

Role of Innovation and Digital Technologies in Food Processing

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Outline

- Historical Perspective
- Innovations Behind Development of Food Processing
- Digital Technologies in Food Processing
- Final Thoughts

The History of Food Processing

- **The First Methods**

- **Cooking, Salting, Pickling, Drying, Smoking, Fermenting**

- Cooking started as early as 1.5 million years ago.
- Simple food preservation methods such as drying, smoking and salting, started as early as 9600 BC.
- Food processing began with a number of preservation and cooking techniques that are still used today. Techniques were developed by some of the earliest empires, such as ancient Greece, India, China and Peru.

- **The 19th Century**

- **Pasteurization and Canning**

- Pasteurization and canning were popularized in the 1800's.
- Pasteurization, developed by French microbiologist Louis Pasteur, kills microbes by applying heat, without affecting the nutritional quality or taste of the food, allowing long term storage and transportation of foods.
- Other inventors developed bottling and the canning. The tin can would become particularly popular during World War I and the high demand for cheap, long-lasting, transportable food for soldiers.

- **The 20th Century**

- **Mass production of packaged foods**

- Spray drying, evaporation, freeze drying and the use of preservatives for increased shelf life and artificial sweeteners and colors for palatability.
- Household appliances such as refrigerators, freezers, microwave ovens etc paved way to the development of frozen foods,

Innovation Behind Food Processing

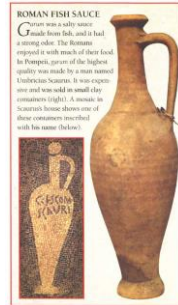
BC 3000

AD

1000

1900

2000



Traditional Experience applied to food processing

Cooking
Salting
Pickling
Drying
Smoking
Fermenting

Modern Science & Technology applied to food processing

Chemistry
Hydrolysis
Isolation
Synthesis
Pasteurization
Preservatives
Industrial Processing

Taste and Smell Science
Chemical Analysis
Receptor Science
Biotechnologies
Fermentation Technologies
Enzyme Technologies
Digital Technologies
Artificial Intelligence
Robotics

Example of Ancient Food Technology: Fish Sauce

Current Fish Sauces in Asia

- Vietnam nyoc-mam
- Thailand nam-pla
- Philippines patis
- Myanmar ngan-pya-ye
- Japan shottsuru、ishiri
- Cambodia tak-trei

