Making the Most of Beef Co-products

Dequan Zhang PhD, Professor

Institute of Food Science and Technology,

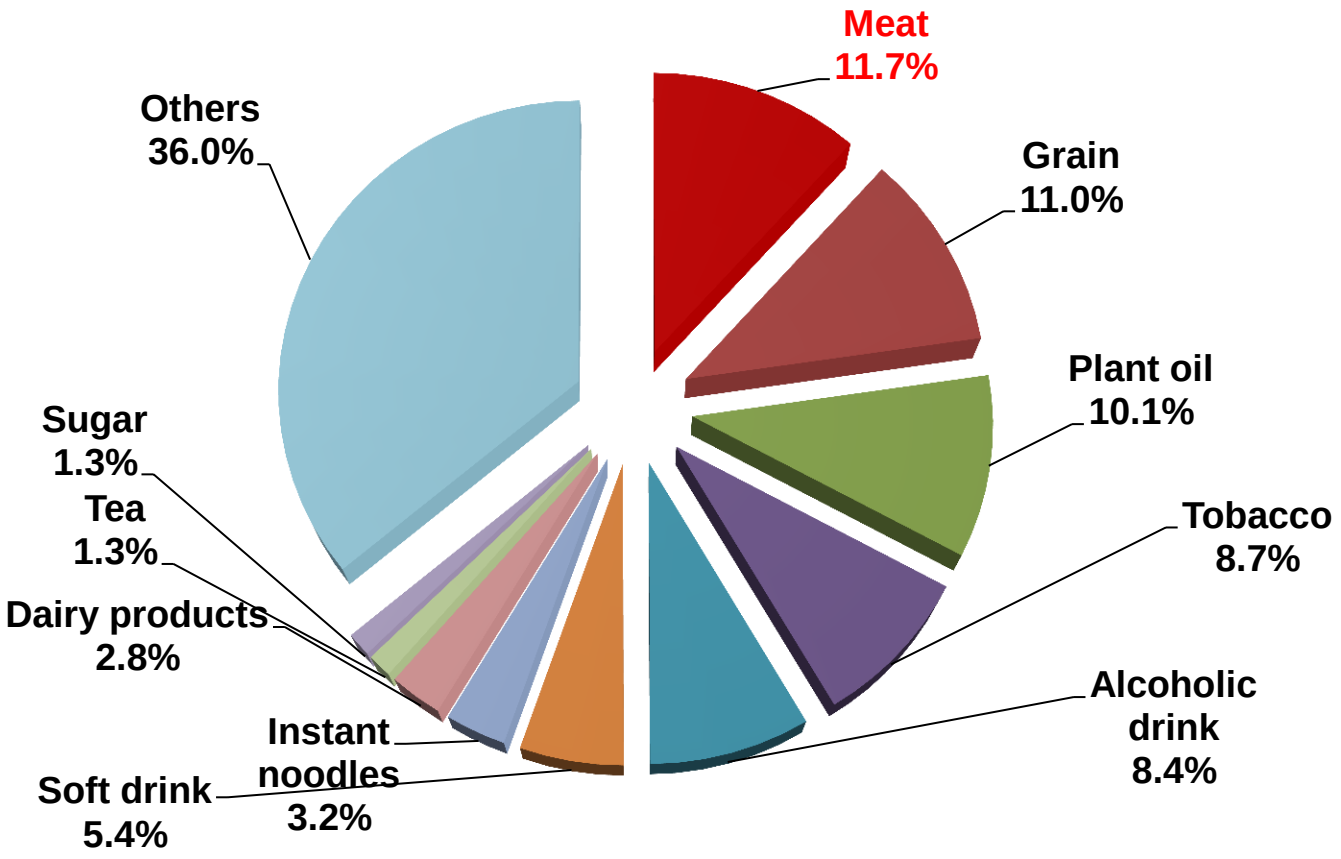
Chinese Academy of Agricultural Sciences

Email: zhangdequan@caas.cn/dqzhang0118@126.com

2 February, 2017

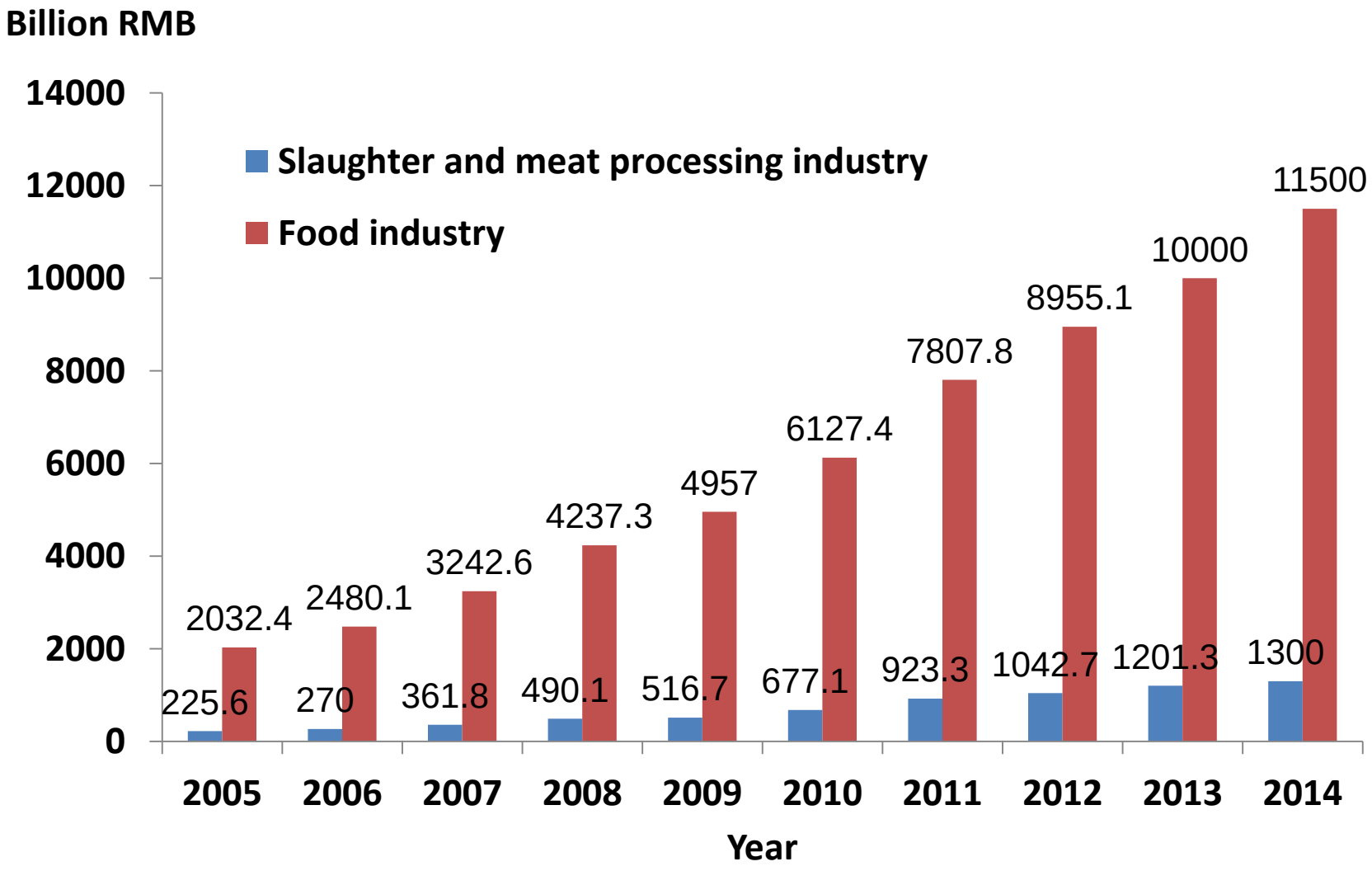
Current Usage of Livestock and Poultry Co-products in China

