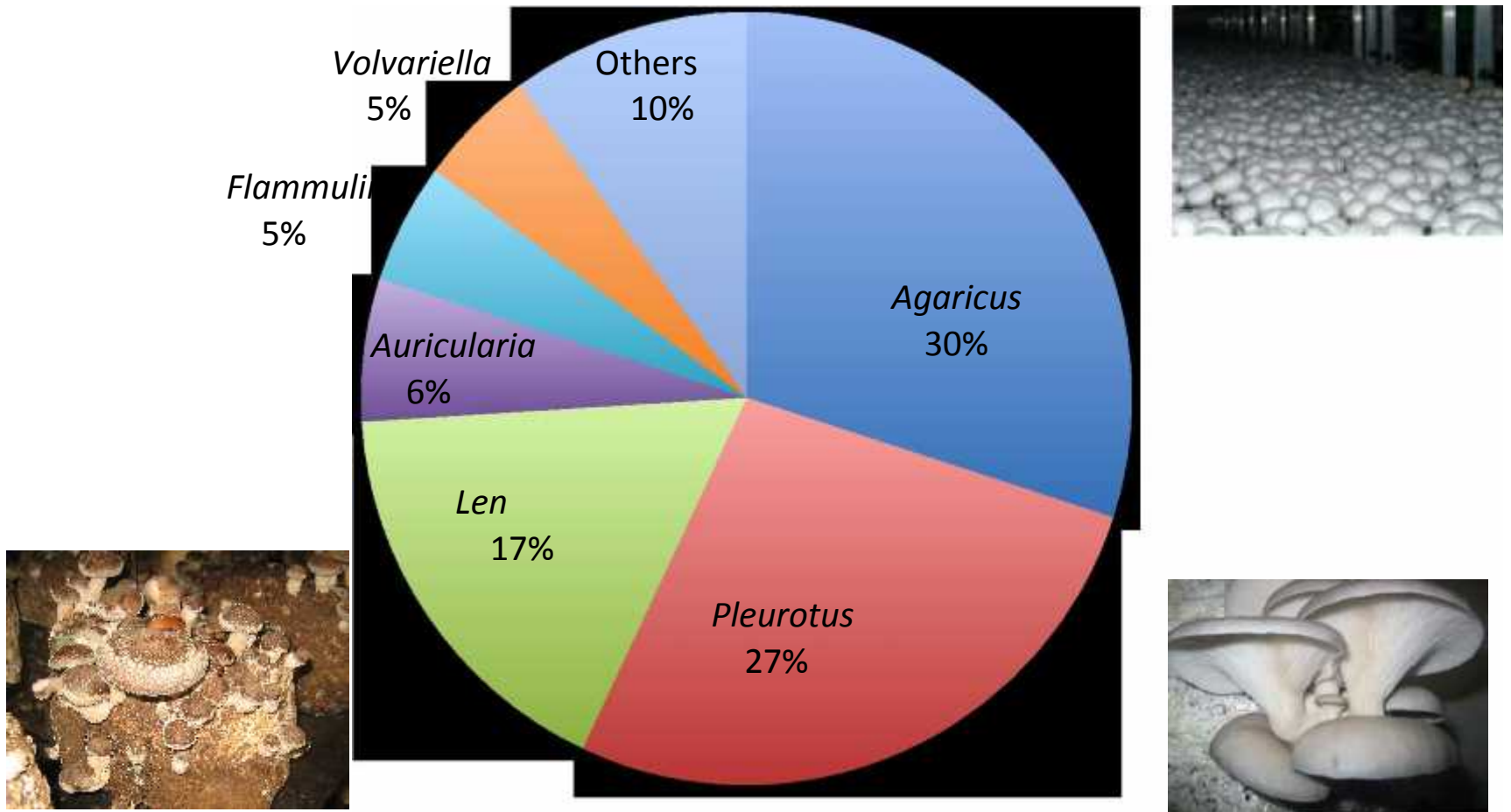
# World Populaon vs. Mushroom Producon



# Mushroom Production in Selected Countries (2010)

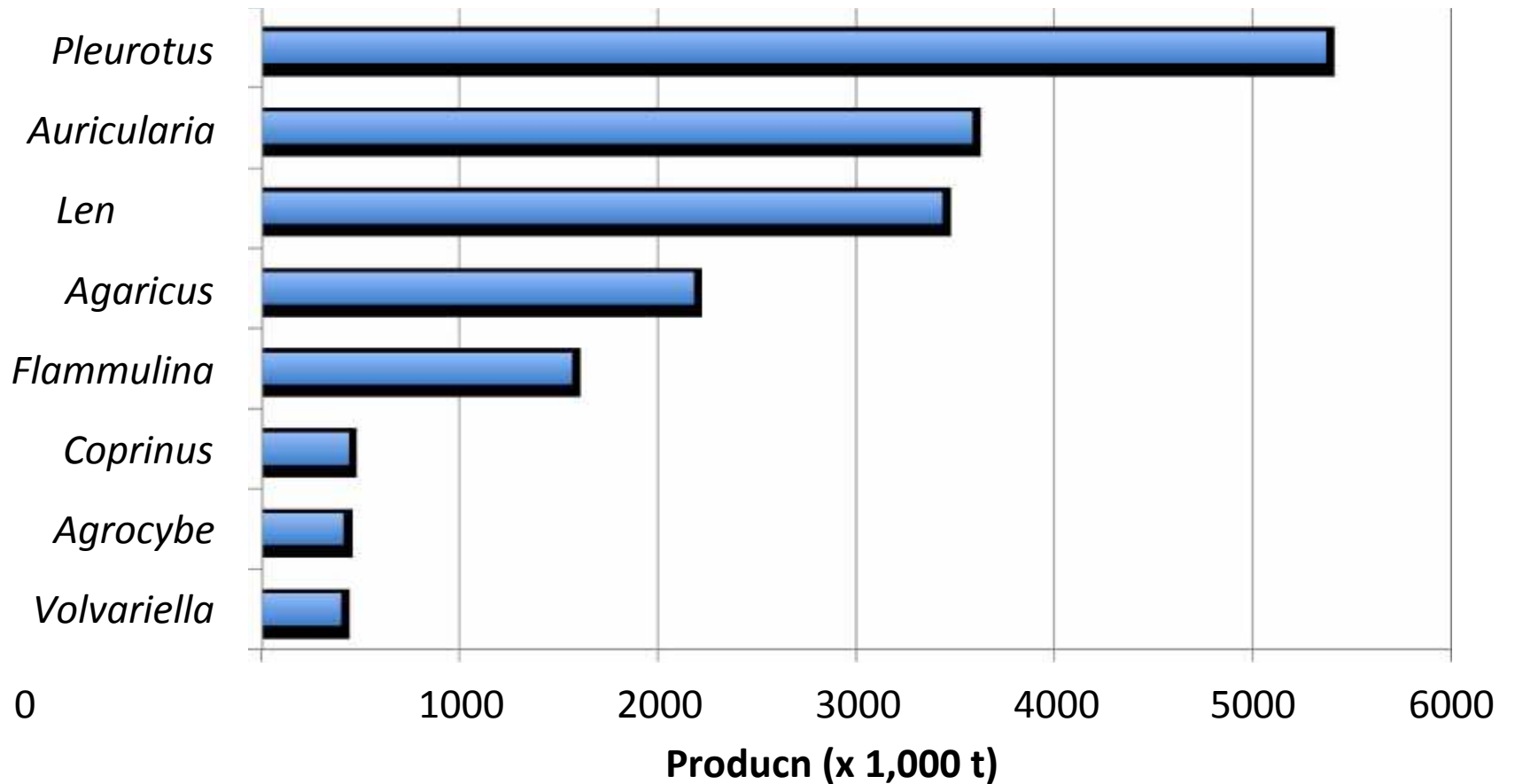


# Cultivated Edible Mushrooms



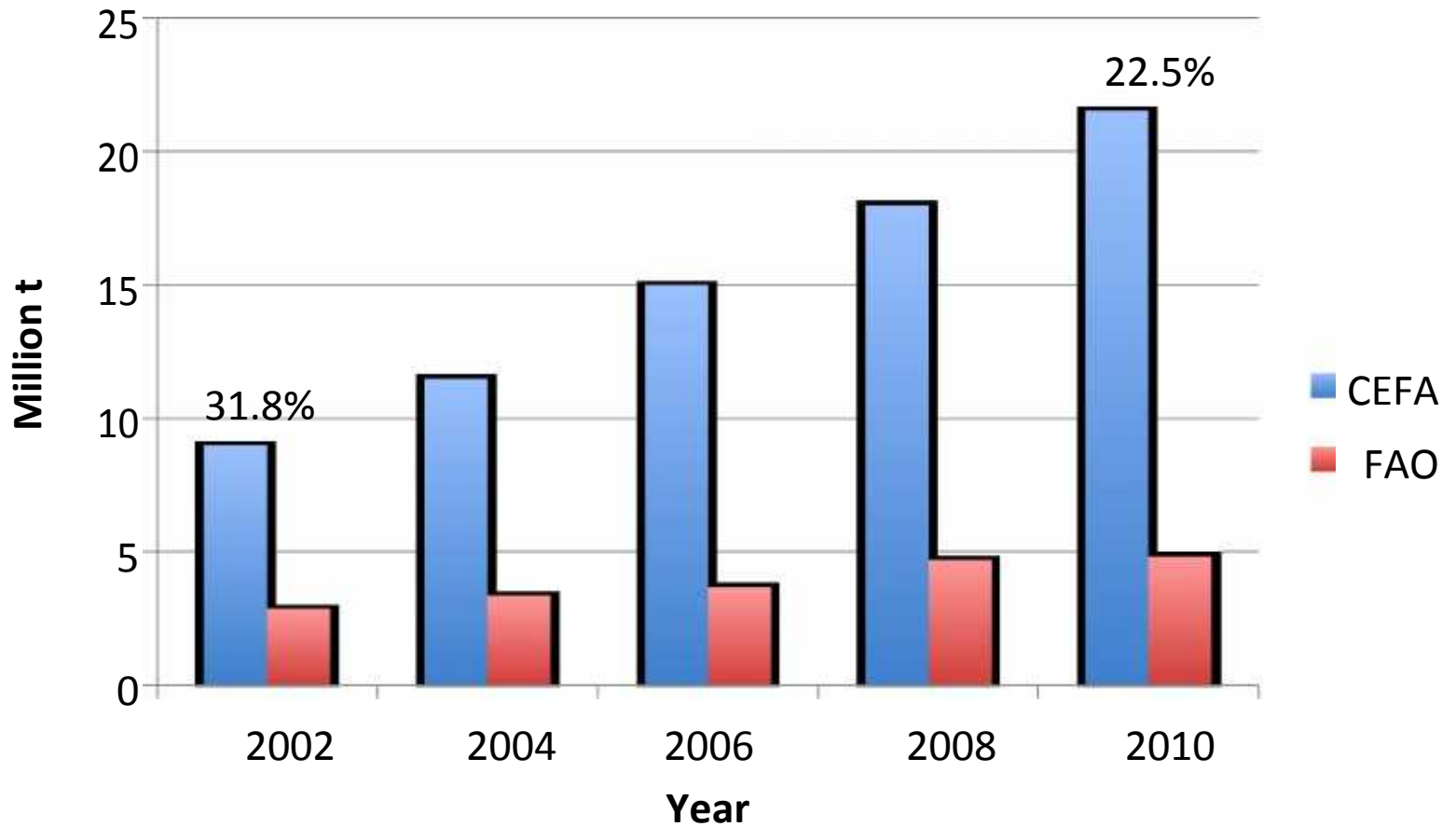
Chang 2006, ISMS 2007, Li 2012

