Insect-based biorefinery for converting waste biomass into protein and energy

Longyu Zheng, PhD

State Key Laboratory of Agricultural microbiology
National Engineering Research Center of Microbial Pesticides
Huazhong Agricultural University
Wuhan, China
Ly.zheng@mail.hzau.edu.cn

華中農業大學
HUAZHONG AGRICULTURAL UNIVERSITY

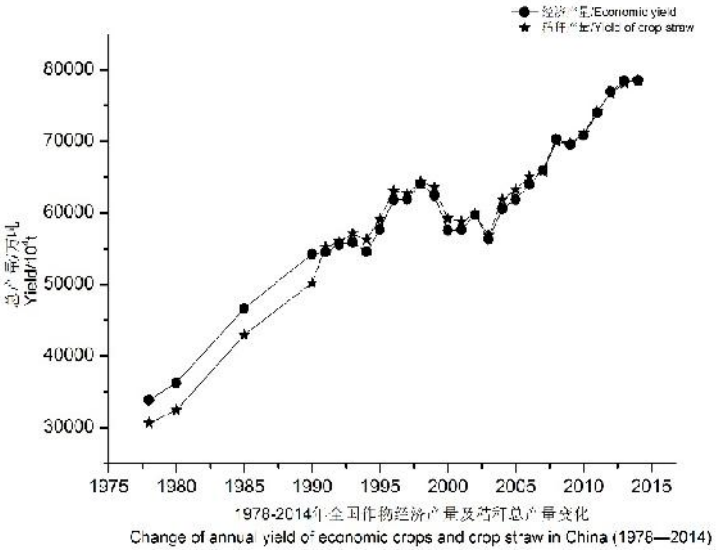
Animal manure pollution in China

Animal husbandry has become the No. 1 in agricultural non-point source pollution!

- Water pollution—eutrophication
- Land pollution
- Odor pollution—NH_3, H_2S, etc.
- Pathogen, parasite

Long-term National Science and Technology Development Program (2006-2020) has put pollution and waste recycling as the key area and the theme of the priority in agriculture.

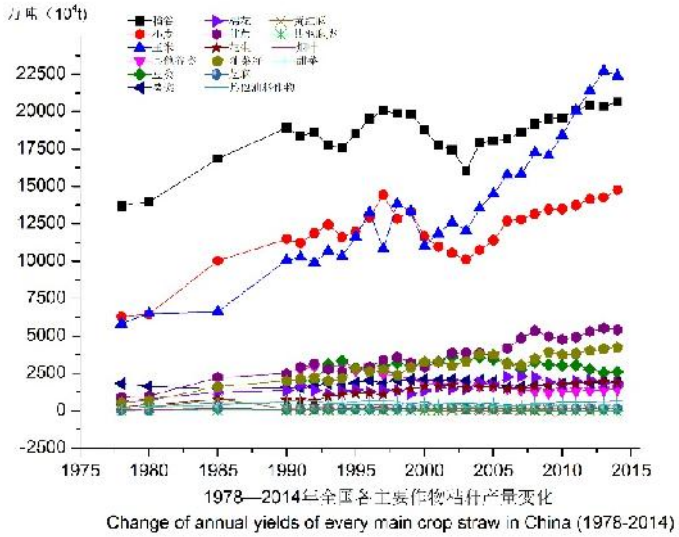
Crop straws production in China



1978-2014年全国作物经济产量及秸秆总产量变化

Change of annual yield of economic crops and crop straw in China (1978—2014)

