

Application Data

Endless possibilities

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Foods



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ELSZ-2000

Zeta-potential &
Particle size Analyzer



FPAR-1000

Fiber-Optics Particle Analyzer
with Auto-sampler



Agilent 7100

Capillary Electrophoresis

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Zeta-potential & Particle size Analyzer ELSZ-2000



Fiber-Optics Particle Analyzer with Auto-sampler FPAR-1000



Capillary Electrophoresis Agilent 7100

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1 FPAR Particle diameter evaluation of non-homogenized milk, low-fat milk, and natural milk

Particle diameter

Purpose For milk, the average particle diameter and the distribution of particle diameters depend on differences in production methods. Natural milk is processed to prevent separation via homogenizer processing, which atomizes the milk fat components. But other kinds of milk are also available: non-homogenized milk, which isn't processed, and low-fat milk (processed milk), which obtained from non-fat dry milk.

We measured the average particle diameter and particle diameter distribution of each kind of milk without dilution by the backscattering/dynamic light scattering method.

Result Natural milk is characterized by particle diameters ranging from about 200 nm to about 2.5 μm. Non-homogenized milk exhibits a very wide particle diameter distribution ranging from around 100 nm to more than several tens of μm. Low-fat milk exhibits the narrowest particle diameter distribution, with values ranging from around 200 nm to 1.5 μm.

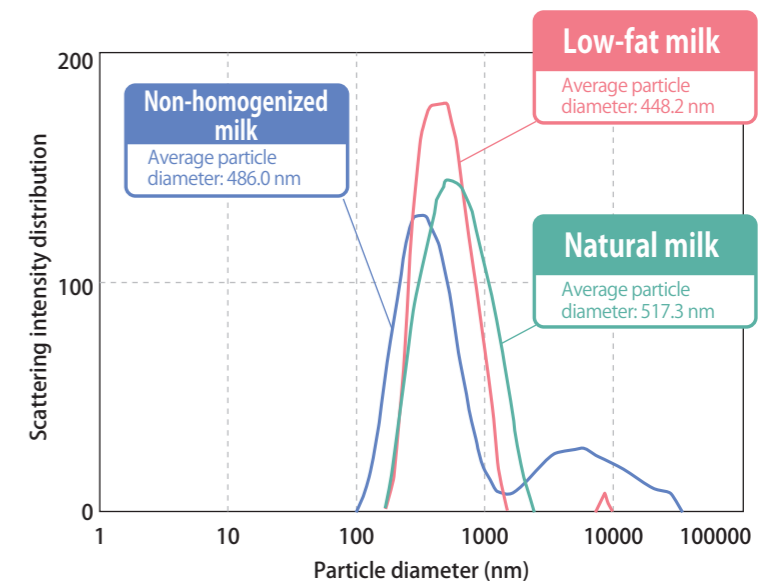


Fig. 1 Distribution of particle diameters for various kinds of milk

2 ELSZ Particle diameter evaluation by temperature change of milk

Particle diameter

Purpose The size of the emulsion particles in various foods is said to influence taste, feeling on the tongue, and mouthfeel. It's also said to influence flavor and can affect product quality and features.

Using the ELSZ-2000, we performed particle diameter measurements over temperature changes for various commercially available types of milk. We measured samples of undiluted milk in 5 degree increments from 0°C to 90°C. The samples were kept warm (temperature control) for 10 minutes before measurement to stabilize sample temperature.

Result Figure 1 shows a graph of average particle diameter with changing temperatures. The average particle diameter tended to be smaller as temperatures rose, increasing somewhat at 85°C and 90°C. The result indicates temperature affects the emulsion state. This may have applications to accelerated food testing.

