Strategies for designing novel functional meat products

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Functional Foods

‘Processed foods having disease-preventing and health-promoting benefits in addition to their nutritional value’

Much attention has been paid to physiological functions of foods. Progress has been made in the development of functional foods, such as functional dairy products. However, ---
Functional meat products?

Many books on functional foods have been published. There has been little focus on meat and meat products.
"The meat industry must adapt to the new concepts in nutrition. There is now a potential market for functional foods, based on the principle of added value linked to health benefits, which is one of the main trends in the development of food products."

"New approaches for the development of functional meat products" (Chapter 11) Jiménez-Colmenero, Reig & Toldrá (2006)
Nutritional and sensory properties of dry fermented sausages enriched with $n$-$3$ PUFAs

Valencia et al.
University of Navarra, Spain

Meat Science, 72: 727-733
April 2006
Potential probiotic *Lactobacillus* strains from fermented sausage: Further investigations on their probiotic properties

Pennacchia et al.

Università degli Studi di Napoli, Italy

*Meat Science, 73* : 90-101

May 2006
Conjugated linoleic acid

Factors influencing proportion and composition of CLA in beef

De La Torre et al.
INRA, France

Meat Science, 73 : 258-268
June 2006
Utilization of natural antioxidants: Green tea extracts and *Thymbra spicata* oil in Turkish dry-fermented sausage

Bozkurt
University of Gaziantep, Turkey

*Meat Science, 73 : 442-450*

July 2006
Possible strategies for developing healthier meat and meat products

1. Modification of carcass composition
2. Manipulation of meat raw materials
3. Reformulation of meat products

Jiménez-Colmenero et al. (2001)
Meat Sci., 59: 5-13
Reformulation of meat products

- Reduction of fat content
- Modification of fatty acid profile
- Reduction of cholesterol
- Reduction of calories
- Reduction of sodium content
- Reduction of nitrites
- Incorporation of functional ingredients

Jiménez-Colmenero et al. (2001)
Outline of this presentation

1. Meat-based bioactive compounds
2. Overview of functional meat products
3. Meat protein-derived bioactive peptides
4. Development of probiotic meat products
5. Concluding remarks

“Strategies for designing novel functional meat products”
Attractive meat-based bioactive compounds
Meat-based bioactive compounds
(Nutraceutical compounds in meat)

- Conjugated linoleic acid
- Carnosine, anserine
- L-Carnitine
- Glutathione
- Taurine
- Creatine, etc.
Conjugated linoleic acid (CLA)

Beef fat contains 3-8 mg of CLA/g fat.
- Anticarcinogenic activity
- Antioxidative activity
- Immunomodulative activity

Some lactic acid bacteria promote the formation of CLA in fermented milk.

formation in fermented meats?
Histidyl dipeptides

These peptides are the most abundant antioxidative in meats.

- Wound healing
- Recovery from fatigue
- Antistress activity
L-Carnitine

L-Carnitine is abundant in beef.

- Assistance in producing energy
- Lowering levels of cholesterol
- Assistance in absorbing calcium
- Maintenance of stamina
- Recovery from fatigue
Focus on physiological activities

Focusing on these activities is one possible approach for designing healthier meat and meat products.

The feeding conditions of animals affect the contents of CLA and L-carnitine.

Such efforts could lead to the creation of differentiated meat and meat products.
Overview of functional meat products
Examples of healthy meat products

- **Fat-free Bologna ham** (USA)
- **Calcium and fiber-fortified sausages** (Japan)

*Kitasato University*
Foods for specified health use (FOSHU)
established in Japan in 1991

FOSHU are foods that, based on knowledge of the relationship between foods or food components and health, are expected to have certain health benefits and have been licensed to bear labeling claiming that a person using them may expect to obtain health benefits through the consumption of these foods.