Meat processing industry is the largest part in food industry in China

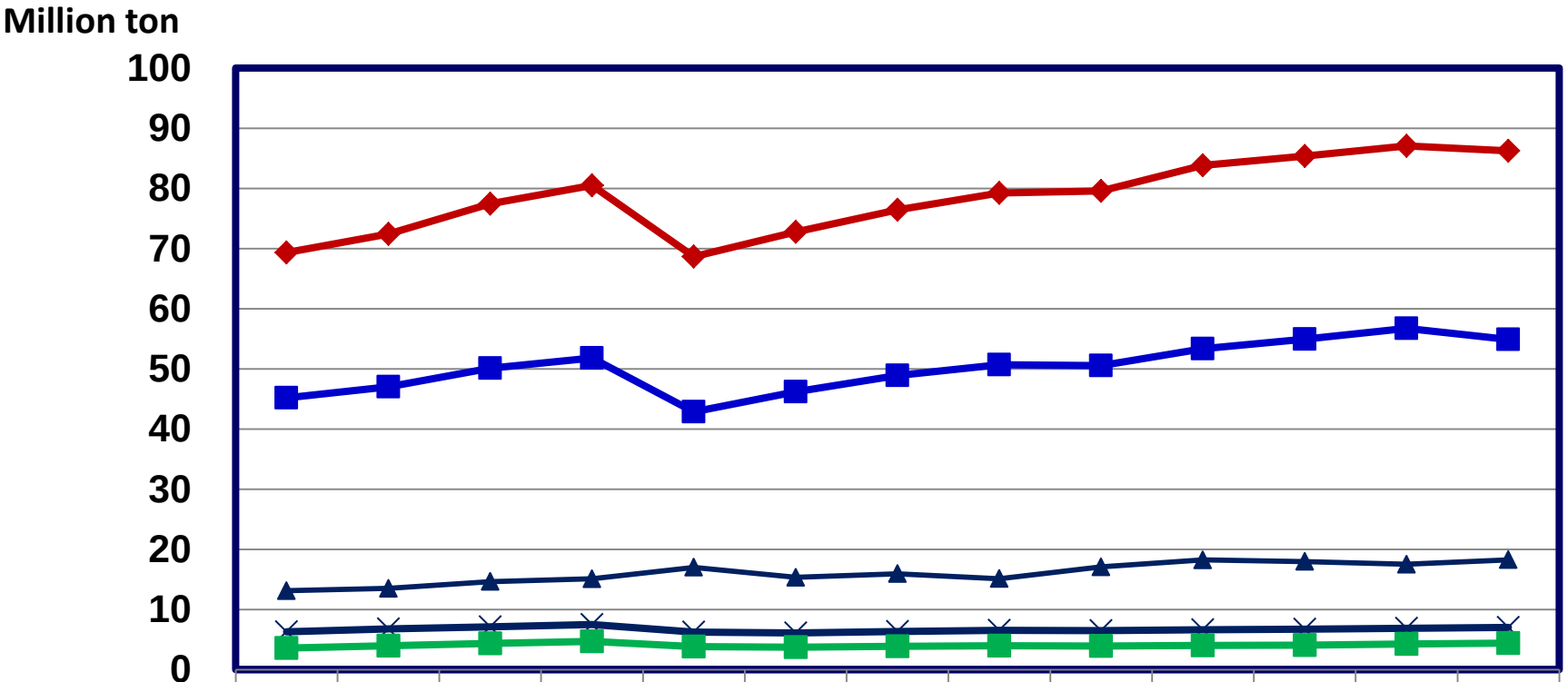


Data source: China Food Association, 2015

Output value of slaughter and meat processing industry in China



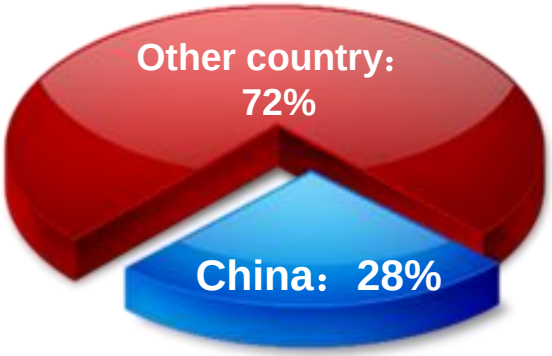
Meat production in China



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	69.33	72.45	77.43	80.51	68.66	72.79	76.42	79.25	79.57	83.84	85.36	87.07	86.25
Pork	45.19	47.02	50.11	51.79	42.88	46.20	48.89	50.70	50.53	53.35	54.93	56.71	54.87
Poultry	13.12	13.51	14.64	15.09	17.00	15.34	15.95	15.13	17.09	18.23	17.98	17.51	18.26
Beef	6.31	6.76	7.12	7.50	6.23	6.10	6.36	6.53	6.48	6.62	6.73	6.89	7.00
Mutton	3.57	3.99	4.36	4.70	3.83	3.76	3.89	3.98	3.93	4.01	4.08	4.28	4.41

Livestock and Poultry Bone Resources in China

- ✓ **China has 38 million ton livestock and poultry co-products**
- ✓ **Livestock and poultry bone is above 12 million tons**
- ✓ **Rich in protein, fat, mineral, polysaccharide (chondroitin sulfate, CS), etc**
- ✓ **Good ingredient for spice and functional food**



Ratio of meat in China/world

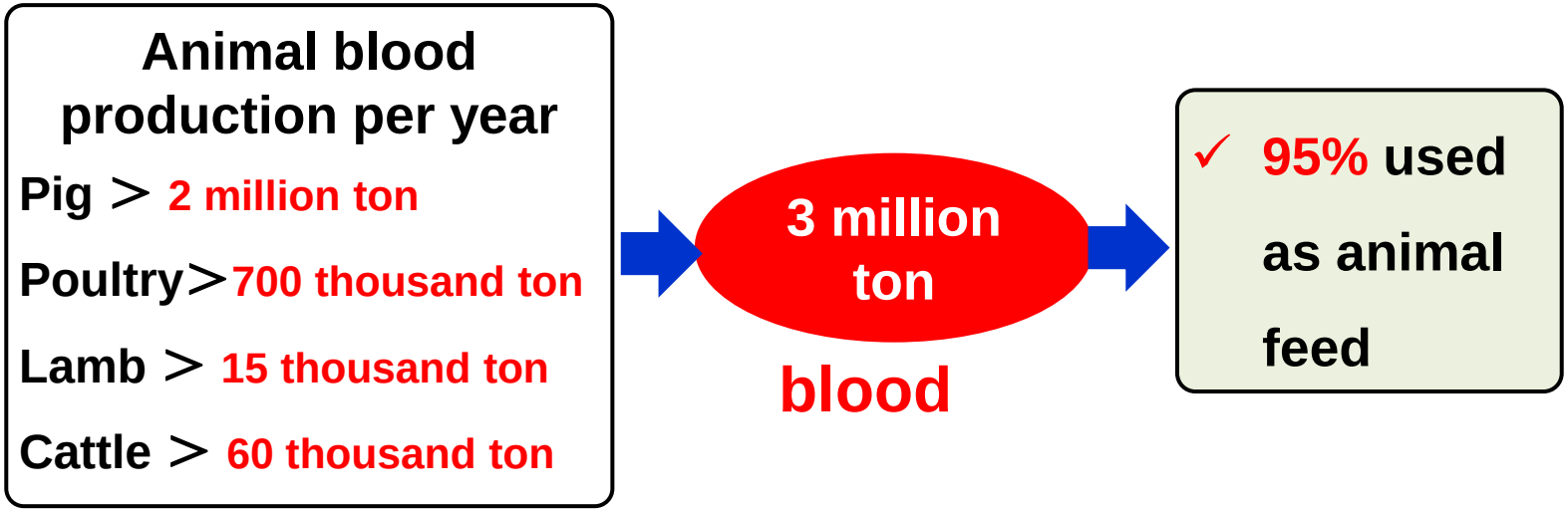
Living stocks in China and the world

Living Stock	Porcine (10^6 heads)	Chicken (10^8 heads)	Bovine (10^6 heads)	Sheep (10^6 heads)
Total of the world	918	178.6	1534	1917
China	425	45.1	104	283
China/Total (%)	46.4	25.3	6.7	14.8

(FAO, 2009)

The development of edible bone resources have broad prospects.

Blood Resources in China



Comprehensive utilization technologies are request.

Animal Fat Resources in China

Ujimqin sheep

Sunit sheep

Kazakh sheep

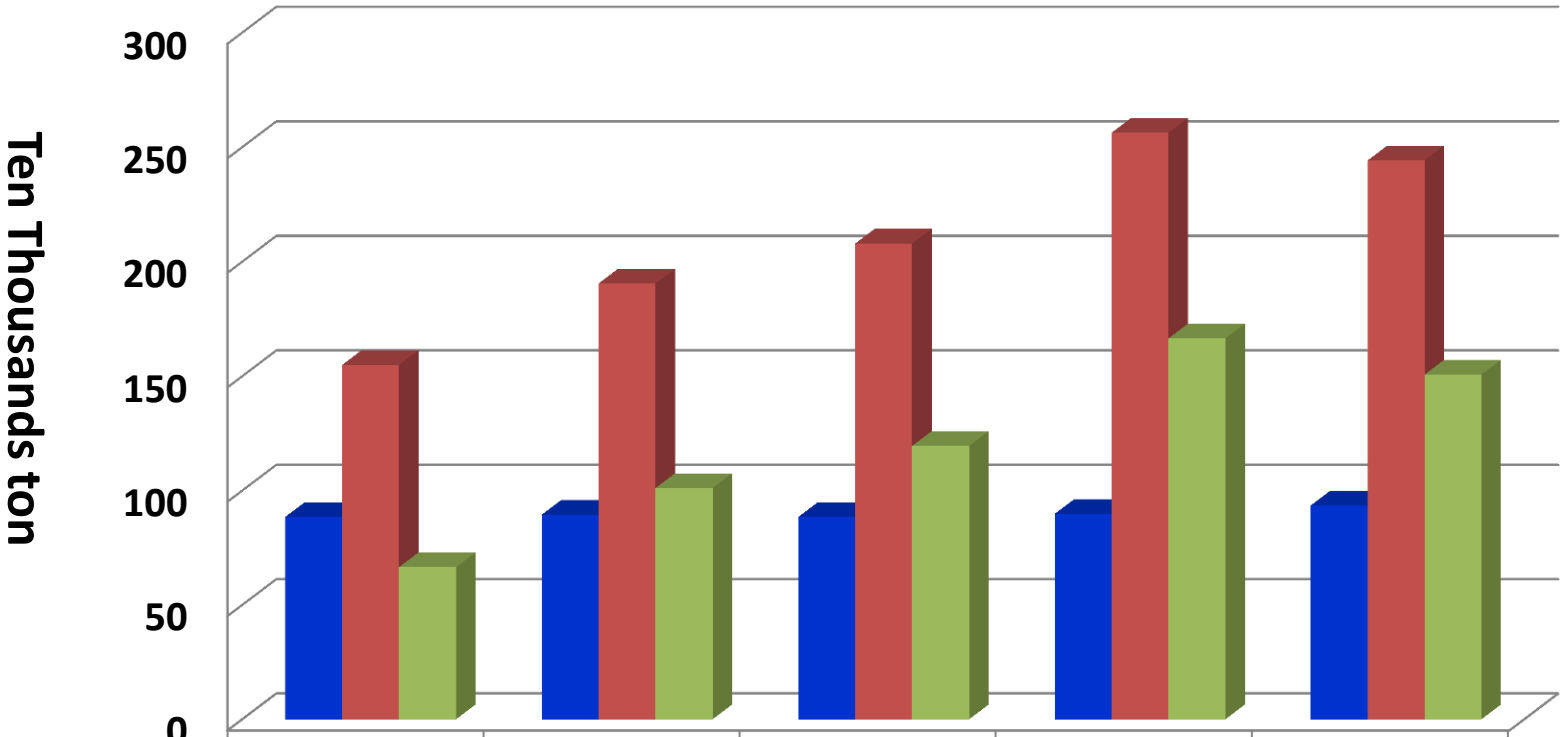
＞60 thousand tons tail fat

- ✓ Deep-processing rate less than 1%
- ✓ 3 ¥/kg

Mutton roll

Pilaf

Meat and Co-products Import and Export in China



	2010	2011	2012	2013	2014
export	88.4	89.4	88.4	89.8	93.5
import	154.9	190.5	207.9	256.3	244.2
Deficit	66.5	101.1	119.5	166.5	150.7

Data: China State General Administration of Customs, 2015

Traditional Usage of Co-products

1. Bone

✓ **Bone soup:** Qin Dynasty, 2200 years ago

2. Blood

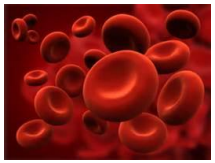
✓ **Medicinal materials:** used in traditional Chinese medicine

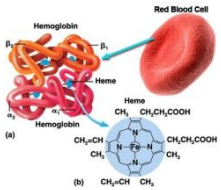
✓ **Blood tofu/sausage/pudding:** Qing Dynasty (1875-1908), Sun Zhiping took the blood tofu into the country.

