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Application of micronized konjac gel for fat analogue in mayonnaise

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ABSTRACT

Application of micrometre-scale konjac gel as fat analogue in mayonnaise was studied. Three concentrations of konjac glucomannan (KGM) were applied to prepare micronized konjac gel. The best combination of fat analogue used in mayonnaise was 4.0 wt% konjac glucomannan and 0.36 wt% sodium carbonate. Then fat was partially substituted by micrometre-scale konjac gel at levels of 10, 20, 30, 40, 50, and 60% which were referred to as R10, R20, R30, R40, R50, or R60 formulations, respectively while the full fat (R0) mayonnaise without konjac gel substitution was used as a control experiment. The effects of substitution ratio was determined by rheology measurements, colour measurements, optical microscope observation and caloric values analysis which indicated that fat in mayonnaises substituted with konjac gel of not more than 30% was acceptable. At the meanwhile, the product has good storage stability in a certain storage period. This study shows good potential for spent micronized konjac gel to be used as a fat analogue in mayonnaise.

1. Introduction

Public health problems caused by high-fat foods with low fibre have brought crisis to society. It is the requirement of health industry and the competitive hotspot in the field of food science that substituting part of the fat in fatty foods without lowering the taste.

Mayonnaise is an oil-in-water emulsion that is commonly prepared by mixing egg yolk, vinegar, oil, and spices that widespread consumption worldwide (Shen, Luo, & Dong, 2011). Mayonnaise made in traditional way typically contains 70–80% fat (Zhao et al., 2002). Therefore, it is necessary to use fat analogue of different functions to supply the quality attributes lost when fat removed.

Mancini, Montanari, Peressini, & Fantozzi (2002) added algal alginates to the full fat mayonnaise as stabilizers resulted in an improvement of emulsion strength. Marinescu, Stoicescu, & Patrascu (2011) reported the application of beta-glucan prepared from spent brewer's yeast as a fat replacer in mayonnaise. They claimed that it has been demonstrated that spent brewer's yeast beta-glucan can be used as a fat replacer in mayonnaise as well as an emulsion stabilizer. Kontogiorgos, Biliadens, Kiosseoglou, and Doxastakis (2004) claimed that cereal β-glucans could be used as stabilizers in model salad dressings.

Liu, Xu, & Guo (2007) studied the properties of low-fat mayonnaise with different fat mimetics that showed good potential for pectin weak-gel and microparticulated pectin gel to be used as a fat mimetic in mayonnaise. The mayonnaise fat was partially substituted (50%) with the 4αGTase-treated starch in combination with xanthan gum. This study demonstrated that the use of 5.6 wt% of 4αGTase-treated starch and 0.1 wt% of xanthan gum produced a reduced-fat mayonnaise with similar rheological properties and appearances as full-fat (FF) mayonnaise with gum (Mun et al., 2009).

Xanthan gum, citrus fibre and variable concentration of guar gum (GG) were used to formulate the optimum ratios of polysaccharide gums as fat replacers. The fat content in low-fat mayonnaise was reduced to 50% comparing with full-fat mayonnaise, and the products still maintained ideal rheological properties (Mun et al., 2009).

More recently, Shen, Luo, & Dong (2011) used oat dextrin to produce low-fat mayonnaises which has similar acceptability, appearance, colour, odour, and a higher viscosity with their full-fat counterpart but lower calorie.

Konjac glucomannan (KGM) is a kind of dietary fibre, which has significant health functions. It has been widely used in food industry because of its good swelling, gelling and other features. The state of KGM gel transfers from rubber-like elastomer to pseudoplastic viscoelastic body after pelletizing in the presence of alkaline,

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and these properties provide possibility for KGM's application as fat replacer (Jimenez-Colmenero, Cofrades, Herrero, Solas, & Ruiz-Capillas, 2012). Konjac gel was generally used as fat replacer in meat products. Researchers from Ciudad Universitaria (Spain) have done a number of works in application konjac gel in reduced/low-fat meat products. They employed konjac-starch mixed gel replacing 70% of pork fat produced a similar product to pork liver pâté but with nearly 10% more water (Delgado-Pando, Cofrades, Ruiz-Capillas, Triki, & Jimenez-Colmenero, 2012). Then they reported the effect of an edible seaweed, Sea Spaghetti on the technological and sensory characteristics of reduced- and low-fat, low-salt (NaCl) frankfurters prepared with konjac gel as a fat substitute (Jiménez-Colmenero et al., 2010). Recently, they studied the effect of konjac gel on processing (Jiménez-Colmenero, Cofrades, Herrero, Fernández-Martín, et al., 2012, Jimenez-Colmenero, Cofrades, Herrero, Solas, et al., 2012) and chilled and frozen storage of meat products.