(Japanese Ministry of Health and Welfare)

Approved FOSHU: 600 products
Market scale: € 4 billion/year
Representative functional ingredients used for FOSHU products

- Oligosaccharides
- Dietary fibers
- Lactic acid bacteria
- Sugar alcohols
- Sterol esters
- Diacylglycerols

- Soy proteins
- Peptides
- Calcium
- Iron
- Glycosides
- Polyphenols
Examples of FOSHU products

"for people with high blood pressure"

"preventing fat accumulation"

Sour milk ('Ameal-S')

Cooking oil ('Econa')
Examples of meat-based FOSHU products

Pork Vienna-type sausages with indigestible dextrin (beneficial effects on intestinal disorders)

Pork frankfurters with soy proteins (maintenance of proper blood cholesterol level)
Items of functional modification in meat and meat products

- Modification of fatty acid and cholesterol levels
- Addition of vegetable oils to meat products
- Addition of soy
- Addition of antioxidative natural extracts
- Sodium chloride control
- Addition of fish oils
- Addition of vegetal products
- Addition of fiber

Fernández-Ginés et al. (2005)
J. Food Sci., 70: R37-R43
Utilization of meat protein-derived bioactive peptides
Generation of bioactive peptides from food proteins

Food proteins → Enzymatic digestion → Bioactive peptides

These sequences are inactive within the parent proteins.

CRC Press, 2006
Representative activities of food protein-derived bioactive peptides

- Antihypertensive
- Antioxidative
- Opioid agonistic
- Immunomodulatory
- Antimicrobial
- Prebiotic
- Mineral-binding
- Hypocholesterolemic
Products utilizing bioactive peptides

Ameal-S (Japan)

Evolus (Finland)

Kotsukotsu Ca (Japan)

Antihypertensive peptides

Caseinophosphopeptides
Generation of bioactive peptides from meat proteins

1. Gastrointestinal proteolysis
   pepsin, trypsin, chymotripsin, etc.

2. Aging and storage
   calpains, cathepsins, etc.

3. Fermentation
   muscle enzymes, microbial enzymes

4. Enzymatic treatment
   proteinases from various sources
Antihypertensive peptides generated from meat proteins

Among bioactive peptides from meat proteins, ACE inhibitory peptides have been studied extensively.
Role of ACE in blood pressure regulation

Angiotensin I

Angiotensin II

Increase of blood pressure

ACE: Angiotensin I-Converting Enzyme

ACE Inhibitor
Identification of ACE inhibitory peptides

Pork proteins hydrolyzed by thermolysin
(most potent ACE inhibitory activity)

- Purification

Met-Asn-Pro-Pro-Lys
Ile-Thr-Thr-Asn-Pro

Both sequences are found in myosin heavy chain.

Arihara et al., 2001

Both peptides showed antihypertensive activity when administered orally to SHR.
ACE inhibitory peptides derived from enzymatic hydrolysates of animal muscle protein: A review

Vercruysse et al.
Ghent University, Belgium

ACE inhibitory activities of extracts prepared from fermented sausages

Wine-flavored salami (USA)
Abruzzese (USA)
La. Estrella (Argentina)
Gold salami (Netherlands)
Cacciatore (Switzerland)
Salami Norcinetto (Italy)
Le Bastou (France)
Salami Fiorillo (Italy)
Saucisson Sec (France)
Salami Felino (Italy)
ACE inhibitory activities of fermented sausages

![Graph showing ACE inhibitory activities of different fermented sausages](image-url)
Antioxidative peptides generated from meat proteins

Antioxidative substances have been reported to play many physiological roles, such as prevention of diseases related to oxidative stress.
Antioxidative activities of pork hydrolysates

Antioxidative activities were assayed by using a hypoxanthin-xanthine oxidase system as the source of superoxide anion.

Proteinases used for digestion:
- Papain
- Pepsin
- Trypsin
- Chymotripsin
- Thermolysin
- Proteinase K
- Pronase E
- Ficin
- Carnosine

Activity (%)
Experiment on anti-fatigue effect

Animals: 5-week-old male ICR mice
Samples: water, pork proteins, hydrolysates
Measurements: running time to exhaustion
Anti-fatigue effect of pork protein hydrolysate

Oral administration (2mg/mouse) prior to running

a, b: P<0.05
Anti-stress effect of pork protein hydrolysate

6-week-old male rats → Administration of samples (7 days) → Water immersion stress (10 hours) → Stomach extirpation

Results of studies → Pork protein hydrolysates showed anti-stress activity

Normal stomach

Stressed stomach (ulceration)
Identification of antioxidative peptides

Pork proteins hydrolyzed by papain

Purification

Asp-Leu-Tyr-Ala
Ser-Leu-Tyr-Ala
Val-Trp

These sequences are found in actin.

