An Effective Approach to Evaluate the Emulsifying Property of Soybean Protein

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Abstract

A method in measuring trubidity to evaluate the emulsifying properties of soybean protein was developed. A linear relationship existed between tubidity and protein concentration (r=0.983) in the emulsion phase. The slope of the straight line (0.502) was a good index of emulsifying capacity for preventing the influence of protein oncentration. Plots obtained by turbidity against blending time for emulsion solutions at various protein conentration and oil/porotein ratios were also linear (r=0.914-0.975), when the emulsion solutions were set beyond 20 min. An essentially constant slope ranged from -1.26×10^{-3} to -1.58×10^{-3} min^{-1} for the protion of all the straight lines suggests if may reflect the emulsifying stability. Phase changes in emulsifying process can also be clearly provided during turbidity measurement.

Key words: Emulsifying property, Turbidity method, Soybean protein

Introduction

Soybean protein products have received wide application in fabricated foods because of their high protein content and functional properties[1,2]. Although no marked difference in compositions, some soybean protein products show dramatically different physical properties. For example, the isolated soy protein SUPRO 660 has good emulsifying property and SUPRO 620 has exellent propert in gel formation. Specific processing conditions may influence the extent of denaturation during the isolation process and influence the response to its utility.

Functional properties such as solubility, whipping ability, and emulsifying property are those primary factors that determine the applicability of soybean proteins in food system. Emulsifying properties including emulsifying capacity (E. C.) and emulsifying stability (E. S.) are of utmost importance to their utilization in salad dressings and comminuted meat products[3,4]. E. C. stands for the ability to form an emulsion and E. S. stands for the time period for such emulsion maintains[5]. E. C. is generally determined by adding oil to an aqueous solution of protein

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followed by mixed in a blender and is expressed as the total quantity of oil that can be emulsified by a known amount of protein.

Visual method by the color change of an oil-soluble dye[6,7], aural method by the sound change of blender's motor, and electrical method by an increase in resistance are commonly used to determine the emulsion properties[8,9]. In addition to end point determination, many variables such as types and ratios of materials, equipment used, energy output of blender, and running time may result in difficulty in standardization of data obtained from different researchers[10-12]. In the present study, a simple turbidity method was developed for evaluation of emulsifying property of soybean protein.

Materials and Methods

Materials

Soy protein isolate SUPRO 660 (Protein Technologies International Co.) and soybean oil (Taiwan Sugar Co.) were obtained from a local processor. Protein dispersions used contained protein concentration at 0.5 ~ 2.0% in distilled water.

Emulsifier

An apparatus consisting of a mixer, blades and an inverted pint ball jar was used. This was attached to a powerstat rheostat to provide variable speeds to the motor.

Emulsion preparation

Twenty-five ml of soluble soy bean isolate aqueous solution and various quantity of oil were placed in the mixer at 25 °C . Mixing speeds were controlled at 12,200, 13,800, 16,900 and 19,000 rpm. Several emulsions were made with varying dispersion time from 0.25 to 5 min.

Turbidity measurement

The emulsions were diluted serially with water, phosphate buffer and 0.2% SDS-0.1M sodium phosphate buffer. Absorbance of the diluted emulsion was determined at 500 nm in a UV-2000 spectrophotometer (Hitatch, Japan). Identical cvettes were used for all samples and were rinsed with distilled water between determinations. Triplicate aliquots of each emulsion were measured in each sample [13,14].

Analysis of data

Linear regression analysis was used to determine the slope and correlation coeefficient.

Results and Discussion

Blending speed and time

The effect of blending speed on emulsifying property of the protein is shown in Fig.1. Turbidity of the emulsions increased with the increase in blending speed. A linear relationship between blending speeds and turbidity (0.965) was observed. High blending speed promoted the emulsifying capacity of the protein[15]. Oil was dispersed into small particles by strong shear force during blending. As a result, turbidity of the emulsion increased, as reported previously[16,17].

