SHIMADZU
Excellence in Science

C10G-E052

Analyzing Flavor Scientifically

Analytical and Testing Instruments for Food Development

World Map of Shimadzu Sales, Service, Manufacturing, and R&D Facilities

Analyzing Flavor Scientifically

At Shimadzu, we are using our technologies to support the realization of everyone's wish, to eat safe and delicious food.

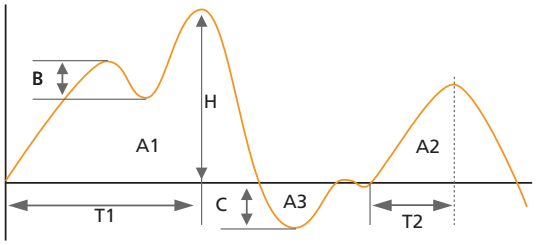
In this brochure, we introduce applications showcasing the use of analytical instruments for the objective evaluation of a variety of subjective factors, such as flavor and food texture, which together with taste are sensed by people as deliciousness. The test methods supplement sensory tests, and are used as methods for obtaining quantified objective results in the fields of food development and quality control.

Contents

Texture

The texture of food, including the sense of crispness, springiness, firmness, and the feeling on the tongue, is an important element that together with taste has an impact on the deliciousness of food.
Food texture is normally evaluated using sensory tests. However, sensory tests are often difficult to reproduce, due to individual differences in people's sensations and physical condition.
Shimadzu's texture analyzer supplements sensory tests, and is used as a method for obtaining objective results in the form of numerical values for use in the field of food development.

Texture Analyzer
EZ-SX



Example of a Method for Evaluating Texture Characteristics

Features

High Precision

The system uses a high-precision load cell with a guaranteed precision of ±0.5 % of the indicated value, enabling highly reliable measurement results.

A Wealth of Jigs

To obtain measurement results with a high correlation to sensory evaluations, Shimadzu has a lineup of various evaluation jigs designed with consideration to the characteristics and shapes of each food product.

Easy-to-Operate Software

With intuitive test parameter settings and automatic analysis functions, TRAPEZIUM X, the software for operations and analysis, can be used to obtain highly reliable measurement results.

Texture Analyzer (Strength Testing Machine)

This instrument evaluates the characteristics and texture of food materials by applying forces and deformations to them through compression, shear, and piercing. A variety of food materials can be measured by changing the measurement conditions and jigs.

Hardness: H
Maximum test force when loads are applied to a food by a plunger.
Fracturability: B
Force by which food is broken down in the mouth.
Stickiness: A3
Force by which food is pulled apart when it is touched by hands or put in the mouth, and adheres to the teeth, tongue, and oral cavity.
Cohesiveness: A2/A1
When a load is applied to a food product, the food is deformed and broken down.
Ratio of the 1st and 2nd load areas (energy) when loading is applied twice in succession.
Springiness: T2/T1
Ratio of depression and displacement when loading is applied to a food twice in succession with a plunger.
Gumminess: H × A2/A1
Hardness × cohesiveness, semi-solid food products.
Chewiness: H × A2/A1 × T2/T1
Hardness × cohesiveness × springiness, solid food products.

Szczesniak's Texture Profile

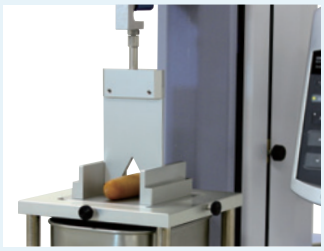
Properties	Primary Properties	Secondary Properties	Common Terms	Description of Properties
Mechanical Properties	Hardness		Soft-Firm-Hard	Force required for a given deformation volume. Internal cohesive forces that give the food its shape.
	Cohesiveness	Fracturability	Crumbly-Crunchy-Brittle	Force required to crush food. Related to hardness and cohesiveness.
		Chewiness	Soft-Tough	Energy required to chew solid food until it can be swallowed. Related to hardness, cohesiveness, and springiness.
		Gumminess	Crumbly-Powdery-Pasty-Rubbery	Energy required to chew semi-solid food until it can be swallowed. Related to hardness and cohesiveness.
	Viscosity		Light and runny-Thick and sticky	Degree of flow for a unit of force
	Springiness		Plastic/ductile-Elastic	Proportion of a deflection caused by an external force that returns to the original position after the force is removed
	Adhesiveness		Gooey-Sticky-Slimy	Force required to overcome the attractive force between the surface of a food product and other things (such as the tongue, teeth, and palate)

Note: Alina Surmacka Szczesniak
Texture-related terminology was arranged and systematized for the first time internationally in 1963.

Evaluation of Food Products Using a Diversity of Jigs

Shimadzu offers a wide variety of jigs designed to suit the characteristics and shapes of each food product. This allows users to obtain measurement results with a high correlation to sensory evaluations.

Potato Chip Breakage Test

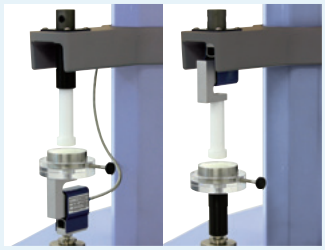


Sausage Shearing Test

Cereal Compression Shearing Test

Tensile and Shearing Test for Noodles

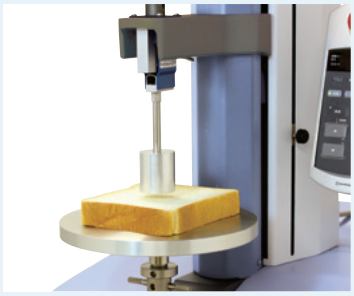
Viscosity Test for Liquids



Standard-Compliant Tests for Nursing Care Foods

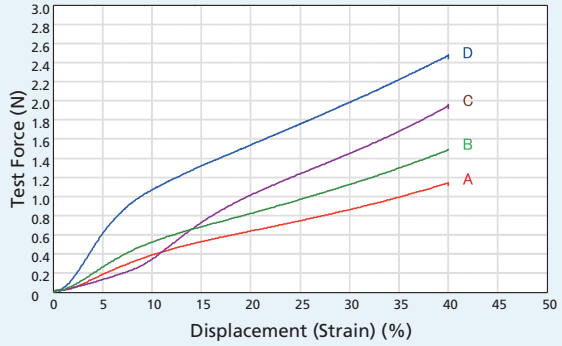
Evaluation of Bread Using Two Jigs

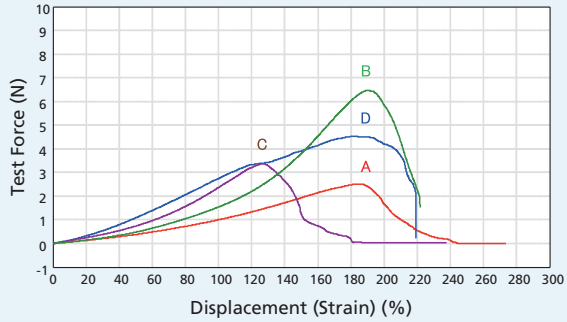
The food texture, including the springiness, crispness, and firmness, is an important factor in shaping the deliciousness of bread. This example shows a compression test and punching test of the same bread using two different jigs. In the respective tests, evaluation results with differing perspectives were obtained. It was confirmed that by combining the different tests, more multifaceted evaluation results were obtained than would have been possible with a single test.



