Taste Sensing System

TS-5000Z

- Objective evaluation of taste with a unique taste analyzer
- Enables strategic development of foodstuffs through clarification of taste
- Effectively presents the attraction of products with various graphs
- Simple measurement with wizard-type touch panel
- Easy analysis with single click through macro function

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Intelligent Sensor Technology, Inc.

Taste Sensing System
TS-5000Z

The Taste Sensing System TS-5000Z,
which employs the same mechanism as that of the human tongue,
converts the taste of various substances such as food and drugs into numerical data.

Using unique aftertaste measurement technology,
even aspects such as "richness" and "sharpness,"
which could not be measured by conventional chemical instruments, can be expressed.

Moreover, the proprietary analysis application makes obtaining analysis results easy.

As a support tool for sensory evaluation,
the TS-5000Z is a powerful tool for use in a variety of fields such as quality control,
product development, marketing, and sales, where objective evaluation of taste is required.

Features

- Use of multi-channel type lipid membrane sensors imitating living organisms
- Quantification of taste via original algorithms
- Measurement operations done via touch panel. Wizard format makes operation easy, even by novices.
- Rich array of graph tools for producing radar charts, two dimensional scatter plots, and three dimensional scatter plots.
- Dramatically higher analysis efficiency through macro functions, which helps users to shorten analysis time.
- Enables data analyses and graph displays from remote locations via the Internet
- User management with two user levels: administrators and users, preventing erroneous operation by users
- Global management of measurement data in database
- Easily expandable through control of multiple instruments with a management server
- Built-in self diagnosis functions

Artificial Lipid Membrane "Taste Sensor" Imitating Taste Reception Mechanism of Living Organisms

Expectations for Taste Sensors

Sensory evaluation is effective for taste evaluation, but imposes a substantial burden on members of tasting panels. On the other hand, chemical analysis allows quantification of the components included in various foods, but not the evaluation of "taste" itself. Therefore, the development of systems that enable the measurement of taste has been desirable, for product development, public relations, etc.

More than 20 years ago, together with Professor Kiyoshi Toko of Kyushu University, Intelligent Sensor Technology, Inc. launched a project for the development of taste sensors and succeeded for the first time in the world in developing such products for practical use. A large number of patents have been acquired for this technology both in Japan and elsewhere.
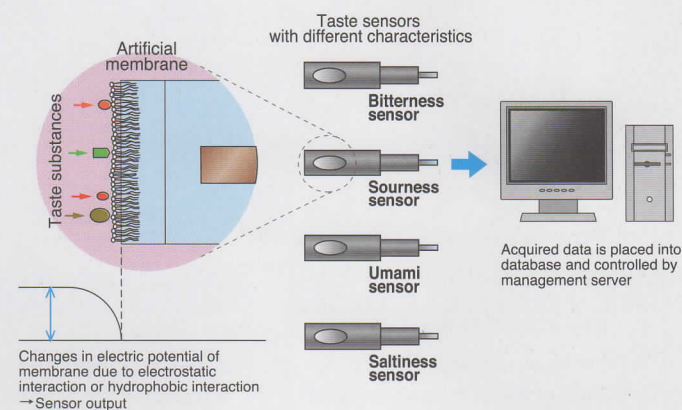
Taste sensor use examples

- Support tool for sensory evaluation in product development
- Differentiation of company products
- Setting of freshness expiration dates
- Trend analysis
- Quality control

Taste Sensors Model Taste Reception Mechanisms of Living Organisms

The surface of the tongue of living organisms is formed of a lipid bilayer with its own specific electric potential. This electric potential varies according to the electrostatic interaction or hydrophobic interaction between various taste substances and the lipid. The amount of change is perceived by the human brain as taste information, an activity referred to as taste judgment.

Our taste sensors imitate this taste reception mechanism of living organisms. Our taste sensors consist of an artificial lipid membrane (similar to that of the human tongue) that causes electrostatic or hydrophobic interactions with various taste substances, allowing them to sense "taste."

Reaction principle of taste sensors

Artificial membrane

Taste substances

Taste sensors with different characteristics

Bitterness sensor

Sourness sensor

Umami sensor

Saltiness sensor

Acquired data is placed into database and controlled by management server

Changes in electric potential of membrane due to electrostatic interaction or hydrophobic interaction → Sensor output
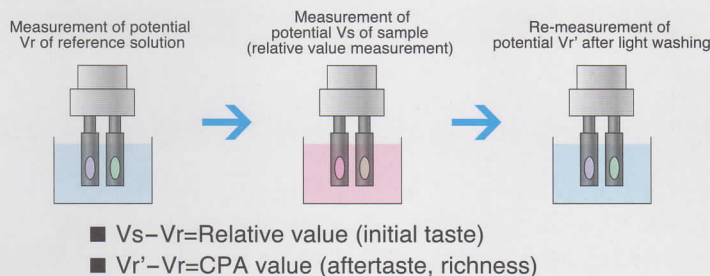
Measurement Method

The taste sensors evaluate two types of taste, namely initial taste, which is the taste perceived when food first enters the mouth, and aftertaste, which is the persistent taste that remains in the mouth after the food has been swallowed. Using the potential of a reference solution* as zero, the difference in potential with the sample liquid is measured as the initial taste. The sensors are then lightly washed and the difference in potential with the reference solution is measured as the aftertaste.