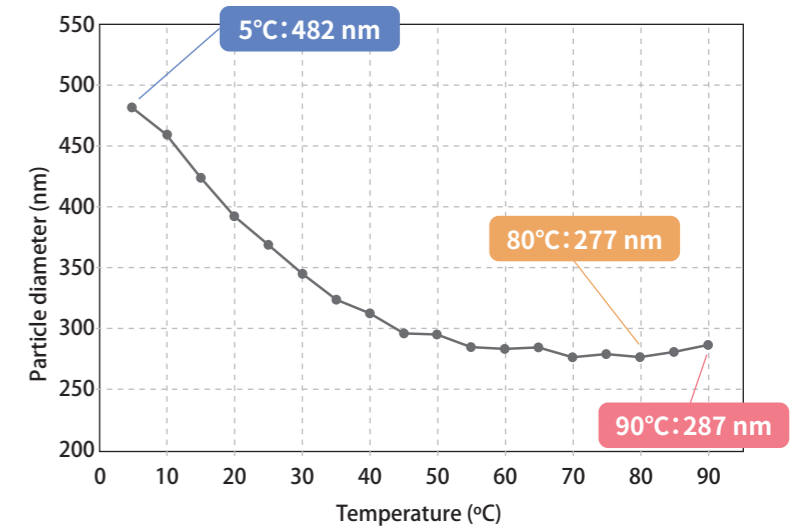


Fig. 1 Change in average particle diameter due to effects of temperature on milk emulsion

Drinks

Milk

Coffee

Probiotic drinks

Alcoholic beverages

3

ELSZ

Isoelectric point evaluation of milk and soy milk by pH titration measurement

Zeta potential

Purpose Containing many nutrients including proteins, lipids and calcium, milk is known as an important food that strengthens bones and teeth and improves immunity and physical strength. Soy milk, which has grown in popularity in recent years, contains significant amounts of isoflavone, a polyphenol, augmenting the effects of female hormones, reducing bad cholesterol in blood, and stabilizing blood pressure, all effects that have drawn attention.

We performed pH titration measurements of milk and soy milk to identify isoelectric points, diluting commercially available drinks 50-fold with a 10 mM NaCl solution and making pH adjustments with 0.5 N HCl and 0.5 N NaOH.

Result Figure 1 shows the result of a pH titration for milk. The zeta potential of milk has a positive charge on the acid side and decreases as acidity falls, becoming zero (the isoelectric point) at around pH 4.5 and gaining a negative charge as pH increases. The isoelectric point coincides with that of casein, which accounts for 80% of the protein found in milk.

Figure 2 shows pH titration results for soy milk. The zeta potential of soy milk has a positive charge on the acid side and decreases as acidity falls, becoming zero and reaching the isoelectric point around pH 4.6. The charge grows more negative as pH continues to rise. The isoelectric point of soy bean protein ranges from pH 4.2 to pH 4.6, agreeing well with the value. Isoelectric point measurements are important for understanding the physical property of the proteins.

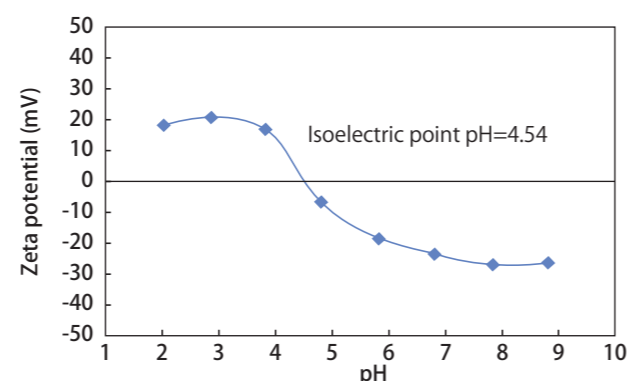


Fig. 1 pH titration curve for milk

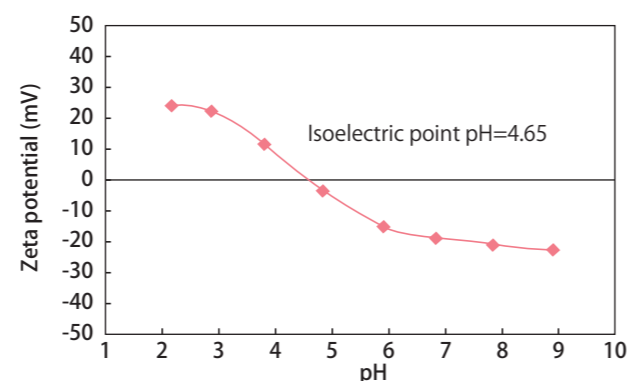


Fig. 2 pH titration curve for soy milk

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ELSZ

Particle diameter evaluation of homogenized soy milk and plain soy milk

Particle diameter

Purpose Soy milk is a drink obtained from ground soy beans. It contains proteins, plant lipids, essential fatty acids, and oligosaccharides, creating a popular health food. Sometimes used as a substitute for dairy milk, soy milk is classified into plain soy milk, processed soy milk, and soy milk drinks. Many dislike plain soy milk due to the strong flavor and aftertaste unique to soy beans. For this reason, taste is adjusted by adding sugar, salt, flavors, or fruit juice to create processed soy milk and soy milk drinks.