Arihara et al., 2005

Synthesized Asp-Leu-Tyr-Ala showed strong anti-fatigue and anti-stress activities.
Development of probiotic meat products

Intestinal lactobacilli

Kitasato University
Definition of probiotics

'Live microorganisms which, when administered in adequate amounts, confer a health benefit on the host'

Representative probiotic bacteria

Intestinal strains of *Lactobacillus* & *Bifidobacterium*
Properties of probiotic bacteria

- Human origin
- Resistance to acid and bile toxicity
- Adherence to human intestinal cells
- Colonisation of the human gut
- Antagonism against pathogenic bacteria
- Production of antimicrobial substances
- Immune modulation properties
- History of safe use in humans
Functions of probiotic bacteria

- Modulation of intestinal flora
- Prevention of diarrhea
- Improvement of constipation
- Lowering faecal enzyme activities
- Lowering plasma cholesterol level
- Modulation of immune responses
- Prevention of food allergies
- Prevention of cancer occurrence
Examples of probiotic dairy products

Probiotic dairy products are popular in many countries, including Japan, Germany, Finland, France, Korea, USA, New Zealand.
Lactobacillus rhamnosus FERM P-1520 has been selected from the collection of human intestinal lactobacilli for a probiotic meat starter culture. Sameshima et al. (1998)

In addition to the probiotic properties, screening was carried out to clear the following regulations in Japan.

- use of 200 ppm nitrite & 3.3% NaCl
- processing at a temperature below 20°C
Developed probiotic meat product

Fermented meat spread product (“Breadton”, Prima Meat Packers Ltd, Japan) utilizing the human intestinal *Lactobacillus rhamnosus*. 
Fermented Meat (Chapter 10)

Hammes et al.
Hohenheim University, Germany


“It may be possible to select bacterial strains that are capable of producing a fermented meat product with all the sensory qualities preferred by consumers and that at the same time provide beneficial probiotic effects.”
Prebiotics

‘Non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon and thus improve the health of the host’

Prebiotic substances (oligosaccharides, dietary fibers) enhance the activity of probiotic bacteria.
Desirable attributes of functionally enhanced prebiotics

- Targeting at specific probiotics
- Active at low dose
- Lack of side effects
- Resistance through the colon
- Protection against colon cancer
- Enhancement of the effect to pathogens
- Inhibition of adhesion of pathogens

Rastall et al., 2000
Meat protein-derived prebiotic peptide

Pork proteins

↓ Papain digestion

Bifidobacterium growth-promoting activity

↓ Purification

Identified prebiotic peptide

Glu-Leu-Met

Growth of Bifidobacterium was promoted selectively.

Arihara et al., 2006
Probiotics, prebiotics and synbiotics

**Synbiotics**

Mixture of probiotics and prebiotics

The growth of probiotic bacteria is enhanced by prebiotics, thus increasing the chance of the probiotic bacteria becoming established in the gut and conferring a health benefit.

Meat products with probiotics, prebiotics and synbiotics have a great future potential.
Combination of peptides & probiotics
(Utilization of enzymes and bacteria)

- Generation of bioactive peptides
- Utilization of probiotic bacteria

Development of functional fermented meat products could be a possible strategy in the meat industry.
Promising functional foods?

- Rediscovery of traditional fermented meats
- Development of novel fermented meats
Hurdles in developing and marketing novel functional meat products

Such products are unconventional and consumers in many countries regard meat products to be bad for health.

1. Demonstrate the benefits for health.
2. Inform consumers of the exact value.
3. Ensure the safety of new products.
January

May

August

October
Thank you very much for your attention.