Fig.2 shows that blending time had the same effect as blending speed on determination of emulsifying property. Several emulsions with different cocentrations of protein

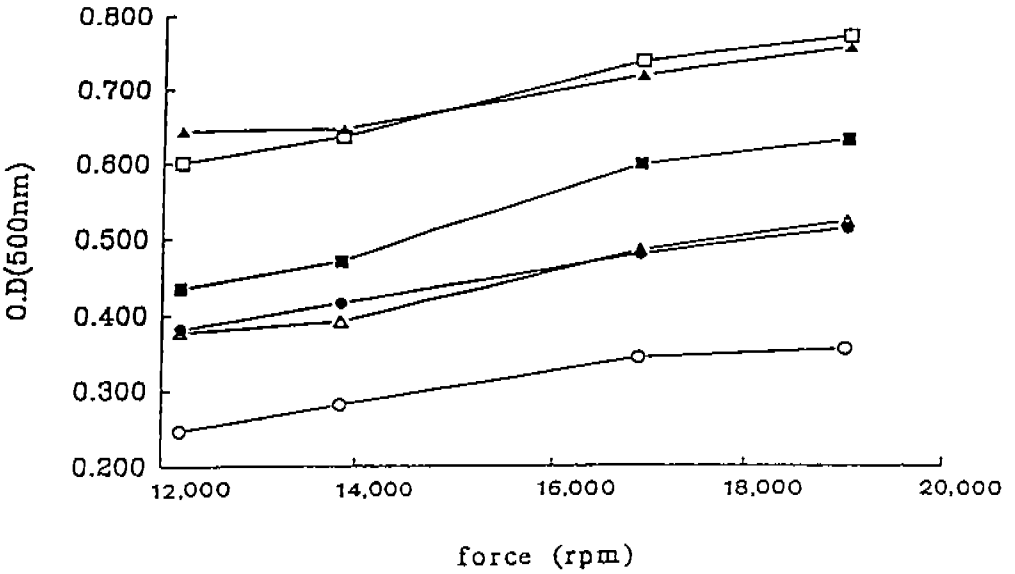

Fig.1 Effect of blending speed on the turbidity of emulsions prepared using protein and oil at different ratio.

○－○ : 0.5% protein, 10 mL oil
●－● : 0.5% protein, 30 mL oil
△－△ : 0.5% protein, 50 mL oil
▲－▲ : 1.0% protein, 70 mL oil
■－■ : 1.0% protein, 20 mL oil
□－□ : 1.0% protein, 50 mL oil

