



## Full Paper

# PRODUCTION OF MAYONNAISE FROM CORN OIL AND SOYAOIL USING SKIM MILK AS EMULSIFIER

O. C. Otitoola

Department of Science Laboratory Technology  
Federal Polytechnic  
Ede, Nigeria  
[lolaotitoola@yahoo.com](mailto:lolaotitoola@yahoo.com)

C. T. Akanbi

Department of Food Science And Technology  
Obafemi Awolowo University  
Ife, Nigeria

## ABSTRACT

The objective of this study was to investigate the use of skim milk as an emulsifier in salad dressings and to compare its chemical, rheological and sensory properties with egg yolk based mayonnaise. Mayonnaises were produced (with or without gum) from corn oil and soya oil using egg yolk or skim milk as emulsifiers. The emulsification capacity (EC) of the emulsifiers, proximate composition, rheological and sensory properties of the mayonnaises were determined. The emulsification capacity was 50 and 57% for skim milk and egg yolk respectively. Addition of 0.2% sodium carboxyl methylcellulose increased the EC to 86 and 90% respectively. Moisture, protein, fat, sugar and starch of the samples were found to be in the range of 17.2-47.7%, 0.4-2.0%, 11.0-70.0%, 1.0-13.0 and 0.4- 6.1%. Egg yolk based dressings were more viscous (216-315Nms<sup>-2</sup>) than skim milk based dressings (90-216Nms<sup>-2</sup>), although all products were found to be pseudo plastic. The results of sensory evaluation showed that egg yolk based dressings were preferred for such quality attributes as smoothness, texture, hand feel and mouth feel. However there was no significant difference (P<0.05) between skim milk based dressings and egg yolk based dressings in terms of taste, colour and flavour.

**Keywords:** salad dressing, rheology, emulsifying property, proximate composition, sensory evaluation.

## 1. INTRODUCTION

Mayonnaise is a stable emulsion consisting of oil, egg yolk with vinegar or lemon juice, condiments and spices. The emulsion is formed when the egg yolk coats the tiny droplets of oil in suspension thereby preventing it from separating out. Mayonnaise is generally regarded as a high-fat and energy-dense food because the oil content of a traditional mayonnaise is more than 65% (Depree and Savage, 2001). Research has found a positive association between high dietary fat consumption and development of chronic heart diseases and cancer. Several studies have been conducted to reduce the fat content of mayonnaises using fat replacers (Worrasinchai et al. 2006; Liu et al., 2007). Oat dextrin (Shen et al., 2011), polysaccharide gums (Su et al., 2010) and enzyme (4-alpha-glucanotransferase) treated rice starch (Mun, et al, 2009) have been used as fat replacers in low fat mayonnaise and the fat content was reduced to half that of the conventional mayonnaise. It is important to know that while reducing

the fat content of mayonnaise, the quality attributes (such as flavor and taste) contributed by fat in the mayonnaise is also reduced (Su et al., 2010).

Although egg is the emulsifier used in mayonnaise it has been found to contribute significantly to high blood cholesterol as it contains a substantial amount of cholesterol which is naturally produced in the body. In traditional mayonnaise gums are generally used as emulsion stabilizers. Apart from stabilizing emulsion, gums are used for suspension of particulates and control of crystallization, inhibition of syneresis, encapsulation, formation of films and thickening in various industries (Benhura and Marume; 1993). Studies have shown that groundnut protein isolate; soybean isolate and casein also have good emulsifying properties and could be used as emulsifiers in mayonnaise production (Ramanathan et al., 1978). Low calorie dressings have been developed using milk and locust bean as stabilizers (Chiralt et al., 1992) however, not much information is documented on the physico-chemical, rheological and sensory properties of mayonnaise produced with skim milk as alternative emulsifiers. This study sought to bridge the gap.

## 2. MATERIALS AND METHODS

### 2.1. Materials

The ingredients used in the study included vinegar (8% acetic acid) and mustard cream, which were purchased from Leventis stores in Ibadan, Nigeria. Soybean oil and corn oil were obtained from Foodco supermarket, Ibadan. Sugar and salt were purchased from a local market in Ife. Skim milk powder was obtained from UTC stores, Ibadan. Eggs were obtained from Agricultural farms of the Obafemi Awolowo University and Sodium carboxyl methylcellulose from Neimeth Plc Lagos. All ingredients purchased were of standard quality and grade.