We measured and compared particle diameters and the zeta potential of plain soy milk and processed soy milk using the ELSZ-2000, diluting the solutions with distilled water to achieve a 1% concentration of solid soy bean ingredients for measurement.

Result Figures 1 and 2 show the results of particle diameter distribution measurements for plain soy milk and processed soy milk. The distribution for plain soy milk has two peaks, one at 33 nm and one at 472 nm. They appear to correspond to protein aggregates and emulsion particles. In contrast, processed soy milk has one broad peak ($d = 743$ nm), indicating a clear difference between plain soy milk and processed soy milk. The zeta potentials for plain soy milk and processed soy milk are -25 mV and -21 mV, again showing a difference paralleling the difference in particle diameters, although the difference is small.

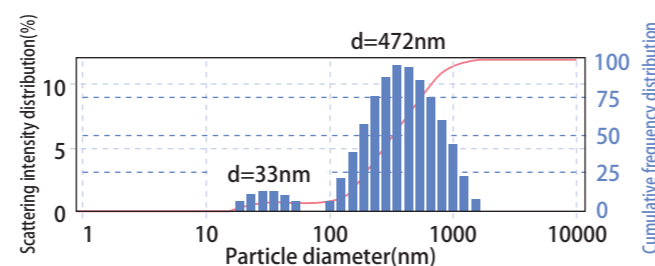


Fig. 1 Distribution of particle diameters for plain soy milk

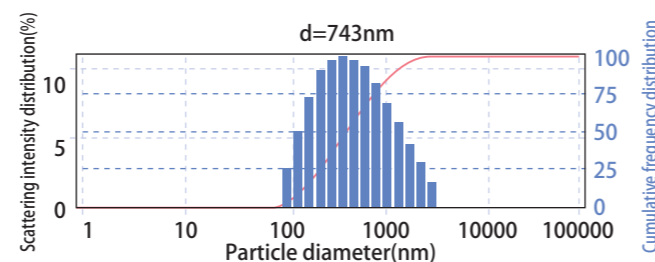


Fig. 2 Distribution of particle diameters for processed soy milk

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FPAR

Particle diameter evaluation of canned coffee

Particle diameter

Purpose Canned coffee is sold at different temperatures: iced in summer and hot in winter. Since the period from production to consumption can be long in certain cases, stable emulsifying technologies become more important. For evaluations of this aspect of quality, particle diameter measurements provide useful information.

We evaluated particle diameters for canned coffees from different makers by the backscattering/dynamic light scattering method, which is capable of making measurements without dilution.

Result Figure 1 shows the average particle diameter and the distribution of particle diameters for canned coffees from three different makers. The differences in average particle diameter are small, ranging from 314.4 nm to 385.1 nm, but the range of distribution of particle diameters within a single brand differs significantly. Differences in average particle diameter and the distribution of particle diameters of the various products appears to depend on difference of materials and method of production by each maker.