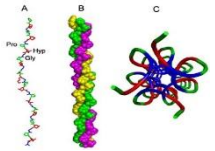
3. Animal fat

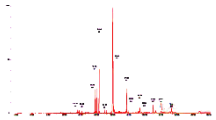
✓ **Edible oils by Stir-Frying:** Bei Wei Dynasty (533-544), 《Qimin Yaoshu》

Current Main Usage









High value utilization technology

Collection

Extraction

Separation

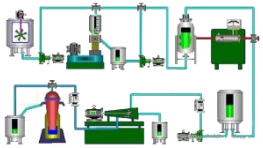
Drying

……

Industrialization

Automation

Intelligentization



Market is expected to be 50 billion

Industrialized Production

Edible Food Production

Animal Feed Production

Fertilizer Production

Theory → Technology → Equipment → Product

Innovation Research of Co-products in Our Team

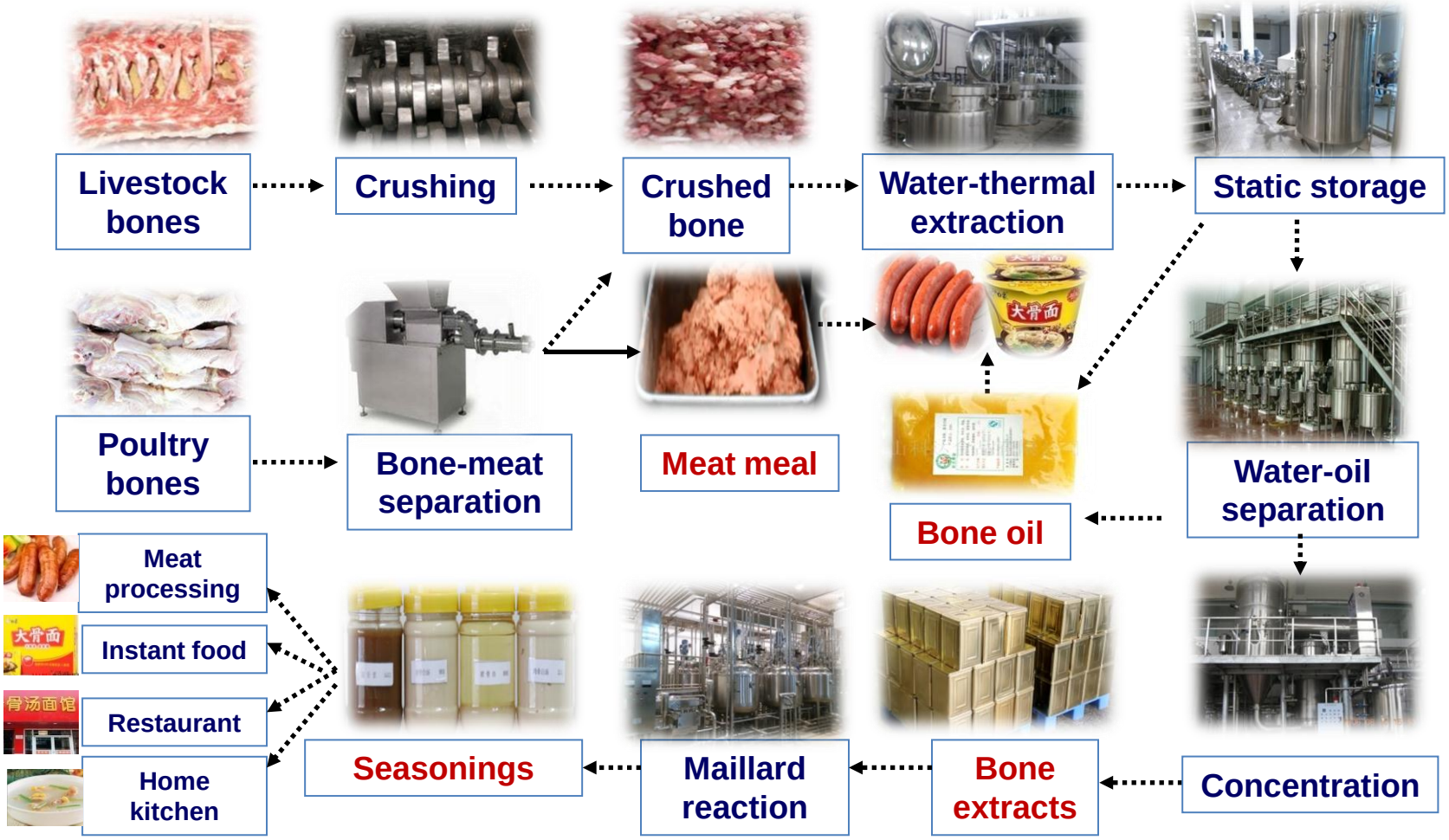
Case 1: Livestock and Poultry Bones Utilization

Nutrients composition of animal bone

Type	Protein %	Fat %	Ash %	Moisture %	Calcium %
Chicken	16.3	14.2	3.1	65.6	1.0
Bovine	11.5	8.0	15.4	65.1	5.4
Porcine	12.0	9.6	11.0	62.7	3.1
Goat	11.7	9.2	11.9	64.2	3.4
Fish	18.2	1.9-20	13.2	64.7	2.1




1. Bone utilization technology



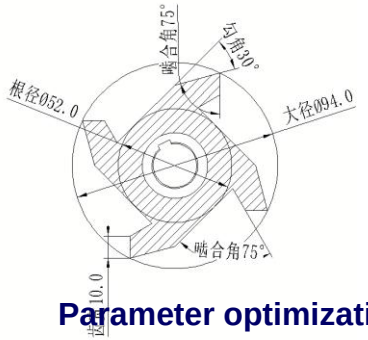
➢ Efficient rodent bone crusher

Problems:

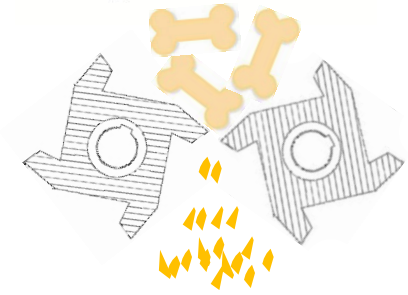
- **High hardness and irregular shape of animal bone**
- **Material blockage**

Solutions:

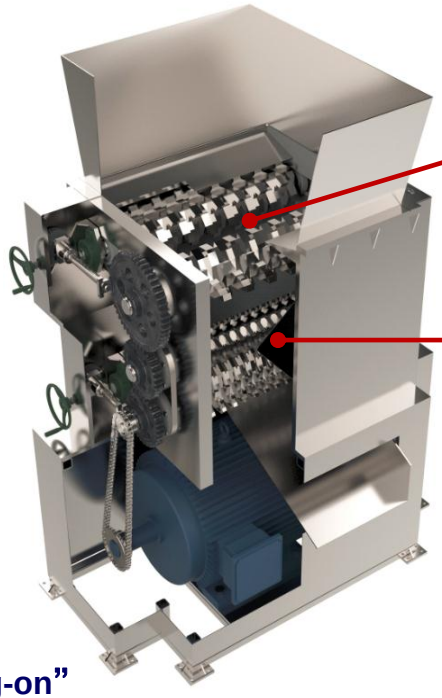
- **Design of rodent crusher; optimization of "scrap handing" and "holding-on"**
- **Two-step crushing; adjustable space**



Parameter optimization



"Scrap handing" & "Holding-on"



Primary breaker

Secondary crusher

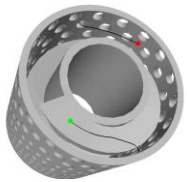
Version	NPG-2
Crashed rate	99.7%
Energy consumption	8 kg/kWh
Productivity	2 t/h

Chinese Patent (ZL. 201610178702.8)

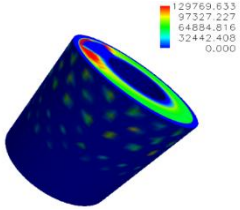
➢ Graded type of meat-bone separation

Graded type separating sieve drum was designed based on the physical properties of animal bone and the pattern of screw extrusion

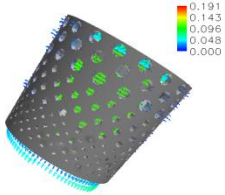
- The combination of material inlet and controllable-pitch double screws broken
- The combination of taper single screw and graded type separating sieve drum



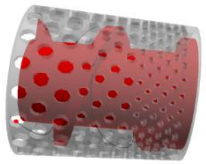
Screw-sieve drum



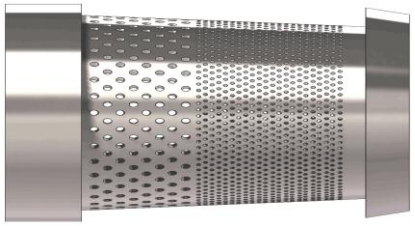
Shear stress field



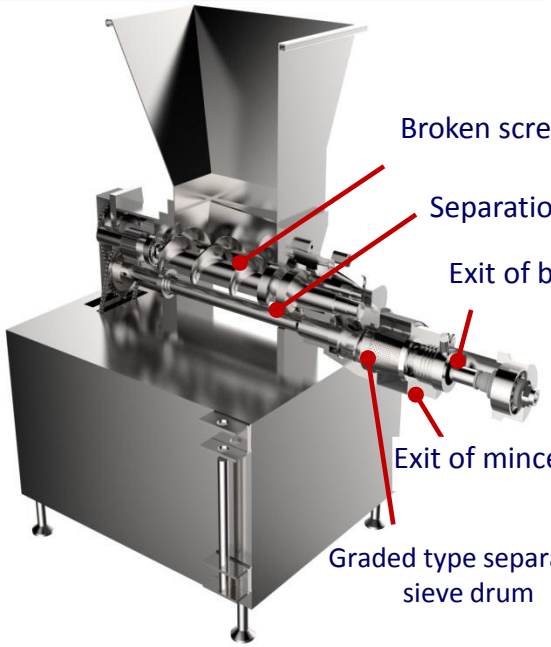
Extrusion



Motion trail



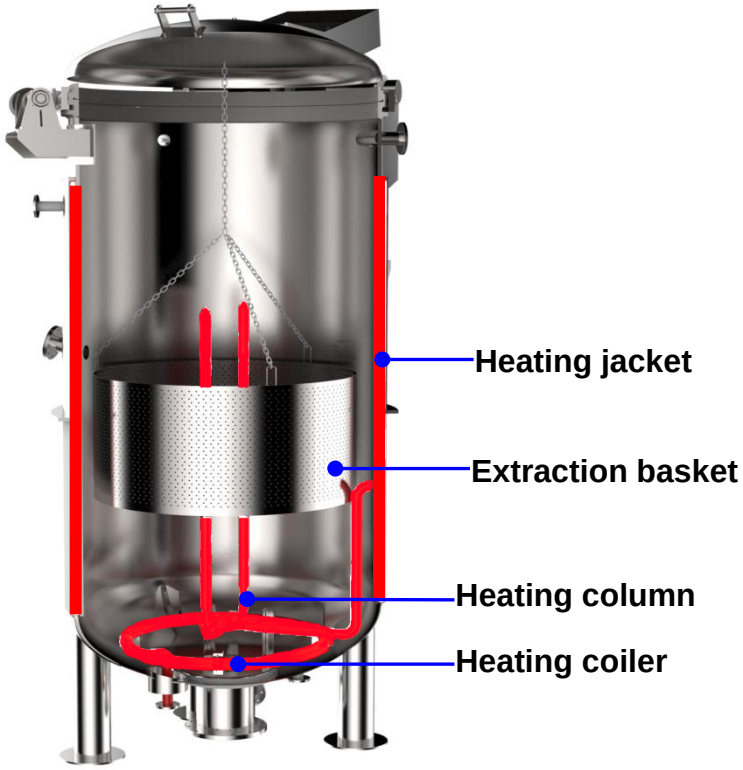
Graded type separating sieve drum



Version	GRF-2000
Separation rate	90.5%
Extrusion rate	0.1%
Energy consumption	14kg/kWh
Productivity	2t/h