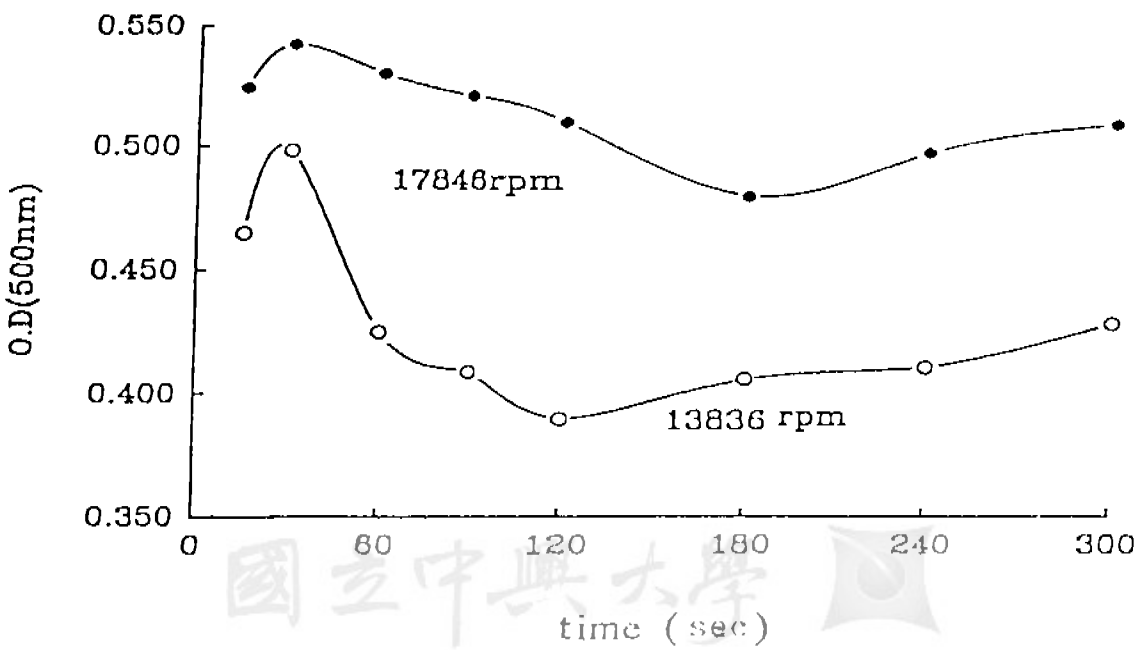

Fig.2 Effect of blending time on the turbidity of emulsion.
Oil/protein ratio was 1:1
(50mL oil: 50mL 1% protein).

and ratios of oil/protein were made by varying blending time from 0.25 to 5 min. The highest turbidity of the emulsions were observed at a blending time of 30 sec. The oil may have dispersed into small particles and thereby increase the surface area if it was blended beyond 30 sec. This resulted in incomplately emulsified oil by a limited amount of soluble protein. Thus, a prolonged blending time was required to evaluate the emulsifying capacity in a method by which measure emulsion breakdown and collapse as parameters. On the other hand, temperature of the emulsions increased with increasing the blending time. As the temperature raised, oil droplets became less viscous and tended to expand. Thus, the surface area was in considerable excess of that could be achieved theoretically. High temperature would also promote coalescence of the oil droplets. This further caused less oil to be emulsified[18]. These results indicate that the final temperature of the emulsion process is critical for determining the emulsifying eapacity. The turbidity method was not only rapid but also devoid of the possible influence of temperature.

Dilution

The turbidity of emulsions is likely being too high to get sccurate measurement. Therefore, dilution is needed to decrease the emulsion concentration and stabilize the emulsion particles. Influence of distilled water, sodium phosphate buffer and 0.2% SDS-0.1M sodium phosphate buffer on emulsifying property were investigated in this experiment. Fig.3 shows that buffer containing SDS was more effective to provide stability of the dispersion of emulsified particles than the other two dilutents.

Protein conentration and oil/protein ratio

Effect of protein concentration and oil/protein ratios on turbidity and stability of emulsion are shown in Fig.4 Turbidity increased with the increase in the oil/protein ratio. The emulsifying process could be divided into five phases, including water, oil in water, emulsion, water in oil, and emulsion collapsed. Phase changes in the emulsifying process could also be obtained from Fig.4. Methods for detection of emulsion inversion often lack of precision. Several methods have been employed to determine the endpoint or collapse of emulsion. In addition to blending speed and emulsion apparatus, other variables such as protein concentration, pH of the medium, oil addition rate and kind of oil may also affect the determination of emulsifying properties. The emulsifying capacity was not a solely property of the protein[19]. Furthermore, the emulsifing capacity and the amount of emulsifier were required to produce a satisfactory emulsion when the amount of oil is less than that required for phase inversion. In the cases where very viscous emulsions are formed, mixing of oil into the emulsion may be inefficient or incomplete and the observed emulsified value may be erroneous.

The increase in temperature of emulsion with operation also influenced the precision of determination. The method proposed by Pearce and Kinsella[3] for the determination of emulsification activity is influenced by protein concentration and ratio of dilution.

