The Preparation and Characterization of Bifunctional Sago Starch as Emulsifiers and Stabilizers in Low Fat Mayonnaise

Nurul Atikah Muhammad Taha, Muhammad Abrar Mohd Tazri, Sabrina Mohd Yusof, Muhammad Adib Fadhlullah Muhammad Lukman,

Nursakinah Md Hazir2, Azwani Shah Mat Lazim

1PERMATApintar™ College, Universiti Kebangsaan Malaysia (UKM)

²School of Chemical Sciences and Food Technology, Universiti Kebangsaan Malaysia (UKM),

43600 UKM Bangi, Selangor, Malaysia

Abstract

Mayonnaise is one of the most popular types of condiments in the world. However, it contains a high amount of fats and cholesterol which is up to 70% to 80%, heightening the risk of heart disease and obesity. The aim of this research is to create a low fat mayonnaise with the aid of modified sago starch as the emulsifier to satisfy the demands of healthier and more nutritious food. The research was conducted through literature review and producing various formulations of mayonnaise. This includes formulations eliminating egg yolk, substituting egg white with egg yolk, addition on 10% sago starch solution and addition of 20% sago starch solution. The physicochemical properties tested included parameters such as: pH, fat content, and emulsion stability of the formulations. It is found that sago starch emulsified and stabilized the mayonnaise solution while reducing its fat content. This is achieved by partially replacing egg yolk with modified sago starch in a reduced-fat mayonnaise formulation with a significantly reduced oil content. It is found that 20% sago starch solution with egg white replacing egg yolk in a reduced oil formulation produces a mayonnaise with the most similar viscosity as commercial mayonnaise. Thus, healthy low-fat mayonnaise is successfully created with the aid of sago starch as an emulsifier and stabilizer.

*Keywords*: Sago starch, emulsifier, stabilizer, cholesterol, mayonnaise

The Preparation and Characterization of Bifunctional Sago Starch as Emulsifiers and Stabilizers in Low Fat Mayonnaise

Mayonnaise is infamous for its high fat content. However, its richness is also the reason why it is loved among people of all ages. The high fat content in mayonnaise is due to its two main ingredients which are egg yolk and oil. Eggs and oil cannot be mixed. Therefore, an emulsifier and stabilizer is needed to combine the two ingredients and maintain its structure. Lecithin has emulsifying properties and is naturally found in egg yolk. Therefore, egg yolk is commonly the emulsifier of mayonnaise. Unfortunately, egg yolk contains a high amount of fats and cholesterol making it unhealthy. Consequently, those on diet or susceptible to heart disease choose to exclude mayonnaise from their meals and avoid it entirely.

The research is conducted to produce a low fat mayonnaise with the aid of sago starch as an emulsifier and stabilizer. It is desirable to replace egg yolk as the emulsifier due to the health risks it brings. Oil content should also be reduced to satisfy the demand of heathier food. The research also aims to achieve the best formulation of mayonnaise which is most similar to its commercial counterpart in terms of taste, colour, smell and viscosity.

This research will attempt to discover the most suitable formulation of low fat mayonnaise. In the study, egg yolk will try to be eliminated. It is expected that modified sago starch will be able to emulsify and stabilize the formulation in the place of egg yolk.

**Literature Review**

Egg yolk in mayonnaise must be reduced. One problem with egg yolk is that it has a very high cholesterol level. Medical authorities have determined that having a high level of cholesterol inthe blood is susceptible to heart attacks. To avoid the risk of heart disease, many, especially those with high blood cholesterol levels, have reduced their consumption of products containing high levels of cholesterol, including egg yolk. Accordingly, the reduction of egg yolk from mayonnaise to reduce its cholesterol content would be highly desirable.

Egg yolk also may reduce the period mayonnaise can be stored due to the susceptibility of egg to microbiological spoilage. More particularly, egg yolk may contain certain microorganisms prior to its use in mayonnaise which may ultimately contaminate the entire mayonnaise product, especially after the consumer has opened it. Mayonnaise, therefore, generally may have a shortened shelf life. The elimination of egg yolk from mayonnaise-type products would, therefore, benefit that product's storage capability. (Dartey, Trainor, & Evans, 1998).

Modified starches from different sources are usually used as thickening agents to provide desired structures in food products (Ghazaei, Mizani, Piravi-Vanak, & Alimi, 2015). Therefore, sago starch is used to emulsify the mayonnaise without egg yolk. The low-cholesterol mayonnaise hassimilar viscoelastic properties when compared to commercial mayonnaise. (Antonio & Ball Jr. 2007).