### 2.2. Preparation of the mayonnaises

The oil in water emulsions were prepared as presented in Table 1. These emulsions were prepared as described by Tressler and Sultan (1975) and Li -Hsieh and Regenstein (1991). The liquid phase containing the egg yolk (or skim milk powder), water, mustard cream, sugar and salt was blended into a smooth paste at speed 2 using Kenwood mixer for 2 minutes (during which sodium carboxyl methyl cellulose was added for emulsions with gum). The oil was then added while blending for 5 minutes after which vinegar was added and blended for 1 minute. The emulsions were filled manually in bottles with caps, sterilized at 121°C for 15 minutes, cooled with chilled water then stored at between 8-10°C inside a refrigerator. Fig 1 shows the processing steps involved in the production of the mayonnaises.

### 2.3. Emulsification capacity of the emulsifiers

Emulsification Capacity (EC) of egg yolk and skim milk powder was determined by the method described by Yasumatsu et al. (1972). About 3.5g of each emulsifier was dispersed in 50ml of water followed

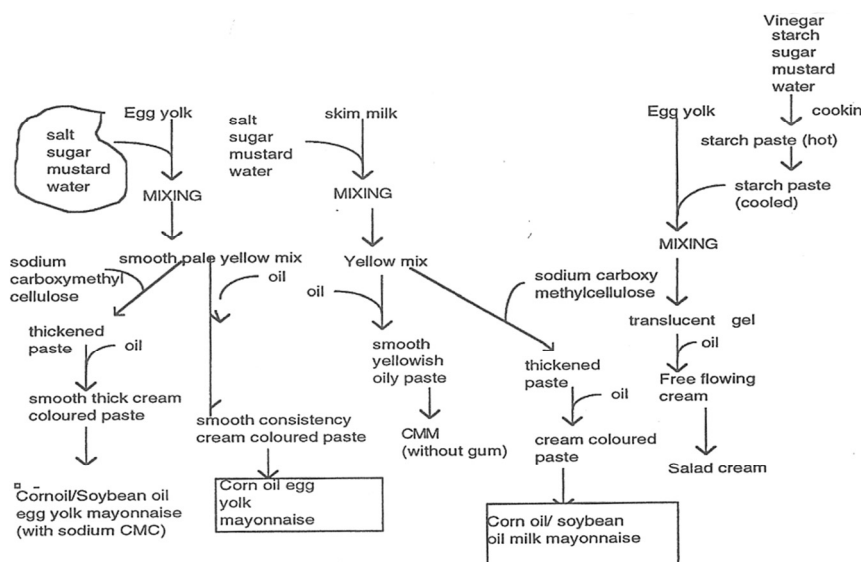


Fig 1: Processing steps in dressing production

Table 1 Percentage Composition of Mayonnaise

	CEM	CMM	CEM*	CMM*	SEM	SMM*
Corn oil	78.5	65.09	72.70	59.25	-	-
Soya oil	-	-	-	-	72.79	59.25
Egg yolk	5.90	-	16.28	-	18.28	-
Skim milk	-	5.40	-	3.33	-	3.33
Mustard	0.30	0.30	0.29	0.30	0.29	0.30
Vinegar	4.80	7.88	5.81	5.93	5.81	5.93
Sugar	1.80	1.80	1.45	1.48	1.45	1.48
Salt	1.20	1.20	0.45	0.44	0.45	0.44
Water	7.50	18.33	3.00	28.14	3.00	28.14
Sodium CMC	-	-	0.02	0.02	0.02	0.02

CEM = Corn oil egg mayonnaise

CMM = Corn oil milk Mayonnaise

CEM\* = Corn oil egg mayonnaise (with Gum)

CMM\* = Corn oil milk Mayonnaise (with Gum)

SEM = Soya oil egg mayonnaise

SMM = Soya oil milk Mayonnaise

by the addition of 50ml of oil and the mixture was homogenized at 10,000rpm for 1.0 minute. Equal volume of the emulsion formed was filled into centrifuge bottle and centrifuged at 2,050 rpm for 10 minutes. The emulsification capacity was then expressed as:

$$EC = \frac{\text{Height of the emulsified layer}}{\text{Height of the total contents in the tube}} \times 100 \quad (1)$$

#### 2.4. pH of Mayonnaise

The pH values were measured at a temperature of 25°C using a pH meter

#### 2.5. Composition Analysis

The official methods of analysis (AOAC, 1995) was used for the determination of protein, fat and moisture while sugar and starch were determined calorimetrically by the phenol-sulfuric acid method of Dubois *et al.* (1956) and Joslyn (1970). Caloric values were calculated using Atwater.