# Mushroom Production in China by Genus (2010, CEFA)



# Mushroom Production In China

Chinese Edible Fungi Association vs. FAOSTAT



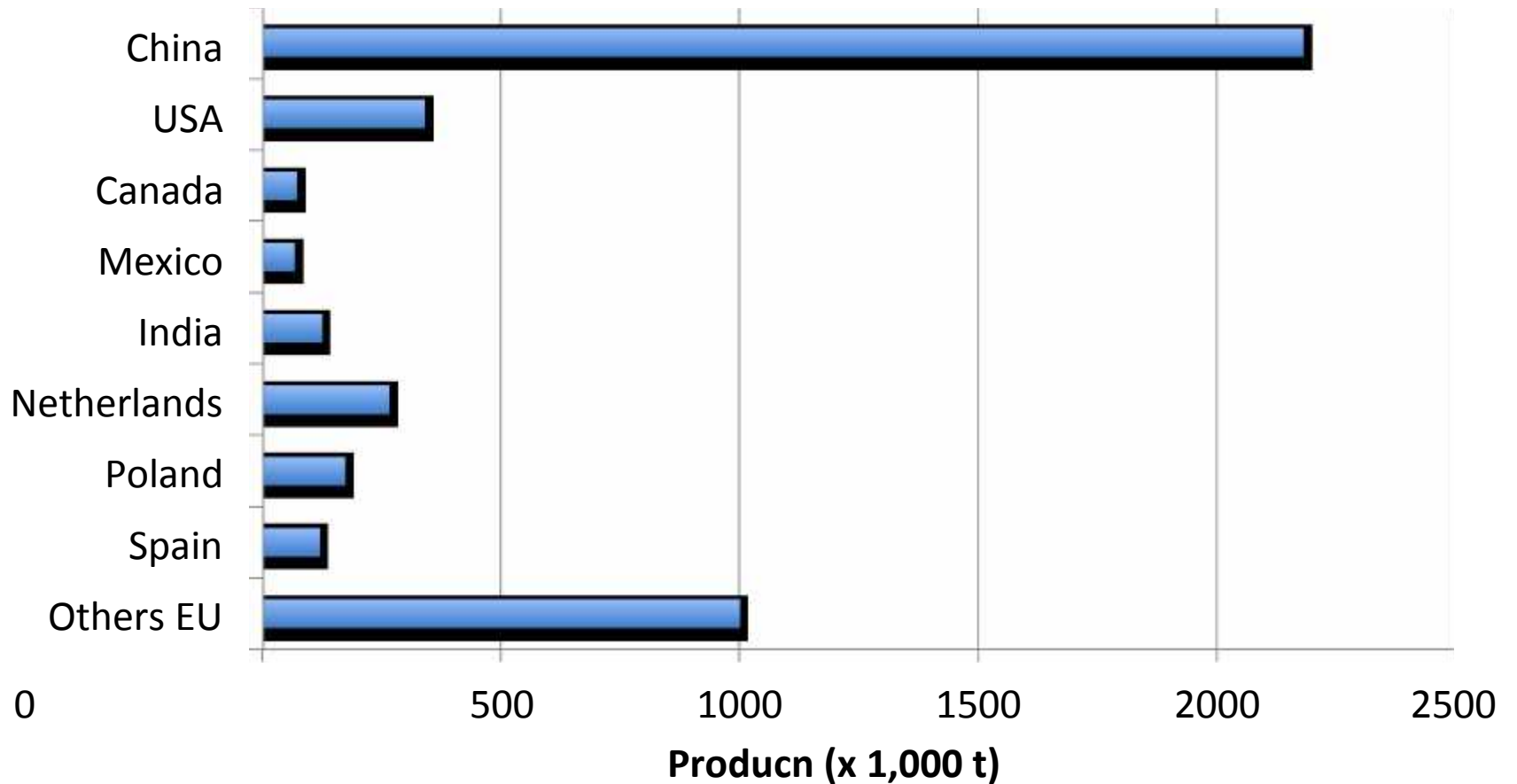


# *Agaricus*



- 30% of world produc
- Primarily *A. bisporus* (some *A. brasilensis*)
- White (90%)
- Brown (10%)
  - Crimini
  - Portabella