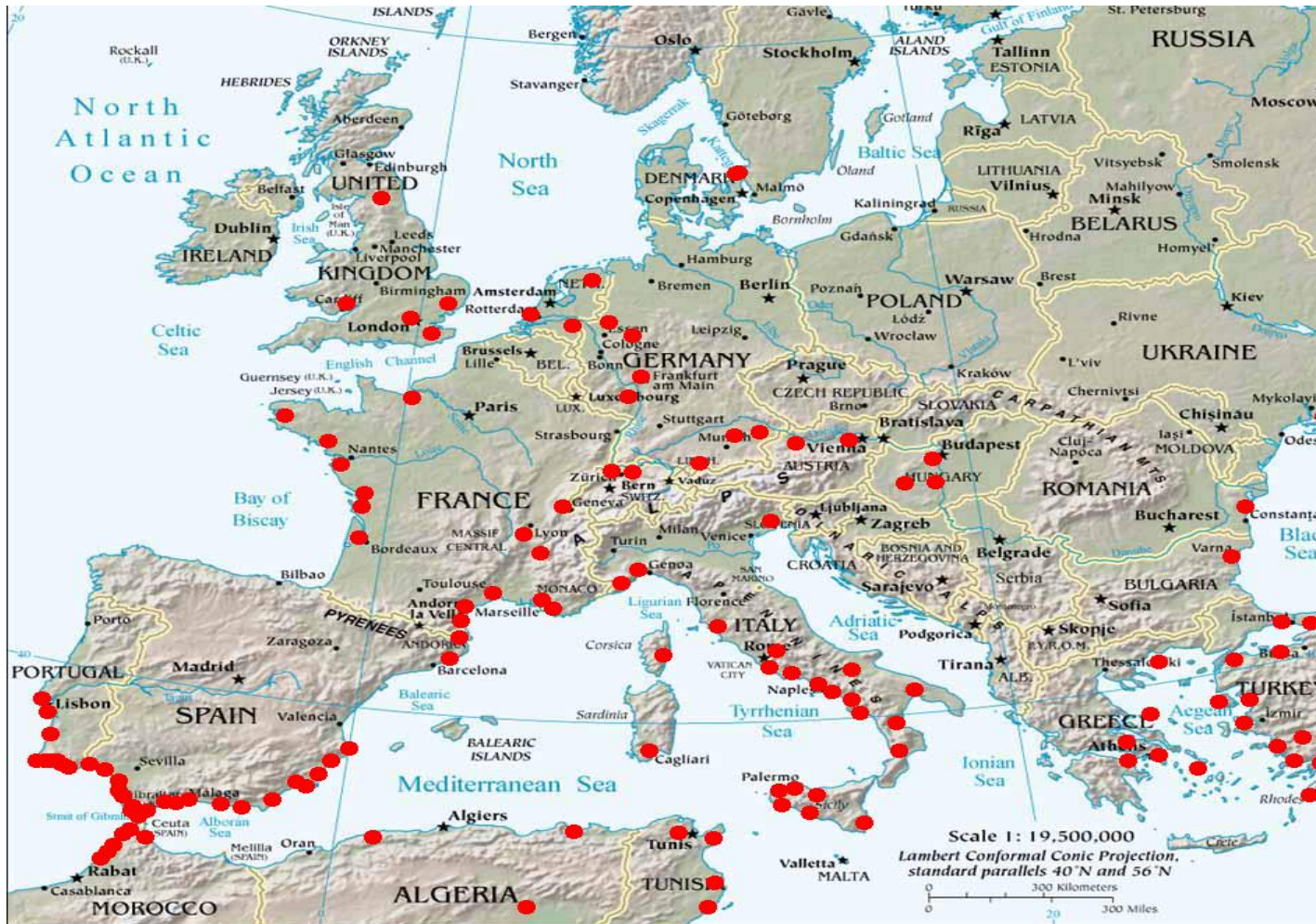
Fish Sauces of Ancient Greece and Rome

- Ancient Greece : garon
- Ancient Rome : garum
 liquamen

Dr. Robert I. Curtis: U. Georgia, Professor of Classics
Garum and Salsamenta
Production and Commerce in Material Medica
Studies in Ancient Medicine, Pub: E.J.Brill 1991

Sites of Ancient Fish Sauce and Salted Fish Production

(Form Curtis 1991)



Mediterranean Coast

Spain, Italy, North Africa

Written evidence for garum production
in 5th century BC in Spain

Black Sea

Garum factory site from 6th century BC

Record of trade with ancient Greece

Sites of Mediterranean Fish Sauce Factories



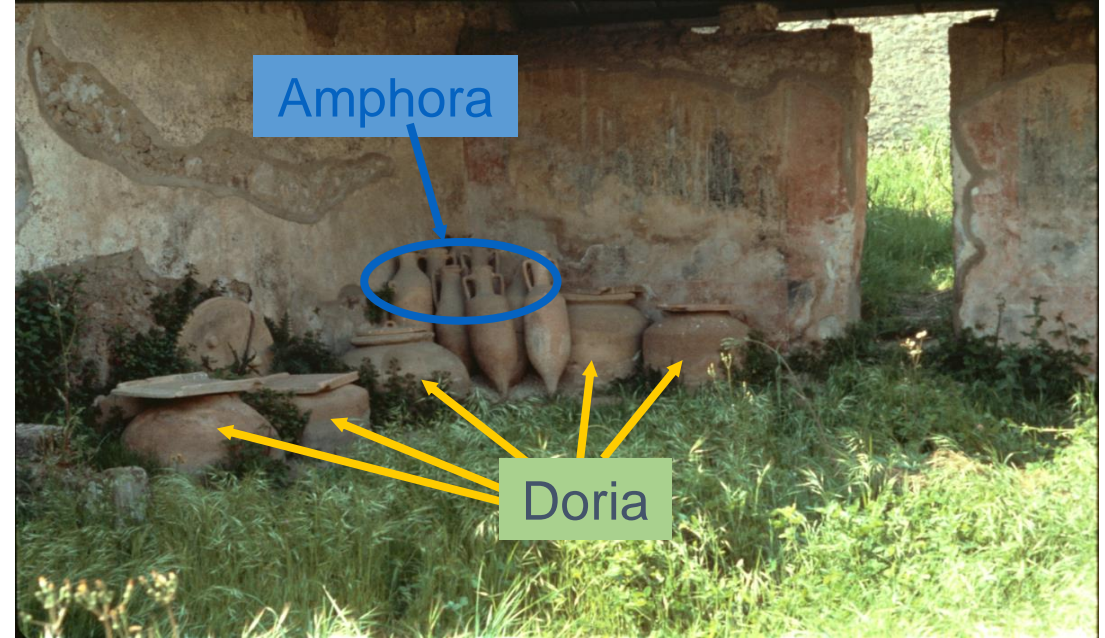
(From Curtis 1991)

Garum Shop of Pompeii

Entrance to Garum (Fish Sauce) Shop of Pompeii
(Courtesy of Dr. Curtis)