A modified starch having emulsification properties whose emulsions are characterized by improved stability and resistance to oiling and gelling during storage, comprising a starch derivative containing a hydrophobic group or both a hydrophilic group and a hydrophobic group, of which up to 70%, by weight, has been degraded by an exo-enzyme capable of cleaving 1,4-alpha-D-glucosidic linkages from non-reducing ends of the starch but incapable of cleaving 1,6-alpha-D-glucosidic linkages of the starch. This also the reason we use sago starch as emulsifier to the mayonnaise. It can keep the viscosity of the mayonnaise while reducing the fats.

 The rheological behaviour of six sample of sago starch of 4% (w/w) paste were studied at 30°C, 40°C, 50°C, 60°C and 70°C and it was found that the rheological and viscosity of were inversely related to the temperature and they showed different temperature sensitivity but their granules are essentially identical in size and configuration . Still there is a lack in the Literature regarding the rheological behaviour of sago starch protein- starch mixture. Kyaw et al. used sago starch with fish to starch ratio of 0:100, 10:90, 15:85, 30:70 and 50:50, respectively with added water in the percentage of 0, 10, 15, 20, 30, 50 and 70% and found that an increase in the viscoelasticity of the product was corresponded to the ratio of fish to starch added (F/S).

Dextrose equivalent is defined as total percentage of invert sugar in solid glucose syrup. Therefore, increasing in the invert sugar level will also increase DE value. The level of sweetness can be divided into three levels: low if the DE is 26-29%, high if the DE is 40-45%, and sweetest if the DE is 56-64% (Jacobs, 1944). A converted gelling starch suitable for use as a fat- and/or oil-replacement in foodstuffs, characterized in that the starch has a dextrose equivalent (DE) of less than 5 and characterized in that aqueous dispersions thereof at 10-50% by weight of starch solids have a hot flow viscosity of at least about 10 seconds at 55° C. and are capable of forming gels having a strength of at least 25 g. within 24 hours at 4° C. (Lenchin, Trubiano, & Hoffmann, 1984)

**Methodology**

**Preparation of Mayonnaise**

All ingredients were purchased at a local grocery store. Reduced fat mayonnaise samples were formulated as a mixture of about 2.2% sugar, 1.0% salt, 1.5% mustard, 0.07% Potassium Sorbate, 0.03% Sodium benzoate, and 9% vinegar using a previous research (El-Bostany, Nahla, Gaafar, & Salem, 2011) as a guideline. The eggs, sago starch, and oil were used in different samples as shown in [Table 1](http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0101-20612015000100150#t01).

The egg yolk and egg white is separated and used according to the formulation. They are partially heated before being added to the mayonnaise mixture to kill bacteria, reduce spoilage and diminish unwanted smell. Starch solution is produced by mixing an exact ratio of distilled water and sago starch. The mixture is heated and with a hotplate and stirred. Unlike the past research by El-Bostany et. al. (2011), which homogenized the mayonnaise while slowly adding oil in sections and used a standard mixer, this study prepared mayonnaise by mixing all ingredients beforehand and using a homogenizer. This is to create a thicker viscosity similar to that of mayonnaise. The mayonnaise is homogenized at speed 4 then slowly raised to speed 7 for five minutes or until completely homogenous. The samples are then put into plastic containers and labelled.

The samples are analysed by the following physicochemical tests in triplicates using a research by Ghazaei et. al. (2015) as a guideline.The results are expressed as mean ± standard deviation. Data followed by the same letter in a column are not significantly different. Samples are classified by percentage of egg yolk in each formulation.