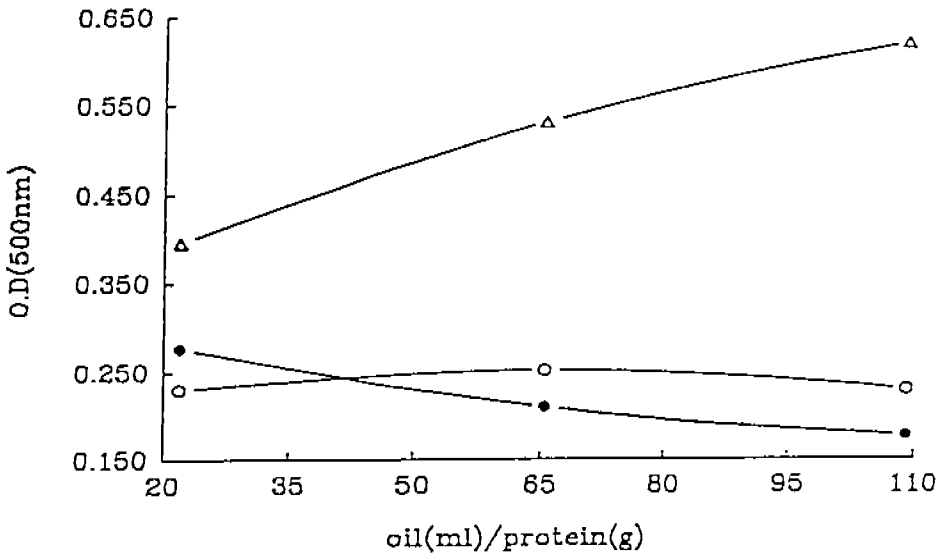

Fig.3 Effect of dilute solutions on the turbidity of emulsions prepared using protein and oil at different ratios.
○－○ : water
●－● : 0.1M sodium phospate (pH 7.0)
△－△ : 0.1% SDS-0.1M sodium phospate (pH7.0)

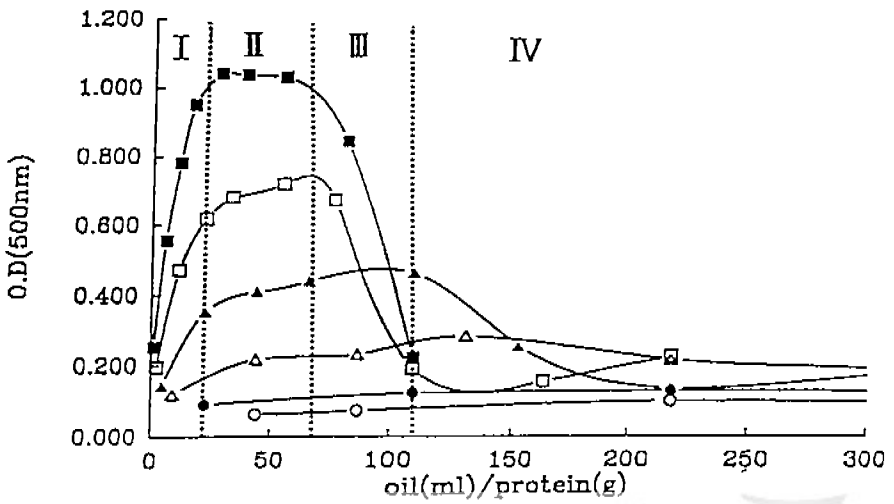

Fig.4 Effect of protein concentrations on the turbidity of emulsions prepared using protein and oil at different ratio.
○－○ : 0.05% protein
△－△ : 0.25% protein
□－□ : 1.00% protein
●－● : 1.00% protein
▲－▲ : 1.50% protein
■－■ : 2.00% protein
Region I : oil in water phase
Region II : emulsion phase
Region III : water in oil phase
Region IV : emulsion collapsed phase

Thus, it is quite difficult to obtain a reliable result. In our study as shown in Fig.5, a linear relationship existed between turbidity and protein concentration in the emulsion phase with a slope(s) of 0.502 and a correlation coefficient (r) of 0.983. The slope can conveniently and reliably be used to represent the emulsifying activity or capacity.