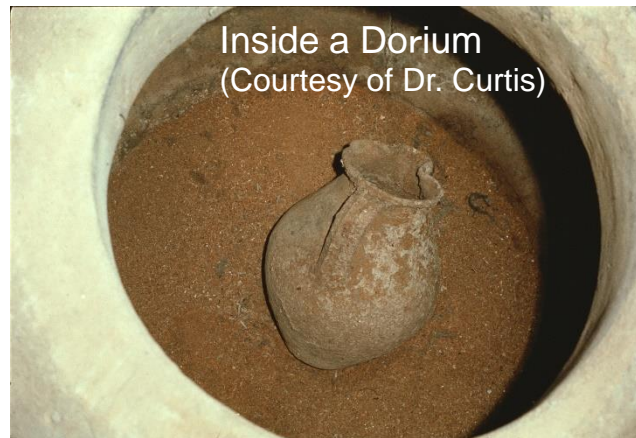
Amphora and Doria in Back Yard of Garum (Fish Sauce) Shop
(Courtesy of Dr. Curtis)



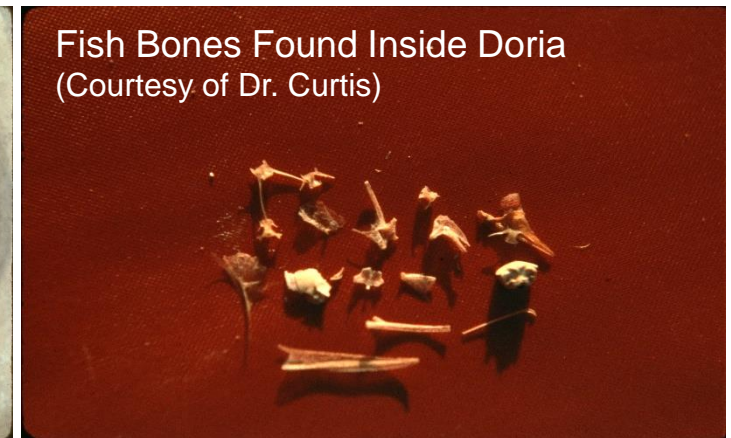
Distribution in long vessels called amphora.

There were regions where guilds controlled the manufacturing of garum.

Name, grade, place of manufacture, main ingredient, name of distributor etc have been found inscribed on amphora, indicating a systematic distribution of the product.



Inside a Doria
(Courtesy of Dr. Curtis)



Fish Bones Found Inside Doria
(Courtesy of Dr. Curtis)

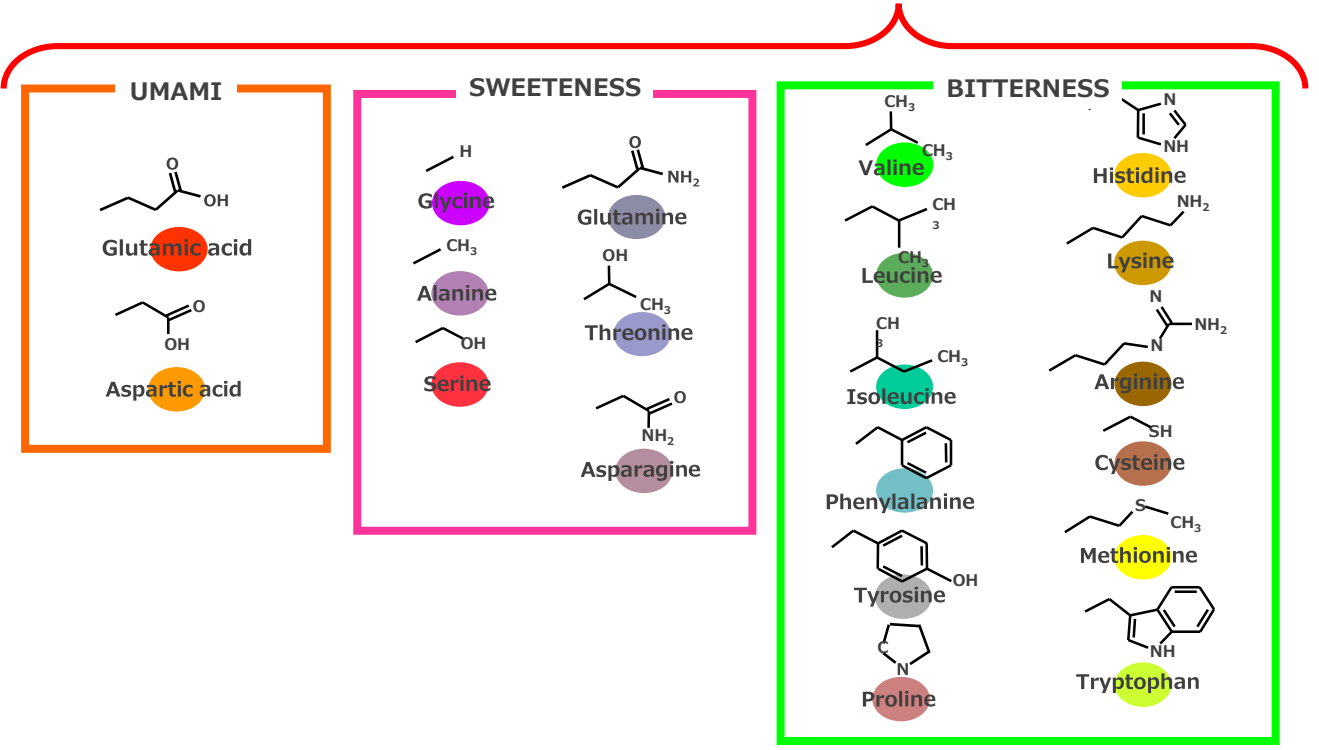
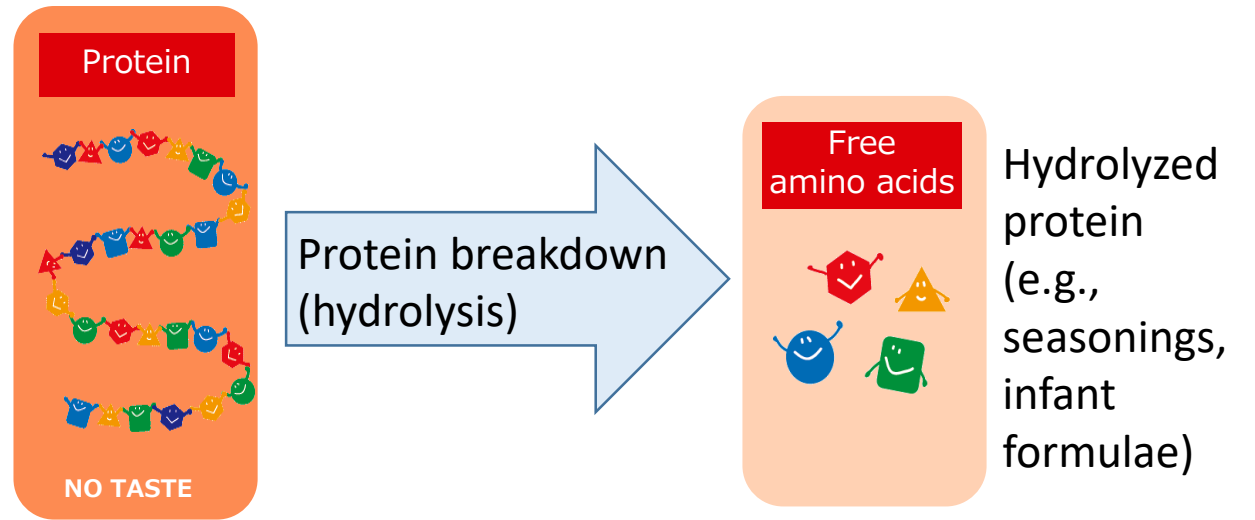
Taste of amino acids