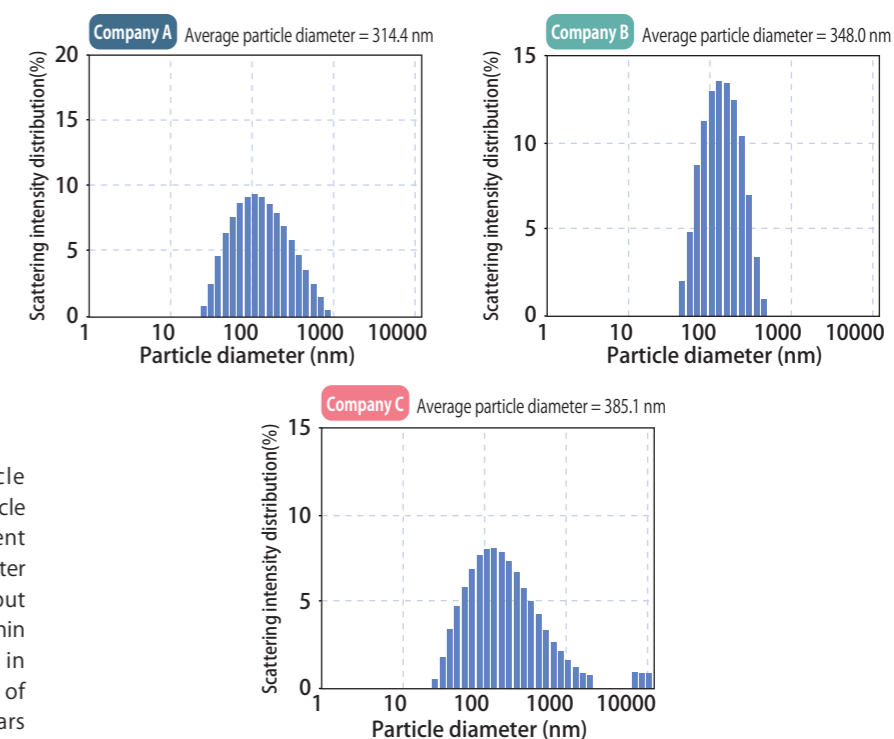


Fig. 1 Distribution of particle diameters for canned coffees from three different makers

6

FPAR

Particle diameter evaluation of probiotic drinks

Particle diameter

Purpose People have consumed probiotic drinks to maintain health and fight aging since antiquity. Products to which various features and functions are added has recently been developed and many kinds of probiotic drinks are commercially available. Particle diameter measurement is an important method to control their quality.

We evaluated the particle diameters of various commercially available probiotic drinks by the backscattering/dynamic light scattering method, which is capable of evaluating suspension systems.

Result Figure 1 shows curves for the distribution of particle diameters. The drinks were found with good reproducibility to have a broad distribution of particle diameters ranging from about 400 nm to 3.5 μ m.

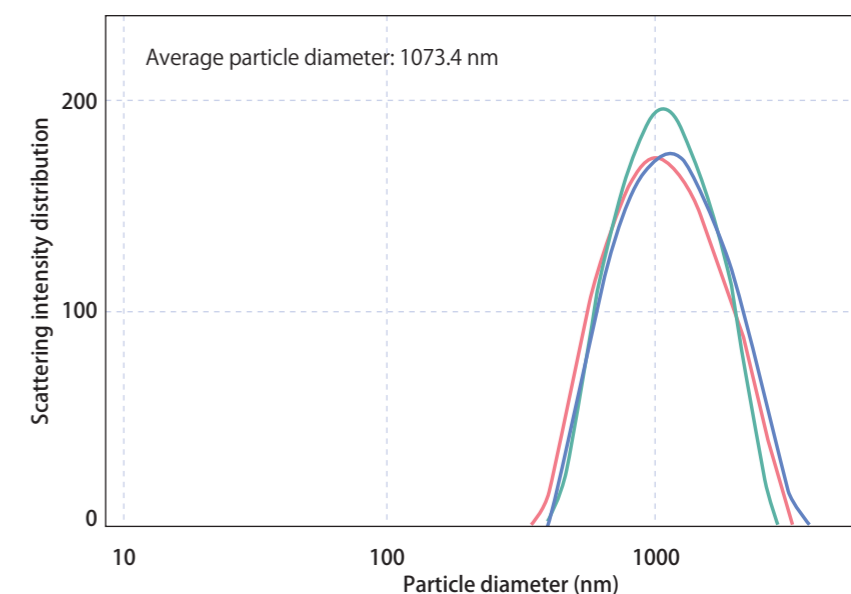


Fig. 1 Distribution of particle diameters for commercially available probiotic drinks

Purpose With a history stretching back to antiquity, wine is an alcoholic beverage consumed around much of the world. Wine contains many minerals, vitamins, polyphenols, and other components with bactericidal action and antioxidant, hypotensive, and cancer-fighting effects. Grape juice produced from the same raw materials as wine can also be expected to exhibit similar effects.

Using a capillary electrophoresis apparatus, we measured wine and grape juice to analyze and compare differences in components.

Result Figure 1 is an electropherogram of red wine (diluted 20-fold). Figure 2 is an electropherogram of grape juice (diluted 20-fold). Fermentation is said to increase the succinic acid, acetic acid, and lactic acid occurring in wine, something our measurements confirmed. Since the flavor and maturity of wine varies depending on the concentrations of these organic acids, such measurements can be applied to control the quality or other aspects of wine.

The results shown above indicate capillary electrophoresis method is useful in analyzing wine for concentrations of these substances.