#### 2.6. Rheological measurements

Rheological measurements of samples were made in a rheometer BS viscometer (Tokyo Keiki Co Ltd) equipped with rotors of varying sizes and numbers (1-7). Rotor 4 was used for the measurement. All the samples were kept at 25°C before measurement. The rheological properties of the samples were

measured at various speeds: 1000, 2000, 5000 and 10,000 rpm. The conversion table as contained in the operation manual for the model and rotor was used to obtain the viscosity in Nm/s<sup>2</sup>. The method of Chiralt *et al.* (1992) was used for thixograms. Thixograms were produced for each sample at 25°C, using rotor 4 during a 4 minute- shearing at 5 seconds interval to reach constant shear stress.

#### 2.7. Sensory evaluation

Sensory evaluation was carried out in the Department of Food science and Technology using a panel of eighteen assessors. Samples were assessed under normal illumination. Portions of 30g each of salad dressings were served in a randomized order within replicates and with respect to each assessor. The profiles – sourness, sweetness, saltiness, colour, mouth feel, hand feel, spread ability, texture, smoothness, consistency, flavour and overall acceptability- were assessed using five hedonic scale (1=dislike very much, 5=like very much). Values above 3 shows the samples were Data from hedonic assessment were averaged over all the panelists. The sample presentation order was randomized (Lin and Yeh, 2003).

#### 2.8. Statistical Analysis

All analyses were replicated thrice. Data were subjected to One-way Analysis of Variance (ANOVA). Comparison of means used Duncan’s multiple range tests. Differences of P<0.05 were considered to be significant. The statistical analyses were conducted using science analysis system (SAS)

### 3. RESULTS AND DISCUSSION

#### 3.1. Emulsification capacity

Table 2 shows the emulsification capacity (EC) of the two emulsifiers. The EC of egg yolk was higher than that of the skim milk. This shows that egg yolk will form a stable emulsion more easily than skim milk. However addition of 0.2% CMC almost doubled the emulsification capacity. This observation showed that the ability of skim milk to form a stable emulsion can be greatly improved by gum. Carboxymethyl cellulose has been shown to increase viscosity of syrups (Collins and Dincer, 1973). Another factor influencing emulsification capacity include rate of mixing (Hegarty *et al.*, 1963; Carpenter and Saffle, 1964; Swift *et al.*, 1961) which was believed to be due to the fact that increased speeds produced greater shear rate which decreased the particle size of the oil droplet (Carpenter and Saffle, 1964). The addition of sodium chloride has been shown to increase EC over a pH range of 7-10 but at lower pH 3-6 (the pH of



mayonnaise) the increase in EC was observed only at 0.1M NaCl concentration (Ramanathan *et al.*, 1978). This shows that the salt added to the mayonnaises has no effect on the emulsification capacity of the emulsifiers.

Table 2: Emulsification Capacity of the Emulsifiers

Emulsifier	% Emulsification capacity
Skim milk	50.00±0.41 <sup>b</sup>
Egg yolk	57.14±1.51 <sup>b</sup>
Skim milk with Na CMC*	86.21±0.69 <sup>a</sup>
Egg yolk with Na CMC*	89.89±0.48 <sup>a</sup>

\* Sodium carboxymethyl cellulose

Means with the same letter in the same row are not significantly different at  $p < 0.05$

### 3.2. pH of mayonnaise

The pH values of the mayonnaise are shown in Table 3. The pH of commercial mayonnaise was significantly lower than the prepared mayonnaises. Earlier studies had shown low fat mayonnaise to have higher pH than full fat mayonnaise due to the effect of the fat replacer used (Hathcox *et al.*, 1995). Su *et al.* (2010) observed the contrary, there was no significant difference between low fat mayonnaise and full fat mayonnaise.