# *Agaricus* Production in Selected Countries (2010)



# *Agaricus* producon - China

- Began in 1925 – introduced from Europe
- 1966, Fujian province - large scale producon
- 1996, 75% of producon in China
- A1996, 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

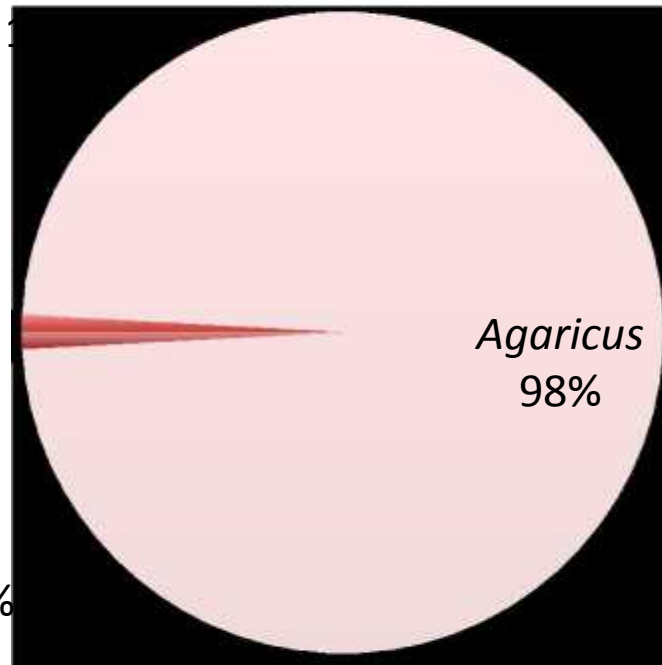


# Agaricus - United States

## Product



*Pleurotus* spp.