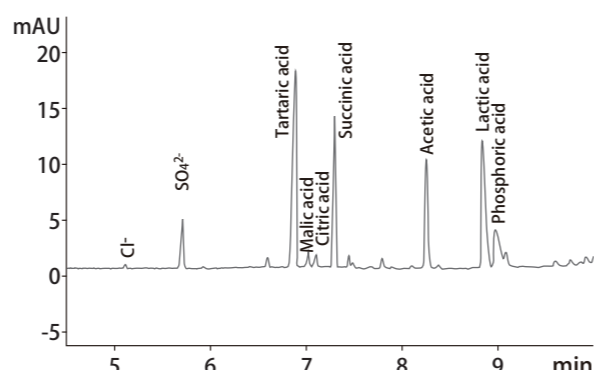


Fig. 1 Electropherogram of red wine (diluted 20-fold)

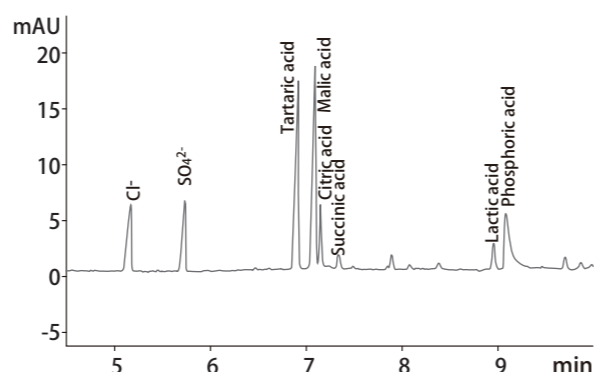


Fig. 2 Electropherogram of grape juice (diluted 20-fold)

Purpose Found in significant amounts in fruits and honey, fructose is the sweetest of natural sugars. Its sweetness is known to vary depending on temperature. As shown in Figure 1, the C2 ketone group of chain-structured D-fructose readily forms intramolecular hemiacetals with C5 and C6 hydroxy groups to form cyclic structures. Four types of D-fructose cyclic structures, namely, ① α-D-fructofuranose, ② β-D-fructofuranose, ③ α-D-fructopyranose, and ④ β-D-fructopyranose, are formed depending on cyclization at C5 or C6 and α-type or β-type. Five structures, including a chain structure, occur in an equilibrium in aqueous solution. Fructose is said to be sweeter at low temperatures because the ratio of the sweetest β-D-fructofuranose in equilibrium is higher at low temperatures and lower at high temperatures.

We applied the dynamic light scattering method to evaluate the temperature dependence of the diffusion coefficient of an aqueous fructose solution. We used fructose obtained from Wako Pure Chemicals and added water distilled through a filter with a pore size of 0.2 μm to prepare a 40 weight % solution. We used the ELSZ-2000 for dynamic light scattering measurements. Measurement temperatures were set from 25°C to 50°C at 5°C intervals. The retention time at each set temperature was 10 minutes; measurements were performed in both the heating and cooling processes.

Result Figure 2 shows plots of the scattering coefficient against measurement temperature. Since behavior changes at the boundary temperature of 40°C as shown in Figure 2, a difference in the ratio of β-D-fructofuranose is assumed to emerge as a difference in the scattering coefficient. This shows that the dynamic light scattering method can detect differences in equilibrium states due to temperature.