Compression Test

Punching Test





Sensory Evaluation
A: Very soft B: Springy C: Crispy (whole wheat flour) D: Firm

Particle Size Distribution

With food products, the particle size distribution is said to have an impact on food texture, particularly the feeling on the tongue and crunchiness. The human tongue is very sensitive, and is said to be able to recognize the touch of a particle several dozen micrometers or larger. The particle size distribution is an important factor in food development, as depending on the product, the particles can be tiny and uniform, creating a smooth impression, or conversely, large and non-uniform, producing a subtle food texture. Particle size analyzers can measure particle sizes in the range from 17 nm to 2.5 mm. They are used in the fields of food development and quality control with the objective of quantitatively assessing the particle size distribution related to food texture.

Features

Wide Measurement Range

The measurement range is a wide 17 nm to 2.5 mm, enabling application to the measurement of various food products. The resolution is also high, and can be applied to the measurement of mixed samples.

Supporting a Wide Range of Measurement Objectives

This can be used for a wide range of measurement objectives including wet measurements, dry measurements, and high-concentration sample measurements.

Assisting Measurement Reliability with Standard Operating Procedure (SOP)

The measurement conditions and procedures, including pretreatment, can be registered, so results can be obtained with high reproducibility even if the analyst or the measurement site changes.

Laser Diffraction Particle Size Analyzer

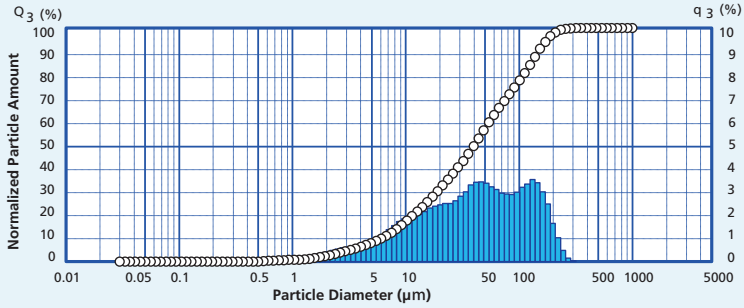
SALD-2300

Laser Diffraction Particle Size Analyzer

With this instrument, particles are irradiated with laser light, and the particle size distribution is then calculated from the intensity distribution pattern of the diffracted and scattered light generated. A wide range of samples can be applied, and it is used for various applications, from food development to manufacturing and quality control.

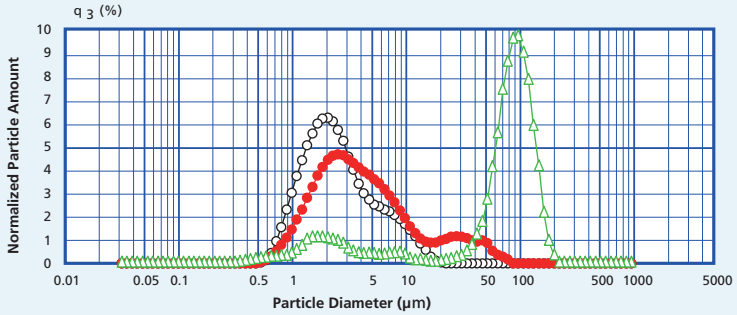
Particle Size Distribution Measurements for Soybean Powder

The raw ingredients for bread, noodles, and many other processed foods are powders. The distribution of these particles is known to have a significant effect on food texture. Accordingly, the particle size distribution is measured with the objective of developing food products and controlling their quality.
This example shows the measurement of the particle size distribution of soybean powder, which is used as a raw ingredient for a variety of processed food products. It was confirmed that the particle sizes can be objectively evaluated and controlled.



Food Texture and Particle Size Distribution of Ice Cream

Ice cream comes in a wealth of variations, with differences in form, amount of milk content, and flavor, and many types are commercially available.
This example shows the measurement of the particle size distribution for three different flavors of ice cream: vanilla, green tea, and red bean. The results obtained reflect the impression that the vanilla is smooth, the green tea is somewhat granular, and the red bean is even more granular in terms of food texture.



○ : Vanilla
● : With green tea powder
△ : With red beans

The peak centered near 2 μm represents the main component of the particle size distribution.
A small peak, centered near 3 μm and likely due to the particles of green tea, is added to the distribution of vanilla.
A large peak, centered near 80 μm and likely due to the ground red beans, is added to the distribution of vanilla.

Moisture Content

The moisture in food products is one of their constituent substances. In addition to having a major impact on food texture, specifically a food's firmness and smoothness, it acts as a solvent for the gustatory components sensed as flavor and fragrance. If the moisture content in food products is changed even slightly, the unique flavor and food texture of the respective food products can be lost, so the moisture content has a significant effect on the deliciousness of food products. A moisture analyzer is used for a wide range of applications, including food development and quality control, through measurement of the moisture in food products.

Features

Accurate Moisture Ratio Measurements with Simple Operations

Simply place the sample in the sample pan, and close the cover to begin the measurements.
The sample tray is a large 95 mm, and the sample can be uniformly heated, to provide high-precision measurements.

Measuring a Range of Samples with a Variety of Measurement Modes

With a variety of measurement modes, the instrument can measure samples in a range of forms, including powders (wheat flour, etc.), granules (grains, etc.), solids (dried noodles and processed foods, etc.), and even liquids (beverages, etc.) & pastes (flavorings, etc.).

Outstanding User Friendliness

The instrument is equipped with a number of user-friendly functions, including a USB port for connection to a computer using a single cable, an observation window for checking the condition of a sample during heating, and a halogen heater which can be replaced easily.

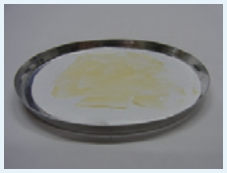
Moisture Analyzer
MOC63u

Moisture Analyzer

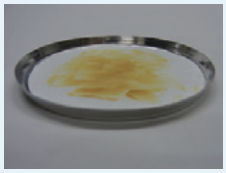
This instrument determines the moisture ratio by heating a sample to vaporize the moisture, and then calculating the change in mass before and after heating.
The measurement procedure is simple, so it is widely used for moisture ratio measurements in the food industry.

Measurement of Mayonnaise Using a Fiberglass Sheet

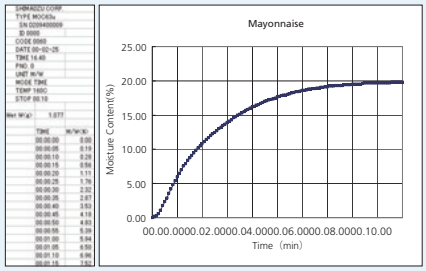
Mayonnaise is highly viscous, so by placing the sample on a fiberglass sheet (optionally available), and then spreading it out to a uniform thickness using a spatula before measurement, the drying time can be shortened, and data can be obtained with high reproducibility.



(Before measurement)
The sample is placed on a fiberglass sheet, and is then spread out uniformly using a spatula.



(After measurement)
The drying surface of the mayonnaise is increased by the fiberglass sheet, and it dries uniformly.



Using the computer connection function, the data can be imported into Excel.

Moisture Ratio Measurements for Various Food Products

The table below summarizes moisture ratio measurements for various food product samples using the moisture analyzer.