*Len*  
1%



Brown value = 22%  
Specialty value = 6%

USDA 2014



# *Agaricus* - United States

- Value \$1.05 billion (2013)
- 2<sup>nd</sup> largest producer in world – 400,820 T – 0% increase from 2011
- *Agaricus* – New Dutch style farms



# *Agaricus* - United States

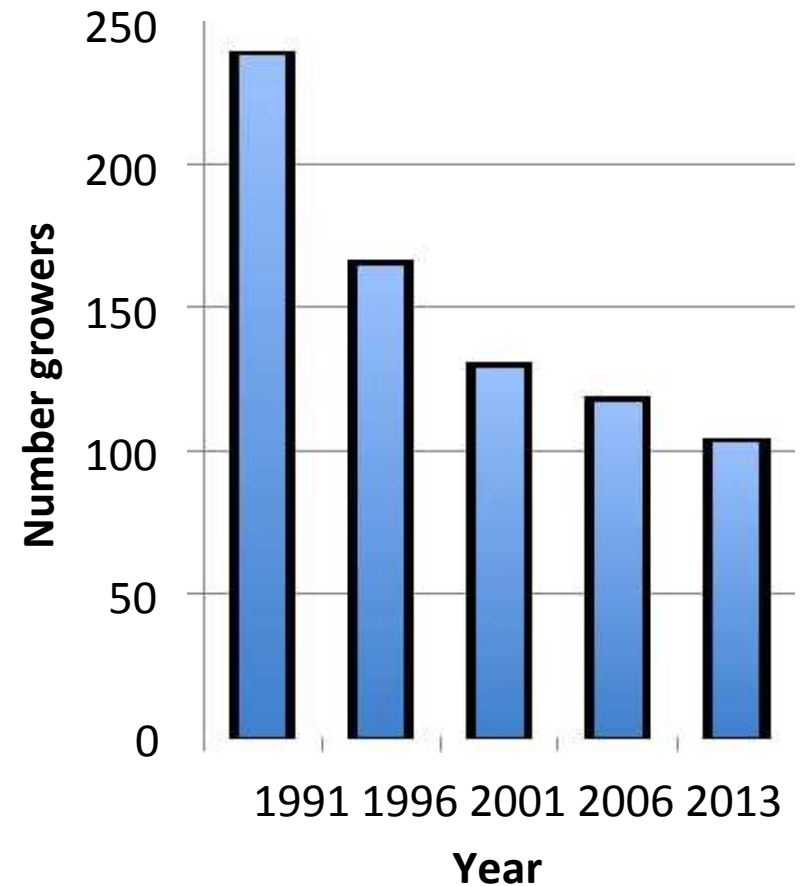
- 65% in Pennsylvania
- 12% California
- 3% organic sales
- 87% sold fresh
- 13% processed
- 19% of growers certified organic



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





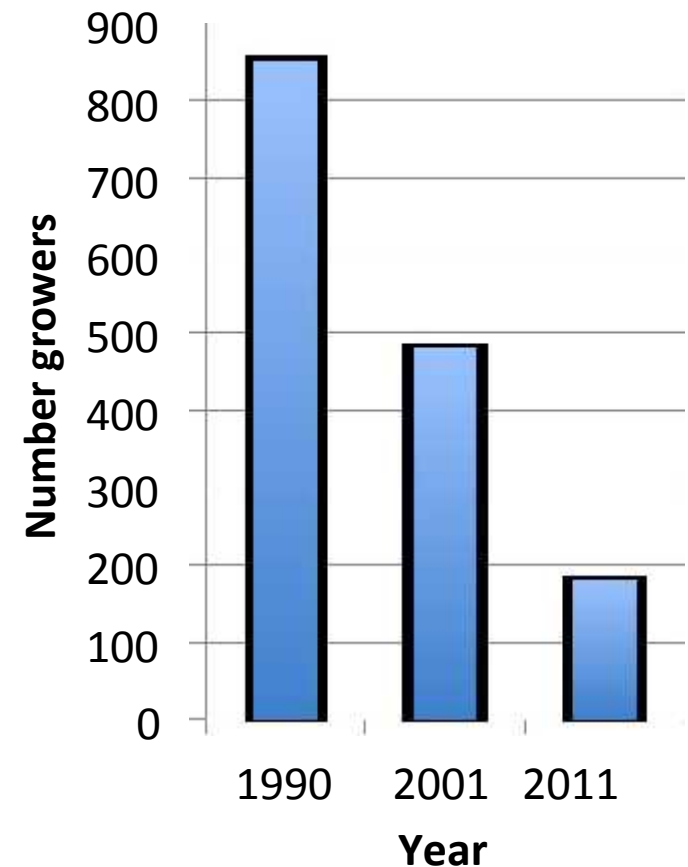
# *Agaricus* - Netherlands



- 95% *Agaricus bisporus*
- World's 3<sup>rd</sup> 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

- Production continues to move eastward
- Poland now equals output of Netherlands
- 80% Poland's production 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