Chinese Patent (ZL. 201610179451.5)

➢ Water-thermal extraction technology and equipment



Version	GCT-2000
Working pressure	0.4 MPa
Heating rate	3 °C/min
Productivity	0.9 t/h
Temperature accuracy	+0.4/-0.2 °C
Temperature uniformity	+0.7/-0.5 °C

✓ Water-thermal extraction equipment:

- Multi-site heating: **heating jacket**, **spray column**, and **bottom coiler**
- Comprehensive extraction yield for **protein**, **lipid**, and **chondroitin sulfate:** 85%-95%

Chinese Patent (ZL. 201520040084.1)
Food Chemistry (2014)

➢ Separation of water and oil in multiple emulsion

- ✓ The combination of electrolyte (NaCl), gravity settling and high speed centrifugation were used to demulsify multiple emulsion
- ✓ High quality product:
  - Separation rate: ＞99.5%;
  - Residual oil ratio: ＜0.48%;
  - Water content in bone oil: 0.5%

Gravity settling

Centrifugation

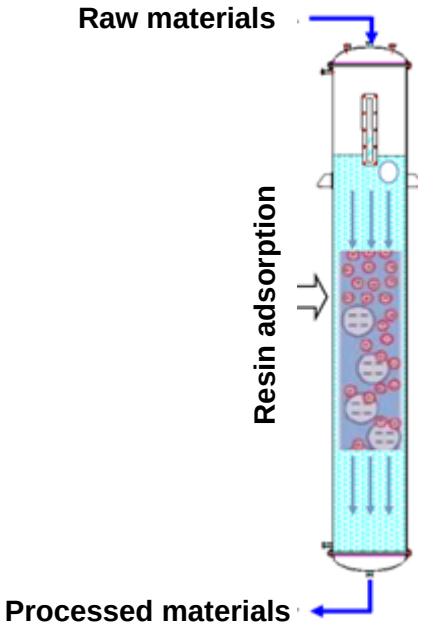
Bone oil

Chinese Patent (ZL. 201310036689.9)

➢ Separation of chondroitin sulfate

- ✓ Chondroitin sulfate (CS) plays an important role in the enhancement of joint function
- ✓ **Macro-reticular resin adsorption** was used at 50-70℃
- ✓ CS: Product rate: 95.6%; Purity: 92.6%

Complete sets of equipment

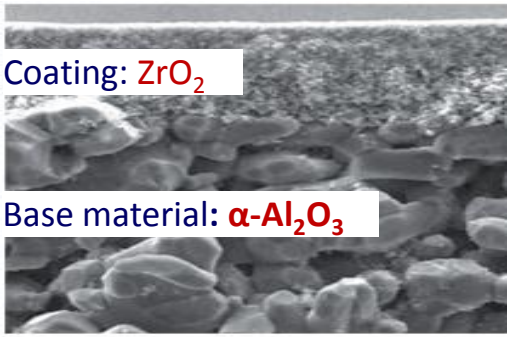


Chondroitin sulfate

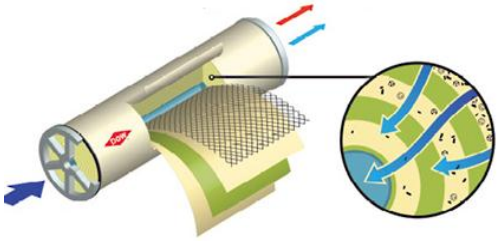
Chinese Patent (ZL. 201610169646.1)

➢ Graded membrane concentration of bone extraction

- ✓ Ceramic microfiltration membrane and reverse osmosis membrane are used and heat resistance up to 90℃
- ✓ Browning reaction can be avoided
- ✓ **Efficiency:** Threefold of vacuum concentration



50 nm micro-filtration membrane



Polyamide/polysulfone
reverse osmosis membrane

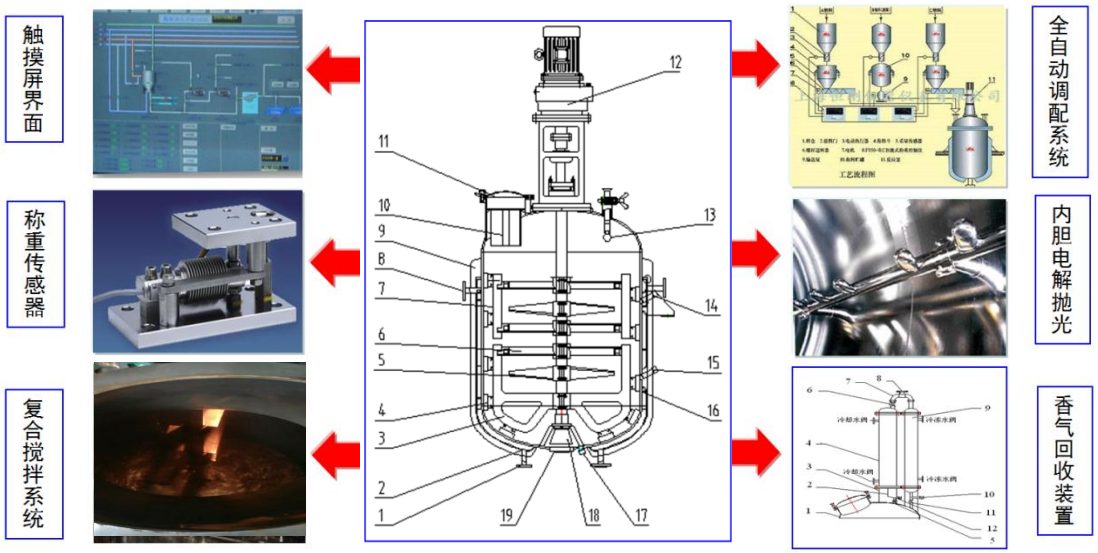
Ceramic microfiltration membrane

Reverse osmosis membrane

Chinese Patent (ZL. 201610178717.4)

➢ Multi- enzymolysis-maillard reaction

- ✓ Improving the heat transfer efficiency to guarantee the Maillard reaction thoroughly and balanced.
- ✓ Automatic control system design includes automatic feeding and weighing , temperature and time control



Enzymolysis-maillard reaction tank

Bone extracts

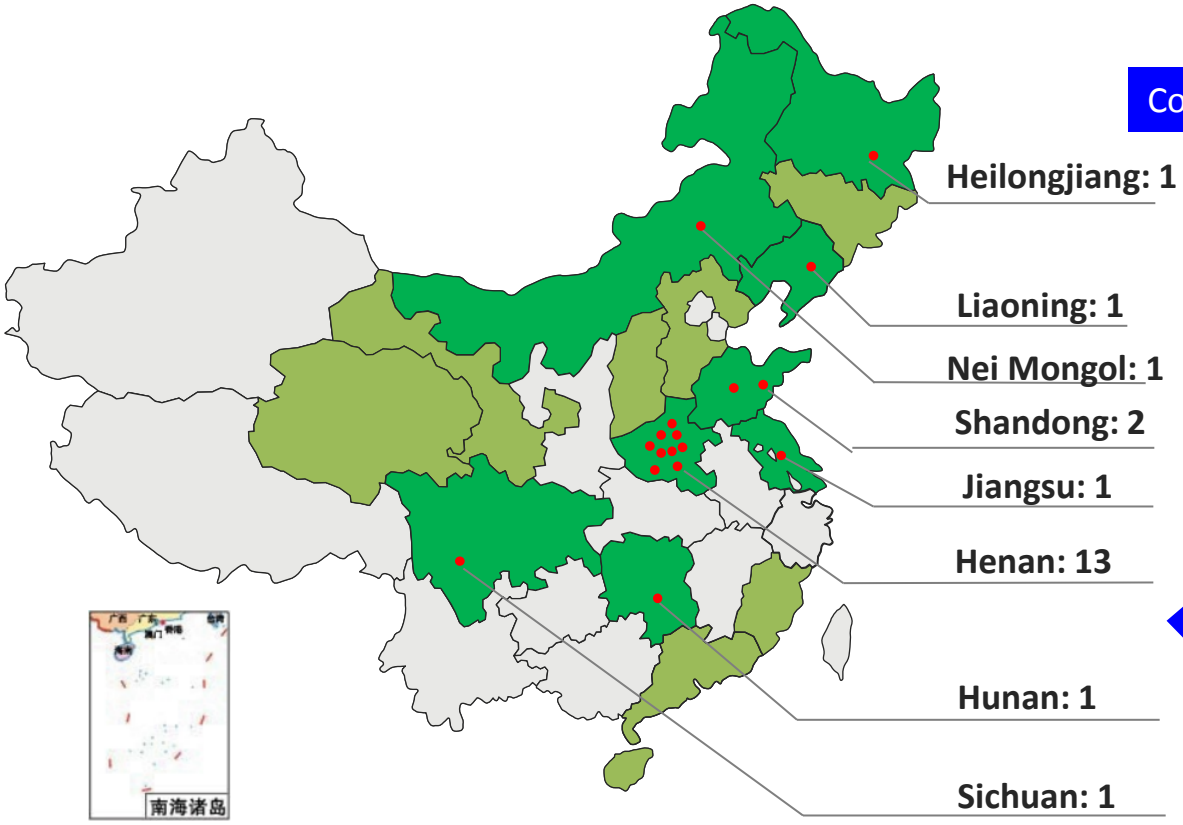
Food & Nutrition Research (2016)

