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Effect of protein microparticle and pectin on properties of light mayonnaise

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ABSTRACT

The efficiency of egg white protein microparticle (EWPM) and pectin sol (PS) addition in blocking flow behavior of light mayonnaise was investigated in this study. The texture properties, color, microstructure and thermal resistance were also measured for better understanding of synergistic effect of EWPM and PS on characteristics of light mayonnaise. At ratio of 2:4 (in weight ratio of PS and EWPM), the sample showed higher viscosity and hardness, attributed to the formation of larger protein aggregates induced by repulsion between protein and pectin molecule. The speculation was verified through the microstructure of mayonnaise samples observed by laser light confocal microscope. With the amount of EWPM increased, the yellow value of light mayonnaise increased, but thermal resistance decreased. For EWPM-rich samples, moderate heat treatment can strengthen the interaction between particles, inducing the increase of viscosity.

1. Introduction

Mayonnaise is a kind of oil-in-water emulsion, traditionally prepared through mixing egg yolk, vinegar, oil, and salt. The traditional full fat mayonnaise containing 70–80 g/100 g of fat, is one of the most widely used sauces in the world (Liu, Xu, & Guo, 2007). Over the past decades, the consumption of low-fat food products has become very popular, in consideration of avoiding diseases such as obesity, cardiovascular diseases and cancer (induced by high fat and salt diets) (Jimenez-Colmenero, Cofrades, Herrero, Solas, & Ruiz-Capillas, 2013). However, as an essential food component, fat plays important role in determining rheological properties and sensory characteristics of foods, such as flavor, mouth-feel, color, and texture (Depree & Savage, 2001; Shen, Luo, & Dong, 2011). With the decrease of fat concentration, the aqueous phase and water content may increase correspondingly, inducing the decrease of viscosity and firmness of semi-solid emulsion. Particular fat substitutes in specific quantities are possible to produce a product with a texture close to that of traditional mayonnaise. Therefore, it is a big challenge to use fat analogue with different functions to remove partial fat and remain traditional pleasant properties.

Food technologists have focused their efforts on fat replacers to promote the formulation of the low fat products, particularly on hydrocolloids (like modified starch, pectin, algal alginate, xanthan gum and so on) to improve stability and viscosity of light mayonnaise (Mun et al., 2009; Murphy, 1999). Liu, Xu, & Guo (2007) indicated the good potential for pectin weak-gel and microparticulated pectin gel to be used as a fat mimetic in mayonnaise, in comparison with some other mimetic in terms of thickness and color of final low fat product (Liu, Xu, & Guo, 2007). Several researchers studied on the possibility of protein aggregations to be used as fat substitutes. The capacities of protein microparticles to confer sensory impressions of full-fat emulsions upon low-fat foods was a serendipitous discovery, which was proved to be the bellwether for the recent food industry campaign against high-fat dietary (Ma, Drake, Barbosa-Canovas, & Swanson, 1997; Roller & Jones, 1996; Yazici & Akgun, 2004). The most popular microparticulated protein types of fat mimetic started from whey protein

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concentrate, and some relative products had been used in low fat diary and meat products (Singer, 1996).

Rheology properties of semi-solid emulsions are closely related to many industrial productions and practical applications influenced by the flow behavior, and proved to be an effective method to investigate reliability of simulated food system. The resulting rheological properties vary depending on solid content, space volume of various component, the presence of functional groups, and degree of interaction between dispersed phases (Bengoechea, Romero, Aguilar, Cordobés, & Guerrero, 2010). As previous studies shown, mayonnaise samples always performed as a yield stress, a pseudoplastic behavior and time dependent characteristics (Batista, Raymundo, Sousa, & Empis, 2006). Steady shear and oscillatory shear measurements were carried out on mayonnaise samples in many studies, behaving good relevance with actual sensory evaluation.

This study, we focused on the application of egg white protein microparticle (EWPM) in light mayonnaise, and investigated the synergistic effect of pectin addition on rheology, texture, color and thermal resistance of the samples. Scan laser confocal microscope was used to observe the distribution of protein microparticle and oil droplets in the emulsion system, to further reveal the function of protein particles and pectin molecule in influencing the flow behavior of light mayonnaise. The results would provide theoretical guidance for the production of light mayonnaise or some other low fat semi-solid foods with egg white protein microparticle and pectin as thickener.

2. Materials and methods

2.1. Materials

Hen eggs were supplied by Rongda, an enterprise in Xuancheng, Anhui, China. For the preparation of the light mayonnaise, sunflower oil and vinegar was bought from Arowana, a local supermarket, and used without further purification. HCl, NaOH, high-methoxyl pectin, sodium chloride (NaCl), sodium azide (NaN_3) was obtained from Sigma-Aldrich (St. Louis, MO, USA).