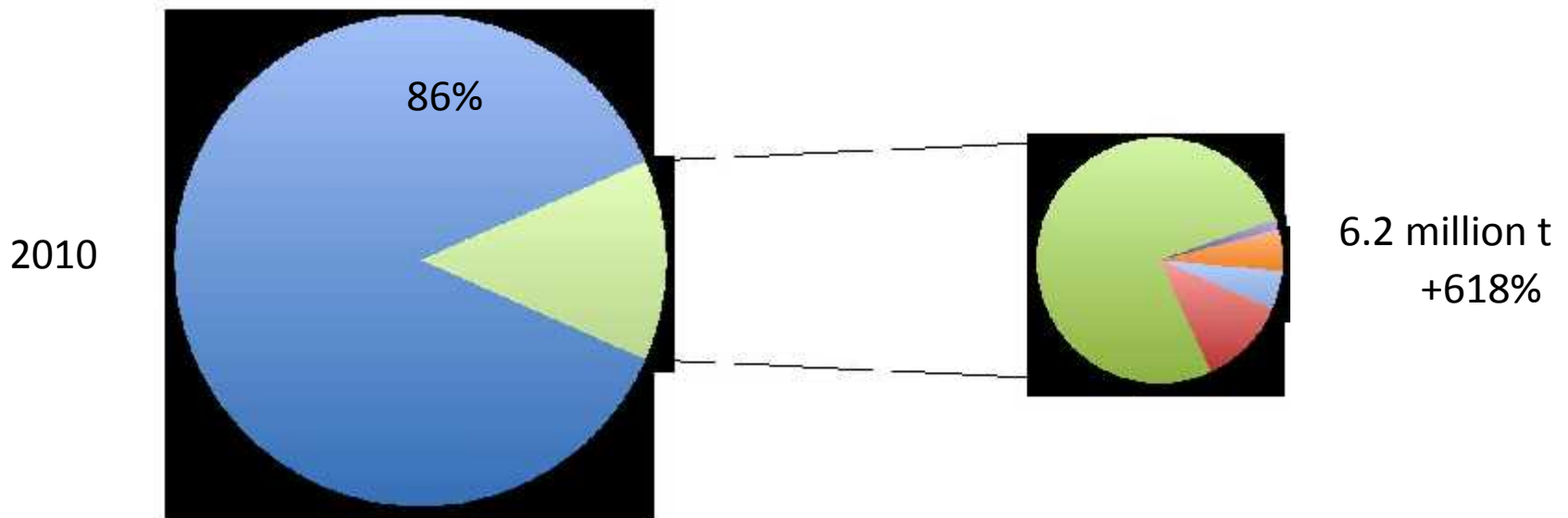
# *Agaricus* - Speed Spawn

- Alternative to grain spawn
- Less susceptible to green mold disease
  - Like starch, more protein
- Greater particles per unit weight
  - Faster colonization of compost





# *Pleurotus* Production in Selected Countries and Regions



# China – *Pleurotus* spp.

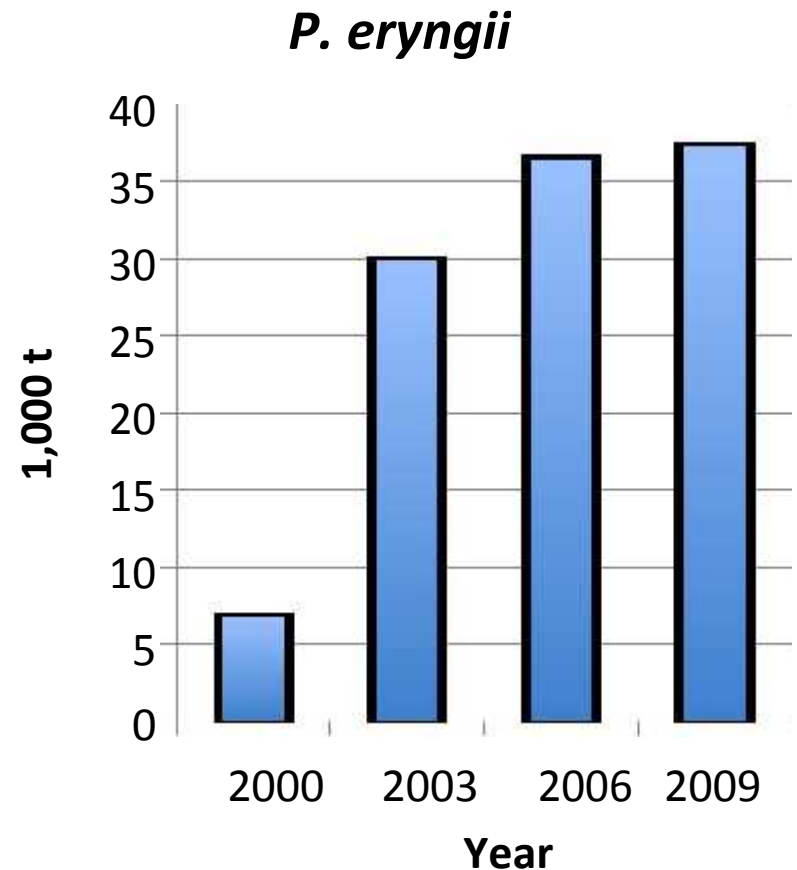
- Primarily from 2 species:
  - *P. ostreatus*, *P. cornucopiae*
- Administrative agencies guide farmers:
  - Regions, and resources
- Northeast of China (cool climate & sawdust avail):
  - *P. ostreatus*, *P. eryngii*,  
*P. nebrodensis*