2. Products

- ✓ Full utilization, five product category, more than 20 kinds of products

Classification	Products	Application
Flavoring	Light soup, soup stock, etc.	Food processing, Catering business, Home kitchens
Bone peptides	Stuffing, Peptide-calcium powder	Soup dumplings, Nutrition-enhancing food ingredient
Bone oil	Bone oil	Food processing, Catering business, Home kitchens
Chondroitin sulfate	Chondroitin sulfate	Dietary Supplement, Health foods
Ultrafine bone powder	High absorption bone powder, Flavouring-bone powder	Calcium nutritional supplement

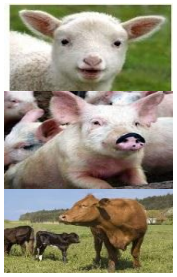
- ✓ Application in 15 company in China, covered cattle, chicken, pig, sheep and fish bone processing
- ✓ Product line: 21 lines in China



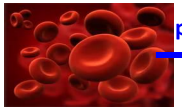
Cooperations of Companies

1. 黑龙江仁龙生物
2. 辽宁辽丰生物
3. 内蒙古蒙都羊业
4. 山东悦一、凤祥
5. 徐州联益生物
6. 河南双汇、普乐泰
   河南永达、雏鹰农牧
   河南白象、河南众品
   河南虢国、河南汇通
   河南一品香
7. 湖南嘉品嘉味
8. 四川蓝雁集团

Case 2: Animal Blood



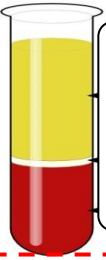
Properties of material



physicochemical

Sanitation

The quality control of material

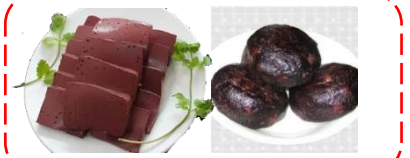


Material quality

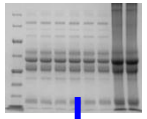
Storage technique

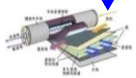
Effective separation technique

Traditional blood products



Derivatives of plasma protein





Nanofiltration

Enzyme

Low ash content
Good gel forming
Strong adhesiveness

Peptides

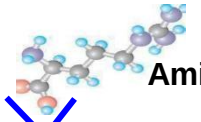
Base on composition

Break through the key technology

Aim at high-value products

Derivatives of hemoglobin

Hemoglobin



Amino acid

Coordinate

Stabilization

Traditional products

➢ blood tofu, sausage and other products

Collection of fresh and safe blood

Cold storage

blood tofu, double color blood tofu products

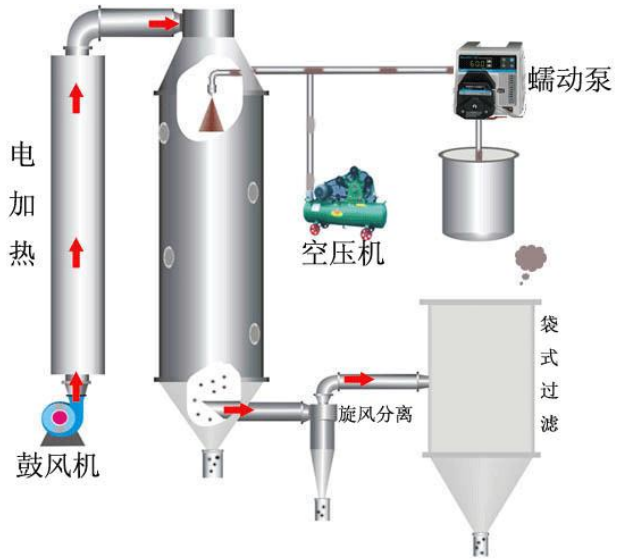
Chinese Patent (ZL. 201310740001.5, ZL. 201310740703.3)

Novel products

➢ Plasma protein powder and spray-dried blood cells

Plasma protein powder

Blood cells 45%-50%



Airflow spray dryer

Product 1: plasma protein powder

Product 2: spray-dried blood cells

Optimize centrifugal separation process and spray drying parameters

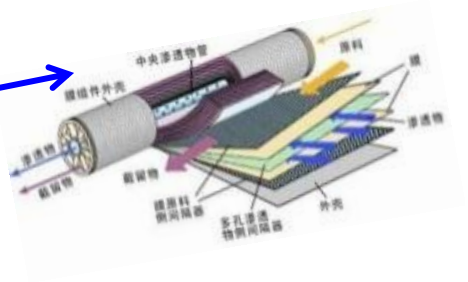
2437 g, centrifugation time: 10 min

Chinese Patent (ZL. 201611190745.4)

➢ Low ash plasma protein powder

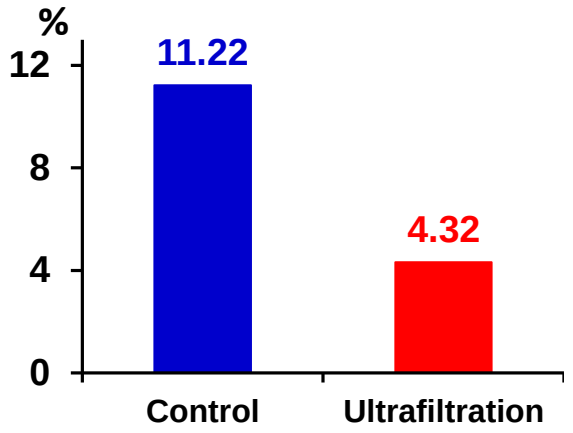
Ash content < 5%

Ultra-filtration desalination



ultrafiltration-nanofiltration

Low ash plasma protein powder

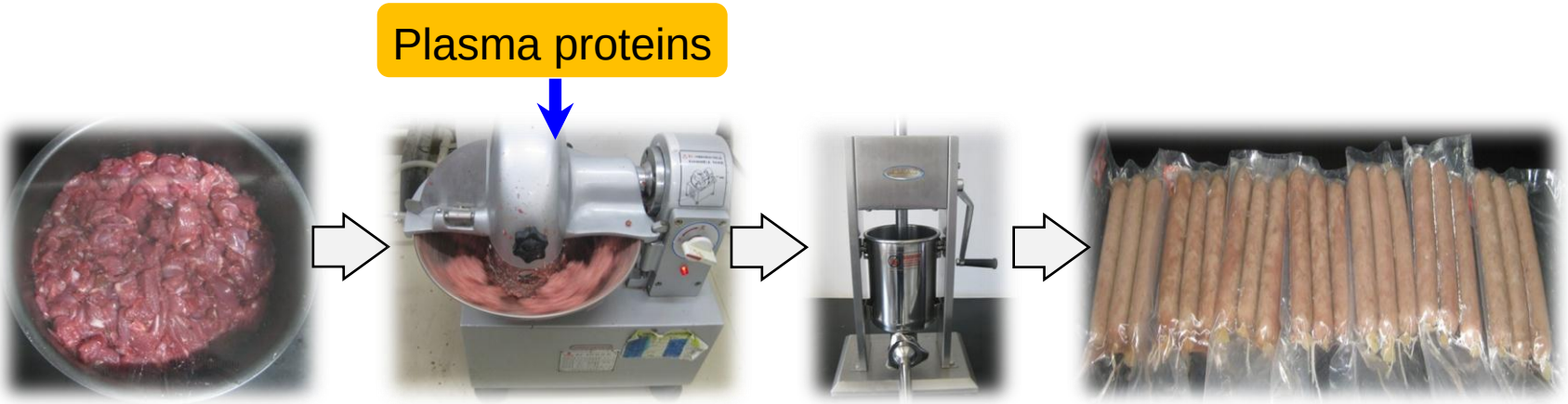


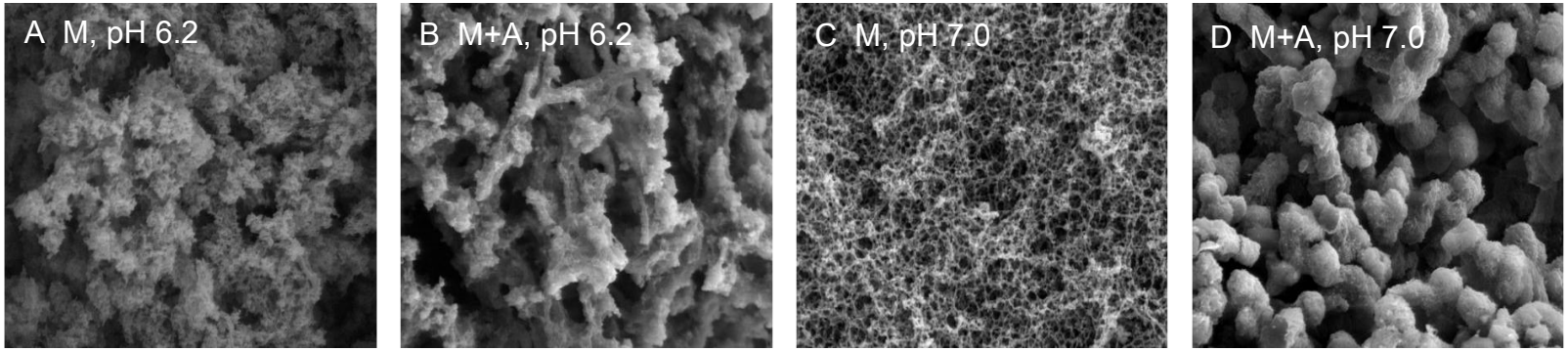
Comparison of ash content of Plasma Protein before and after ultrafiltration

Ultrafiltration pressure: 0.6 MPa, pH of plasma: 9

Chinese Patent: A preparation method of low ash plasma protein powder

➢ Plsma proteins used as emulsifier





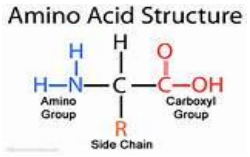
Food Science and Biotechnology (2014)

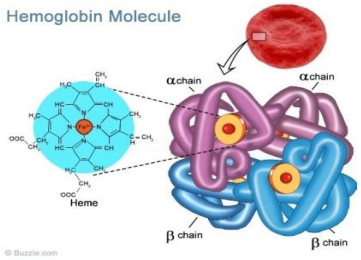
Sensory characteristics of cooked reduced sodium beef sausages containing plasma proteins