Table 3: pH of Mayonnaise

Mayonnaise	pH
CEM*	4.17±0.01 <sup>c</sup>
CMM*	4.09± 0.02 <sup>c</sup>
SEM*	4.83±0.02 <sup>b</sup>
SMM*	4.97±0.01 <sup>a</sup>
CEM	4.76±0.05 <sup>b</sup>
CMM	5.11±0.03 <sup>a</sup>
Commercial Mayonnaise	3.77±0.02 <sup>d</sup>

CEM = Corn oil egg mayonnaise

SEM = Soya oil egg mayonnaise

CMM\* = Corn oil milk Mayonnaise (with Gum)

SMM = Soya oil milk Mayonnaise

CEM\* = Corn oil egg mayonnaise (with Gum)

Means with the same letter in the same row are not significantly different at  $P < 0.05$

### 3.3. Chemical composition and caloric values

The chemical compositions and caloric values of control (commercial mayonnaise) and prepared mayonnaises containing either egg yolk or skim milk are listed in Table 4. The moisture content of prepared salad dressings ranged between 17.24 and 46.30%. The moisture content of the prepared mayonnaise without gum (SEM and CEM) was very close to that of commercial mayonnaise (13.79%). These values agreed with 16.6% obtained earlier for full fat mayonnaise (Su *et al.*, 2010). The mayonnaises prepared with gum had moisture values of 26.1%-46.3%. These values were within the range reported in literature (Tressler and Sultan, 1975; Su *et al.*, 2010). Due to the high moisture content of the fat replacers (sodium carboxymethyl cellulose and skim milk) the moisture content of the samples increased (Su *et al.*, 2010; Akoh and Min, 2002). The high moisture content could encourage lipid oxidation of the mayonnaise during storage. The reported protein value for commercial mayonnaise was found to be 0.9%, while the prepared dressing ranged from 0.42-1.97%. Addition of some egg white could greatly upgrade the protein level of egg yolk based dressings, although a weak mayonnaise (which may break due to the diluted emulsifier) will be produced (Meyer, 1960). The fat content of the prepared dressings (40% -70%) compared well with Literature value, 41-80% (Shen *et al.*, 2011; Su *et al.*, 2010).

The sugar content of milk based dressing (2.0 -2.8%) was higher than that of egg yolk based dressing (1.0 -1.8%). This is due to the effect of lactose in skim milk. The starch content of dressing with gum (0.7 - 0.9%) was about twice those without gum (0.4%). The milk based mayonnaise had lower caloric values (379-494 kcal/100g) compared to the egg based mayonnaise (537-639kcal/100g). Similar

result was obtained for low fat mayonnaise, 385-398kcal/100g (Su *et al.*, 2010) and 598kcal/100g (Shen *et al.*, 2011). This shows that using skim milk as emulsifier could greatly reduce the caloric content of mayonnaise.

Table 4: Chemical Composition of Mayonnaise

Salad Dressings	Protein %	Fat %	Moisture %	Starch %	Sugar %	Energy kcal
CEM*	0.42	62.0	26.09	0.7	1.6	569
CMM*	1.15	47.0	36.75	0.8	2.8	442
SEM*	1.97	58.0	32.49	0.8	1.0	537
SMM*	1.60	40.0	46.30	0.9	2.0	379
CEM	0.49	70.0	17.24	0.4	1.8	640
CMM	1.20	53.0	17.50	0.4	2.8	495
Commercial Mayonnaise	0.90	57.0	13.79	0.4	1.8	628

CEM = Corn oil egg mayonnaise

SEM = Soya oil egg mayonnaise

CMM\* = Corn oil milk Mayonnaise (with Gum)

CMM = Corn oil milk Mayonnaise

SMM = Soya oil milk Mayonnaise

CEM\* = Corn oil egg mayonnaise (with Gum)

Means with the same letter in the same row are not significantly different at  $p < 0.05$

### 3.4. Rheological properties of mayonnaise

All samples exhibited similar flow behavior with relation to speed. Most protein dispersions exhibit pseudo plastic flow behaviour in which the fluid exhibit shear thinning over a wide range of shear stress. The results obtained compared well with literature (Ramanathan *et al.*, 1978). This shear rate thinning effect is due to the fact that in polymer dispersions, molecules are oriented and entangled when fluid is at rest. This random structure gives the system the tendency to maximize entropy. The material behaviour when sheared may be imagined to change over different shearing conditions. As the shear rate is increased, the asymmetric dispersed molecules tend to align themselves with the shear planes so that frictional resistance is reduced resulting in a decreased apparent viscosity (Collins and Dincer, 1973).