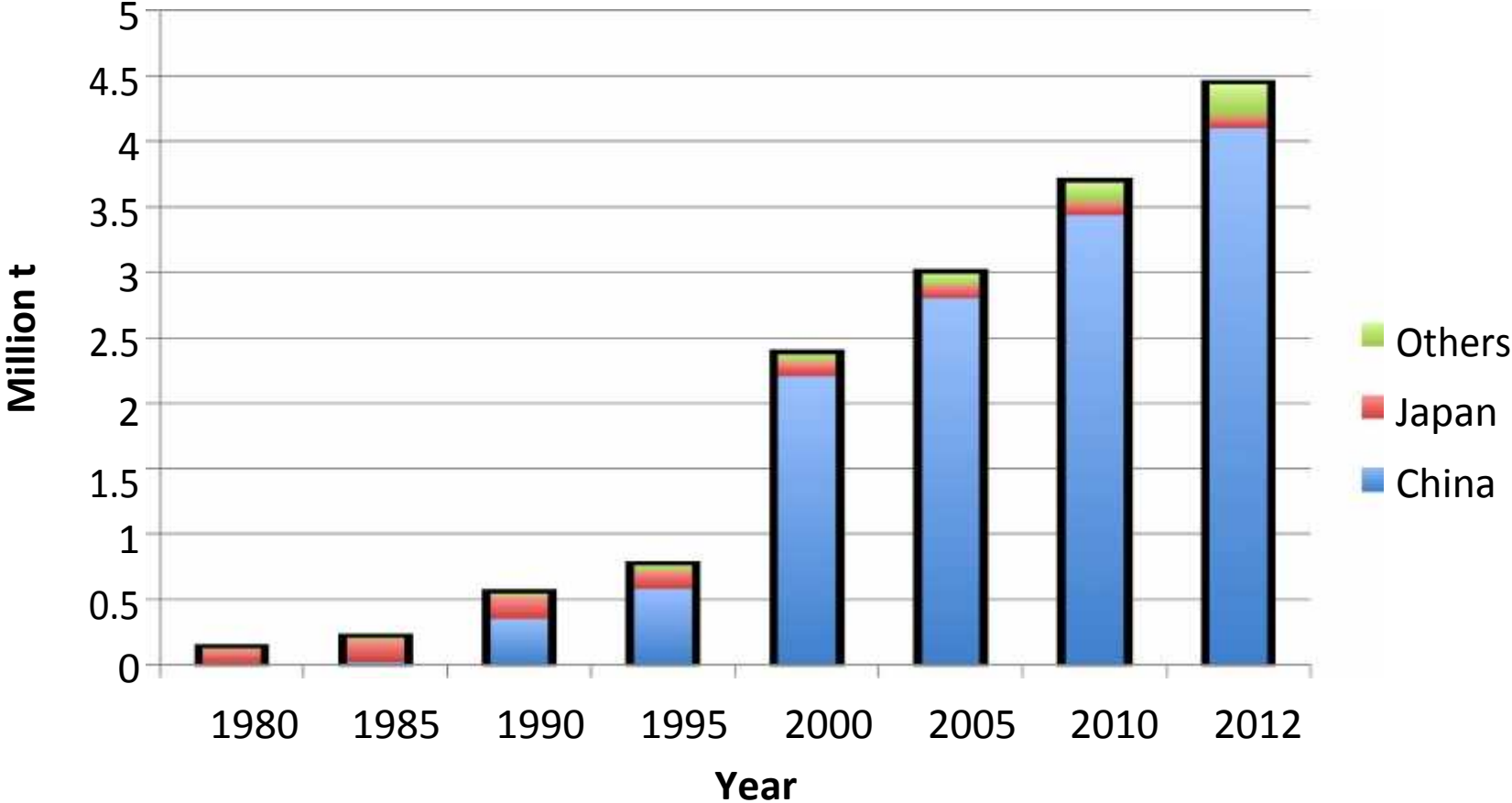


# Japan – *Pleurotus* spp.

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



# Growth in World Shiitake Production



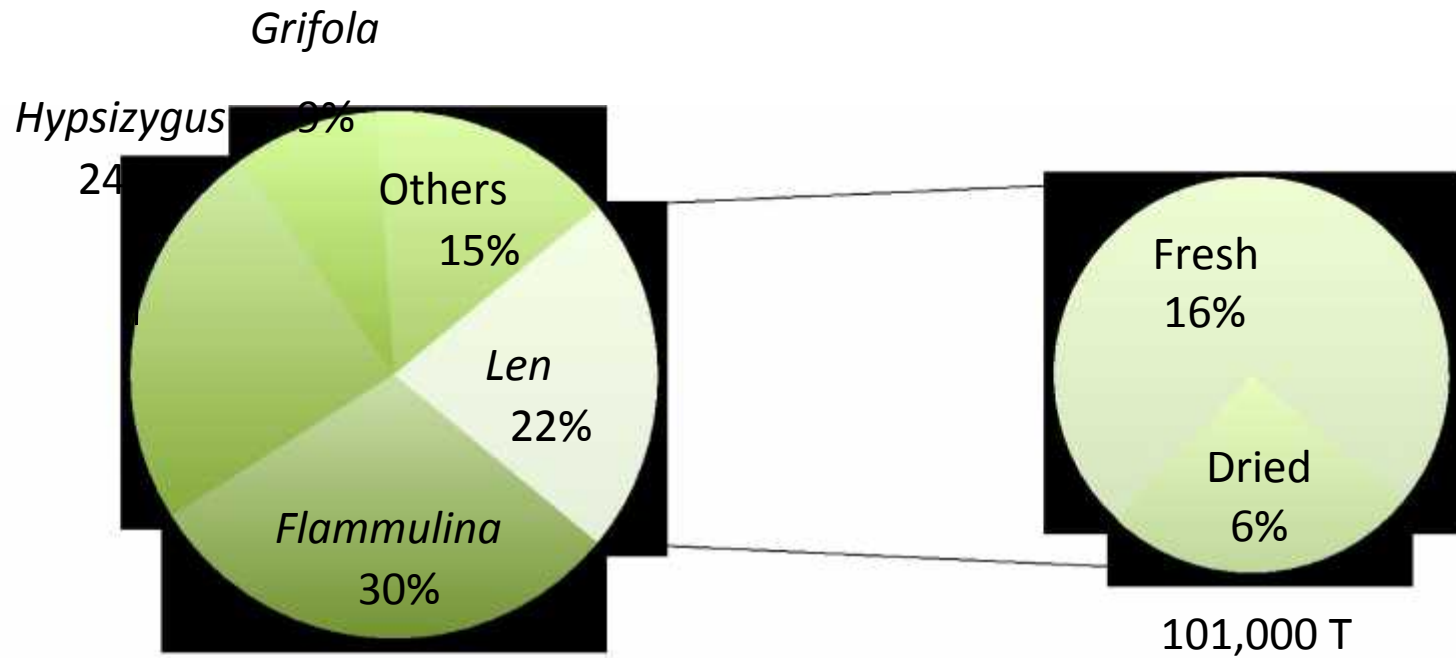
# Shiitake - China



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

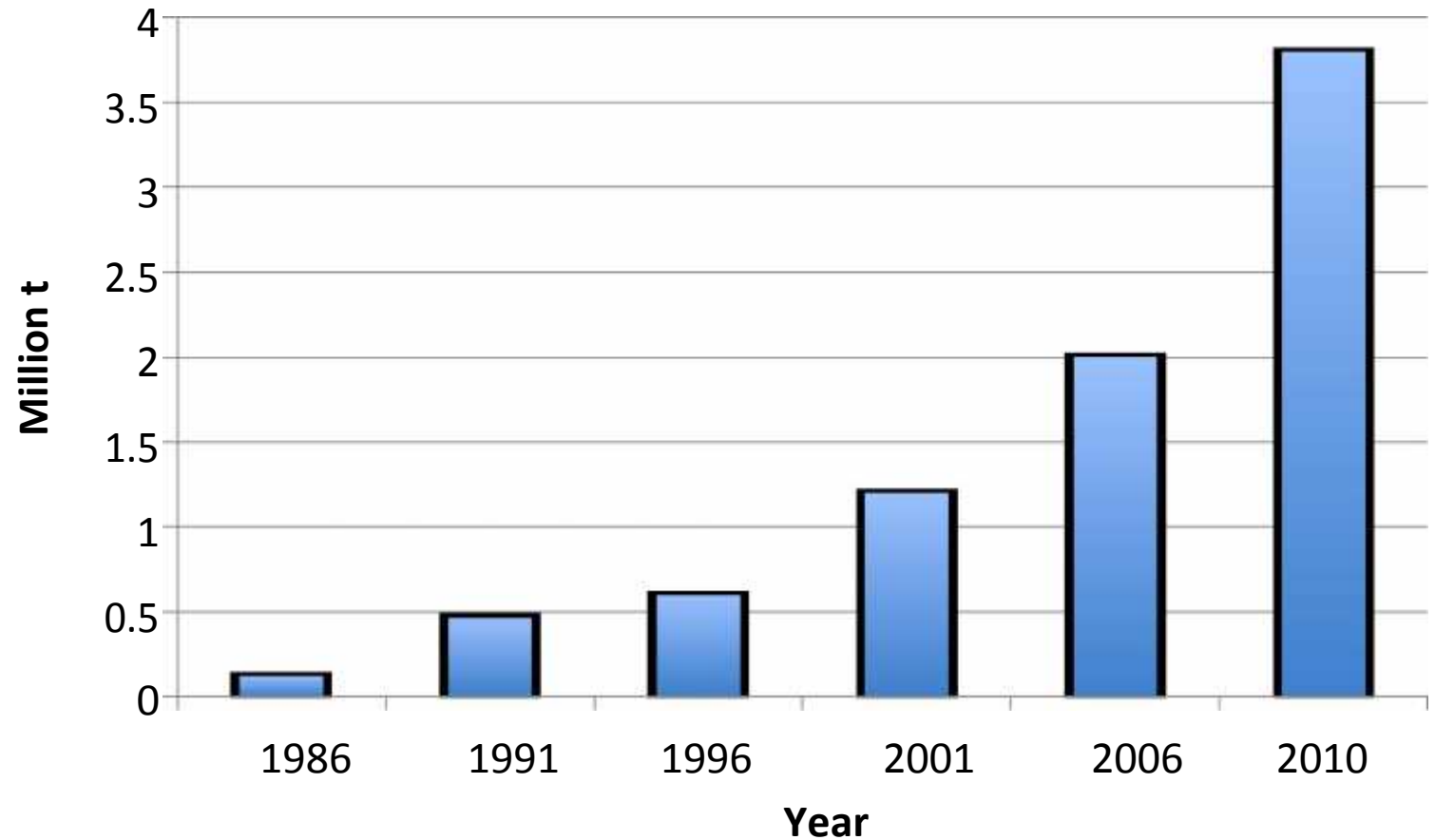
# Shiitake - Japan

461,107 T



Yamanaka 2009

# Growth in World *Auricularia* spp. Production (1986-2010)



# *Auricularia* sp. – China

- Major producer
  - 3.6 million tons
- Earliest cultivated mushroom
- Two species
  - *A. auricula*, *A. polytricha*
- Domesticon of wild type strains selected for season, locaon