*Reference solution: Almost completely tasteless solution containing 30 mM KCl and 0.3 mM tartaric acid. The Taste Sensing System uses it as a substitute for human saliva.

Measurement method of taste sensors

Measurement of potential Vr of reference solution

Measurement of potential Vs of sample (relative value measurement)

Re-measurement of potential Vr' after light washing

- Vs–Vr=Relative value (initial taste)
- Vr'–Vr=CPA value (aftertaste, richness)

Taste information

Initial taste: Sourness, bitterness, astringency, umami, saltiness, sweetness

Aftertaste: Aftertaste from bitterness, aftertaste from astringency, umami richness

The taste information is an indication of taste obtained from the results measured by the taste sensors. The evaluation of many different tastes is possible by changing the settings of sensors.

Realization of Efficient Operation via Network

Management System through Networks

The TS-5000Z instruments and PC terminals form a network via a management server.
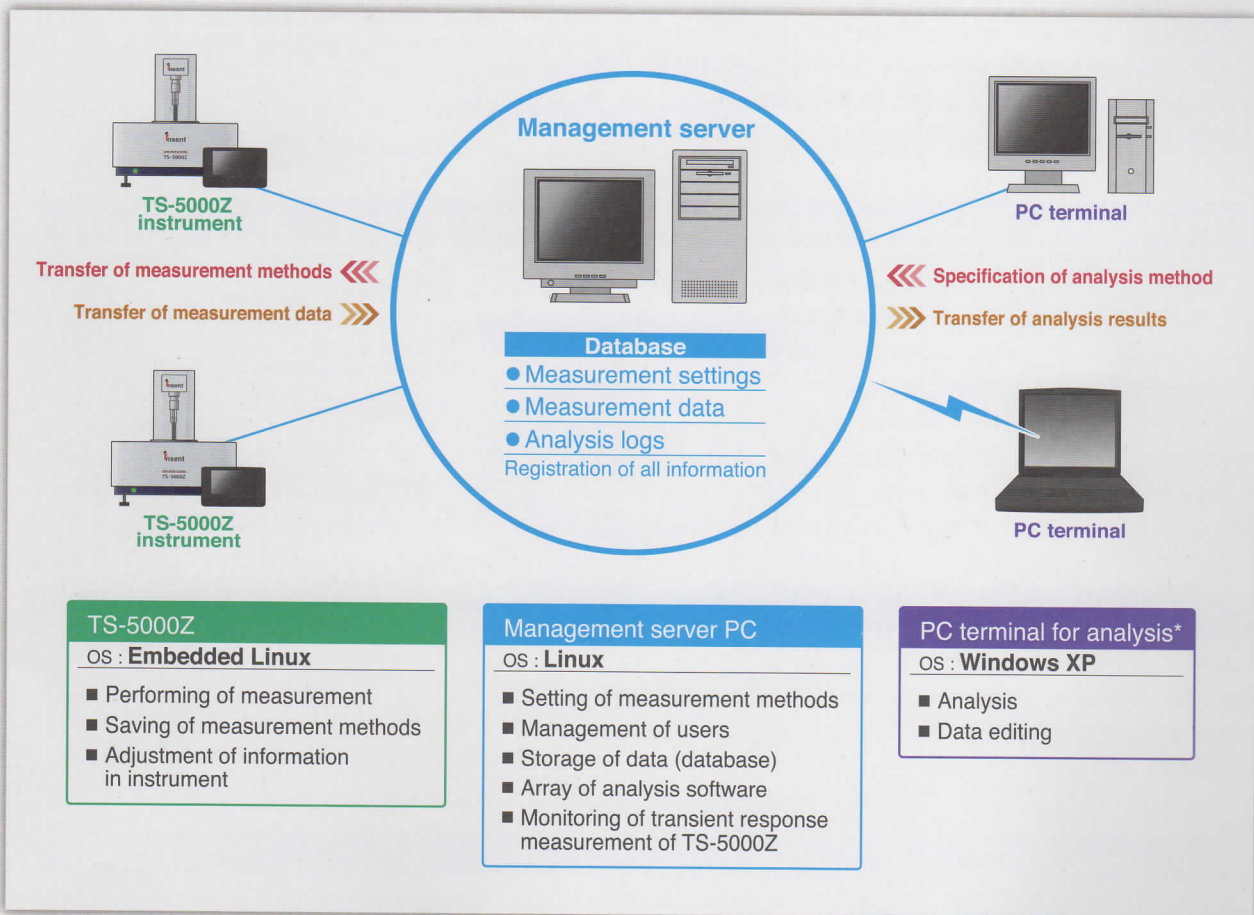
Users can make various settings, such as measurement methods, from the management server.