The so-called liquamen is made in this manner:

The intestines of fish are thrown into a vessel and salted.

Small fish either the best smelt, or small mullet, or sprats, or wolffish, or whatever is deemed to be small, are all salted together and, shaken frequently are fermented in the sun.

Geoponica: 10th century Greek agricultural manual, from 6th century Latin treatise

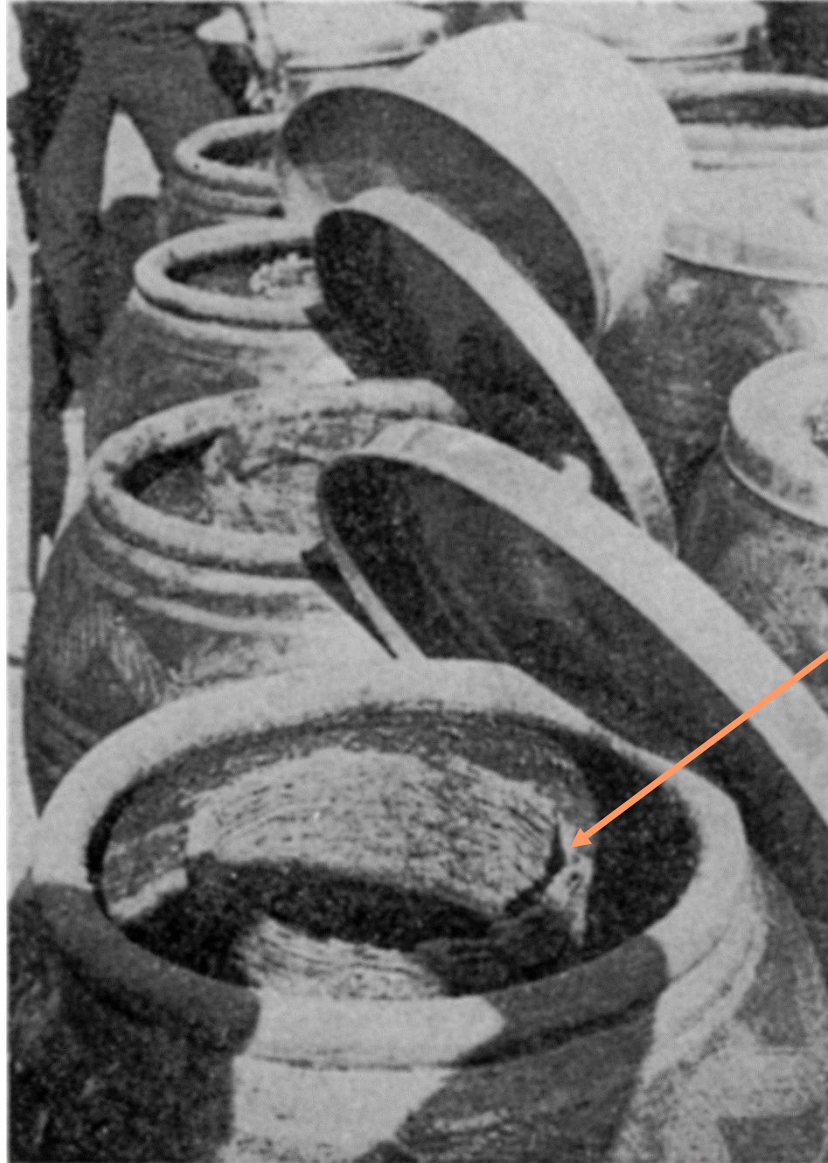


Similarities between Ancient Greco-Roman and South East Asian Fish Sauce Production Methods

After it has been reduced in the heat, garum is obtained from it in the following way:

A large, strong basket is placed into the vessel of the aforementioned fish, and the garum streams into the basket. In this way the so-called liquamen is strained through the basket when it is taken up. The remaining refuse is alex.

Geoponica: 10th century Greek agricultural manual, from 6th century Latin treatise



Bamboo Basket

Fish Sauce Production in Thai Family Business

**From: Ishige & Ruddle
National Museum of Ethnology
Research Report 12-2**

Modern Discoveries in Taste: Taste Receptors

Mammalian taste receptors and cells					
Umami	Sweet	Bitter	Sodium	Sour and carbonation cells	
T1R1+T1R3	T1R2+T1R3	~30 T2Rs	ENaC	PKD2L1 CA IV	
L-glutamate L-amino acids glycine L-AP4	Sugars Sucrose, fructose, glucose	Cycloheximide (mT2R5)	Low NaCl Sodium salts	Acids Citric acid Tartaric acid HCl	Carbonated drinks
Nucleotide enhancers IMP, GMP, AMP	Artificial sweeteners saccharin, acesulfame K aspartame, cyclamate	Denatonium (mT2R8, hT2R4)			
	D-amino acids D-alanine, D-serine, D-phenylalanine	Salicin (hT2R16)			
	Glycine	PTC (hT2R38)			
	Sweet proteins Monellin, thaumatin	Saccharin (hT2R43, hT2R44)			
		Quinine strychnine atropine			