Table 1

*Ingredients*

|  |  |
| --- | --- |
| Ingredients | Quantity |
| Use basic ingredients (oil, egg white, egg yolk) | Oil (ml) | Egg White (g) | Egg Yolk (g) |
| 20 | 50 | 50 |
| 40 | 40 | 40 |
| 60 | 30 | 30 |
| 80 | 20 | 20 |
| Egg yolk, 0 g | Oil (ml) | Egg White (g) | Egg Yolk (g) |
| 20 | 100 | 0 |
| 40 | 80 | 0 |
| 60 | 60 | 0 |
| 80 | 40 | 0 |
| Oil, 100 ml | Oil (ml) | Egg White (g) | Egg Yolk (g) |
| 100 | 0 | 20 |
| 100 | 10 | 10 |
| 100 | 20 | 0 |
| Egg white and egg yolk solution | Oil (g) | Egg (g) | Starch (g) |
| 30 | 45 | 30 |
| 50 | 25 | 30 |
| Replace egg yolk with starch | Oil (g) | Egg White (g) | Starch (g) |
| 65 | 45 | 10 |
| 60 | 40 | 20 |
| 50 | 40 | 30 |
| 55 | 30 | 35 |
| Egg white and Egg Yolk Solution + Starch Solution | Oil (g) | Egg (g) | Starch Solution (g) |
| 60 | 40 | 20 |
| 50 | 25 | 45 |
| Egg white + starch solution | Oil (g) | Egg White (g) | Starch Solution (g) |
| 60 | 40 | 20 |
| 50 | 40 | 30 |
| 55 | 30 | 35 |
| Starch solution (10% concentration), total mass 66 g | Oil(g) | Egg White (g) | Starch Solution (g) |
| 60 | 40 | 20 |
| 50 | 40 | 30 |
| 55 | 30 | 35 |
| Starch solution (20% concentration), total mass 66 g | Oil (g) | Egg White (g) | Starch Solution(g) |
| 30 (45%) | 16 (25%) | 20 (30%) |
| 27 (40%) | 16 (25%) | 23 (35%) |
| 24.5(37%) | 17 (25%) | 24.5 (37%) |
| 23 (35%) | 16 (25%) | 27 (40%) |
| 20 (30%) | 16 (25%) | 30 (45%) |

**Chemical Analyses**

The pH of the mayonnaise samples was lowered by putting 10% of vinegar in the mayonnaise. This to longer the shelf-life of mayonnaise. Apart from that, 0.07% of Potassium sorbet (E202) and 0.03% of Sodium Benzoate (E211) were put into the mayonnaise as preservative. The percentage and type of preservatives used are similar to that of commercial mayonnaise.

**Emulsion Stability**

Samples were left in room temperature for few days and the condition was observed every day.

**Sensory Evaluation Tests**

Sensory characteristics including taste, color, odor, viscosity, or consistency, texture, appearance, and overall acceptability were evaluated by based on a 9*-*point Hedonic scale (1 as the lowest and 9 as the highest score) . The mayonnaise samples were served at room temperature in plastic cups. Four panelists were requested to assess the samples according to the parameters stated in the sensory evaluation score sheet.

**Optical Microscopy**

A reflective optical microscope was used to investigate the microstructure of the mayonnaise samples. A drop of each sample was placed in the microscope glass slide, which was observed at a magnification of 40×.

**Results and Discussion**

Stabilizers are used to keep the emulsion stable. The finer or smaller the particles within the emulsion are, the less likely it is to separate but some separation nearly always happens over time. The use of a stabilizer prevents this to happen. Starch and egg white are the most commonly used stabilizers. The starch makes it more difficult for the emulsion to separate. Egg white has a similar effect. Table 2 shows the results of different ingredients.

Table 2

*Results of Different Ingredients*

|  |  |
| --- | --- |
| **Ingredients** | **Results** |
| Use basic ingredients (oil, egg white, egg yolk) | Oil and egg separated. 3 different layer produced after several days. |
| Egg yolk, 0 g | White. Oil layer separated. Clumpy and oily after few days. |
| Oil, 100 ml | Yellow. Oil separated. White layer at bottom of beaker. Sediment formed. |
| Egg white and egg yolk solution | Oil separated. |
| Replace egg yolk with starch | Become solid and does not flow. Thick and concentrated. |
| Egg white and egg yolk solution + starch solution | Oil and egg separated. |
| Egg white + starch solution | Become oily and separated. |
| Starch solution (10% concentration) | White and does not separate. Concentration too low. |
| Starch solution (20% concentration) | White and does not separate. Thicker concentration. Has same viscosity and colour as real mayonnaise. |

Mayonnaise emulsion without egg yolk cannot stabilize and oil is separated over time. However, as egg yolk is replaced with sago starch solution with a specific concentration, the emulsion stabilized and perfect viscosity was achieved with 20% concentration of sago starch solution. Egg yolk is replaced with egg white to reduce fat and cholesterol content while maintaining the hint of egg flavour in the mayonnaise. The oil content is also successfully reduced to 35%. Overall, the percentage of the best formulation is 40% of 20% concentration of sago starch, 35% of oil and 25% of egg white. The mayonnaise had similar colour and viscosity to commercial mayonnaise, does not separate after long periods of time and can be kept at room temperature for up to one week with the aid of preservatives. Thus, sago starch can replace egg yolk and reduce oil content in mayonnaise resulting in the creation of a low-fat mayonnaise.