Treatments	Color	flavor	Tenderness	Juiciness	Overall acceptability
Con	6.40±1.20^{b}	5.15±1.94	6.10±1.07^{b}	6.60±1.15^{bc}	6.10±1.51^{b}
TC	5.50±0.53^{c}	5.00±1.51	4.80±0.79^{c}	5.60±1.17^{d}	4.60±1.07^{c}
T1	6.55±0.96^{b}	4.85±1.92	5.60±0.66^{b}	6.40±0.94^{cd}	5.90±1.10^{b}
T2	6.95±0.90^{ab}	5.10±2.13	6.25±0.95^{b}	6.95±0.69^{abc}	6.55±0.90^{ab}
T3	7.50±0.67^{a}	5.45±2.14	7.00±0.82^{a}	6.95±1.17^{abc}	6.95±0.64^{ab}
T4	7.67±0.66^{a}	5.55±2.06	7.35±0.67^{a}	7.60±0.70^{a}	**7.38±0.76^{a}**
T5	7.67±0.90^{a}	5.40±2.27	7.30±0.82^{a}	7.40±0.70^{ab}	6.90±1.22^{ab}

1. Values shown are mean±SD; a-e means within a column with different letters are significantly different (P<0.05).
2. Control, 3.5% salt; TC, 1.5% salt; T1, 1.5% salt+1% PP; T2, 1.5% salt+2% PP; T3, 1.5% salt+3% PP; T4, 1.5% salt+4% PP; T5, 1.5% salt+5% PP

➢ Hemoglobin colorant



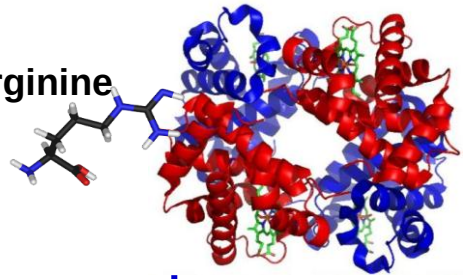


Amino acid

Hemoglobin

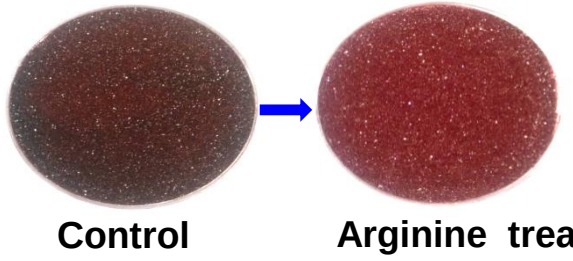
Complex

Arginine



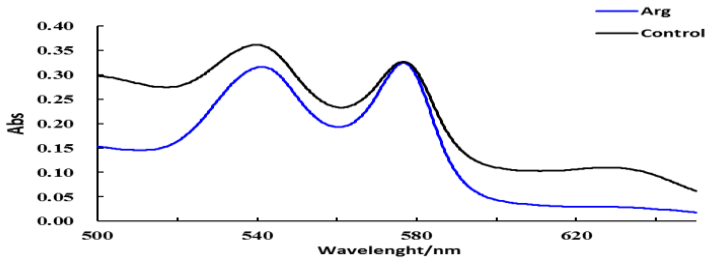
Hemoglobin from cattle

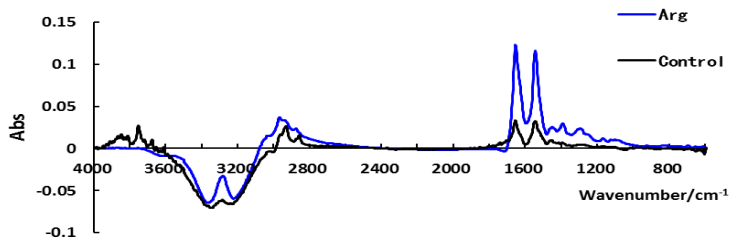
Stability↑



Control

Arginine treated



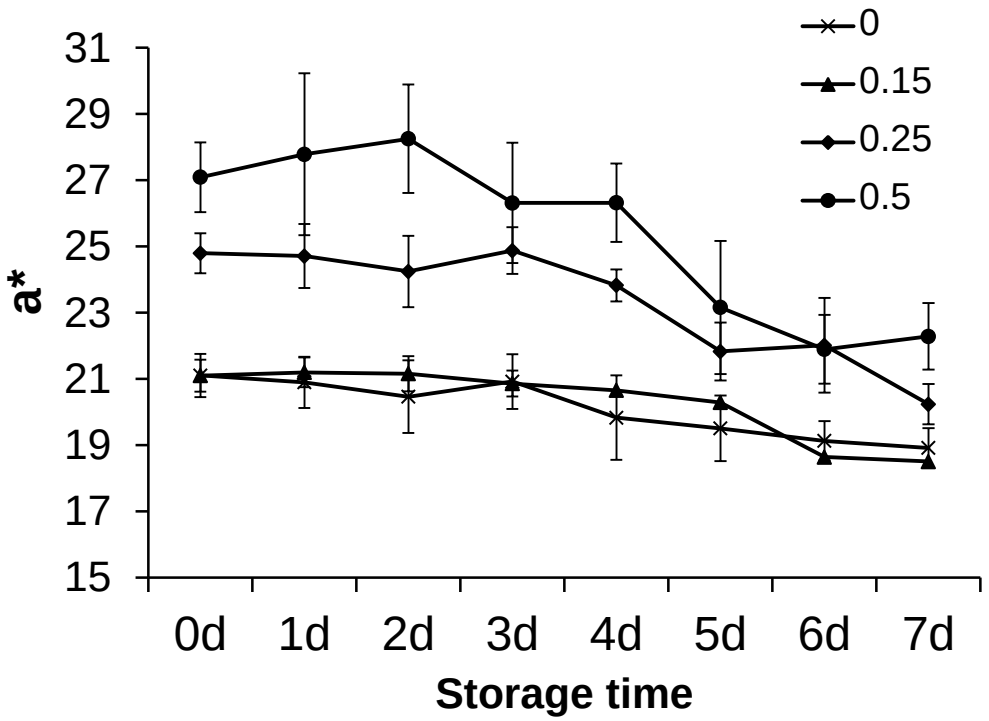


Structural identification of arginine-hemoglobin

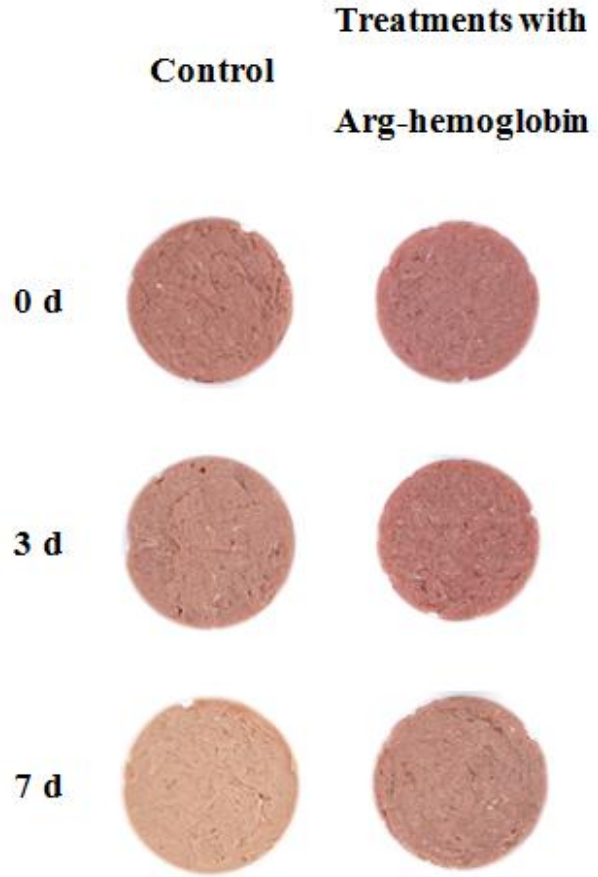
Providing technical support for development of high-stability hemoglobin

Chinese Patent (ZL. 201610976262.0)