1908: Discovery of umami, the fifth basic taste

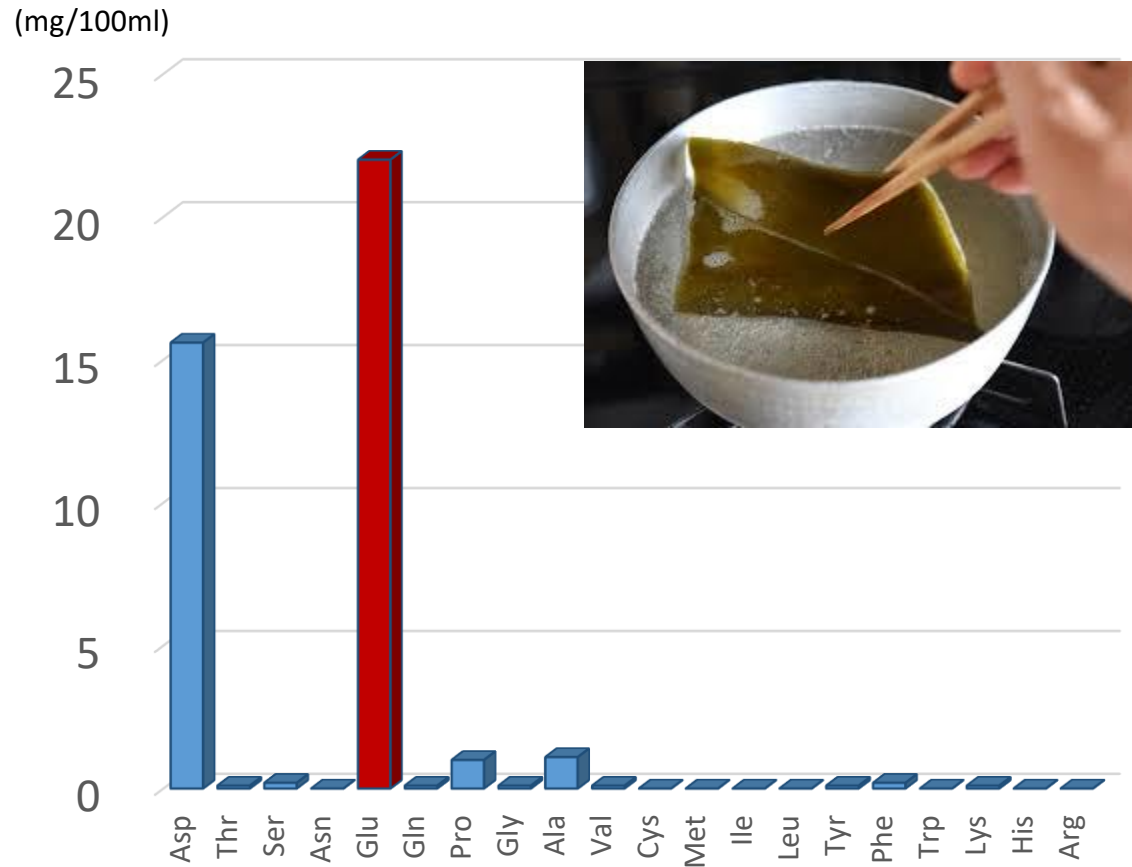


An attentive taster will find out something common in the complicated taste of asparagus, tomatoes, cheese and meat, which is quite peculiar and cannot be classed under any of the well defined four taste qualities, sweet, sour, salty and bitter.

(Prof. K. Ikeda's presentation at the 8th Int'l Congress of Applied Chemistry, Chicago, 1912)