Sample Name	Sample Amount	Measurement Mode		Heating Temp. (℃)	Measurement Time (min)	Moisture Ratio (%)	CV Value (%)
		Ending Mode	Ending Conditions (% or min)				
Mayonnaise	1g	TIME	10 min	160℃	10:00	20.61%	0.46%
Instant coffee	1g	TIME	10 min	120℃	10:00	7.43%	1.18%
Chocolate	3g	AUTO	0.01%	140℃	6:18	2.36%	1.49%
Corn starch	5g	AUTO	0.05%	200℃	7:54	12.94%	0.16%
White rice	5g	AUTO	0.05%	200℃	12:30	15.12%	0.53%
Tea	5g	AUTO	0.05%	120℃	9:05	3.76%	0.41%
Milk	1g	AUTO	0.05%	140℃	7:30	87.36%	0.04%

Amino Acids

Of all the amino acids, glutamic acid is widely known as a component of the umami taste (delicious taste). Further, the types and component ratios of amino acids largely control the flavor of this food product. For example, glycine and alanine are sweet, valine and leucine are bitter, and aspartic acid and glutamic acid are sour.
In addition, in recent years, it has been reported that L- and D-amino acids have different flavors, with D-amino acids exerting a broad influence on the flavor of fermented foods and aged foods. Numerous amino acids are being analyzed for purposes of food development and quality control, with new components of the umami taste and sweetening agents expected.

High-Performance Liquid Chromatograph

• Post-Column Amino Acid Analysis System
• Pre-Column Derivatization Amino Acid Analysis System

Prominence Post-Column Amino Acid Analysis System

Nexera Pre-Column Derivatization Amino Acid Analysis System

Amino Acid Analysis System

Most amino acids do not have an absorption band in the short wavelength region, so derivatization is required for highly sensitive and selective analysis. The more suitable system is used to suit the sample being analyzed and the objective.

Post-Column Derivatization System

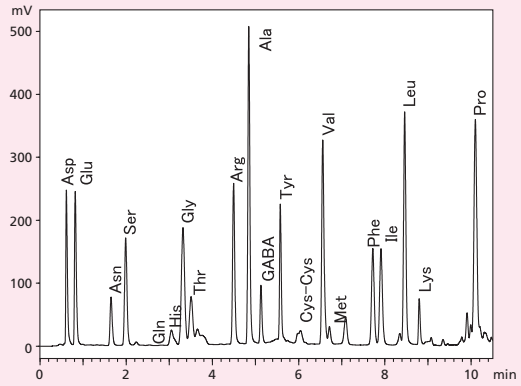
After the amino acids are separated from impurities, they are made to react with a derivatization reagent. From this process, the impact of impurities is reduced, and this system can be applied to a wide range of samples, with excellent quantitation capability and reproducibility.

Pre-Column Derivatization System

The amino acids are first subjected to derivatization, and are then separated in reverse phase mode. Analysis can be performed with high sensitivity, high separation, and high throughput by combining this with the automatic pretreatment function of an autosampler, and an ultra high performance liquid chromatograph.

Analysis of Amino Acids in Black Vinegar

Food products contain amino acids with a variety of flavors. Their types and component ratios have a significant impact on the flavor of the food product.
This example shows the analysis of the amino acids in black vinegar using a pre-column derivatization amino acid analysis system. Pretreatment is automated by using the SIL-30AC autosampler with its pretreatment function. This saves on labor, and at the same time, enables analysis with high accuracy.



Analysis System for D/L Amino Acids

High Performance Liquid Chromatograph Mass Spectrometer + LC/MS/MS Method Package for D/L Amino Acids

LCMS-8060

Analysis System for D/L Amino Acids

With two chiral separation columns, this analysis system uses an LC/MS/MS method package containing the parameters for a simultaneous analysis of 22 D/L amino acids in 10 minutes. Derivatization during pretreatment is not necessary, and high-sensitivity analysis can be performed in a short period of time for more efficient analysis.

Note: The analysis methods in this method package were developed based on the results of research by the Fukusaki Laboratory at the Graduate School of Engineering, Osaka University.

Reference: Nakano, Y., Konya, Y., Taniguchi, M., Fukusaki, E., Journal of Bioscience and Bioengineering, 123, 134-138 (2016)

Analysis of D/L Amino Acids in Yogurt Drinks

It has been reported that D-amino acids other than aspartic acid, glutamic acid, and proline give sweet taste, and that when there are multiple D-amino acids with taste embellishing effects in a food product, they create a composite flavor quality.
This example shows the analysis of D/L amino acids in yogurt drinks from different manufacturers. For some amino acids, the D-amino acid ratio is relatively high, and significant differences in the component ratio of D/L amino acids are evident depending on the manufacturer. It is suggested that this may contribute to differences in flavor qualities.

D/L Component Ratio	Yogurt A	Yogurt B
Alanine	164.0%	40.2%
Arginine	6.9%	36.5%
Asparagine	43.2%	16.5%
Aspartic acid	38.1%	15.3%
Cysteine	-	-
Glutamine	0.6%	19.8%
Glutamic acid	4091.1%	5069.6%
Histidine	-	5.2%
Isoleucine	0.8%	1.0%
Alloisoleucine	59.4%	39.3%
Leucine	1.0%	-
Lysine	73.5%	3.5%
Methionine	0.9%	-
Phenylalanine	0.5%	1.5%
Serine	14.4%	29.3%
Threonine	1.5%	4.6%
Allothreonine	42.5%	23.7%
Tryptophan	1.9%	13.3%
Tyrosine	2.1%	107.4%
Valine	0.4%	0.9%

Source: Shimadzu Application News No. C156.

Organic Acids

Organic acids contained in food products are important components that contribute to their deliciousness, including their sourness and umami tastes. In addition, recently, they have become a topic of interest for their digestive stimulant and antibacterial effects.
The analysis of organic acids is a useful approach to food development. However, know-how is needed to detect various organic acids specifically and with high sensitivity in samples with many impurities such as food products. The organic acid analysis system is used in the field of food development as a simultaneous analysis method for various organic acids.

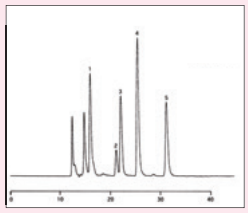
High-Performance Liquid Chromatograph
Organic Acid Analysis System

Organic Acid Analysis System

This organic acid analysis system features excellent selectivity and sensitivity due to the post-column pH-buffered electric conductivity detection method.
The organic acids are separated by ion exclusion chromatography. Then a pH buffering reagent is continuously added to the column eluate. Since the pH is maintained at nearly neutral, the organic acids are dissociated and detected via electric conductivity. This is suitable for the analysis of samples with many impurities.

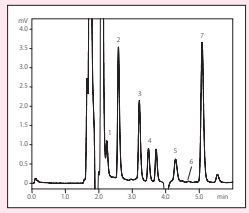
Analysis of Organic Acids in Food Products

Organic acids such as citric acid and acetic acid shape the flavor and aroma of food products in various ways.
This example shows the analysis of organic acids in food product samples. It was confirmed that organic acids can be analyzed with high accuracy, and with no interference from impurities.



Tomato Extract

1. Citric acid
2. Succinic acid
3. Lactic acid
4. Acetic acid
5. Carbonic acid



White Wine (UHPLC analysis)

1. Formic acid
2. Malic acid
3. Lactic acid
4. Acetic acid
5. Citric acid
6. Pyroglutamic acid
7. Succinic acid

Source: Shimadzu Application News No. L208 and No. L436.