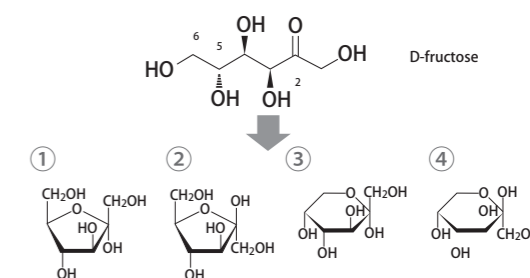


Fig. 1 Cyclic structure of D-fructose

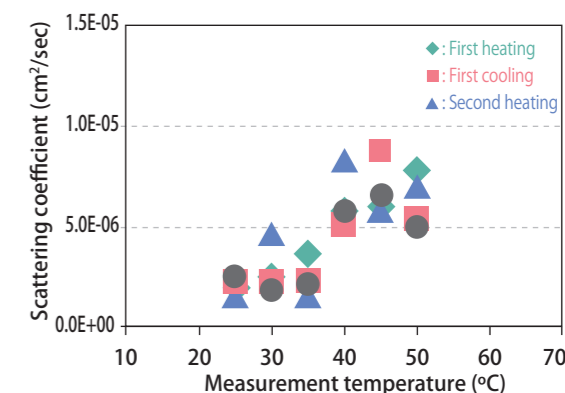


Fig. 2 Temperature dependence of scattering coefficient in D-fructose

Purpose Sweeteners can be divided into sugar-based sweeteners and non-sugar sweeteners. Non-sugar sweeteners can be further divided into natural and artificial sweeteners. Natural sweeteners like stevia and glycyrrhizin are extracts of sweet constituents found in plant leaves. Artificial sweeteners are chemically synthesized. They are roughly 200 times as sweet as sugar and used mainly as sugar substitutes in products like drinks and chewing gum for the calorie reductions. They are also used in combination to approximate the sweetness of sugar. Representative artificial sweeteners include aspartame and acesulfame potassium, among others.

We used a capillary electrophoresis apparatus to analyze artificial sweeteners (aspartame and acesulfame potassium) in drinking water.

Result Figure 1 shows the structural formulas of aspartame and acesulfame potassium. These compounds absorb ultraviolet radiation and have an electric charge, allowing analysis by free zone electrophoresis separation. Figure 2 shows the results of measurements of three soft drinks diluted 50-fold. Aspartame and acesulfame potassium are detected in all of the samples. The concentration of artificial sweeteners in soft drink P is greater than those in others. The results are in good agreement with subjective human comparisons of sweetness.

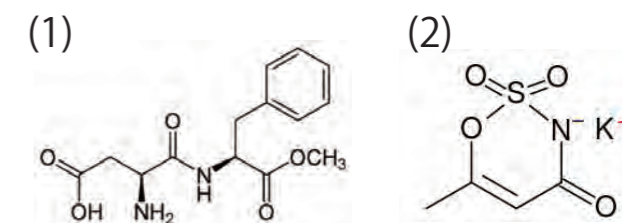


Fig. 1 Structural formulas of aspartame (1) and acesulfame potassium (2)

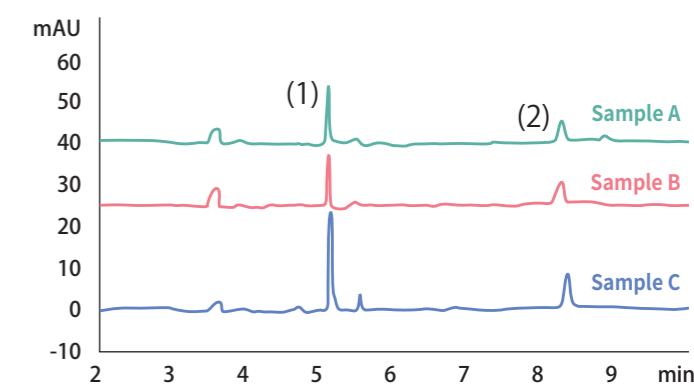


Fig. 2 Results of soft drink measurements
Peak (1): aspartame, peak (2): acesulfame K

Purpose Essential to Japanese cuisine, broth (*dashi*) contains various dissolved organic compounds that give it its flavor. Of these, glutamic acid, which was first discovered by the Japanese as a flavor component, inosinic acid, and guanylic acid are flavor components that significantly influence the taste of dishes.

We used a capillary electrophoresis apparatus to analyze the flavor components occurring in broths obtained from kelp, bonito, and dried shiitake and in Japanese broth seasoning.

Result Figure 1 shows results for standard samples. Three flavor components were analyzed within 20 minutes. Since each component has a characteristic absorption spectrum, the peaks are readily identifiable. Figure 2 shows results for actual samples. Kelp broth contains glutamic acid, while bonito broth contains inosinic acid. Shiitake broth contains guanylic acid in small amounts. While Japanese broth seasoning contains mainly glutamic acid and inosinic acid, peaks corresponding to other components are not clearly present.