Setting time

Fig.6 shows that the change of the turbidity was unrelated to oil/protein ratio or to protein concentration during setting. The turbidity rapid decreased within the first twenty minutes of setting, and then gradually decelerated. The plots obtained by turbidity against blending time for the emulsion solutions at various protein concentrations and oil/protein ratios after setting for 20 min were essentially linear (r=0.914–0.975) and parallel (slope ranged from -1.26×10^{-3} to -1.58×10^{-3}). High correlation coefficient indicates that the slope represents the emulsifying stability precisely.

Conclusions

In comparius with other methods being reported in the literature, the turbidity method developed in this study is satisfactory for evaluation of the protein emulsifying properties. The method has advantage of without having any restriction in conditions during the determination and having faultless in the endpoint decision.

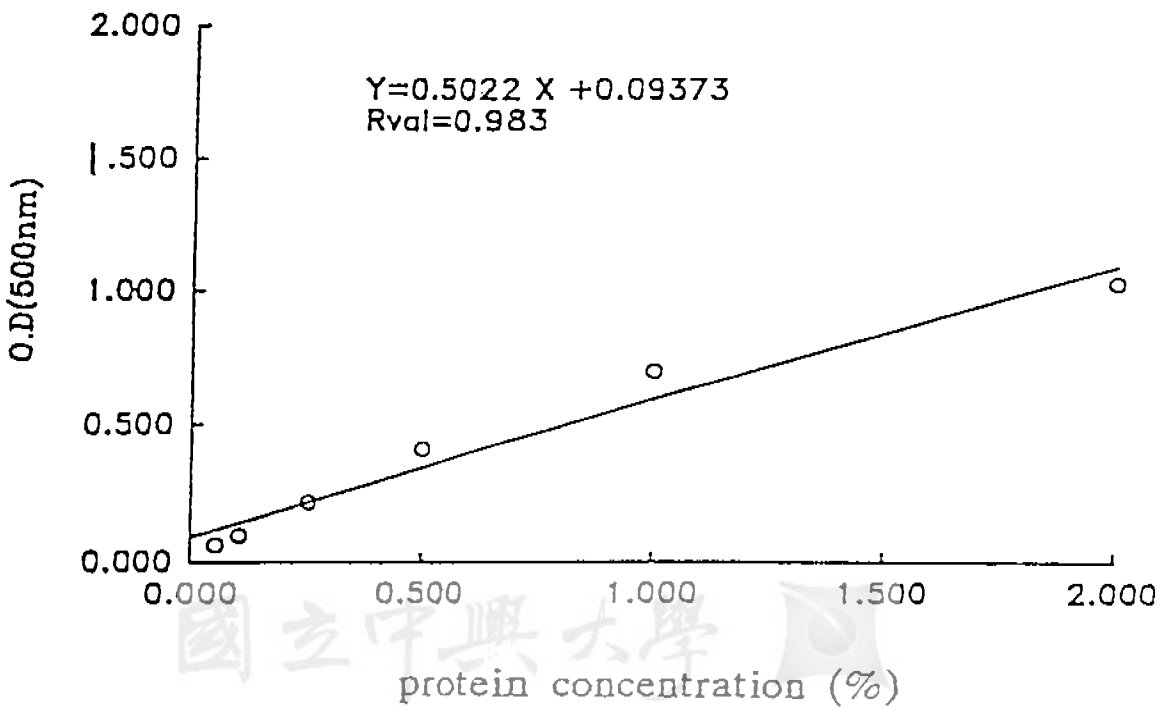

Fig.5 Emulsion capacity expressed using the slope of emulsion turbidity as a function of protein concentration.