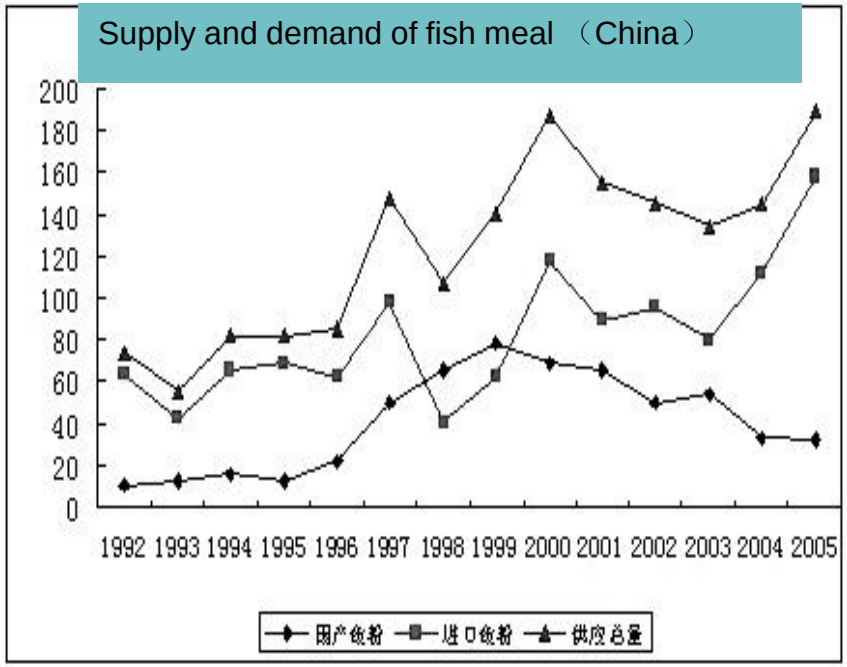
- **The production of main crop straws in China is increasing and reached 0.8 billion tons in 2015.**
- **Among which: rice, wheat, corn, oil crops, sugarcane, beans, cotton, potato, beet and tobacco.**

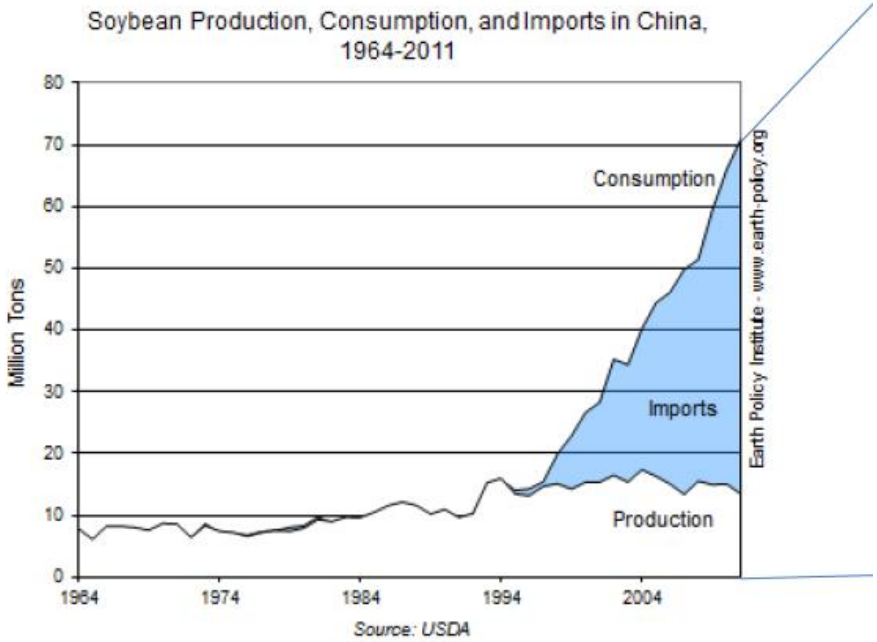


1978—2014年全国各主要作物当年产量变化

Change of annual yields of every main crop straw in China (1978-2014)

China :No.1 importer of protein material





China bought a record 70 million tonnes of soy (FAO, 2013)