Sugar

As the basis for sweetness, sugar is one of the most familiar components used as raw ingredients and flavoring agents in food products. However, although they are all referred to as sugar, there are many varieties, and they differ significantly in their sweetness and bioactivity. In addition, diets and health consciousness are in favor these days, the development of sweetening agents and functional foods are a focus of attention, and research and development of sugar are actively conducted. The reducing sugar analysis system is used in the field of food development as a high-sensitivity analysis method for various reducing sugars from brewed food products and other samples.

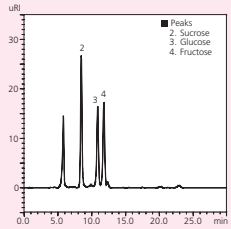
High-Performance Liquid Chromatograph
Reducing Sugar Analysis System

Reducing Sugar Analysis System

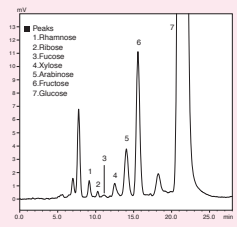
This reducing sugar analysis system uses the post-column fluorescence derivatization detection method with arginine as the reaction reagent. It is capable of high-sensitivity analysis with high selectivity for reducing sugar, even in samples with very little sugar content and many impurities.

Analysis of Sugars in Food Products

This example shows the analysis of sugars in foods using the reducing sugar analysis system.
It was confirmed that high-sensitivity analysis can be performed with high selectivity for trace sugar content, in food product samples with many impurities.



Orange Juice



Vinegar

Source: Shimadzu Application News No. L467 and No. L382.

Fats and Oils

With meats and fish, in addition to being gustatory components, fats and oils, which are components of adipose tissue, and do not have an intrinsic chemical flavor, elicit deliciousness by imparting a mellow taste. In addition, fats and oils give a crispy texture to foods, and create a creamy texture by incorporating air in the form of tiny bubbles, so they play an important role in the physical structure of food products.
The characteristics of triacylglycerol, the main component in fats and oils, differ depending on the type of fatty acids derived from the raw ingredients, and desaturation and oxidation. In developing more delicious food products, it is important to fully grasp the content and chemical properties of these fats and oils. Gas chromatographs, infrared spectrophotometers and other analytical instruments are used in the field of food development as tools for the analysis of fats and oils.

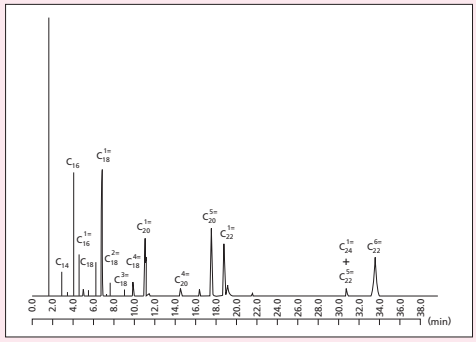
Gas Chromatograph
Nexis GC-2030

Gas Chromatograph

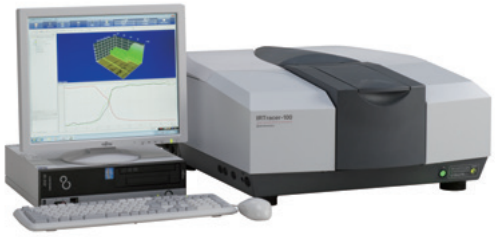
This analytical instrument measures the content of various components in samples. The components in the sample are separated, and then qualified and quantified.
It is capable of high-sensitivity trace quantity analysis, and is widely used in the fields of food development and quality control.

Analysis of Fatty Acids in Fish Oil

In addition to bolstering deliciousness, components of fatty acids contained in fish, such as EPA and DHA, are known for their functionality.
This example shows the analysis of fatty acid methyl esters in fish oil. It was confirmed that various fatty acids could be detected with high separation.



Fourier Transform Infrared Spectrophotometer
IRTracer-100

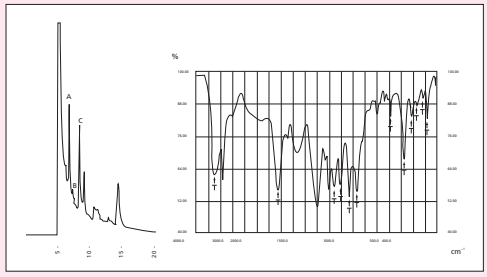


Fourier Transform Infrared Spectrophotometer

This instrument mainly performs structural estimations of organic compounds. When molecules are irradiated with infrared rays, the absorbance of the infrared rays differs depending on the structure of the molecules. Quantitation and structural estimations of compounds are performed by investigating the absorbance (infrared absorption spectrum) pattern.
Measurements can be performed with relatively easy pretreatment and a wide range of samples can be applied.

Analysis of Fatty Acids in Red Wine

Food products consist of mixtures of a variety of compounds. Accordingly, combining various analysis methods is an effective approach to the analysis of components.
In this example, red wine is filtered using a membrane filter. The components are then separated by a liquid chromatograph, and the separated materials are measured by the infrared spectrophotometer. Using a library search tartaric acid (a fatty acid) was identified.



Bitter and Astringent Components (Functional Components)

The bitterness and astringency of coffee and tea, and the bitterness of beer, chocolate, and edible wild plants are indispensable elements of the deliciousness of food products. Polyphenols, alkaloids and other compounds are known to be bitter and astringent components. These compounds are also widely known to be functional components, with antioxidant and metabolic stimulation effects.
Analytical instruments such as liquid chromatographs are used in the field of food development as analysis methods for the various gustatory components and functional components in food products.

Ultra High Performance Liquid Chromatograph
Nexera X2

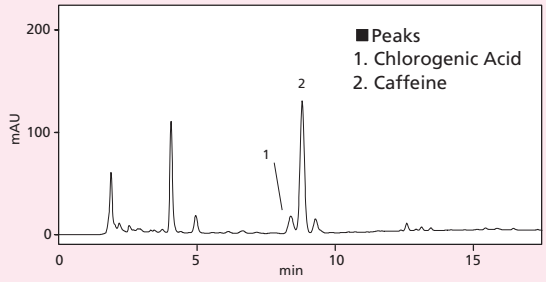
High Performance Liquid Chromatograph (HPLC)

This instrument measures the amount of various components in samples. The components in the sample are separated, and then quantified. It is very versatile, and is widely used for analysis in the food sector. In addition to instrument configurations suited to the sample and application, our lineup features models aimed at high-speed analysis.

Analysis of Chlorogenic Acid in Coffee

Chlorogenic acid is one of the many bitter and astringent components in coffee. It is a polyphenol compound widely distributed amidst the higher plants. In addition, recently, its antioxidant capabilities have become a focus of interest, and a variety of related research is being pursued.
This example shows the analysis of chlorogenic acid in commercially available instant coffee. It was confirmed that trace amounts of chlorogenic acid can be specifically detected.

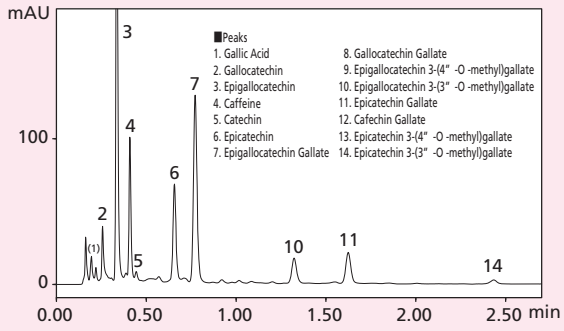
Source: Shimadzu Application News No. L306.



