TREND IN FOOD SCIENCE OF ANIMAL RESOURCES IN JAPAN

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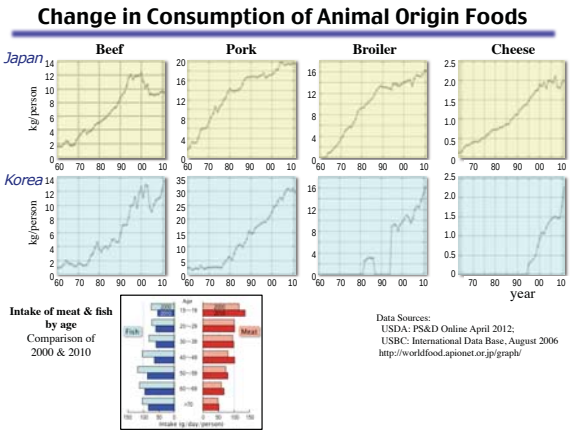
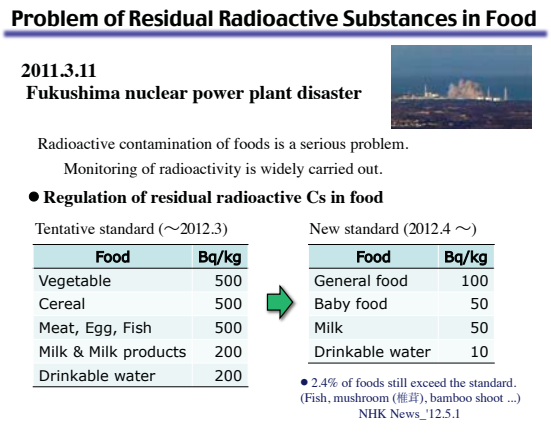
Most of Japanese did not take animal products up to a century ago under the influence of Buddhism, and it was said that human life is only 50 years. The main protein resources in Japanese diet were fish and soybean products. After World War II, the consumption of animal products increased with economic recovery. Together with the development of medical care, the improvement in nutritional level, especially taking of animal products, gives us longevity, and the average life expectancy of Japanese is now the top of the world. Nowadays, it is said that Japanese takes enough nutrients except calcium in our diet.

The increase in the intake of animal products leaded to activate the researches in animal resources such as meat, milk, and egg. In 1950s, "Japan Dairy Society Association" and "Japan Society for Meat Science and Technology" were founded, and the both societies keep their activities up to the present date.

It is pointed out that the recent problems in Japanese diet are nutritional excess and the unbalanced intake of nutrients as well, so that many people are anxious about metabolic syndrome. Such trend in the society leads our interest into so-called healthy foods or functional food. Besides classical studies in meat and milk sciences, the studies concerning functional components in foods as well as those physiological efficacies are becoming big trend in food science including animal resource foods. And many fruitful results are obtained for the last few decades.

In my presentation, I will talk about the recent research progress in meat science and milk science in Japan. Please refer the following slides.





Problems in Animal Health in Japan

1) BSE

Outbreak in Japan

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	2	4	5	7	10	3	1	1	0	0

- Cattles above 21 months old are obliged to inspect.
  - ◆ Current status; Controlled BSE risk (2009.5.29～)

2) Foot & mouth disease (FMD)

- First outbreak; 2010.4.9
- Slaughtered animals: Cattle 68,266, Porcine 220,034, Others 343
  - ◆ Current status; FMD free (2011.2.5～)

3) Highly pathogenic avian influenza (HPAI)

- Serious outbreak; 2010.11.27～2011
- Slaughtered chicken: broiler 600,000, egg-laying hen 400,000
  - ◆ Current status; HPAI free (2011.6.24～)

Healthy Foods

- **Metabolic syndrome** is becoming a social problem.
  → Consumers interest in healthy foods.

◆ **Food for Specified Health Uses (FOSHU)** 特定保健用食品

- Any food containing functional component which can provide positive effects on health condition or function.
- Currently, 996 foods are approved.

Efficacy	Effective ingredients
Condition of stomach/intestine	Oligosaccharides
Cholesterol level	Chitosan
Triacylglycerol & body fat	Polyphenol, Medium-chain fatty acids
Blood pressure	Peptides, GABA
Absorption of minerals	Peptides
Bone health	Soy isoflavone
Teeth health	Xylitol, Calcium phosphate
Blood glucose level	Indigestible dextrin

Functional Peptides from Milk

1) Opioid peptide (OP)

- Analgesic activity

Casein exorphine (← α_{s1}-casein) ^{90}Arg-Tyr-Leu-Gly-Tyr-Leu-Glu^{96}

Casomorphin (← β-casein) ^{60}Tyr-Pro-Phe-Pro-Gly-Pro-Ile^{66}

2) Casein phosphopeptide (CPP)

- Promote minerals (calcium, ferrum ...) absorption

α_{s1}-casein → ^{43}Asp --- Lys^{79} (37 residues)