The thixogram curve is shown in Fig. 2. The dressings were found to be thixotropic. The shear stress decayed very quickly in the first minute of shearing and slowed afterwards (Chiralt *et al.*, 1992). After about 1.5 minutes the rate of decay became constant for dressings without gum. The thixogram obtained for dressings without gum similar to that of mayonnaise, though it took a longer time to reach equilibrium.

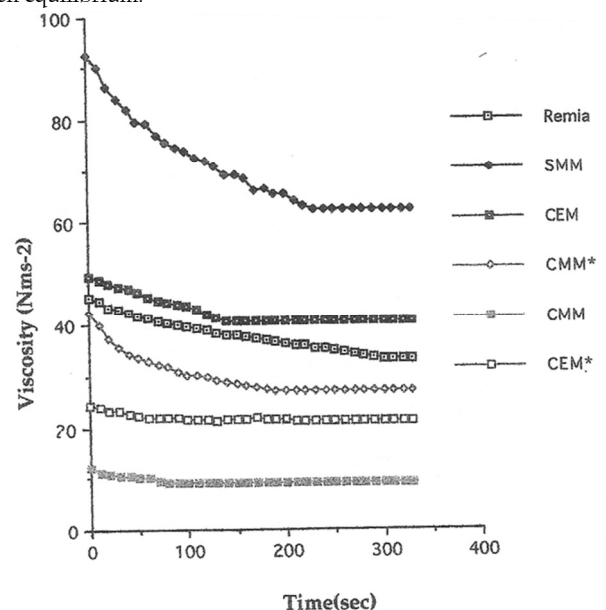


Fig 2. Thixogram curve of the salad dressings

### 3.5. Sensory properties of mayonnaise

The data for mean sensory scores of the quality attributes of the mayonnaise are listed in Table 5. The colour, taste and flavour of prepared mayonnaises were not significantly different ( $P < 0.05$ ) from the commercial mayonnaise. However, all samples were significantly different ( $P > 0.05$ ) in Textural attributes such as mouthfeel, smoothness, handfeel and consistency. In all quality attributes egg yolk mayonnaise was rated next to the commercial mayonnaise. Products of the same emulsifier were not significantly different ( $P < 0.05$ ) from each other in all quality attributes. Generally, all mayonnaises were acceptable to the panelists.

Table 5: The Means of Sensory Scores of Mayonnaise

Attributes	SEM	SMM	CEM	CMM	Commercial mayonnaise	F-value
Sweetness	2.42ab	1.81b	2.44ab	1.94b	2.78a	3.03
Saltiness	2.17a	2.19a	2.00a	1.81a	2.28a	0.64
Colour	3.31a	2.72a	3.25a	2.86a	2.56a	1.61
Mouth feel	3.33b	2.25c	3.28b	2.19c	4.16a	13.79
Hand feel	4.28b	2.78c	4.22b	2.70c	4.94a	31.83
Spread-ability	4.56a	3.67b	4.39a	3.66b	4.97a	5.32
Texture	4.03b	2.53c	3.47b	2.56c	4.76a	24.14
Smoothness	4.17b	2.83c	3.81b	2.94c	4.94a	22.55
Consistency	3.69b	2.67dc	3.22bc	2.25c	4.61a	20.68
Flavour	3.58b	3.00c	3.56b	3.67b	4.22a	6.38
Overall Acceptability	3.61b	2.92c	3.69b	3.33bc	4.44a	9.37

Means with the same letter in the same row are not significantly different at  $p < 0.05$

CEM = Corn oil egg mayonnaise

SEM = Soya oil egg mayonnaise

SMM = Soya oil milk Mayonnaise

CMM\* = Corn oil milk Mayonnaise

### 4. CONCLUSION

The rheological properties and chemical composition of salad dressings produced compared well with commercial mayonnaise. The egg yolk based dressings were found to be closer to the commercial mayonnaise in composition, rheological and sensory properties than the milk based dressings. The study has shown that skim milk could be used as an alternative emulsifier in mayonnaise. However the textural properties (to improve the mouthfeel) and the shelf life need further investigations.

### REFERENCES

Akoh, C. C. and Min, D. B., *Food Lipids*. Marcel Dekker, New York, 2002.  
 AOAC *Official Methods of Analysis of the Association of Analytical Chemists* (15th edn). AOAC, Washington, DC, 1995.  
 Benhura, M.A.N. and Marume, M., Emulsifying properties of the mucilage extracted from Ruredzo (*Dicerocarum zanguebarium*). BSSC Biotechnology-Biochemistry Journal 57(12):1995-1998, 1993.