Analysis of Catechins in Green Tea

Catechins are widely known as astringent components.
At the same time, many research reports have highlighted their ability to lower body fat and cholesterol in the blood, and their antioxidant and cancer-preventing effects. These functional properties are also a focus of attention.
This example shows the high-speed simultaneous analysis of 14 catechins in commercially available green tea, including methyl catechin, which has been reported in the research to have anti-allergy effects. It was confirmed that the various catechins can be analyzed quickly and with high accuracy.

Source: Shimadzu Application News No. L376.

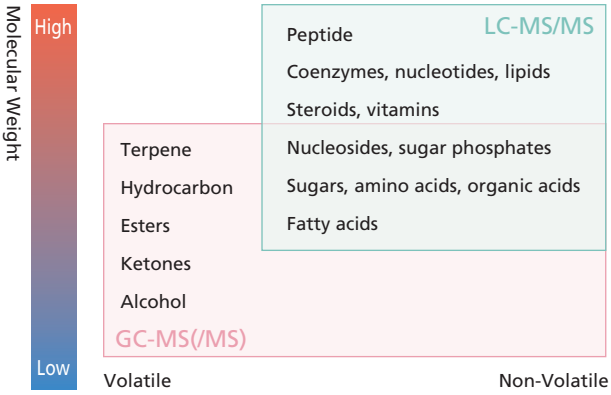


Analysis of Components in Food Products

The information provided in this brochure is just a fraction of what is available. In addition to the information provided in this catalog, Shimadzu has a wealth of experience in analyzing components in food products, including gustatory components, and components with functional properties (such as isoflavone, resveratrol, gingerol, flavanone, and lycopene).
For details, contact your Shimadzu representative.

Taste Components (Search by Metabolome Analysis)

Metabolites in biological samples are widely involved in the flavor and aroma of food products. Accordingly, metabolome analysis methods, which provide a comprehensive analysis of metabolites, are being actively applied to research and development of food products, for such applications as analyzing taste components and determining the stability of the quality of fermented foods. The wide target quantitative metabolome analysis approach combines a triple quadrupole mass spectrometer (GC-MS/MS, LC-MS/MS), which provides excellent separation, quantitation, and stability, with a database for primary metabolite analysis. This approach is used in the field of food development as an efficient and effective method of searching for taste components.



GC-MS(/MS)

LC-MS/MS

GC-MS(/MS)

- Hundreds of components can be analyzed simultaneously with a single measurement.
- Excellent robustness

LC-MS/MS

- Specific metabolites (up to 100 components) can be measured easily.
- High molecular weight, non-volatile metabolites can also be measured.

Database for Primary Metabolite Analysis

GC/MS Database—Smart Metabolites Database

Registered Compounds	Derivatization Method	Measurement Method	Number of Compounds Registered
Organic acids, fatty acids, amino acids, sugars, etc.	TMS	Scan	568
		MRM	475
Fatty acids	Methylation	Scan	50
		MRM	50
Amino acids	EZ:faast	Scan	33

LC/MS Database—LC/MS/MS Method Package Ver. 2

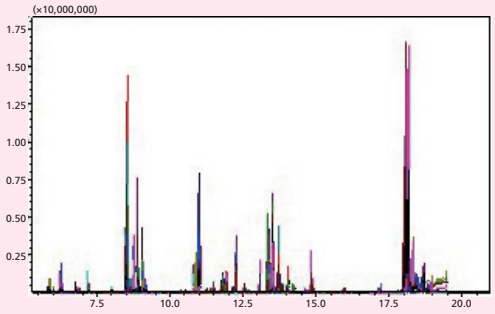
Registered Compounds	Method	Number of Compounds Registered
Metabolites, amino acids, nucleotides, etc. in the major metabolic pathways	Ion pair reagent used	55
Amino acids, organic acids, bases, etc.	PFPP columns used	97

Example of a Food Metabolomics Application

Item	Target	Component	Sample
Deliciousness	Taste Components	Primary metabolites and dipeptides	Liquors, beverages, fermented food products, agricultural crops
	Odor	Volatile components	
Functionality	Functional Components	Secondary metabolites	Agricultural crops, fermented foods, herbal medicines
	Effects of Components	Primary metabolites	Blood, urine, cells
Quality and Productivity	Fermented and Brewed Products	Primary metabolites	Fermented food products
	Plant Breeding (Agricultural Crops)	Primary metabolites, phytohormones	Agricultural crops
Distribution and Storage	Degradation of Components (Mislabeled Food Products, Distribution, Storage Quality)	Volatile components, primary metabolites	Agricultural crops, food products

Evaluation of Various Beer Beverages by Metabolome Analysis

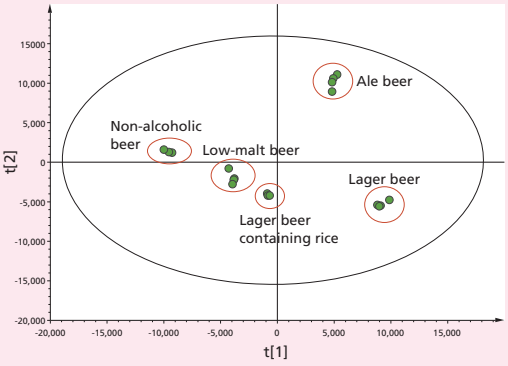
Hydrophilic metabolites in five beer beverages were analyzed using GC-MS/MS and LC-MS/MS, and the database for primary metabolite analysis. As a result of a multivariate analysis (principal component analysis) of the data, it was confirmed that the five samples showed specific clusters in the score plot, and based on the loading plot, sugar, amino acid and other characteristic components with a large contribution to the cluster forms were identified.



MRM Chromatogram

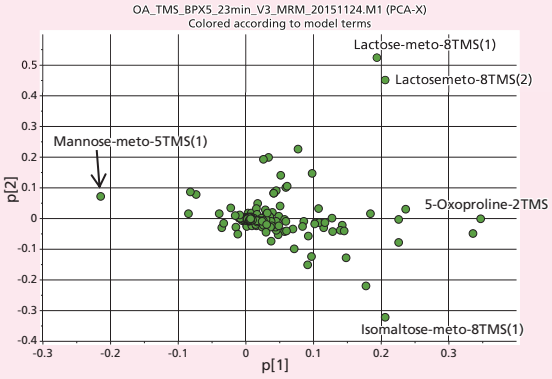
Gas Chromatograph Mass Spectrometer

GCMS-TQ8050



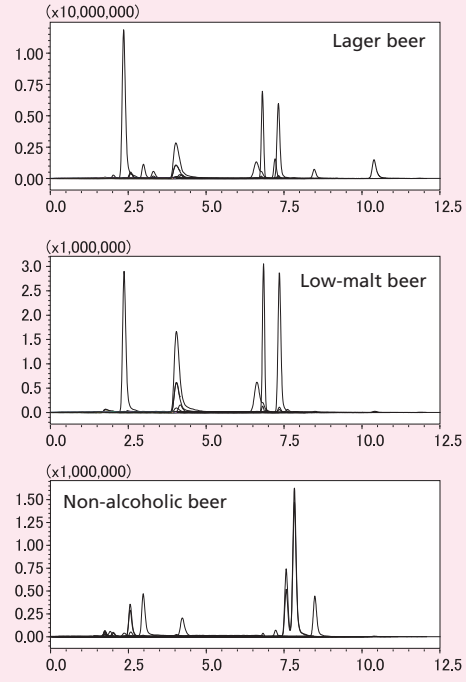
R2X[1] = 0.432 R2X[2] = 0.31

Score plot



R2×[1] = 0.432 R2×[2] =0.31

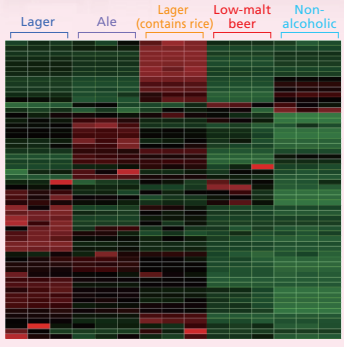
Loading plot



MRM chromatograms

Liquid Chromatograph Mass Spectrometer

LCMS-8060



Classification of beer type by hierarchical clustering analysis (HCA)

Source: Shimadzu Application News No. C134.