β-casein → ^{1}Arg --- Arg^{25} (---Lys^{28}) (25/28 residues)

3) ACE inhibitory peptide

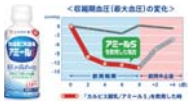
- Blood pressure decrease

CEI_{12} (← α_{s1}-casein) ^{23}Phe --- Lys^{34} (12)

^{194}Thr --- Trp^{199} (6)

$CEI_{7\beta}$ (← β-casein) ^{177}Ala --- Arg^{183} (7)

Lactotripeptide (← β-casein) ^{74}Ile-Pro-Pro^{76}, ^{84}Val-Pro-Pro^{86}



Functional Peptides from Milk

4) Lactoferricin

- Pepsin digestion of lactoferrin
- Anti-microbial and actin-cancer properties

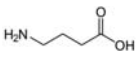
5) Lactostatin

- Tryptic digestion of β-lactoglobulin (Ile-Ile-Ala-Glu-Lys)
- Inhibitory effect on cholesterol absorption

6) κ-Caseinoglycopeptides (CGP)/Glycomacropeptide (GMP)

- Immunomodulatory function
- Stimulation of development of Bifidobacteria
- Antithrombotic activity
- Antihypertensive activity

7) GABA (γ-aminobutyric acid)

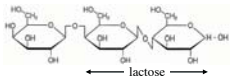


- Inhibitory neurotransmitter
- Antihypertensive activity (inhibitory effect on secretion of noradrenaline)
- Release of stress

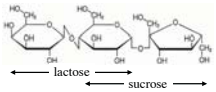
Functional Oligosaccharides in Milk

- **Milk oligosaccharide**

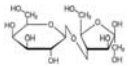
• Galactosyllactose



• Lactosucrose



• Lactulose



- Nondigestible oligosaccharide acts as "prebiotics"

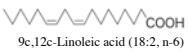
promote *Bifidobacteria* development
→ improve the function of intestine
→ inhibitory effect on allergy

Functional Fatty Acids in Milk

- **Oleic acid**
  - Decreasing effect on LDL cholesterol
    → prevent arterial stiffening

9c-Oleic acid (18:1, n-9)

- **Conjugated linoleic acid (CLA)**
  - Anticancer effect
  - Anti-allergy effect
  - Reduce fatness



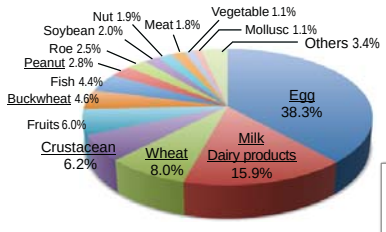
9c,12c-Linoleic acid (18:2, n-6)

Linoleic acid isomerase
(*Butyrivibrio fibrisolvens*)
in rumen

9c, 11t-CLA (rich in milk)

10t, 12c-CLA (rich in milk)

Food Allergy in Japan



- Major allergen in milk
  → β-lactoglobulin
- Major allergen in egg
  → ovomucoid, ovoalbumin, lysozyme, ovotransferrin

Specific allergen

Mandatory labeling of food products (2008.6～)

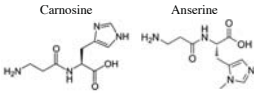
- Wheat
- Buckwheat
- Egg
- Milk
- Peanut
- Shrimp
- Crab

Functional Components in Meat

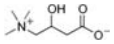
1) Histidyl peptides

- Carnosine (β-alanyl-L-histidine)
- Anserine (β-alanyl-*N*-methylhistidine)

Antioxidant activity



2) Carnitine (3-hydroxy-4-(trimethylazaniumyl)butanoate)



- Beef is a good source (1,300 mg/kg)
- Involved in lipid metabolism
  Acts as a transporter of fatty acids into mitochondria during the breakdown of lipids.
- Effective in relieving fatigue/ maintain stamina (used in sports drinks)

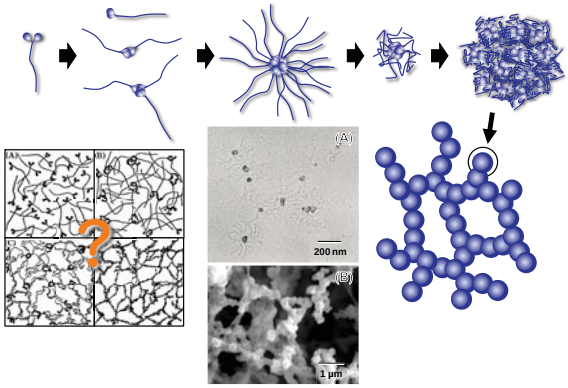
3) Conjugated linoleic acid (CLA)