When the measurement methods are transferred to a TS-5000Z instrument, the instrument performs measurements according to these methods, and the measurement data are saved to the database on the management server.

Analysis of measurement data is performed from a PC terminal, by accessing the database on the management server via the network. The analysis results and graphs can be saved as files and edited on the PC terminal.

The taste sensing system network is formed in this way with the management server as its core.
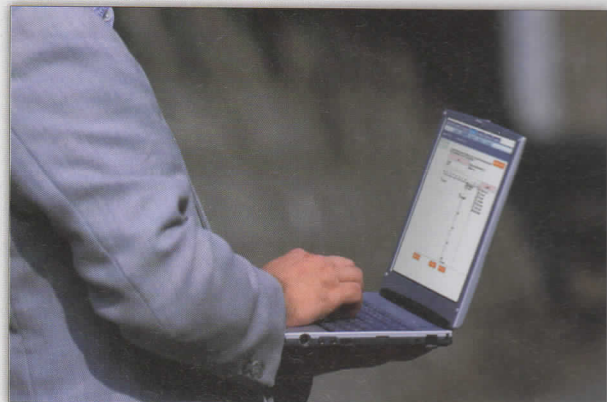

TS-5000Z instrument

Transfer of measurement methods «

Transfer of measurement data »

TS-5000Z instrument

Management server

Database
- Measurement settings
- Measurement data
- Analysis logs
Registration of all information

PC terminal

« **Specification of analysis method**

» **Transfer of analysis results**

PC terminal

TS-5000Z
OS : **Embedded Linux**
- Performing of measurement
- Saving of measurement methods
- Adjustment of information in instrument

Management server PC
OS : **Linux**
- Setting of measurement methods
- Management of users
- Storage of data (database)
- Array of analysis software
- Monitoring of transient response measurement of TS-5000Z

PC terminal for analysis*
OS : **Windows XP**
- Analysis
- Data editing

*Optional PC terminal for analysis is required.

*Depending on the network settings of a company or organization, accessing a management server from PC terminals may be impossible. Please ask our distributors beforehand if you would like to change the network settings.

Data Analysis and Acquisition from Remote Locations

The management server can be accessed by multiple PCs via a network, such as the Internet. Naturally, the latest data can be retrieved for data analysis and graph display even from a remote location.

Note: Access may not be possible depending on the security level of the network.

Superior Ease of Operation through Wizard Type Touch Panel

## Easy Operation via Touch Panel

The touch panel provided with the TS-5000Z instrument employs embedded Linux for the OS. By setting the measurement methods beforehand on the management server, measurements can be performed simply through the touch panel. This saves space, since no PC and peripherals such as a keyboard and mouse are required.

Simple Operation via Wizard Interface

The touch panel employs a wizard as the user interface, implementing simple operation just by following the directions on the screen. The attachment of sensors, allocat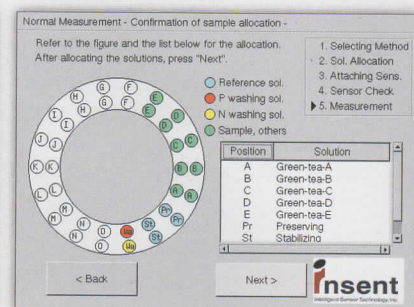ion of samples, and more can be checked on the screen. Moreover, user levels can be set in the instrument application, allowing distinctions between "administrators," who can perform all operations, and "users," for whom some operations are restricted.
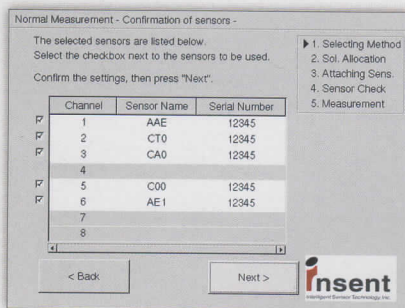
Sensor confirmation screen
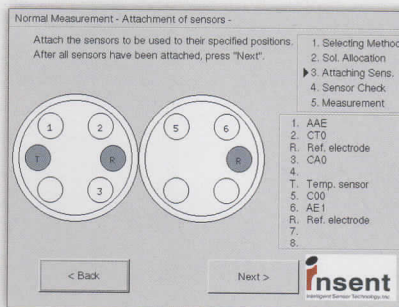
Sensor attachment screen