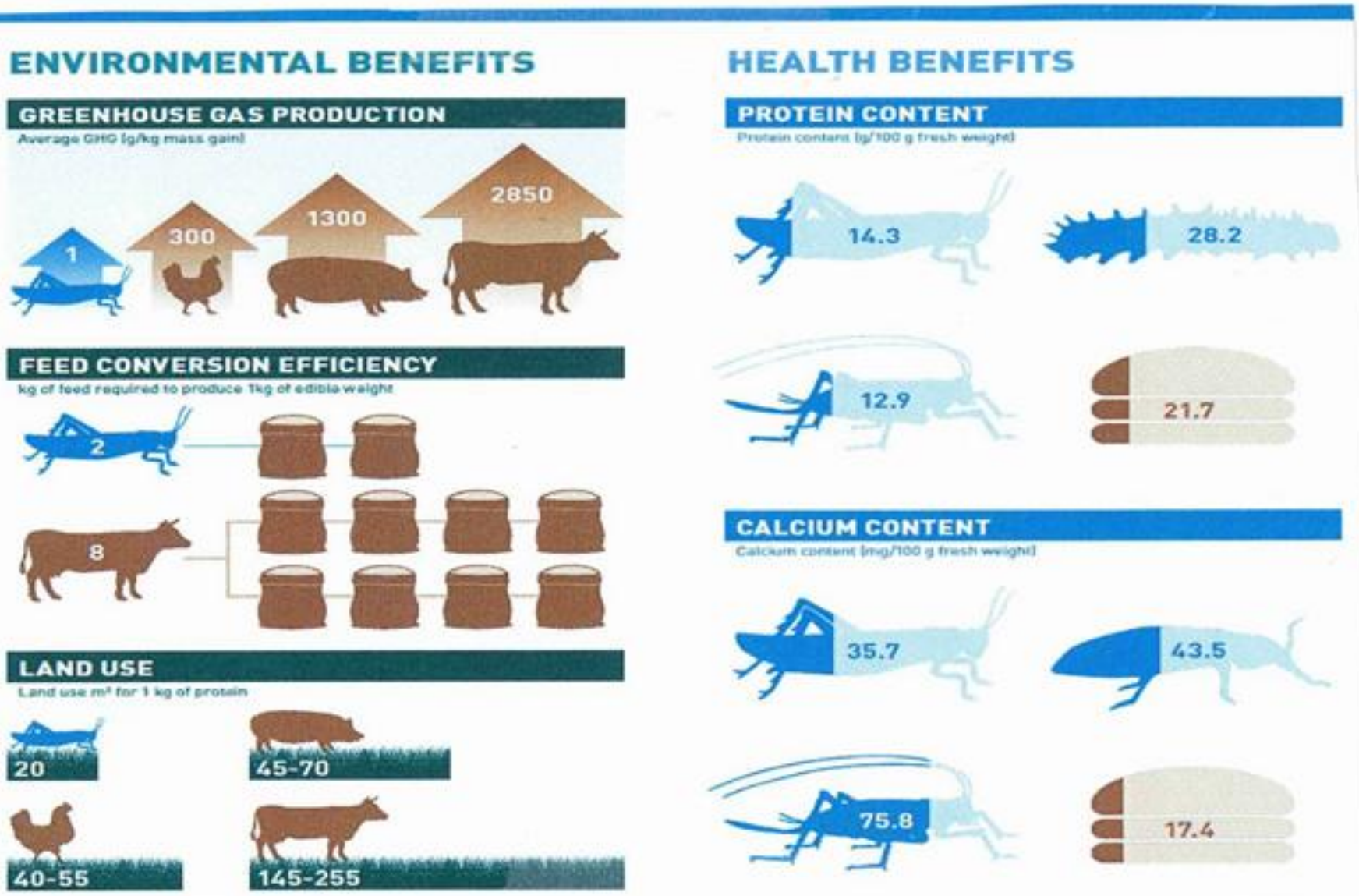
- **1, 200, 000 tons of fish meal imported.**
- **70, 000, 000 tons of soy imported.**

Foreign-trade Dependence >80%

Why insects?

- **Good for <u>health</u>**: Insects are a valuable protein source directly available for human / animal feed
- **Good for the <u>planet</u>**: Mass rearing offers major opportunities for the large-scale production of protein for food <u>and</u> feed with less environmental impact then beef production
- **Good for <u>local business</u>**: Insect farming offers socio-economic benefits both in developed and developed countries at any production scale

Mini-livestocks


ENVIRONMENTAL BENEFITS
GREENHOUSE GAS PRODUCTION
Average GHG (g/kg mass gain)
1
300
1300
2850
FEED CONVERSION EFFICIENCY
kg of feed required to produce 1kg of edible weight
2
8
LAND USE
Land use m² for 1 kg of protein
20
45-70
40-55
145-255
HEALTH BENEFITS
PROTEIN CONTENT
Protein content (g/100 g fresh weight)
14.3
28.2
12.9
21.7
CALCIUM CONTENT
Calcium content (mg/100 g fresh weight)
35.7
43.5
75.8
17.4

(FAO, 2014)

http://www.classhelp.info/Biology/Soldier%20Fly.jpg

Hermetia illucens (Diptera: Stratiomyidae)

- Known as the “black soldier fly”
- Temperate/Tropics
- Colonizes variety of wastes
- April through October

Black soldier fly- waste reduction, animal feed, bioenergy

Crude protein：>42%

- Reduce waste accumulation
- Control house fly
- Inhibit or kill pathogens

Dry matter ： 42%-43%

Insect biomass for feedstuff，coproducts

Crude fat：~35%

Insect fat, biodiesel
Special fatty acids

Promising future!!