Linkage of Arginine with hemoglobin increased the a* value of meat products



The effect of Arginine-hemoglobin on the a* value of meat product

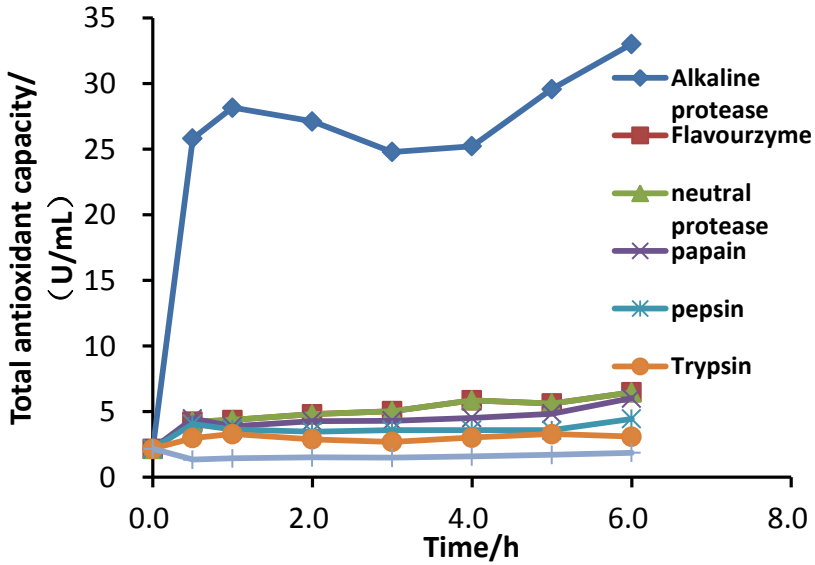


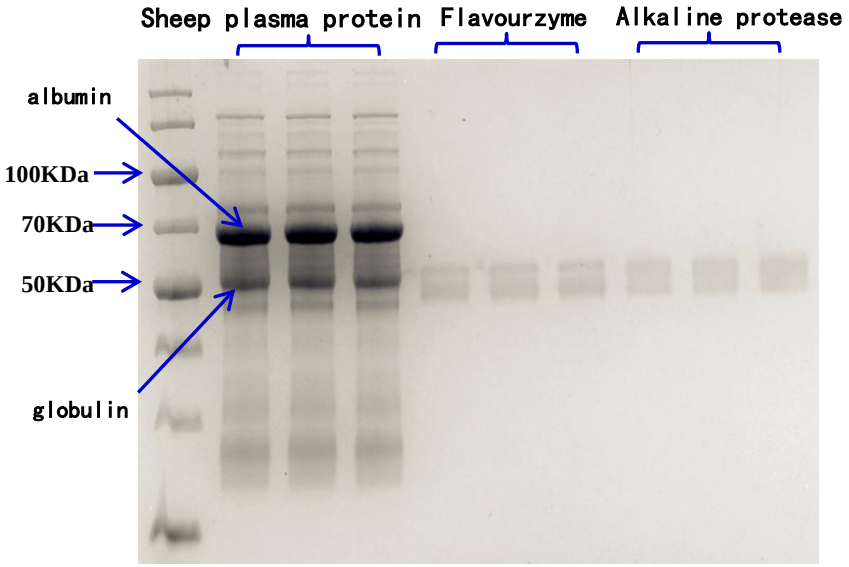
➢ Plasma protein peptide

Plasma protein

protease

Plasma protein peptide





Effects of 7 kinds of protease on the total antioxidant capacity of hydrolysates

Case 3: Animal Fat

Fatty Acid Composition of Ujumqin Sheep Fat

Fatty acid	Location			
	Subcutaneous fat	Suet	Tail fat	Visceral fat
SCFA	1.95±0.12	1.91±0.66	0.84±0.90	1.07±0.89
MCFA	28.40±0.96	29.22±3.17	26.00±2.61	26.82±2.88
LCFA	23.96±4.33	34.33±4.32	23.94±6.51	33.63±6.07
SFA	54.31±3.44	65.43±2.07	50.77±3.25	61.52±2.38
UFA	45.70±3.44	34.54±2.07	49.23±3.25	38.49±2.38
MUFA	41.86±3.30	31.34±1.93	44.96±3.37	34.81±2.43
PUFA	3.84±0.14	3.20±0.36	4.27±0.37	3.68±0.12
n-6 PUFA	2.67±0.04	2.45±0.31	2.75±0.28	2.58±0.23
n-3 PUFA	0.11±0.02	0.093±0.03	0.23±0.08	0.11±0.03
n-6/n-3	25.21±4.39	26.18±7.70	11.91±8.36	24.43±4.74
S/U	1.19±0.16	1.90±0.17	1.03±0.13	1.60±0.17
< 16 C	32.48±2.78	32.10±3.04	29.52±3.12	30.33±2.84
Trans fatty acids	4.42±0.28	5.31±0.42	4.39±1.09	5.13±0.57

SFA: saturated fatty acids; UFA: unsaturated fatty acids;
MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids

How to use?

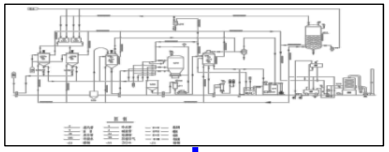
characteristics

Basic research

- Fatty acid composition
- physicochemical properties
- distribution characteristics

→ Theoretical basis

Traditional food



Integrated equipment

Enterprise application

Liquefied oil

dry fractionation

active control	nutrition arrange	Flavor adjustment

Blend oil products

Functional lipid

molecular distillation
adsorption separation

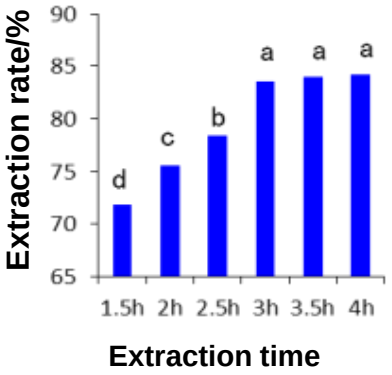
Purified

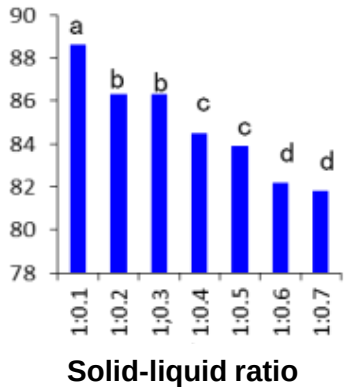
Capsule technology

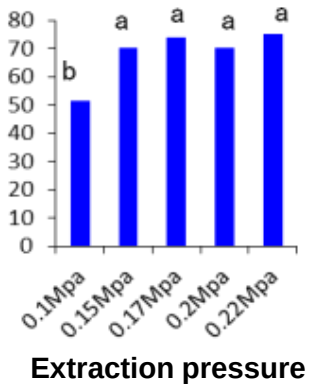
Conjugated linoleic acid capsules

➢Traditional Food

Sheep tail fat → Material selection → Trim → Triturate → Extract→Filter→Crude sheep fat







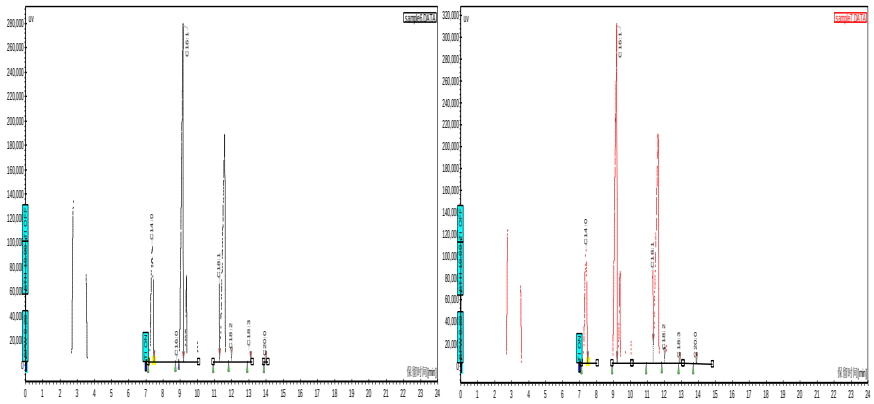
Extraction pressure: 0.15 MPa

Extraction time: 3h

Solid-liquid ratio: 1:0.1

Extraction rate: ＞88%

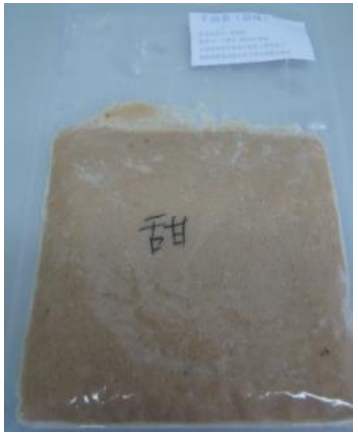
	Tail fat (mg/g)	Refined fraction (mg/g)
C14:0	27.61	31.96
C16:0	102.90	131.23
C18:1 ω9	74.43	104.26
C18:2 ω6	4.69	5.97
C18:3 ω3	4.07	0.08
C20:0	0.75	0.59



Fatty acid composition of sheep tail tallow

Food Science and Technology (2017, Chinese)


Refined sheep tail tallow

Tallow tea

Hotpot condiment

➢Edible liquefied sheep tail oil

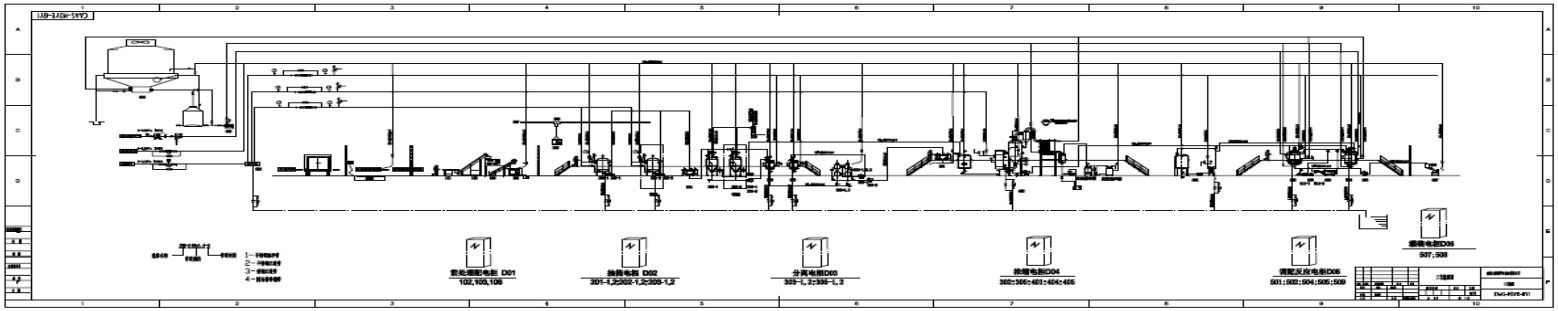
The yield and melting point of separated sheep tail oil by dry fractionation

Crystallization temperature/℃	Liquid oil		Solid oil	
	Yield/%	Melting point/℃	Yield/%	Melting point/℃
32	90.43 ± 0.90	36.0 ± 0.4	9.57 ± 0.90	42.1 ± 0.1
30	80.27 ± 2.14	32.9 ± 0.7	19.73 ± 2.14	43.6 ± 0.2
28	53.73 ± 1.29	14.7 ± 0.3	46.27 ± 1.29	41.8 ± 0.3
26	38.39 ± 1.62	12.6 ± 0.1	61.61 ± 1.62	40.3 ± 0.1
24	12.44 ± 1.15	13.9 ± 0.3	87.56 ± 1.15	38.1 ± 0.1

Trends of Animal Co-products Usage in China

Industrialized Production

- ✓ Co-products become value added, which is 10 to 15 times higher than before
- ✓ Requirement of making full use of the animal co-products

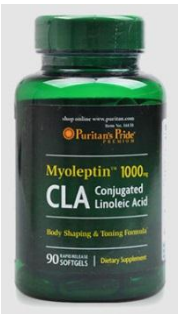


Edible Food Production

- ✓ Bone extracts, bone soup, flavorings
- ✓ Blood tofu, blood sausage
- ✓ Refined animal fat products, liquefied products

Functional Products

- ✓ Functional food production, e.g. bone/blood protein and peptides products
- ✓ Health products: heme iron products
- ✓ Ingredients for makeup production, e.g. lanolin



Animal Feed Production

- ✓ Bone and blood powder are used for mineral and protein resources of animal feed
- ✓ Different type of products, e.g. spray-dried powder, hydrolyzed powder