Solution allocation screen

Rich Array of Advanced Analysis Tools Support Many Different Types of Taste Evaluations
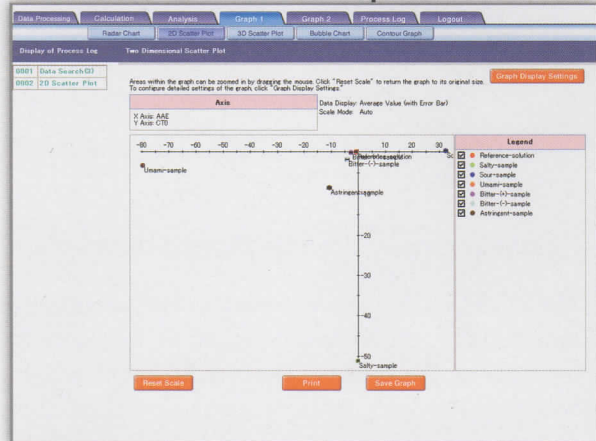
Various Graphing Functions

The analysis application provides eight graphing functions. By using different graphs according to the purpose, measurement results can be displayed in an easy-to-understand manner. These graphing functions can also be used for presentation materials.
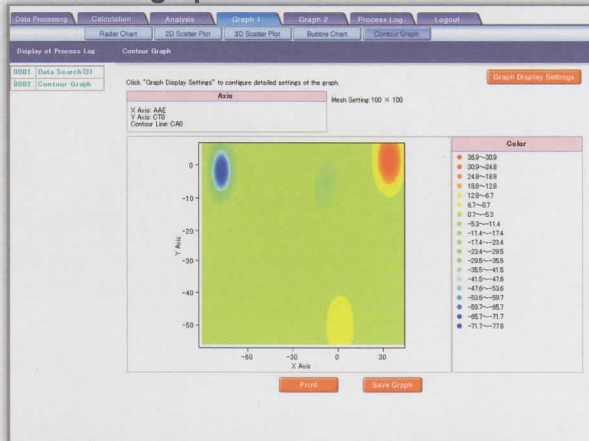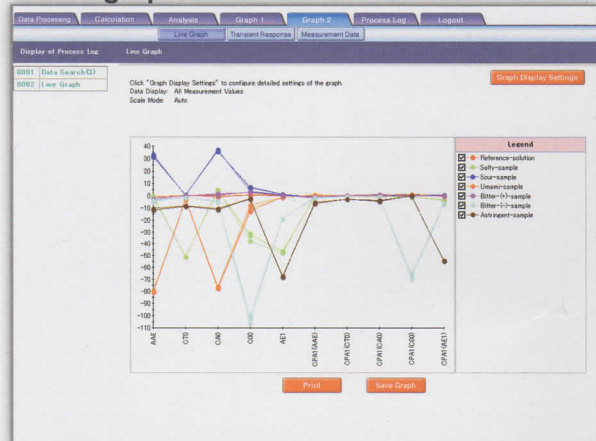
■ Radar chart
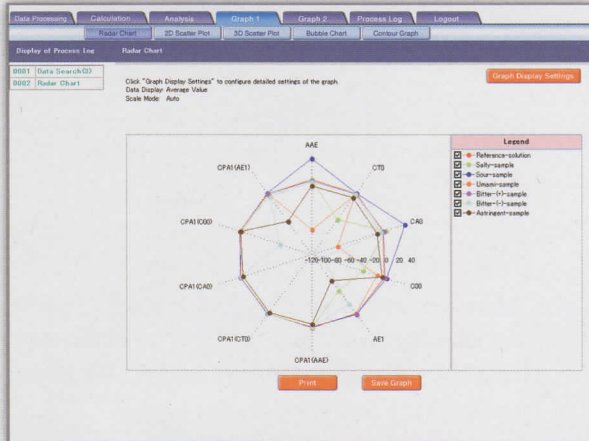
■ Two dimensional scatter plot

■ Contour graph

■ Line graph

Functions of Analysis Application

- Operating with Internet Explorer Web browser
- Sorting function in measurement date and measurement name
- Data editing (combine, add, delete)
- Save and reproduction of process logs in analysis
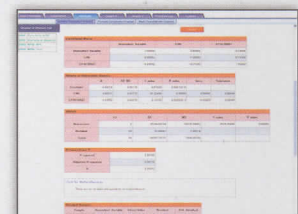- Attenuation rate calculation
- Quality test

Quantification of Taste

Using proprietary algorithms, the analysis application can convert the outputs from the taste sensors into taste information. The taste sensors, such as sourness and saltiness sensors, have selectivity for taste substances; tastes can be converted into numeric data without having to perform sensory evaluation matching, complex statistical analysis or multivariate analysis.

Multiple Regression Analysis and Principal Component Analysis

The analysis application supports two multivariate analysis techniques: multiple regression analysis and principal component analysis.

Multiple regression analysis allows graph representation of data by selecting the optimum variables through all possible subset selection using adjusted R-squares as reference. Principal component analysis allows graph representation by calculating principal component scores, variance-covariance matrices, eigen vectors, and contribution rates.