2.2. Preparation of egg white protein microparticles and light mayonnaise

Egg white separated from washed hen egg was adjusted to pH 3.8 and stirred for 0.5 h. Then the suspension was centrifuged at 6000 rpm for 15 min at 25 °C to remove insoluble proteins. The supernatant was collected and heated in a shaking water bath at 90 °C for 30 min, then cooled in an ice bath immediately and stored at 4 °C for 24 h. The formed gel was minced and homogenized for 2 min at 11,000 rpm using an Ultra-Turrax blender (IKA T25 Basic, Staufen, Germany) equipped with a 12 mm diameter head. The resulted sample was egg white protein microparticle referred as EWPM and used as fat substitute in this study. Pectin sample was mixed with 3 times of distilled water to form sol for usage, referred as PS. The light mayonnaise was prepared with egg yolk, sun flower oil, distilled water, EWPM, PS, salt, and vinegar. The amount of each component for various samples was showed in Table 1. The contents were mixed together through blending for 10 min. The formed mayonnaise samples were stored under 4 °C until analysis and 20 μL of 0.02% NaN_3 was added into each sample as an antimicrobial agent.

2.3. Rheology

Steady shear viscosities. The steady shear viscosities of light mayonnaise prepared by various amount of EWPM and pectin were characterized using a DHR-3 Rheometer (TA Instruments, USA) with flat plates (d = 40 mm) at 25 °C. The gap between two plates was set to 1.0 mm. After 1 min of equilibration, viscosity of the emulsions was recorded as the shear rate was increased from 0.1 to 100 s^{-1}. For better evaluation of flow behavior of prepared low fat mayonnaise, a thixotropic loop measurement was carried out by firstly increasing the shear rate logarithmically from 1 to 90 s^{-1}, then decreasing it logarithmically back to 1 s^{-1}. Shear press (Pa) was recorded for drafting the thixotropic loop.

Dynamic viscoelastic properties. The dynamic viscoelastic properties of the gel-like type emulsions were characterized by the same rheometer using a frequency sweep mode. The frequency was varied from 0.1 to 50 Hz at a constant strain of 1%. The elastic modulus (G'), loss modulus (G''), and loss tangent (tan δ) were recorded. All the experiments were carried out at 25 °C.

2.4. Texture

Texture measurements were carried out using a TA-XT2i Texture Analyzer (Stable Microsystems Ltd., Surrey, England). The samples were carefully filled into a small cylindrical container with smooth surface. The measurements were conducted with a P/0.5 probe, and the probe was penetrated into the sample to a depth of 2 mm at a rate of 1.0 mm/s recording the force exerted on the probe automatically. The parameter hardness, adhesiveness, cohesiveness, and gumminess were recorded. Each sample was tested for six times for averaging the valid values.

2.5. Colorimetry

Objective color of mayonnaise samples was measured with a colorimeter (UltraScan Pro1166, USA), recording tristimulus values L^*, a^*, and b^* parameters, representing lightness, red green axis, and yellow blue axis respectively. Before use, the colorimeter was standardized using the white and black calibration plate respectively. The samples were packed in plastic bags for testing and the tests were repeated six times for each sample.

2.6. Laser scanning confocal microscope and macro photo

The microstructure of light mayonnaise prepared by various amount of EWPM and PS particle was determined by Confocal Laser Scanning Microscopy (CLSM) (Leica TCS-SP5, Germany) equipped with a Power Shot G2 photographic camera (Canon, Tokyo, Japan). For visualization of the distribution state of oil droplets in dense system, the oil was dyed by Nile red. One gram of mayonnaise sample was dyed with 2 μL of 0.1% dye. After standing for 30 min, a small amount of the dyed sample was placed onto a microscope slide and carefully covered with a coverslip. Then the photomicrographs were taken, with 40 × magnification. The excitation wavelength for Nile red is 488 nm and the emission wavelength is

Table 1
The amount of various contents in light mayonnaise samples prepared at various ratios of PS and EWPM.

Contents	PS:EWPM				
	6:0	4:2	2:4	1:5	0:6
Egg yolk (mL)	15	15	15	15	15
Sun flower oil (mL)	15	15	15	15	15
Water (mL)	12	12	12	12	12
PS (g)	6	4	2	1	0
EWPM (g)	0	2	4	5	6
Salt (g)	0.5	0.5	0.5	0.5	0.5
Vinegar (mL)	2	2	2	2	2