有机废物
（organic waste）

水虻与微生物
生物转化
（Co-conversion）

动物蛋白饲料
（Animal feedstuff）

功能微生物肥料
（Microbial fertilizer)

脂肪
(oil)

几丁质
chitin

精蛋白
(refined protein)

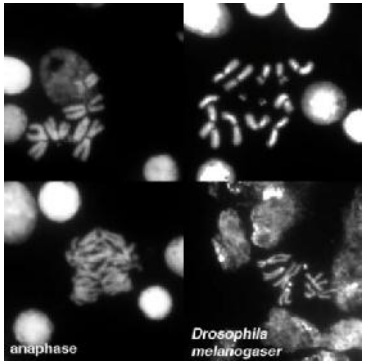
特殊脂肪酸
Special fatty acids

氨基酸产品
(Amino acids products)

壳聚糖及衍生物
Chitosan and derivative

Retrospect on project research process

More……



- •Technological design
- •Industrialization
- •Basic research

2012 **2016**

- •Wuhan strain
- •Mass breeding
- •Co-conversion
- •Basic research

2008 **2011**

- •BSF breeding techs
- •Key technology
- •Conversion techs

2004 **2007**

FAO

- ➢3 Postdoc.
- ➢7 PhD
- ➢22 Master
- ➢30 Articles
- ➢14 Patents

Collaborate with Texas A&M University, University of Georgia, Wageningen University, etc.

Co-conversion demonstration base in Wuhan

Chicken manure : BSF + Microbes

超拓®

水虻与微生物联合转化鸡粪的示范基地

亮斑扁角水虻，外形类似黄蜂，是一种大型双翅目水虻科昆虫。它的幼虫集中取食动物粪便，减少56%的粪便堆积，还消除了粪便的臭味，能够控制家蝇的滋生，极大的减少了粪便对环境的影响。其幼虫含有大量的蛋白、脂肪，还能够生产具有较高经济价值的动物饲料，研究表明它是一种极有应用前景的资源昆虫。

超拓公司于2011年由武汉市畜牧兽医局批准建设40万只全智能化蛋鸡养殖小区的项目（项目批号:武牧[2011]27号），项目总投资5034万元。占地面积238亩，建筑面积2多万平方米，是武汉市首家大型全智能化蛋鸡基地，是市政府菜篮子项目一级目标，于2012年建成并投产，已通过环评达标，是湖北省无公害产品产地。

超拓公司在三年前开始与华中农业大学组织研发本项目。华中农业大学研发力量雄厚，拥有教授30人，副教授6人，博士生导师28人，拥有国家自然科学基金委员会创新研究群体1个，教育部创新团队1个，农业部农业科研杰出人才创新团队21个，湖北省创新团队3个。先后得到湖北省国际合作重点项目和湖北省基金依托基地项目，从2004年开始研发水虻养殖，于2008年完成了具有更高转化性能的亮斑扁角水虻武汉品系的驯化养殖，在此基础上建立了系统的、完善的畜禽粪便水虻生物转化工艺。发表了13篇论文，申请4项专利，被评价为“世界第一，世界最大”的水虻人工研发养殖基地。

本基地建立水虻与微生物转化40万羽鸡粪的中试线，包括水虻与微生物转化，对转化后的水虻进行加工，生产脱脂昆虫蛋白虫粉和脂肪；以及建立鸡粪高温发酵和功能微生物二次发酵的中试车间生产有机肥。通过水虻和微生物联合转化获得生产的水虻虫粉和脱脂虫粉(蛋白饲料原料)，可代替鱼粉等动物蛋白，营养价值高，含有抗菌活性物质,可部分代替抗生素，部分减少抗生素的使用。按年处理一个40万羽鸡场粪便，每年利润可达600多万元。如进行深加工出口（提取航空燃油、抗菌肽、甲壳素等），每年利润可达1800万元以上。真正成为资源节约再利用，环境友好的高新技术推广模式。