Multiple regression analysis test results

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www.coffeelabequipment.com

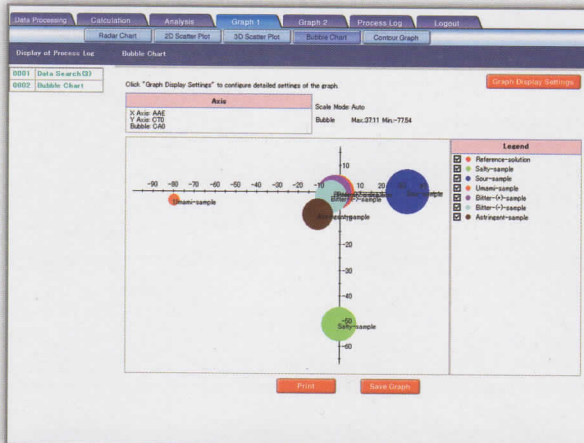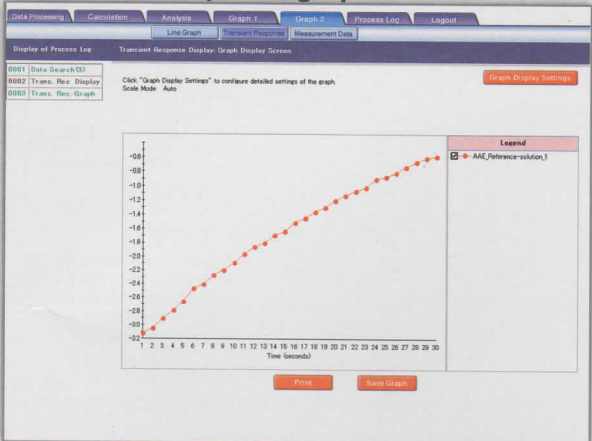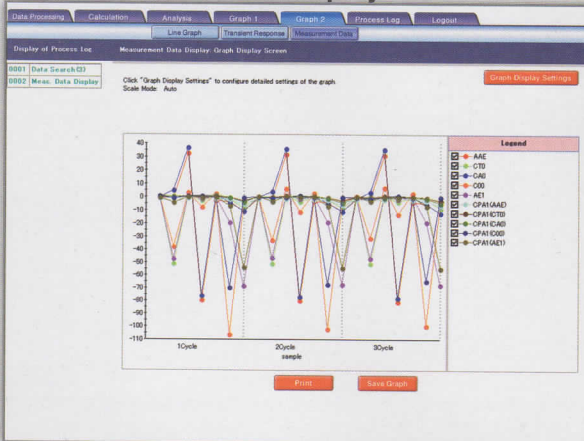## ■ Three dimensional scatter plot
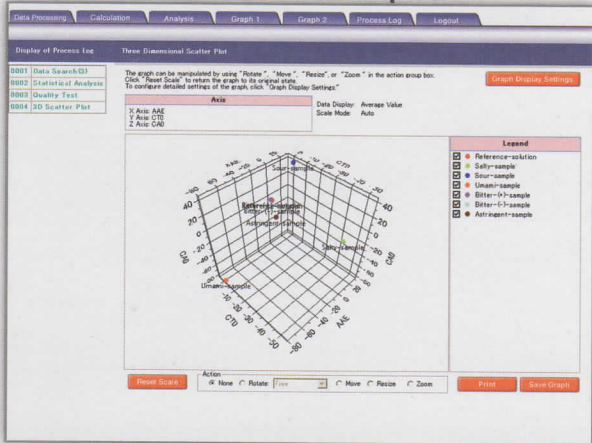
■ Bubble chart

■ Transient response graph

■ Measurement data display

Macro Function

All the procedures performed with the analysis application are recorded by the management server.

By registering a desired procedure as a macro, the same analytical procedure can be reproduced with a single click.

For example, when given measurement data is analyzed and graphed, and the entire procedure is registered as a macro, a graph can be created for exactly the same analysis, but for a different set of measurement data by executing that macro, which can result in considerable time savings.
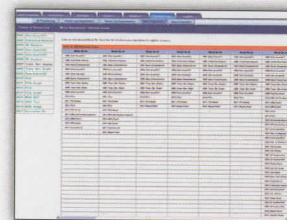
Macro registration screen
from display of all process logs

Correction Processing and Statistical Processing

The analysis application features various correction processing functions that allow sophisticated analysis.