- Antimutagenic effect
- Anti-allergy effect
- Reduce fatness

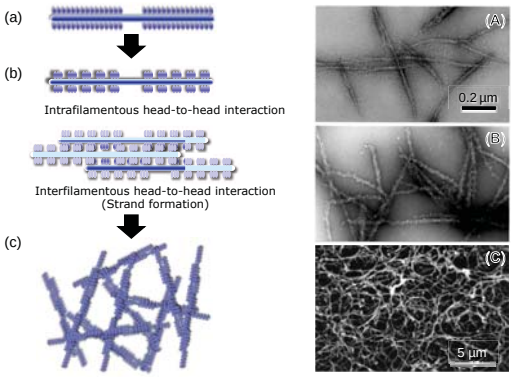
Functional Peptides Derived from Meat

Physiological activity	Source	Sequence
ACE inhibition	Creatine kinase (chicken)	LKA
(Blood pressure decrease)	Creatine kinase (chicken)	FKGRYYP
	Aldolase (chicken)	LKP
	Actin (swine)	VWI
	Actin (chicken)	IVGRPRHQG
	Myosin (swine)	ITTNP
	Myosin (swine)	MNPPK
	Myosin (swine)	FQKPKR
	Myosin (fermented pork)	VFPMNPPK
	Troponin C (chicken)	RMLGQTPYK
	Collagen (chicken)	GFXGTXGLXGF
Antioxidant	Porcine skeletal muscle	VW
		DLYA
		SLYA
		DLQEKLE
Opioid	Hemoglobin (bovine blood)	VVYPWTQRF
		LVVYPWTQRF
Prebiotic	Myosin (swine)	ELM

Heat-induced Gelation of Monomeric Myosin

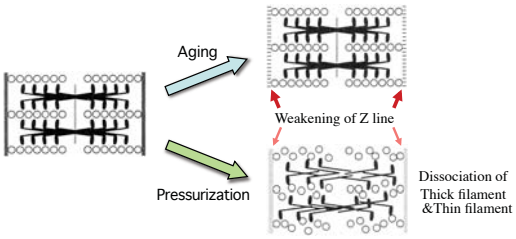


Heat-induced Gelation of Filamentous Myosin

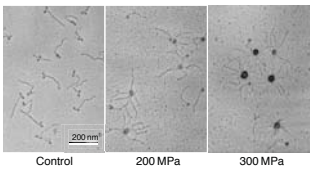


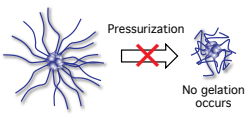
High Pressure Effect on Meat

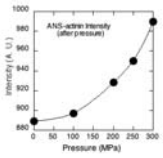
- **High hydrostatic pressure treatment induces tenderization**
  - change in myosin-actin interaction (← dissociation of thick & thin filaments)
  - fragmentation of myofibril (← dissociation of thin filament)
  - weakening of titin filament (← Ca^{2+} release from SR & action of calpain)
  - loosening of collagen network (← release of proteoglycan)

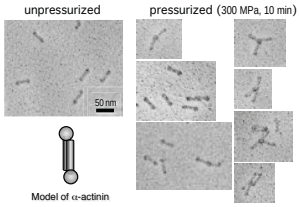


High Pressure Effect on Muscle Proteins



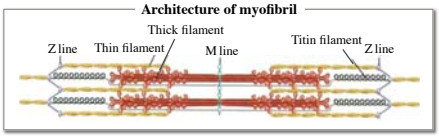






Meat Tenderization during Aging

- **Meat toughness**
  - Background toughness (Connective tissue)
    - Degradation of proteoglycan
      → Loosening of the network of collagen fibrils
  - Myofibrillar (Actomyosin) toughness
    - Fragmentation of myofibril
      Weakening of Z line
    - Recovery of myofibril length
      Weakening of myosin-actin interaction



Changes in Myofibril during Aging

1) **Fragmentation** (Weakening of Z-line)
- Calcium theory (proposed by Prof. Takahashi, Hokkaido Univ.)
  Non-enzymatic weakening of Z line
- Proteolytic enzymes
  Calpain (m-, μ-), Cathepsin, Proteasome, Caspase (Cysteine-Aspartic acid protease)
  - Enzymatic degradation nearby Z-line is suggested.

2) **Recovery of myofibrillar length** (Changes in myosin-actin interaction)
- Possible factors involved in the change of myosin-actin interaction
  - Partial digestion of myosin head by protease (calpain?)
  - Action of paratropomyosin
  - IMP & AMP can dissociate actomyosin
  - GAPDH (glyceraldehyde-3-phosphate dehydrogenase)
    → binds to actin → influence myosin-actin interaction

- **Paratropomyosin (PT)**
  - Inhibits Mg^{2+}-ATPase of synthetic AM
  - Locates in A-I junction
- **Proposed mechanism of PT action** (by the research group of Hokkaido Univ.)
  - Increase of Ca^{2+} to 10^{-4} M during aging (leak from SR & mitochondria)
    → Release of PT from myofibril → PT binds actin → weakening of M-A interaction

QCM for Predicting Meat Aging

A QCM (Quartz Crystal Microbalance) sensor consists of thin quartz disk with gold electrodes. The sensor oscillates at resonance frequency (27MHz). The resonance frequency decreases linearly by mass bond on a QCM sensor surface.