Odors and Other Items

In addition to the five basic tastes sensed by the tongue (sweetness, saltiness, sourness, bitterness, and umami taste), as well as spiciness and astringency, odor is an import factor in the deliciousness of foods. Also, odor is a keen reflection of the freshness of food products.
In addition to the large number of types, odorous substances are sensed in completely different ways depending on the concentration. Further, when multiple odorous substances are mixed together, even a slight change in their component ratios can lead to completely different odors, making objective evaluation difficult.
Gas chromatographs have been introduced in the fields of food development and quality control for their ability to objectively evaluate odors.

Features

High Sensitivity

This instrument can perform a high-sensitivity qualitative and quantitative analysis of highly volatile components including the fragrance components in food products.

High-Speed Performance

It is equipped with the functions needed for high-speed analysis, and can improve both throughout and productivity.

Excellent Versatility

With simple operations and no need for special pretreatment, a variety of samples from solids to liquids can be analyzed.

Headspace Analysis System

HS-20 + GCMS-QP2020/Nexis GC-2030

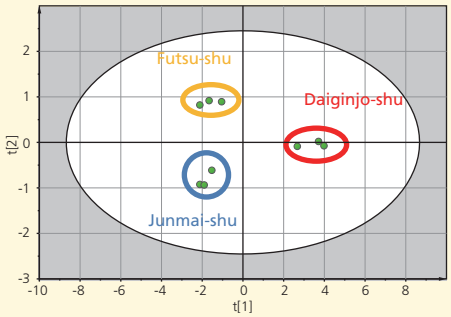
Headspace Analysis System

With this analysis system, a sample is placed in a vial, which is then sealed and heated for a set period. The volatile components that are expelled in the gas phase are taken into the instrument, loaded into a gas chromatograph or gas chromatograph mass spectrometer, and separately detected.

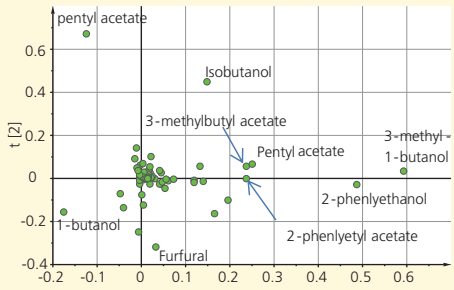
Analysis of Volatile Components in Sake (Japanese Rice Wine)

Using a headspace analysis system, volatile components were detected from different types of sake. As a result of a multivariate analysis of the volatile components detected, the respective sakes indicated clusters in a score plot, and the components specific to them could be narrowed down.

Major Components of Daiginjo-shu	Characteristics
3-methyl-1-butanol	Key aroma of refined sake
2-phenylethabol	Rose-like aroma
pentyl acetate	Banana-like aroma



Scale：Par, R2X[1]:0.9, R2X[2]:0.0719



Source: Shimadzu Application News No. M271.

Optional Devices for Analysis of Odor Components Using GC-MS

In order to collect and concentrate odor components with a wide range of polarities and boiling points, appropriate sample preparation methods are necessary. Optional devices realize efficient and effective odor analysis.

Optic-4: Multimode Inlet for GC-MS

Achieves a wide range of modes for odor analysis including large quantity injection mode, inlet derivatization mode, thermal desorption mode, thermal extraction mode, thermal decomposition mode, and DMI (Difficult Matrix Introduction) mode.

AOC-6000: Multifunctional Autosampler

Accommodates three sample introduction methods: liquid injection, headspace injection, and solid-phase microextraction (SPME) injection, enabling the analysis of samples in various forms.

Optic-4

AOC-6000

Database Supporting GC/MS Off-Flavor Analysis

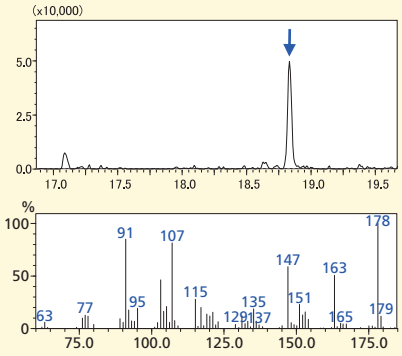
FFNSC 3 Flavour & Fragrance Natural & Synthetic Compounds Library

FFNSC 3 Flavour & Fragrance Natural & Synthetic Compounds Library

The aromatic preparations used for flavor in food products and fragrance in cosmetics and toiletries are complicated mixes of natural and synthetic flavor and fragrance compounds.
The FFNSC 3 flavour & fragrance natural & synthetic compounds library contains mass spectra obtained from GC/MS analysis, as well as retention indices for three columns with different polarities, including wax columns, for 3,462 flavor and fragrance compounds.

Analysis of Flavor and Fragrance Components Using the FFNSC 3 Library

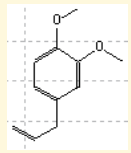
Flavor and fragrance components in samples were scanned using GC/MS, and then subjected to a similarity search using the FFNSC 3 library, enabling them to be identified. Flavor and fragrance components can be identified with high accuracy by using this library, which contains information on 3,462 flavor and fragrance compounds.



Similarity Search Using the FFNSC 3 Library

Hit#	Simila	Regi	Ret. Inde	Compound Name
1	80	☑	1403	Eugenol <methyl-> $$ Benzene, 1,2-dimeth
2	77	☐	1496	Isoeugenol <methyl-> $$ Benzene, 1,2-dim
3	72	☐	1496	Methyl isoeugenol <(E)-> $$ Benzene, 1,2-
4	72	☐	1455	Isoeugenol <methyl-, (Z)-> $$ Benzene, 1,2
5	64	☐	1320	Methyl thujate $$ 1,3,6-Cycloheptatriene-1