Measurement data can also be subjected to statistical processing to calculate not only average values and standard deviations but correlation matrix among sensors and among samples, and also calculate the sensors' ability to distinguish.
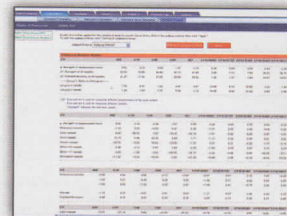
Statistical processing result display screen

Measurement Results by Taste Sensing System

Liquid Food Sample Examples

Beer map (aftertaste from bitterness and sourness)

Legend:
- Beer (red)
- Low-malt beer (green)
- Third Beers (blue)

In-house data
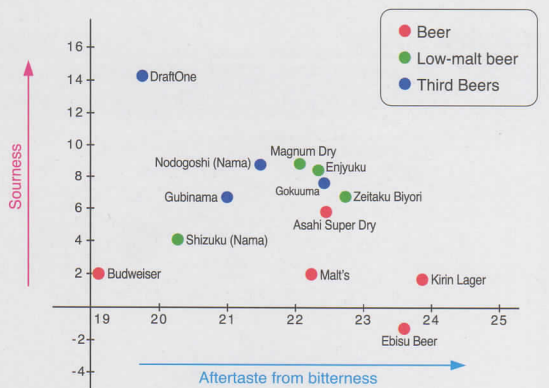
Taste trends for instant soups of various companies based on umami and saltiness

Taste trend of each company can be estimated

Data source:Taste & Aroma Strategic Research Institute (Japan)
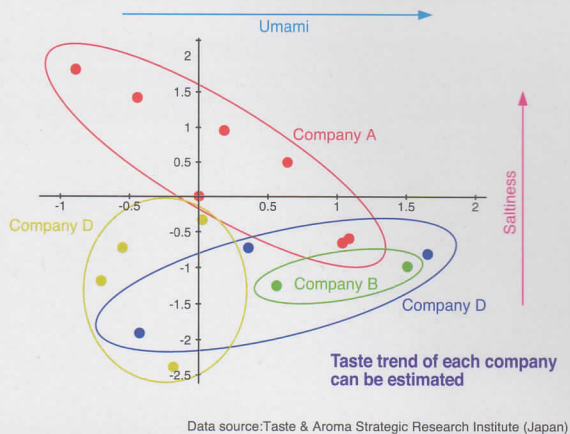
Time-based change in taste of tea drinks through thermal degradation

Degradation temperature=60℃

Increase in aftertaste from bitterness, decrease in aftertaste from astringency

In-house data
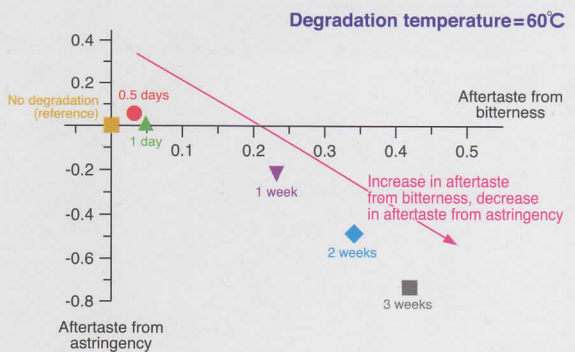
Change in taste of sample with thickener added

Value of unprocessed sample = 100%

Legend:
- Unprocessed sample
- Thick sample (3% starch added)

When thickness is added, aftertaste from bitterness and aftertaste from astringency are suppressed, resulting in a milder taste.

In-house data
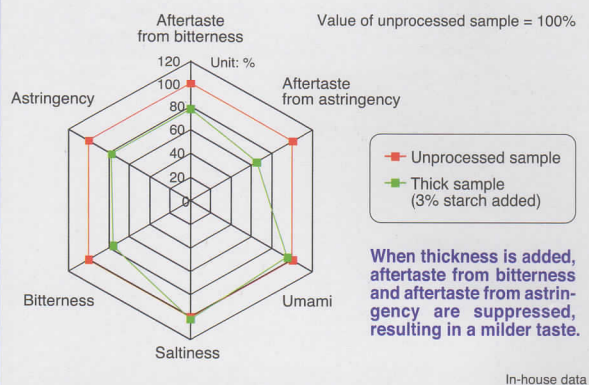
Solid Food Sample Examples

Beef type judgment

Data source:National Agriculture and Food Research Organization (Japan)

Correlation Coefficient R = 0.81

Legend:
- Japanese Black Cattle (higher)
- Japanese Black Cattle (lower)
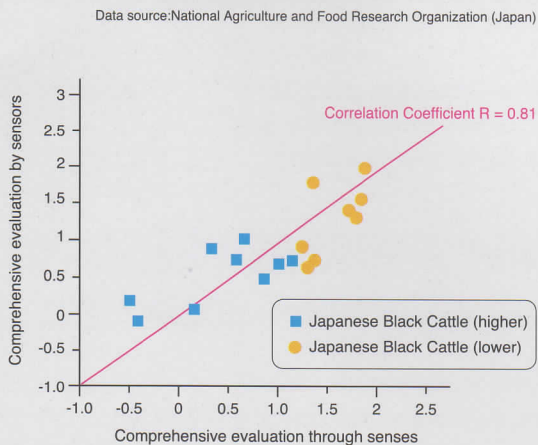
Sliced bread map (umami and saltiness)