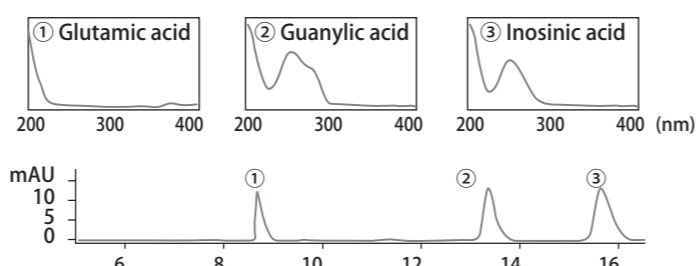


Fig. 1 Spectra and electropherogram of standard samples

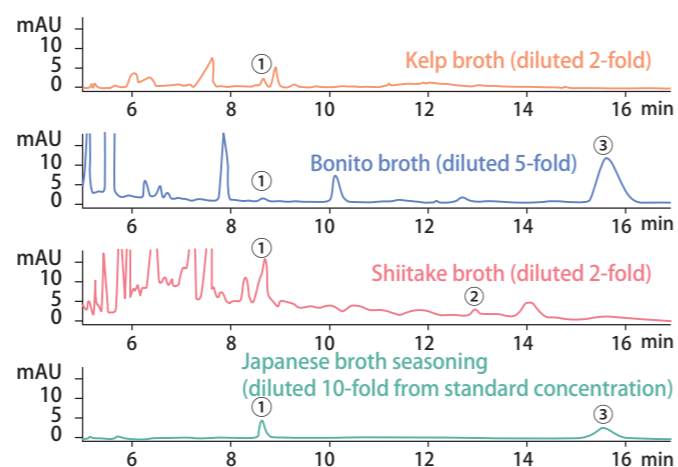


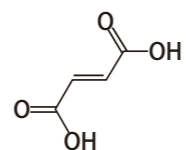
Fig. 2 Electropherograms of various broths (diluted 2- to 10-fold)

Purpose As Figure 1 shows, fumaric acid and maleic acid are geometric isomers with the same structural formula, $C_4H_4O_4$. Fumaric acid is an ingredient widely regarded as perfectly safe to add to food, as a non-volatile acidifier, maleic acid is regarded to be in conflict with Article 10 of the Food Sanitation Act and is not approved by the Minister of Health, Labour and Welfare. Thus, fumaric acid and maleic acid must be separated from other organic acids for detailed analysis.

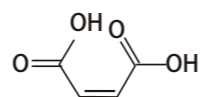
We used the capillary electrophoresis apparatus to study fumaric acid and maleic acid, geometric isomers, as well as other organic acids. As the electrophoresis carrier solution, we used the Electrophoresis carrier solution for analysis of organic acids and metal ions 12 (α -AFQ131, Otsuka Electronics).

Result Figure 2 shows the results of an analysis of the geometric isomers, fumaric acid and maleic acid, and other common organic acids. We found that we could simultaneously analyze fumaric acid, maleic acid, and other organic acids.

■ Structural formula: $C_4H_4O_4$



Fumaric acid (cis form)



Maleic acid (trans form)

Fig. 1 Structural formulas of geometric isomers (fumaric acid, maleic acid)

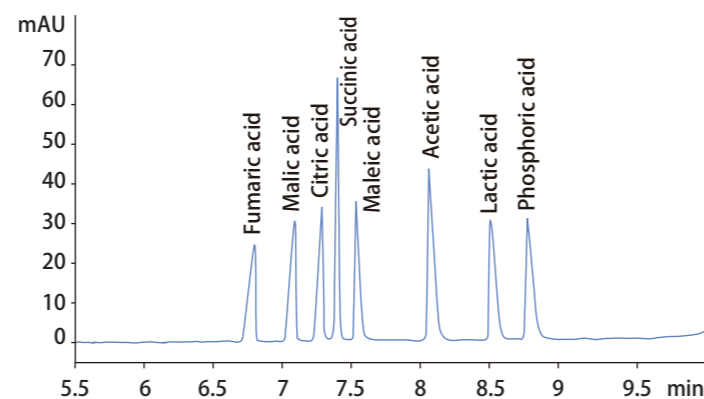


Fig. 2 Measurement results: electropherogram of fumaric acid, maleic acid, and other organic acids (200 ppm each)

Purpose Fatty acids (e.g., stearic acid, oleic acid, linoleic acid, palmitic acid, myristic acid) are monovalent carboxylic acids of long chain hydrocarbons that have recently drawn attention for potential applications as drugs, foods, and for biological research. For these reasons, qualitative and quantitative evaluations of fatty acids have continued to grow more important.

We used a capillary electrophoresis apparatus to analyze fatty acids.

Result The figures show electropherograms for canola oil (diluted 5-fold), olive oil (diluted 5-fold), sesame oil (diluted 100-fold) and butter (20 g/L). All samples were easily separable without pre-treatment such as derivatization required for other methods of analysis, using small amounts (roughly one hundred and several scores μ l) of the samples and dilution alone.