Target: Ret.Index: 1403

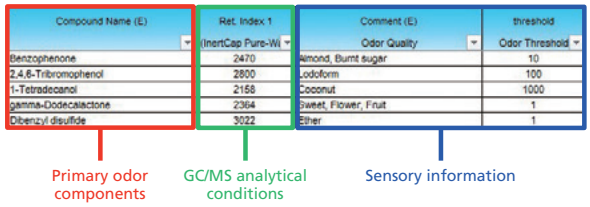


Eugenol <methyl->
Compound identification

Database for Off-Flavor Analysis

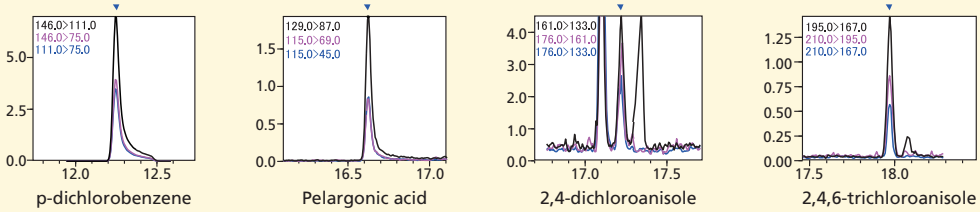
Database for Off-Flavor Analysis

If unforeseen circumstances occur during food product manufacture, storage, transport or other processes and an off-flavor issue occurs, it is necessary to specify the odor-causing substances in order to resolve the problem and prevent a recurrence. Shimadzu has teamed with Daiwa Can Company, which as a wealth of experience and know-how related to off-flavor analysis, to distill this into a database. It contains odor-causing substances identified in off-flavor issues in the past, as well as sensory information (odor characteristics and odor threshold values), so even analysts having no knowledge or experience of off-flavor analysis can start an analysis easily.



Analysis of Food Product Samples Involved in Off-Flavor Complaints

In the analysis of food product samples involved in off-flavor complaints, it was confirmed that four components are more often found in off-flavor products than in normal products. The four components detected were further analyzed using the off-flavor analysis database, and concentration and odor threshold values as well as odor characteristics were confirmed. From the results, 2,4,6-trichloroanisole was identified as an odor-causing substance.



Four Components with Higher Concentrations in Off-Flavor Goods than in Normal Goods	Estimated Concentration (pg/mg)		Odor Threshold Value (pg/mg)	Odor Characteristics
	Normal Product	Off-Flavor Product		
p-dichlorobenzene	0.052	66.558	1000.000	Insect repellent
Pelargonic acid	0	0.851	100.000	Dried fruit-like acid
2,4-dichloroanisole	0	0.003	10.000	Mold
2,4,6-trichloroanisole	0	0.009	0.001	Mold

Source: Shimadzu Technical Report C146-E293.

Sensory Evaluation

Odor and taste vary significantly between individuals, and people's sensory threshold values differ depending on the component. Accordingly, sensory evaluation is indispensable in evaluating the deliciousness of food products. By using equipment to complement various types of sensory evaluation, analysis can be performed more efficiently and effectively than with sensory evaluation alone.

Gas Chromatograph Mass Spectrometer with a Sniffing Port

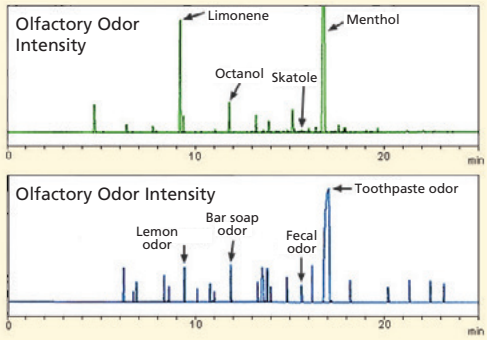
GCMS-TQ8050 + the OP275 Pro Sniffing Port

Gas Chromatograph Mass Spectrometer with a Sniffing Port

With this system, after chromatographic separation, the analyst sniffs the odor, the analyst him/herself, and the odor is detected and identified. It is used for off-flavor analysis for food products, and for searches of fragrance compounds.

Measurement of Mint

A mint sample was evaluated by the gas chromatograph mass spectrometer system with a sniffing port. From the results, it was shown that a strong odor was not sensed even when large amounts of limonene were contained; conversely, a strong odor was sensed with even small amounts of skatole. This indicates that there is no proportionality between the amount of a component and the intensity of the odor.



functional Near-Infrared Spectroscopy System

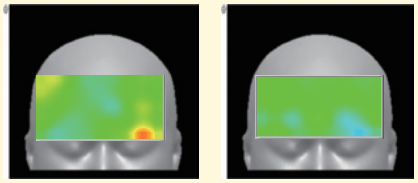
LIGHTNIRS

functional Near-Infrared Spectroscopy (fNIRS) System

This instrument enables real-time visualization of the status of brain surface activity by shining near-infrared light, which readily diffuses through biological tissues, onto the head and then detecting a portion of the light that is reflected as it is scattered and absorbed within the biological body. This makes it possible to measure brain activity safely and in a more natural state, making it application for sensory evaluations of food products.

Brain Reactions to Different Sensory Stimuli

It is evident that there are differences in blood flow in the brain depending on different sensory stimuli.



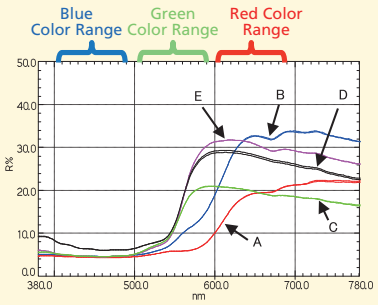
Color

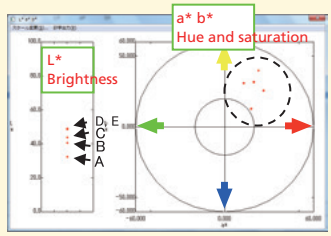
People experience flavor not just through taste but also through their visual experience. Of all the aspects of the appearance of food products, color has the largest impact on human emotion. Even a slight difference in color can have an impact on appetite. This can be expressed in terms of objective numerical values by measuring food product samples with a spectrophotometer, and then performing color calculations using the results obtained.

UV-VIS-NIR Spectrophotometer
UV-3600 Plus

UV-VIS-NIR Spectrophotometer

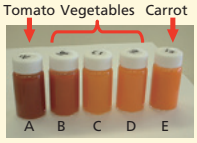
This spectrophotometer can measure a wide range of wavelengths, from ultraviolet to visible and near-infrared. The UV-3600 Plus includes not only the main unit, but also a large-sample compartment, an integrating sphere attachment, and three detectors. This enables high-sensitivity measurements of even solid samples.





Measurements of the Color of Vegetable Juice

Reflectance data obtained from various vegetable juices in a screw-top container using a spectrophotometer were analyzed in color measurement software. The results were plotted in a 2D chromaticity chart, enabling differences in color between samples to be represented objectively.



Source: Shimadzu Application News No. A477.

Freshness

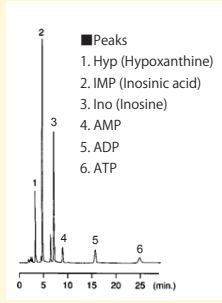
The freshness of food affects its flavor, smell, appearance and texture. In order to maintain freshness, efforts to improve food processing and preservation have been made. As one of the evaluation indicators of freshness, K-value is used for assessing seafood quality.

High-Performance Liquid Chromatograph
Prominence

K-Value of Tuna Meat

K-value represents the ratio between the sum of inosine and hypoxanthine to the sum of all other products of ATP degradation. Those components can be analyzed simultaneously using HPLC.

$$\text{K-Value (\%)} = \frac{\text{Ino + Hyp}}{\text{ATP + ADP + AMP + IMP + Ino +Hyp}}$$



Source: Shimadzu Analysis Guidebook, Food Product Analyses C180-E059.