Konjac powder added in different ways and concentrations has also been used to reduce fat in products by other researchers (Chin, Keeton, Miller, Longnecker & Lamkey, 2006; Chun, 2004; Hsu & Chung, 2000; Hsu & Sun, 2006). There is little publication of the literature on application of konjac gel to partially replace fat in mayonnaise.

The study reported here aims to compare three kinds of konjac gel fat analogue applied in mayonnaise through TPA and chroma analysis. The ultimate aim is to determine effect of substitution ratio on appearance, rheological, microstructure, and storage stability of mayonnaises.

2. Materials and methods

2.1. Materials

Konjac glucomannan (KGM) was purchased from Yi Zhi Konjac Biotechnology Co. Ltd., Hubei, China. Sodium carbonate citric acid and potassium sorbate were purchased from Sinopharm Chemical Reagent Co. Ltd., Beijing, China. Soybean oil, egg yolk, vinegar, salt and sugar were purchased from a local supermarket.

2.2. Preparation of konjac gels and fat analogue

Konjac glucomannan was dispersed into water by mechanical stirring for 10 min at low speed. Na_2CO_3 solution was added to induce gel formation, mixed at low speed for 3 min, and high for 5 min. After 4 h quiescent standing, the mixture was heated in water bath at 100 °C for 1 h to obtain heat-stable gels. Subsequently the gels was cut into small pieces, placed in boiling water for 10 min, and soaked in 0.2% citric acid solution for 10 min. After that the pieces were subjected to crushing, grinding, and centrifugation (2862 g, room temperature, 20 min) to obtain fat analogue.

2.3. Preparation of the mayonnaise

The water phase was first prepared by mixing all of the ingredients apart from the oil. The oil was then carefully mixed with the water phase. The control ingredient of mayonnaise was soybean oil (80 wt%), egg yolk (8 wt%), vinegar (8 wt%), salt (2.2 wt%), sugar (1.7 wt%) and potassium sorbate (0.1 wt%). To choose an appropriate ratio of KGM-Na_2CO_3, three combinations: 4 wt%-0.36 wt% (S1), 3.5 wt%-0.36 wt% (S2) and 3.0 wt%-0.36 wt% (S3) were considered in the preparation of konjac gels which were applied as fat analogue. Soybean oil was replaced by fat analogue at levels of 40% of total oil used. After determining the combination, the soybean oil was replaced by fat analogue at levels of 0% (R0), 10% (R10), 20% (R20), 30% (R30), 40% (R40), 50% (R50) and 60% (R60), respectively.

2.4. Texture analysis

Texture measurements were carried out using a TA-XT plus Texture Analyser (Stable Microsystems Ltd., Surrey, England). The samples were carefully placed into cylindrical containers. Ten repeats per sample were axially compressed to 50% of their original height with probe P/35. A 50-kg load cell was used at a crosshead speed of 1 mm/s.

2.5. Colour measurements

Objective colour CIE-LAB tristimulus values, L^* (lightness); a^* (red green axis), and b^* (yellow blue axis) parameters of the samples were evaluated on a colorimeter (UltraScan XE HunterLab, USA). Ten determinations were performed from each sample. Before use, the colorimeter was standardized using a white calibration plate. Parameters were as follows Mode: RSIN; Area view: small; Port size: 9.5 mm; UV filter: nominal. When mentioned colour difference (ΔE), S0 was defined as control. The changes of parameters were expressed as ΔL^*, Δa^*, Δb^*, respectively. ΔE is the total colour change calculated as below:

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

2.6. Dynamic rheometry measurements

Dynamic rheological experiments were performed in a controlled-stress AR2000ex rheometer (TA instrument Co. Ltd., UK). The measurements were carried out using parallel plate geometry (40 mm in diameter and 1 mm gap). A thin film of methyl silicone oil was gently applied to the edge of each exposed sample in order to prevent moisture loss. Samples were allowed to relax for 5 min before performing rheological measurements as equilibration time. The measurements were made at 25 °C.

A dynamic frequency sweep was conducted from 0.1 to 10 rad/s for each sample using a constant strain of 0.5% (within the linear viscoelastic region). Changes in storage modulus (G') and loss modulus (G'') were recorded.

The steady-state flow curve recorded within a 0.5% tolerance for shear rate variation between two consecutive step shear stresses, in the shear rate range between 0.01 and 10 s^{-1}. Some of the measurements were carried out in triplicate. The reproducibility of the results was quite good.

2.7. Optical microscope observation

The microslide was coated with mayonnaise sample and placed on the stage of DME-2H35 (Leica, Germany). The pictures of the mayonnaise microstructure were obtained by a digital camera connected with the microscope.

2.8. Determination of composition and caloric values of mayonnaise

The amounts of moisture, crude fat, protein and ash in the mayonnaise samples were measured by Chinese standards GB/T 5009.3-2003, GB/T 5009.5-2003, GB 5009.5-2010 and GB 5009.4-2010, respectively. Carbohydrate was determined by subtracting the sum of moisture, protein, fat, and ash percentages from 100%.

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