Data source:Taste & Aroma Strategic Research Institute (Japan)
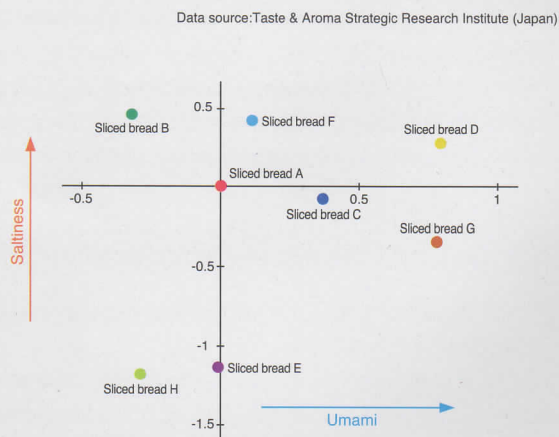
Relations among saltiness, bitterness, and share of instant curries

Bitterness

Saltiness

Curry A

Curry D

Curry F

Curry B

Curry C

Curry E

Curry G

Bubble: Share
Type of taste that tends to be popular is revealed

Data source:Taste & Aroma Strategic Research Institute (Japan)

Miso classification

○ White miso   ● Mixed miso   ● Red miso

Umami richness

Bitterness

Red miso I

Mixed miso E   Red miso G   Red miso H

Mixed miso D

White miso C   Mixed miso F

White miso B

White miso A

Distribution of red miso and white miso, and their intermediate product, mixed miso

Data source:Taste & Aroma Strategic Research Institute (Japan)

Drug Sample Examples

Selectivity of aftertaste from bitterness in drug

- ■ Reference solution (tasteless)
- ● Quinine hydrochloride
- ▲ Trimebutine maleate
- ▼ Dextromethorphan hydrobromide
- ◆ Amitriptyline hydrochloride
- □ Diltiazem hydrochloride
- ○ Propranolol hydrochloride
- △ Promethazine hydrochloride
- ▽ Dibucaine hydrochloride
- ◇ Imipramine hydrochloride
- ☐ Chlorpheniramine hydrochloride

Bitterness sensor output

Strength of aftertaste from bitterness through sensory evaluation

High correlation between sensor evaluation and the output of bitter sensor for various acidic bitter substances

Data source:
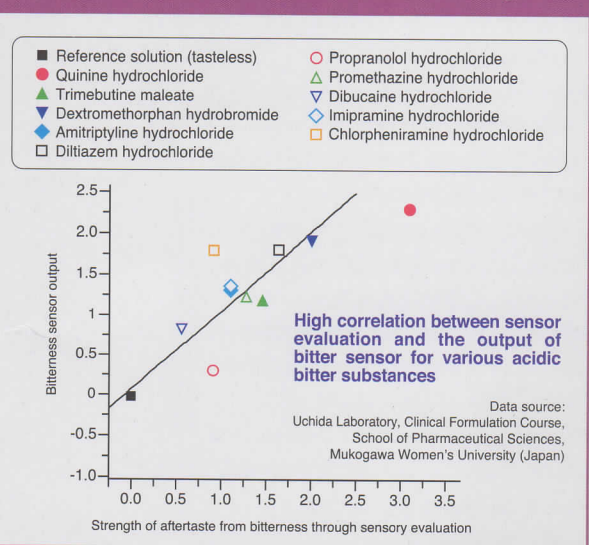Uchida Laboratory, Clinical Formulation Course,
School of Pharmaceutical Sciences,
Mukogawa Women's University (Japan)

Persistence of aftertaste from bitterness in drug

Data source:
Uchida Laboratory,
Clinical Formulation Course,
School of Pharmaceutical Sciences,
Mukogawa Women's University (Japan)

- ■ Quinine hydrochloride
- ● Trimebutine maleate
- ▲ Dextromethorphan hydrobromide
- ▼ Amitriptyline hydrochloride
- ◆ Diltiazem hydrochloride
- □ Propanolol hydrochloride
- ○ Chlorpheniramine maleate
- △ Promethazine hydrochloride
- ▽ Dibucaine hydrochloride
- ◇ Imipramine hydrochloride

Attenuation rate of aftertaste from bitterness

Time (seconds)

Low persistence of aftertaste

Suppression of aftertaste from bitterness of amino acids

Data sources:
Uchida Laboratory,
Clinical Formulation Course,
School of Pharmaceutical Sciences,
Mukogawa Women's University (Japan)

Kyowa Hakko Kogyo Co., Ltd. (Japan)

- ● 100 mM isoleucine
- ▲ +1 mM ornithine hydrochloride
- ■ +10 mM ornithine hydrochloride
- ◆ +100 mM ornithine hydrochloride