**Conclusion**

An emulsifier and a stabilizer is needed to combine the two main ingredients of mayonnaise which are eggs and oil. Starch has emulsifying properties and can maintain its structure. Low-fat mayonnaise with no egg yolk have been produced using egg white, low content of oil, and starch solution.In this research, sago starch is used as mayonnaise emulsifier and stabilizer.Egg yolk was partially replaced with modified sago starch and egg white in a reduced-fat mayonnaise formulation to overcome the problems associated with high cholesterol and induced allergic reactions. Thus, a low fat mayonnaise which has a significantly lower level of fats is successfully created with the aid of modified sago starch solution.

References

Antonio F. Guerrero and Hershell R. Ball Jr. 2007. Effect of Spray-Dried Or Reduced-Cholesterol Yolk And Temperature On The Linear Viscoelastic Properties Of Mayonnaise. [*Journal Of Texture Studies*](http://onlinelibrary.wiley.com/journal/10.1111/%28ISSN%291745-4603)[*Vol 25 Issue 4*](http://onlinelibrary.wiley.com/doi/10.1111/jts.1994.25.issue-4/issuetoc)*.*

Clemence K. Dartey, Thomas M. Trainor,Richard Evans 1998. Low Cholesterol Mayonnaise Substitute and Process for Its Preparation*.* [*A23L27/60*](https://www.google.com/url?id=DhYuBAABERAJ&q=http://web2.wipo.int/ipcpub/&usg=AFQjCNER44F5jlVoswCkvW3YEcB5lW4moA#refresh=page&notion=scheme&version=20130101&symbol=A23L0027600000)*,*[*A23D7/00*](https://www.google.com/url?id=DhYuBAABERAJ&q=http://web2.wipo.int/ipcpub/&usg=AFQjCNER44F5jlVoswCkvW3YEcB5lW4moA#refresh=page&notion=scheme&version=20130101&symbol=A23D0007000000).

Dalton, Louisa (November 2002). ["Food Preservatives"](http://pubs.acs.org/cen/science/8045/8045sci2.html). *Chemical and Engineering News.*

Depree, J. A., & Savage, G. P. (2001). Physical and flavor stability of mayonnaise. *Trends in-Food Science & Technology, 12*(5-6),157-163.

El-Bostany, A. Nahla, Ahmed, M. Gaafar, and Amany, A. Salem (2011). Development of Light Mayonnaise Formula Using Carbohydrate-Based Fat Replacement. *Australian Journal of Basic and Applied Sciences, 5*(9):673-682.

Hockergard, A. (2011). The freeze-thaw stability of mayonnaise and the effect of octenyl-succinic anhydride modified starch as emulsifier .*School of Natural Sciences, Linnaeus University. Kalmar, Suécia*

Julianne M. Lenchin, Paolo C. Trubiano, Stella Hoffmann (1984). Converted starches for use as a fat- or oil-replacement in foodstuffs. *PatentEP 0149258 A2*

Juszczak, L., Oczadły, Z., &Gałkowska, D. (2013). Effect of modified starches on-rheological properties of Ketchup. *Food Bioprocess Technology, 6*(5),1251-1260.

Mun, S., Kim, Y. L., Kang, C. G., Park, K. H., Shim, J. Y., & Kim, Y. R. (2009). Development of reduced-fat mayonnaise using 4alphaGTase-modified rice starch and-xanthan gum. *International Journal of Biological Macromolecules, 44*(5),400-407.

Shiva Ghazaei, Maryam Mizani, Zahra Piravi-Vanak, MazdakAlimi 2015. Particle Size and Cholesterol content Of A Mayonnaise Formulated By Osa-Modified Potato-Starch.*Food Sci. Technol (Campinas) Vol.35 No.1 Campinas Jan./Mar.*

Silva, G. O., Takizawa, F. F., Pedroso, R. A., Franco, C. M. L., Leonel, M., Sarmento, S. B. - S., & Demiate, I. M. (2006). Physicochemical characteristics of modified food starches -commercialized in Brazil. *Food Science and Technology (Campinas.), 26*(1),188-197.

Zhen, M., & Boye, J. I. (2013). Advances in the design and production of reduced-fat and-reduced-cholesterol salad dressing and mayonnaise: a review. *Food Bioprocess Technology, 6*(3),648-670.