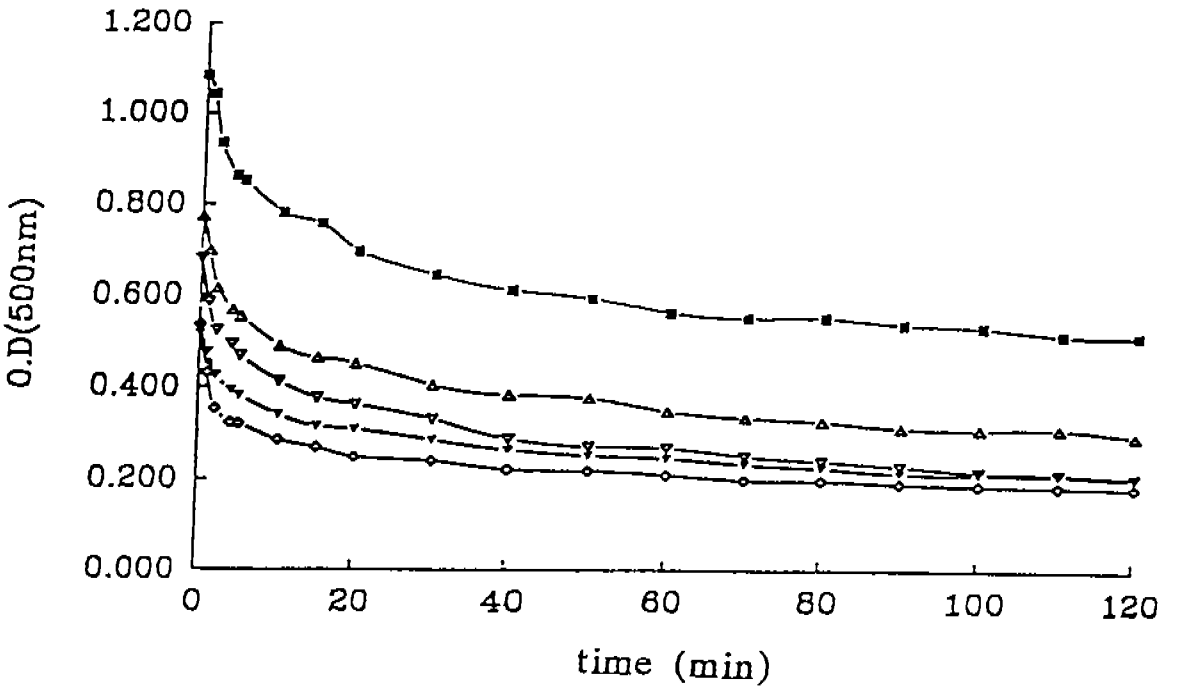

Fig.6 Change in trubidity of emulsions prepared using protein and oil at different ratios during setting.

△－△ : 0.5% protein, 50 mL oil
■－■ : 1.0% protein, 20 mL oil
▽－▽ : 2.0% protein, 50 mL oil
▼－▼ : 2.0% protein, 70 mL oil
◇－◇ : 2.0% protein, 30 mL oil

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黃豆蛋白乳化能力之有效評估方法

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（接受刊載日期：中華民國 85 年 10 月 14 日）

摘要：本研究提出濁度可用於評估分離黃豆蛋白質之乳化性。黃豆蛋白溶液乳化相之濁度與蛋白質濃度呈示線性關係 (r=0.983)，此直線之斜率 (0.502) 爲乳化能力的良好指標，其可避免蛋白質濃度造成之影響。以不同蛋白質濃度及油／蛋白質比率構成之乳化液的濁度對混合時間作圖時，當乳化液放置 20 分鐘後亦可得線性關係圖 ($r = 0.914 \sim 0.975$)。所有直線部份幾乎具有固定之斜率，其範圍介於 $-1.26 \sim -1.58 \times 10^{-3} min^{-1}$，此斜率可作爲乳化安定性之指標。除此之外，濁度測定可提供乳化過程中完整之相變化。

關鍵字：乳化性質、濁度測定、分離黃豆蛋白質

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