Additives

Food additives tends to be perceived in a negative light by the general consumer. In terms of modern eating habits, however, additives are inextricably tied to the deliciousness of food products, including their taste, flavor, color, and continued freshness.

A correct understanding of food additives is indispensable in order to use them appropriately and effectively, and Shimadzu offers an array of instruments that offer highly accurate analysis of these additives.

UV-VIS Spectrophotometer
UV-1900

Features

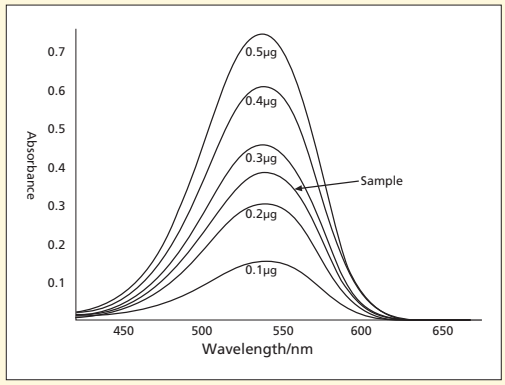
High Performance
- Ultra-fast scan speed (29,000nm/min)
- Low stray light (less than 0.5% at 198nm)
- High photometric repeatability (less than ±0.0002Abs at 0.5Abs and 1.0Abs)

Intuitive Operability
Easy-to-navigate color touch-screen display

Instrument Validation
Automatic/semi-automatic validation of wavelength accuracy and wavelength reproducibility.

Analysis of Preservatives in Food Products

This example shows the analysis of preservatives in food products, usage standards for which are prescribed by the Japanese Food Sanitation Act.
It is confirmed that a variety of components can be analyzed with high accuracy via easy pretreatment and measurements.



Sodium Nitrite in Meats

UV (UV-VIS Spectrophotometer)

This instrument is used to confirm the concentrations and molecular structure of organic compounds and inorganic ions mainly in solutions, using the characteristic absorption of light by specific components. This is used to quantify preservatives, vitamins, and food coloring in food products. Powdered and solid samples can also be measured using using a variety of accessories.

High-Performance Liquid Chromatograph Mass Spectrometer
LCMS-8060

Simultaneous Analysis of Sweeteners

A wide range of low-calorie sweeteners are often used in food products. These sweeteners present unique flavors different from sucrose, glucose, and fructose. They are used together with sugars, and multiple sweeteners are combined to regulate flavors.
This example shows the simultaneous analysis of 16 sweeteners. Good linearity was obtained with a correlation coefficient of 0.997 or higher for all the compounds.

Compound Name	Polarity	Transition	Retention Time (min)	Calibration Curve Range (ng/mL)	Correlation Coefficient
Sucralose	+	414.00 > 199.10	6.36	0.5 - 100	0.999
Dulcin	+	181.20 > 108.10	6.70	0.05 - 10	0.999
Alitame	+	332.20 > 129.00	6.92	0.5 - 100	0.999
Rebaudioside A	+	984.50 > 325.10	8.21	0.5 - 100	0.999
Stevioside	+	822.00 > 319.30	8.23	0.5 - 100	0.999
Acesulfame potassium	-	161.90 > 82.00	5.23	0.1 - 10	0.999
Saccharin	-	181.90 > 42.00	5.58	0.5 - 50	0.997
Cyclamic acid	-	178.00 > 80.00	6.08	1 - 100	0.999
Aspartame	-	293.40 > 261.10	6.53	5 - 100	0.999
Advantame	-	457.30 > 200.30	7.12	0.5 - 100	0.999
Glycyrrhizic acid	-	821.20 > 351.10	7.41	50 - 1000	0.999
Rebaudioside M	-	1289.60 > 802.90	7.66	50 - 1000	0.999
Neotame	-	377.30 > 200.00	7.90	1 - 100	0.999
Rebaudioside C	-	949.50 > 787.20	8.46	1 - 100	0.999
Dulcoside A	-	787.50 > 625.20	8.50	10 - 1000	0.999
Isosteviol	-	317.30 > 317.30	10.46	0.5 - 1000	0.999

Source: Shimadzu Application News No. C133.

Packing Materials

Food containers and packing materials play a very important role in ensuring the deliciousness of processed foods and other food products. To preserve food products, it is important to set appropriate conditions, with consideration to the characteristics of the respective food products. In addition, packing materials must be considered comprehensively in terms of preservation, the prevention of damage, and ease of opening.
To address these requirements, numerous analytical instruments are used to objectively evaluate containers and packing materials, depending on their objectives and applications.

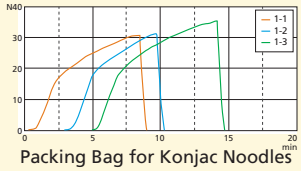
Texture Analyzer
EZ-SX

Texture Analyzer (Strength Testing Machine)

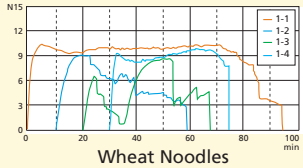
As introduced on page 4, this instrument is for strength testing via the stretching and compression of samples. In addition to evaluating the texture of food products, it is used to evaluate packing materials.

Comparison of the Strength of the Adhesive Parts in Packing Bags for Different Applications

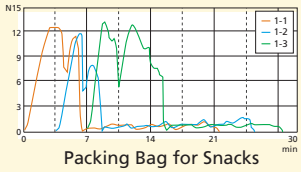
With packing materials for food products, the adhesion method used depends on the characteristics of the food product, with consideration to preservation, the prevention of damage, and the ease of opening. The following shows the measurement results of the adhesive strength of various packing bags.
Differences are seen in the packing strength and the degree of variation, depending on the type of food product.



Packing Bag for Konjac Noodles
(Noodles Made from Yam Cake)



Wheat Noodles



Packing Bag for Snacks

Konjac Noodles: The adhesive part is strong, and the bag breaks anywhere except at the adhesive part.
Snacks: There are more adhesive parts in comparison to other samples.
Wheat Noodles: The adhesive part is rough, and variation is observed depending on the sampling portion.

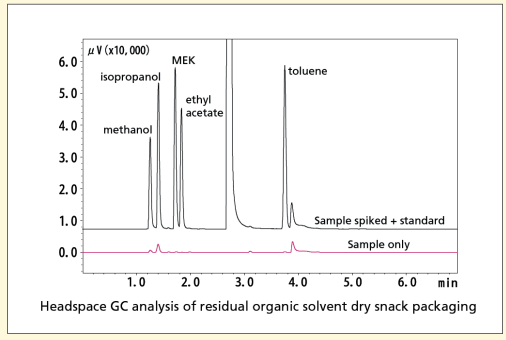
Headspace Analysis System
HS-20 + GCMS-QP2020/Nexis GC-2030

Headspace Analysis System

As introduced on page 14, this system can perform a high-sensitivity analysis of volatile components. It is used to analyze residual solvents in packaging as well as odor components in food.

Residual Solvent Analysis

Quality control of residual organic solvents is required because the manufacture of food packaging materials and containers involves the use of organic solvents in printing inks and adhesives. This example shows analysis of residual organic solvents in dry snack packaging using headspace GC. Trace residual solvents were detected.



Headspace GC analysis of residual organic solvent dry snack packaging

Residual organic solvents in dry snack packaging

Source: https://www.shimadzu.com/an/industry/foodbeverages/e8o1ci0000000b6d_2.htm

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