Aftertaste from bitterness by sensors

Aftertaste from bitterness by sensory evaluation

Suppression effect of aftertaste from bitterness by amino acid

Suppression effect of aftertaste from bitterness by cyclodextrin

- ■ Cetirizine hydrochloride
- ● + α -cyclodextrin
- ▲ + β -cyclodextrin
- ▼ + γ -cyclodextrin
- ◆ + HP- β -cyclodextrin

Aftertaste from bitterness by sensors

Aftertaste from bitterness by sensory evaluation

Suppression effect of aftertaste from bitterness

Specifications of Taste Sensing System TS-5000Z

Name	Item	Specifications
Instrument	Number of measurement samples	14 samples max. (depends on measurement procedure)
	Measurement sample volume	35 to 70 ml (depends on the nature of measurement sample)
	Weight	26 kg
	Dimensions (W x D x H)	470 mm x 530 mm x 510 mm
Touch panel	CPU	SH7727
	OS (embedded)	SuperH Linux
	Memory capacity	64 MB
	Simple Web server	thttpd
Taste sensor	Response mechanism	Membrane potential measurement
	Sensor type	Artificial lipid membrane
	Measurement object	Drinks, solids, drugs, etc. (in case of solids, preliminary liquefaction is required)
Ceramic reference electrode	Liquid junction	Single junction through ceramic
Temperature sensor	Response mechanism	Impedance measurement using platinum resistance thermometer (Pt1000)
Management server PC	CPU	Pentium 4, 2.0 GHz or higher
	Hard disk	160 GB or more
	Memory capacity	1 GB or more
	OS	Linux
	DBMS	PostgreSQL
	Web server	apache + Tomcat
Analysis application	Analysis functions	Data search, data processing function, correction processing (5 types), statistical analysis, multiple regression analysis, principal component analysis, graphing tools (8 types), macro function, etc.

*Windows PC for analysis application is required for analysis PC. For details, please refer to your distributor.

● Customers

National Institute of Health Sciences, National Food Research Institute, National Agriculture and Food Research Organization, National Institute of Vegetable and Tea Science, National Research Institute of Brewing, National Center for Child Health and Development, Nagano Prefecture General Industrial Technology Center, Akita Research Institute for Food and Brewing, Iwate Industrial Research Center, Oita Industrial Research Institute, Yamanashi Industrial Technology Center, Fukuoka Industry Science Technology Foundation, Fukushima Technology Center, Industrial Research Institute of Shizuoka Prefecture, Tokyo Metropolitan Food Technology Research Center, Tottori Institute of Industrial Technology, Kyushu University, Mukogawa Women's University, Niigata University, Tokyo University of Agriculture, Kanazawa Institute of Technology, Kio University, Toyo University, Yamagata University, Kitasato University, KIKUSUI SAKE CO.,LTD., KIKKOMAN CORPORATION, KINREI CORPORATION, Kumamoto Flour Milling co.,Ltd., SHIONO KORYO KAISHA, LTD., Suzuyo Research Institute Co.,Ltd., Soda Aromatic Co., Ltd., Taiyo Kagaku Co.,Ltd., Prima Meat Packers, Ltd., Mitsui Sugar Co.,Ltd., Taste & Aroma Strategic Research Institute, ITO EN, LTD., Itoham Foods Inc., IWAI KIKAI KOGYO CO., LTD., UENO FINE CHEMICALS INDUSTRY, LTD., UNKAI SHUZO CO.,LTD., Eisai Co., Ltd., EBARA FOODS INDUSTRY INC., Endo Seian Corporation, OHKI Co., Ltd., Kao Corporation, KANEKA CORPORATION, KAMEDA SEIKA CO., LTD., KANMONKAI Co., Ltd., KYODO SHIRYO CO., LTD., Kirin Brewery Company, Limited, Colorado Corporation, SANDEN Corporation, Showa Aluminum Can K.K., SugakiyaFoods Co., Ltd., Jellice Co., Ltd., Sougou Shouken Co., Ltd., DAISYO CORPORATION, TSUKISHIMA FOODS INDUSTRY CO.,LTD., Tsumura & Co., TOSOH CORPORATION, Toyo Institute of Food Technology, Doutor Coffee Co., Ltd., TORAYA CONFECTIONARY CO., LTD., Nishi Shuzo Corporation, NICHIMO CO., LTD., NICHIREI CORPORATION, Japan Crown Cork Co., Ltd., Nippon Del Monte Corporation, Nippon Boehringer Ingelheim Co., Ltd., HIGASHIMARU SHOYU CO., LTD., FUKUMITSUYA SAKE BREWERY, FUKUYA Co., Ltd., Fujijin Shoyu Co., Ltd., FUJI OIL CO., LTD., Fundokin Soy Co., Ltd., Marutomo Co., Ltd., Meiji Co., Ltd., Mercian Corporation, Morinaga Milk Industry Co., Ltd., YAMAKI Co., Ltd., UCC UESHIMA COFFEE CO., LTD., etc.

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