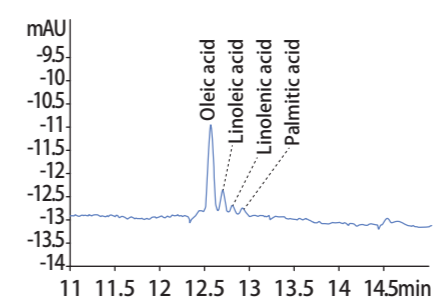


Fig. 1 Electropherogram of canola oil (diluted 5-fold)

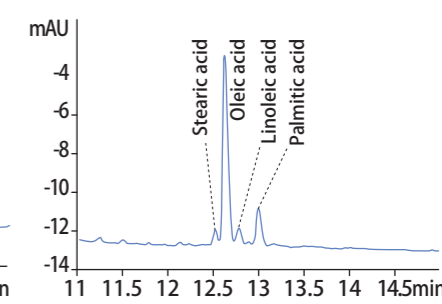


Fig. 2 Electropherogram of olive oil (diluted 5-fold)

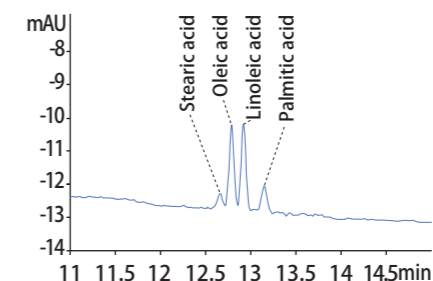


Fig. 3 Example of measurement of sesame oil (100-fold dilution)

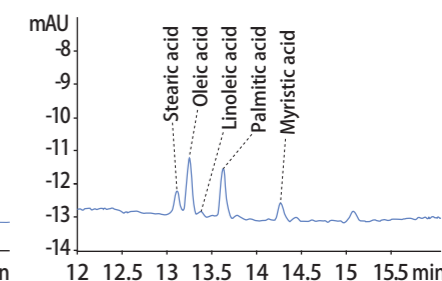


Fig. 4 Example of measurement of butter (20 g/L)

Purpose Docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), both found in significant concentrations in seafood, have various physiological effects. For this reason, they have recently drawn attention both as pharmaceuticals and as food, motivating demand for separation analysis of DHA and EPA in product development and quality control.

We used a capillary electrophoresis apparatus to analyze DHA and EPA.

Result Figure 1 shows an electropherogram of various standard fatty acids and fish oil used as supplements. Measurement with capillary electrophoresis successfully detected various fish oils—not just DHA and EPA, but fatty acids like stearic acid, oleic acid, linoleic acid, palmitic acid, and myristic acid.

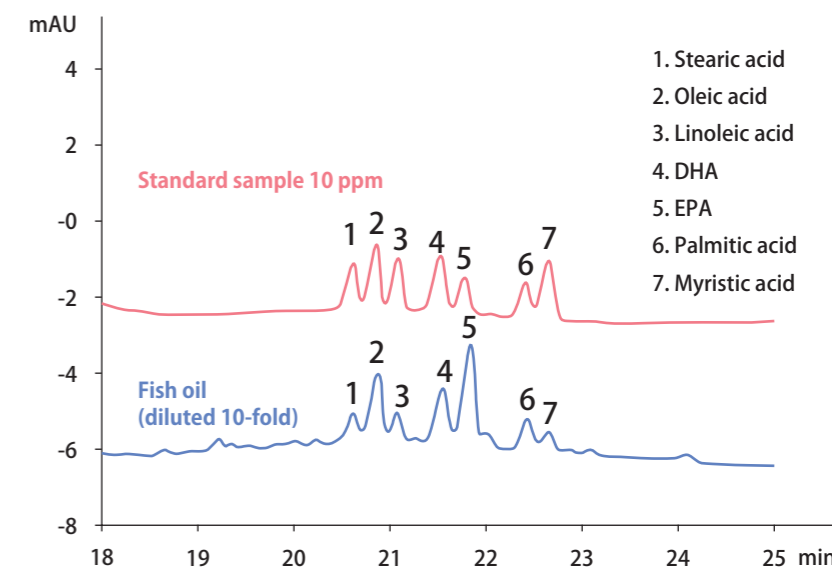


Fig. 1 Electropherograms of standard fatty acid sample (10 ppm) and fish oil (diluted 10-fold)

memo

memo