昆虫大世界，超拓来了！

400, 000 laying hen = > 40 tons manure/day

From organic waste to bioenergy

- black soldier fly make it feasible

Lignocellulose

Food waste

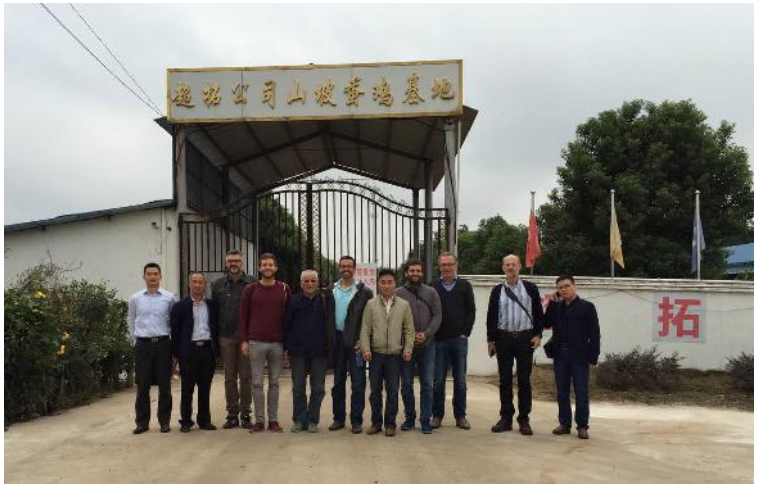
Animal manure

Collaboration with Research Units

Texas A&M University, USA

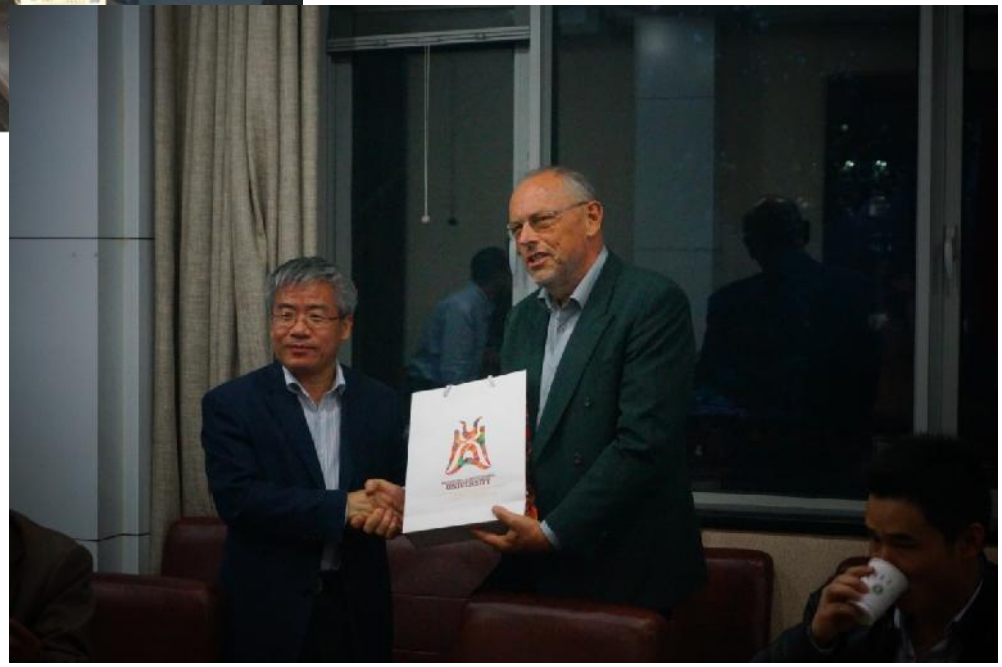
USDA

University of Georgia



Wageningen University, Netherland

Eawag-Sandec, Switzerland



Huazhong Agricultural University

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FAO

Future focuses may include:

- **Integrated organic waste recycling strategy**

  ----New solution or option

- **Specialized bioconversion technology for different waste**

  ----Swine, cow manure, crop straws, etc.

- **Insect breeding and waste conversion process optimization**

  ----Mechanization, Automatization

- **Product development and application**

  ---- Quality and Safety Control System, **etc.**

Thanks for your attention!

Looking forward to cooperation!

Longyu Zheng

ly.zheng@mail.hzau.edu.cn