# *Auricularia* sp. - China



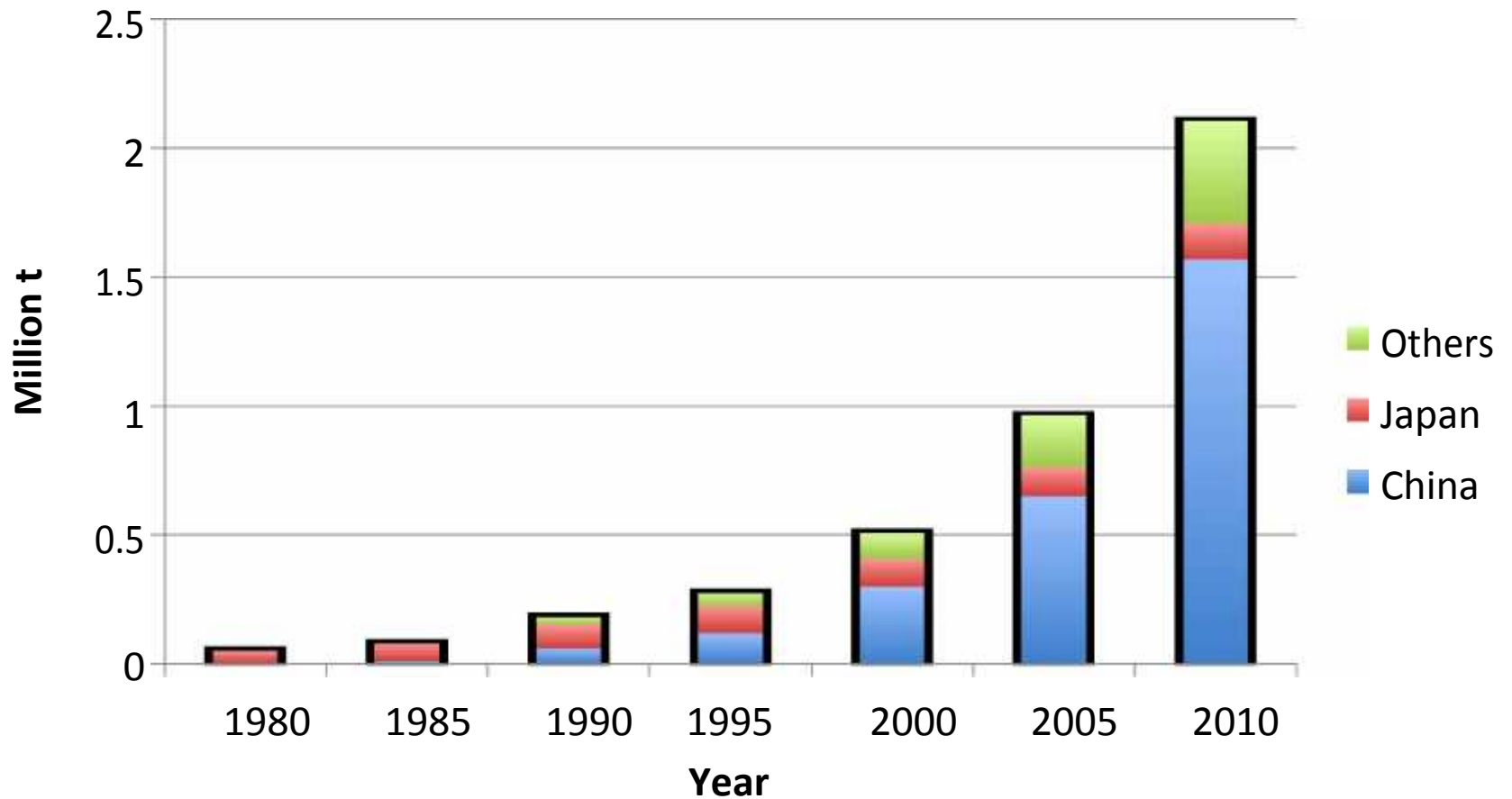


# *Auricularia* sp. - China



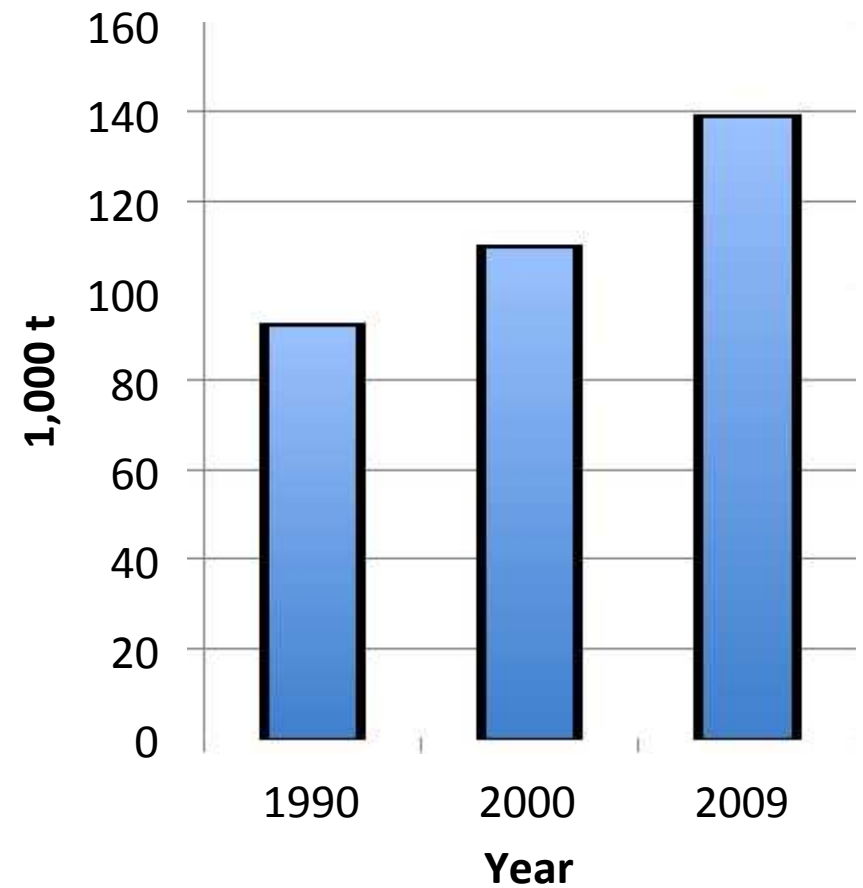


# Growth in World Production of *Flammulina velu* (1980-2010)



# *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 continues 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