Improve Performance

Regulate Immune Function

sonac

baodi 宝迪集团

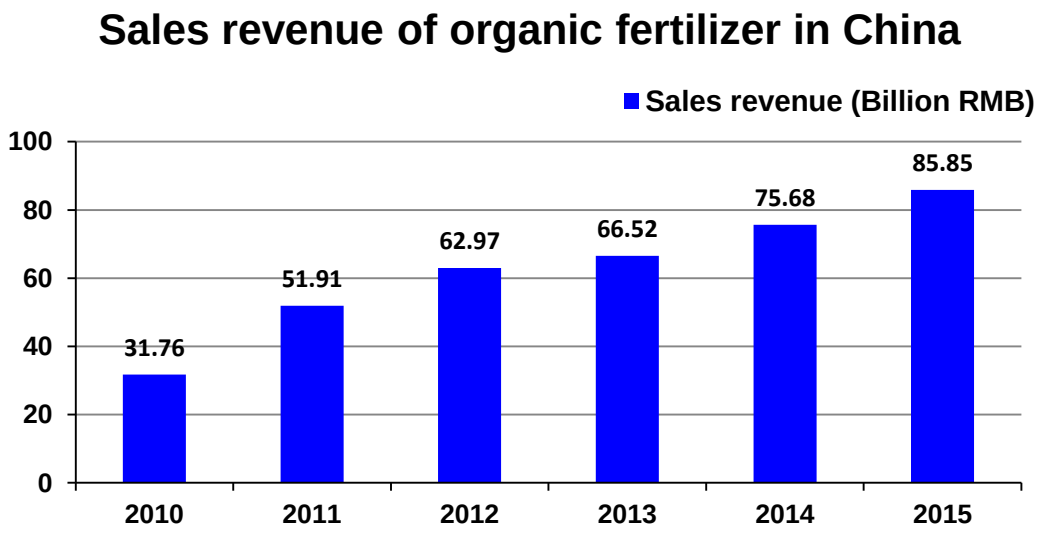
杰隆生物 GENON BIOLOGICAL

Fertilizer Production

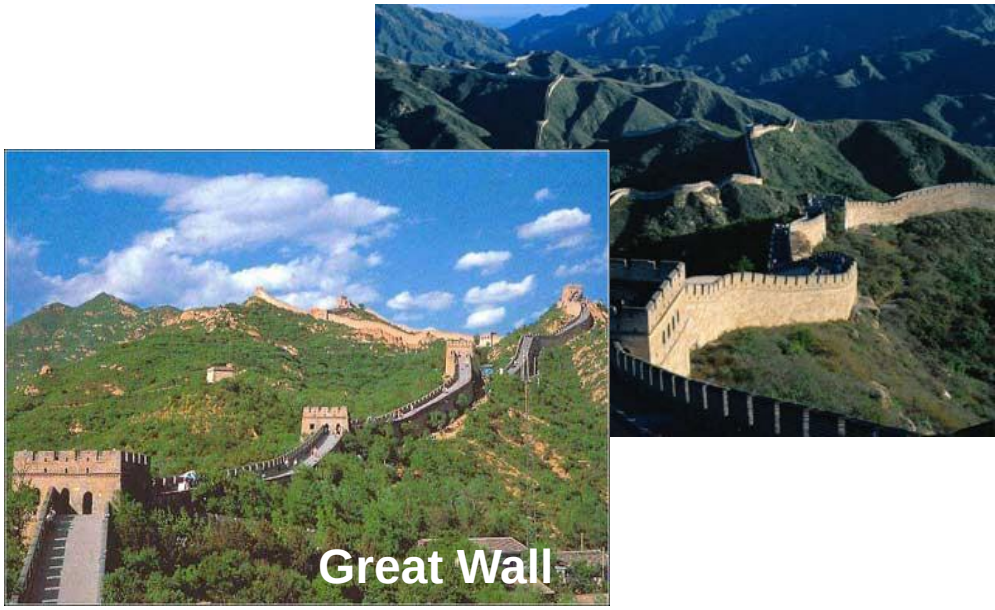
- ✓ Bone and blood meal are good resources of organic fertilizer
- ✓ High quality organic fertilizer which can be used for flower and golf course

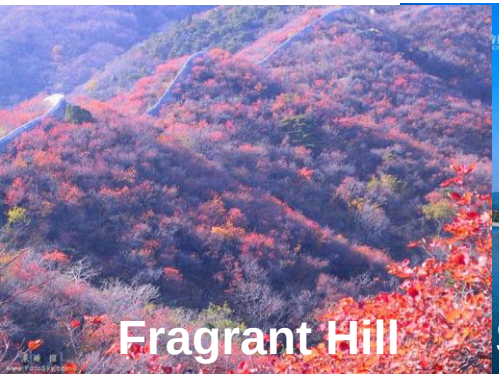
Blood: resource of nitrogen

Bone: resource of phosphorus



Institute of Food Science and Technology, Chinese Academy of Agricultural Sciences





No.1, Xi Beiwang, Haidian, Beijing
100193, P. R. China

Tel: 0086-010-62816594

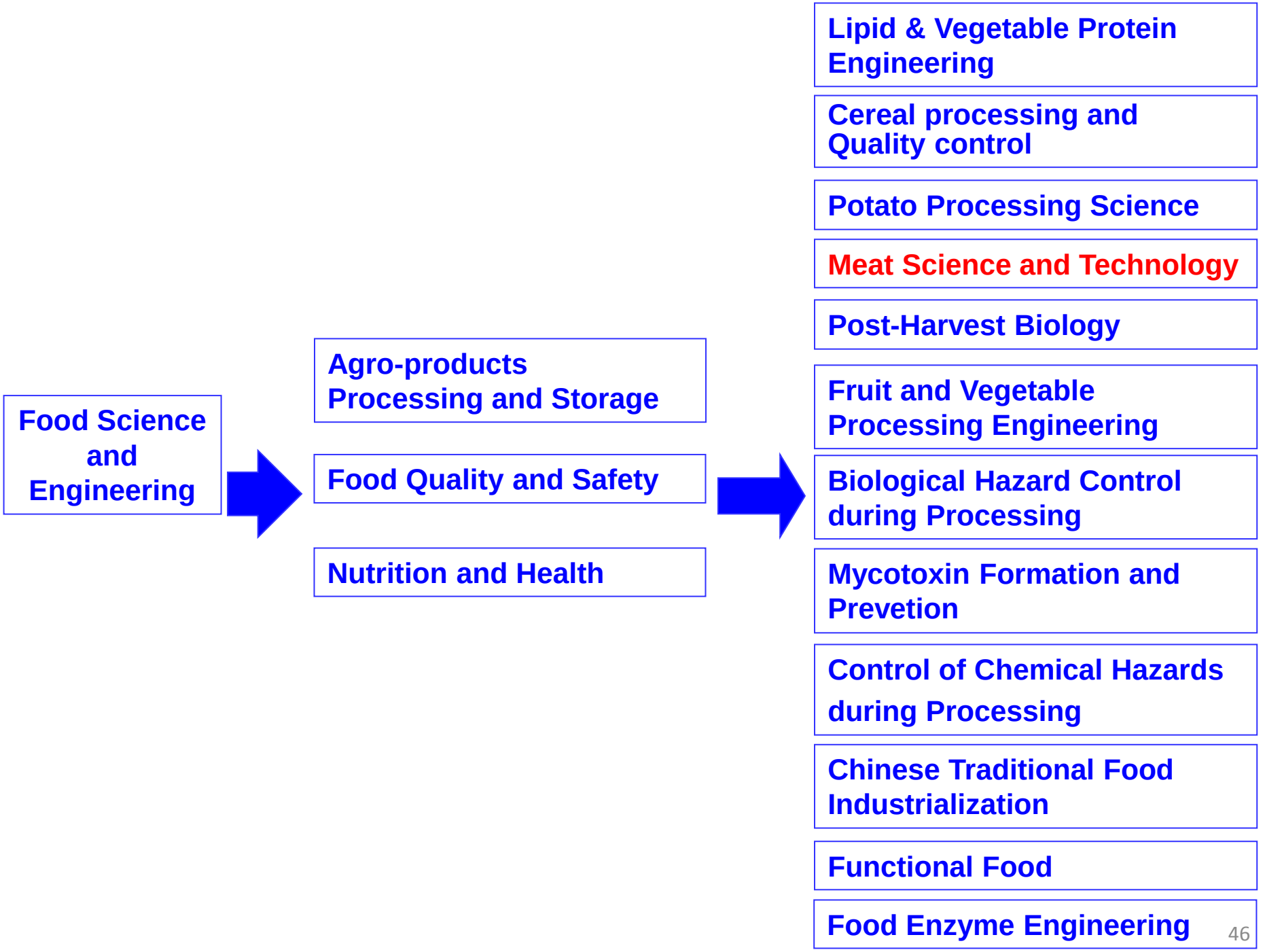
Fax: 0086 -010-62895356

http://www.foodcaas.ac.cn/index.html

- Total staff: 206
- Professors: 22
- Associate professors: 40
- 75% of our people hold postgraduate degrees
- Over 80 hold doctor's degree

- Graduate students: 235
- Post doctoral: 26
- International students: 25

- Scientific funding: 70 million RMB per year
- Income from enterprise collaboration: 30 million RMB per year
- Output of the commercialization of research findings: 300 million RMB per year


Food Science and Engineering
Agro-products Processing and Storage
Food Quality and Safety
Nutrition and Health
Lipid & Vegetable Protein Engineering
Cereal processing and Quality control
Potato Processing Science
Meat Science and Technology
Post-Harvest Biology
Fruit and Vegetable Processing Engineering
Biological Hazard Control during Processing
Mycotoxin Formation and Prevetion
Control of Chemical Hazards during Processing
Chinese Traditional Food Industrialization
Functional Food
Food Enzyme Engineering

Research Team

Chief Scientist

Prof. Dequan Zhang

Core Team Members

Research Assistant

Meat Eating Quality and Control

Prof.
Qingwu Shen

Associ Prof.
Xin Li

Dr.
Li Chen

Dr.
Zheng Li

Dr.
Hang Wang

Quality Control Technology of Chinese Traditional Meat Products

Associ Prof.
Zhenyu Wang

Engineer
Kai Ding

Dr.
Ning Kang

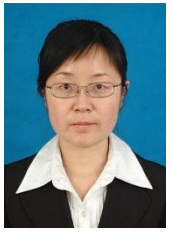
Dr.
Si Mi

Bone, Blood and Fat Comprehensive Utilization

Prof.
Chuihui Zhang

Associ Prof.
Chenli Hou

Dr.
Xia Li



Dr.
Weili Rao

Thank you for your attention!
Grazie!

Meat Science and Technology Innovation Team