Soup stocks / Japanese vs Western

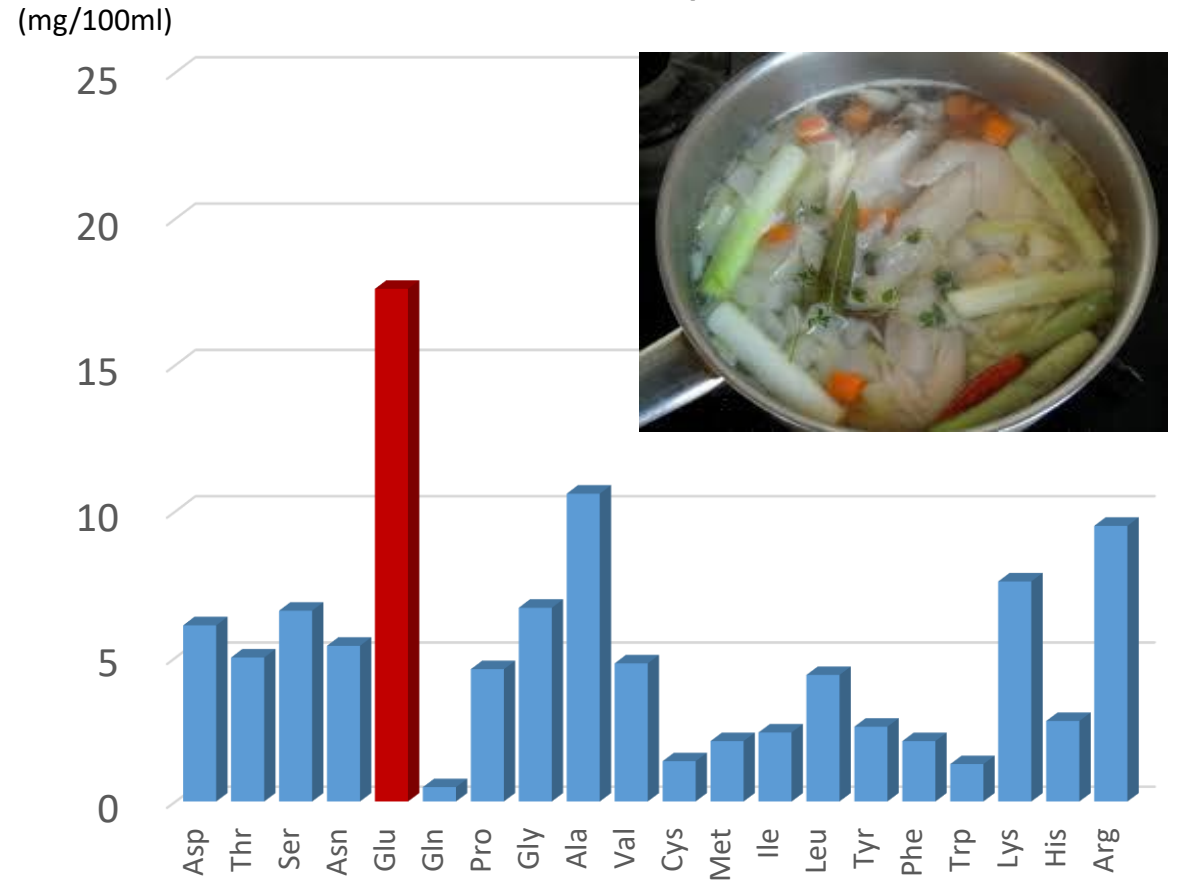
Japanese Konbu dashi



Total free amino acids: 41mg/100ml



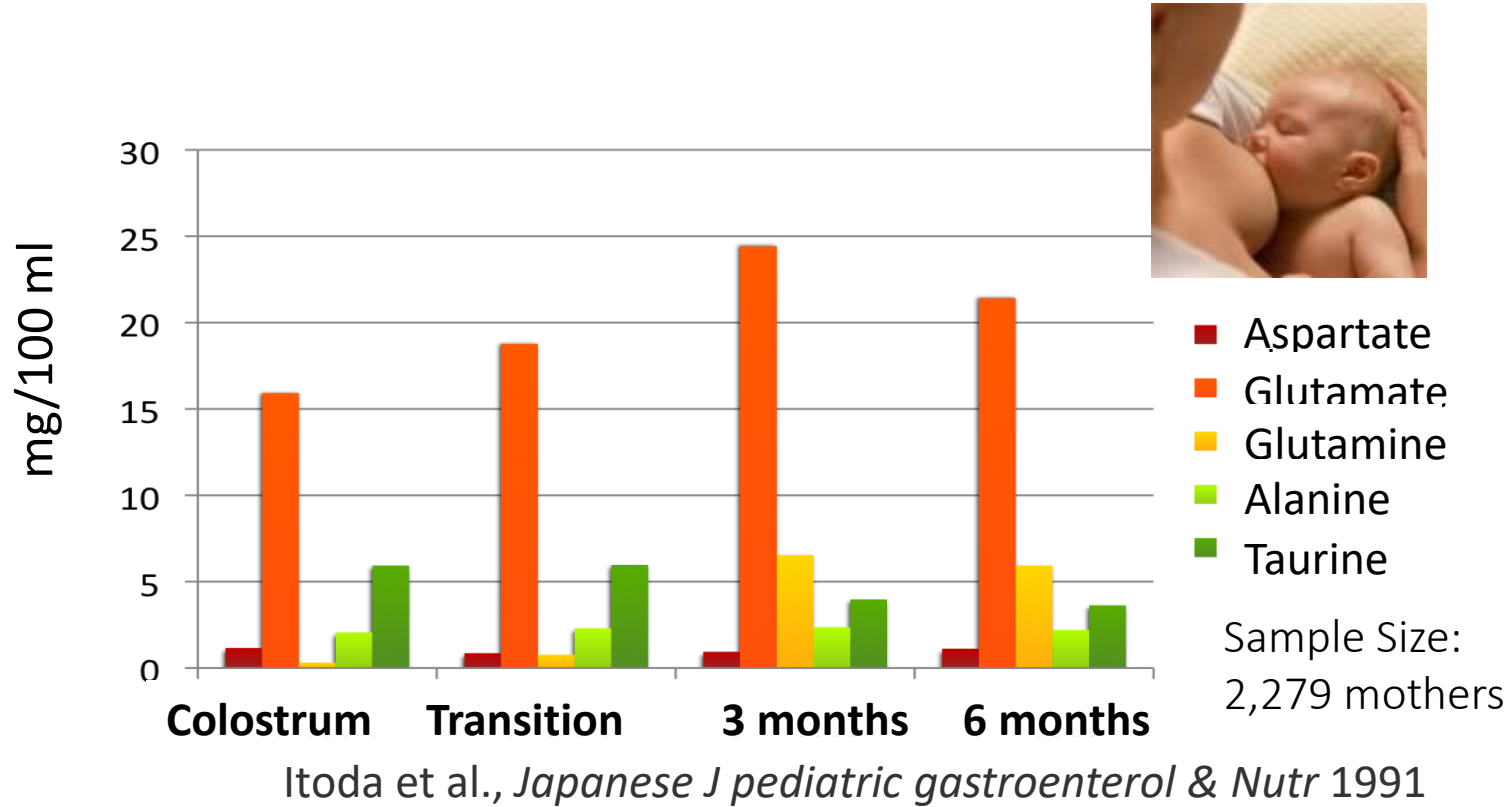
Western Chicken soup stock



Total free amino acids: 104mg/100ml



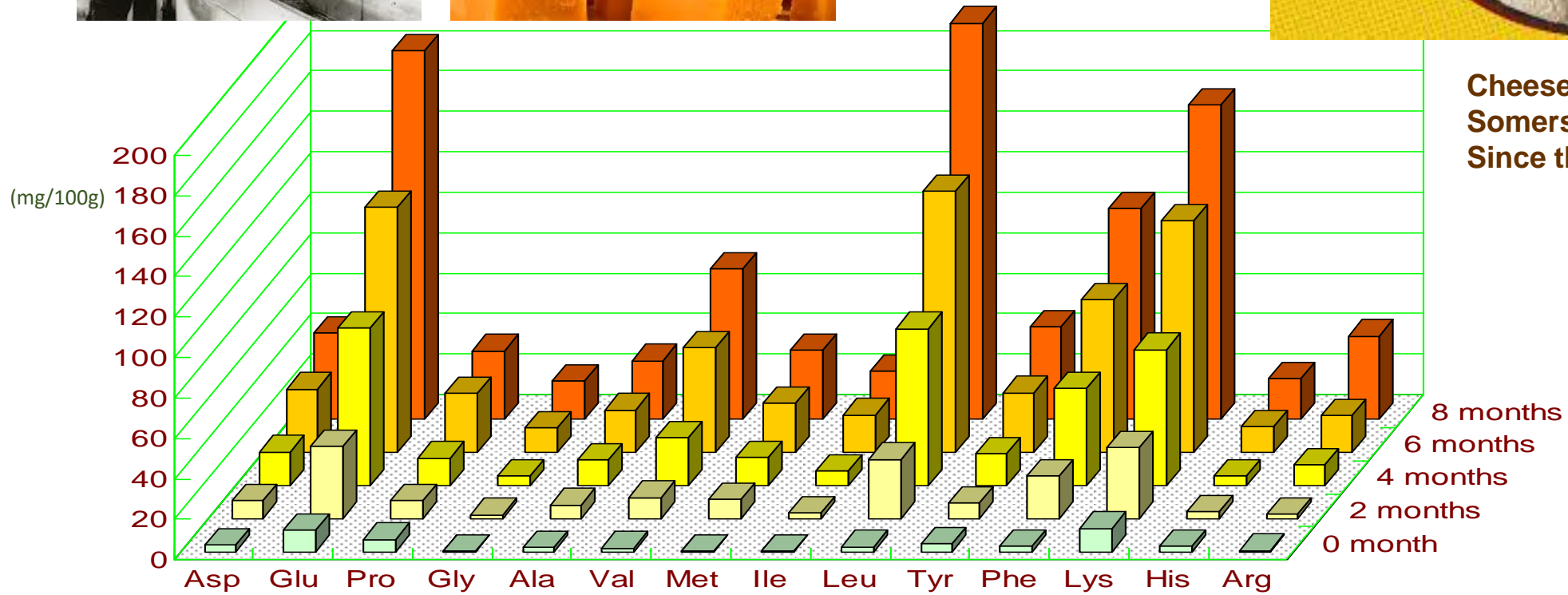
Free Amino Acids in Breast milk



Daily Intake of Free Glutamate:
30.3 – 48.2 mg free glutamate/kg bw for a 3.5 kg infant ingesting approximately 750 ml of milk per day

Based on data from:
Zhang, Z., et al. Amino Acid Profiles in Term and Preterm Human Milk through Lactation: A Systematic Review. *Nutrients* 2013;5:4800-21.

Cheddar cheese



Cheese made in Cheddar, Somersetshire, UK, has been made Since the late 16th Century.

(Weaver and Roger, J. Food. Sci., 43, 579 (1978))

Start of industrial production of seasonings

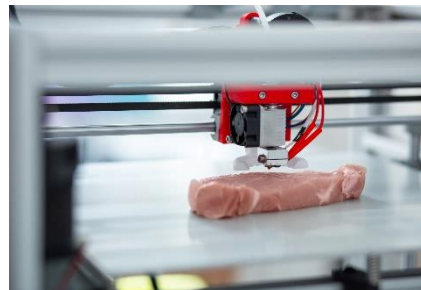