Carpenter, J.A. and Saffle, R.L., Simple method of estimating the emulsifying capacity of various sausage meats. *Journal of Food Science*. 29:774-781, 1964.  
 Chiralt A., Ferragut, V. and Salazar J.A., Rheological characterization of low-calorie milk based salad dressings. *Journal of Food Science* 57(1):200-202, 1992.  
 Collins, J.L.D. and Dincer, B., Rheological properties of syrups containing gums. *Journal of Food Science* 38:489-492, 1973.  
 Depree, J.A. and Savage G.P., Physical and flavor stability of mayonnaise. *Trends Food Sci Technol* 12:157-163, 2001.  
 Dubois, M.K.A., Gilles, J.K., Hamilton, P.A.R. and Smith, F., Colorimetric method for determination of sugars and related substances. *Anal. Chem.* 28:350-356, 1956.  
 Hathcox, A. K., Beuchat, L.R. and Doyle, M.P., Death of enterohemorrhagic *Escherichia coli* O157:H7 in real mayonnaise and reduced-calorie mayonnaise dressing as influenced by initial population and storage temperature. *Appl Environ Microbiol* 61:4172-4177, 1995.  
 Hegarty, G.R., Batilzer, L.J. and Pearson, A.M., Studies on the emulsifying properties of intercellular beef muscle protein. *Journal of Food Science*. 28:663-668, 1963.  
 Joslyn, A. M. *Methods in Food Analysis*. 2<sup>nd</sup> ed. A series of monographs. Academic Press NewYork, 1970.  
 Li Hsieh, Y.T. and Regenstein, J.M., Factors affecting quality of oil mayonnaise. *Journal of Food Science* 56(5):1298-1301, 1991.  
 Lin, C.S. and Yeh, R.Y., *Application and Practice of Sensory Evaluation*. Rui Yu, Taipei, Taiwan, 2003.  
 Liu, H., Xu, X.M. and Guo, S.D., Rheological, texture and sensory properties of low-fat mayonnaise with different fat mimetics. *LWT Food Sci Technol* 40:946-954, 2007.  
 Meyer, L. H., *Oils and fat in Food Chemistry*. 3<sup>rd</sup> edition Reinhold, New York, 1960.  
 Mun, S., Kim, Y.L., Kang, C.G., Shim, J.Y. and Kim, Y.R., Development of reduced fat mayonnaise using 4 alphaGTase-modified rice starch and Xanthan gum. *Int J Biol Macromol* 44(5):400-407, 2009.  
 Ramanathan, G., Ran, L.H. and Urs, L.N., Emulsification of groundnut protein. *Journal of Food Science*. 43:1270-1273., 1978.  
 Shen, R., Luo, S. and Dong, J., Application of oat dextrin for fat substitute in mayonnaise. *Food Chemistry* 126 (1):65-71, 2011.  
 Su, H.P., Lien, C.P., Lee, T.A. and Ho, J.H., Development of low-fat mayonnaise containing polysaccharide gums as functional ingredients *J Sci Food Agric* 90(5):806-812, 2010.  
 Swift, C.E., Lockett, C. and Fryer, A.J., Comminuted meat emulsions- The capacity of meats for emulsifying fat. *Food Technology Journal*. 15:468-473, 1961.  
 Tressler, D.K. and Sultan, W.J. *Mayonnaise and Salad dressing in Cereals baked goods dairy and egg products vol. 2 AVI Food Product Formulary Series*, 1975.  
 Worrasinchai, S., Suphantharika, M., Pinjai, S. and Jamnong, P.,  $\beta$ -Glucan prepared from spent brewer's yeast as a fat replacer in mayonnaise. *Food Hydrocoll* 20:68-78, 2006.  
 Xu, S.Y., Stanley, D.W., Golf, H.D., Davidson, V.J. and Magner, M.L., Hydrocolloid/ milk gel formation and properties. *Journal of Food Science* 57:96-102, 1992.  
 Yasumatsu, K., Sawad, K., Moritaka, S., Toda, J. and Ishi, K., Whipping and emulsifying properties of soybean products *Agricultural Biological Chemistry* 36:719-727, 1972.