- 1847 Concentrated beef extract developed by Justus von Liebig, cheap and nutritious meat substitute.
- 1886 Ready-made soup based on legume by Maggi
- 1889 The Bovril company
- 1902 Marmite Food Extract Company
- 1908 Bouillon cube based on HVP
- 1909 MSG was developed in Japan
- 1910 OXO cube based on beef extracts



Application of Digital Technologies in Food Processing

- **Automation and Robotics**

- Packaged foods easy to handle
- Raw foods more difficult but improving with advances in digital recognition technology



(Courtesy of FANUC Corporation)

- **Drones**

- Agricultural
- Factory Inspection
- 3D mapping of factory site

- **3-D Printing**

- Designing Foods

Application of Digital Technologies in Food Processing

- **AI in Optimizing Operations**

- Use of “Big-Data”
- Supply Chain Logistics Optimization

- **Block-Chain, Distributed Ledgers**

- Traceability
- Preventing Fraud

- **Small Scale Digital Technology in Restaurants and Catering**

- Ordering via Digital Devices
- Robot Chefs
- Robot Servers

Thoughts on Future Developments

- **Expected Future Developments**
 - Farm to Fork Automation
 - Individualized Nutrition
 - Sustainable Foods and Food Production
 - Convenience Foods vs Traditional Cooking
- **Mass vs Niche**
 - Digital automation leads to less human involvement
 - Need for Capital Expenditure = Large Sales Needed
 - Optimization for Max Popular Preference
 - Food Preferences are Diverse = Many Niche Markets
 - Scope for Small Scale Digital Technologies
- **Risks**
 - Hacking: Everything connected = Everything at Risk
 - Increasing Complexity of Algorithm: Unforeseen bugs in software, Reliance on 3rd Party for Repairs

Thank you very much for your attention