AU J.T. 11(3): 154-158 (Jan. 2008)

Influence of Added Water and Konjac Flour as Fat Replacer on Some Quality Characteristics of Celery Mayonnaise

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Abstract

Some physical and sensory characteristics of celery mayonnaises prepared in three different oil reduction levels(50%, 60% and 70%) and added water incorporated with 0.4% konjac flour were investigated. When the percentage of vegetable oil reduction increased, there was a decrease in viscosity and firmness of light celery mayonnaises. Results from sensory analysis also showed a significant decrease ($p < 0.05$) in the scores for thickness, meltability, color and oiliness. The celery mayonnaise with 60% oil reduction exhibited no significant difference ($p > 0.05$) for thickness as compared to the control product.

Keyword: *Sensory analysis, vegetable oil, healing power, mimetics, flocculation, oil replacement.*

Introduction

Worldwide, varieties of mayonnaise have been consumed by serving with some dishes such as Takoyaki, Tyrolean ham cordon bleu, or tuna salad, and sometimes using as the base for many other chilled sauces and salad dressing. Celery mayonnaise is popular in the western world because of its herbal, astringent flavor and succulence. In addition, celery is good for health as it has healing power and curative properties such as the treatment of arthritis and regulation of the nervous system (Wikipedia 2007).

Commercial mayonnaises are more typically 70 - 80% fat content; consequently, food manufacturers are making it easier for fat-conscious consumers to have mayonnaise in low fat versions. "Low fat" mayonnaise products which contain starches, cellulose gel or other ingredients to stimulate the texture of real mayonnaise, can help adult consumers reduce their fat intake to recommended levels.

In response to these trends, many researchers have been extensively investigated on producing low fat mayonnaise with various fat replacers (Pons *et al.* 1994). The ideal fat replacer recreates all the desirable qualities of food fat, such as "mouth feel", texture and flavor, while also significantly reducing fat and calorie content. Cheung *et al.* (2002) reduced the fat content in mayonnaise from 30 to 10% and replaced by Avicel™, N Lite S™ and Simplesse™, three fat replacers classified as mimetics. The mayonnaises containing the replacers all had reduced viscosities and droplet size. Sensory profile analysis revealed the changes in the attributes of thickness, meltability, glossiness and oiliness. However, none of these changes seems to influence on consumer preference.

An easy approach for fat reduction in mayonnaise is to replace oil with water. However, the product has lower viscosity, uneven texture and poor quality eating. To minimize these undesirable effects, hydrocolloids have shown good fat mimetic properties because they can mimic the rheological sensation of fat in the mouth due to the binding and orientation of water in molecule (Yackel and Cox 1992). Konjac flour or gum, one of natural vegetable hydrocolloids, which produces from the tuber of elephant yam (*Amorphophallus* sp.), is generally used as a gelling agent, thickener, emulsifier and stabilizer in many areas of the food industry including: condiments, dairy products, beverages and many other low-fat food products (Tye 1991; Thomas 1997).

The aim of this work was to investigate the effect of oil replacement (50%, 60% and 70%) with water incorporated with 0.4% konjac flour on some quality characteristics of celery mayonnaise and compare them with a standard formulation.

Materials and Methods

Materials

Xanthan gum and konjac flour were purchased from the Thai Food and Chemical Co., Ltd. The mayonnaise ingredients including soybean oil, fresh eggs, fermented vinegar, distilled vinegar, lemon, mustard, sugar, pepper and celery were purchased from the local market.

Preparation of Celery Mayonnaise

The control and reduced-fat celery mayonnaise samples were formulated as shown in Table 1. Mustard, salt, sugar, lemon juice and vinegar were thoroughly mixed in the water and then blended with egg yolk and approx. 10% of the vegetable oil in a food processor for 5 min. Xanthan gum or xanthan gum/konjac flour mixture (previously dissolved in 50^{o}C water for 20 min) was also blended in, before gradually adding the remaining vegetable oil. After the addition of chopped celery and pepper, the mixture of all ingredients was blended for a further 5 min. The samples were kept in a refrigerator prior to analysis.

Experimental Design

Samples of celery mayonnaise were prepared in which 50, 60 and 70% of the vegetable oil content was replaced with water incorporated with 0.4% konjac flour. The physical and sensory characteristics of the light mayonnaise samples were evaluated compared with the control.

Physical Determination

Color: The color of all the samples was determined by using a ColorFlex colorimeter (Hunter Associates Laboratoy, Reston, VA). Values for L^* or lightness, a^* (redness / greenness) and b^* (yellowness / blueness) were recorded for three samples per batch by using a 25 mm aperture.

Firmness: The penetrometer (Model H-1200, Paul N. Gordner Co., Inc, USA) was used to measure the firmness of the samples. The selected needle of instrument was immersed into 250 ml of sample for 10 sec and the depth was measured in millimeter with greater depth indicating lower firmness. Data are mean of three measurements.

Viscosity: The viscosity was measured using a Brookfield viscometer Model RVDV-II (Brookfield Engineering Laboratories, Inc., USA) with a spindle no.7 at a speed of 1, 2.5, 10, 20, 50 and 100 revolutions per minute (rpm). For the study of viscosity and time relationship at constant shear rate, the sample was measured with the same spindle at 20 rpm for 0.5, 1, 2, 3, 4, 5, 10, 15 and 20 min.

Emulsion Stability: Emulsion stability was determined by modifying the method of Yang and Cotlerill (1989). Samples (25 g) were placed in polycarbonate centrifuge tubes and heated to 75^{O} C in a water-bath for 3 hr. Samples were removed from the water-bath, cooled and centrifuged at 4000 x g for 10 min (4^{O} C). After centrifugation, the amount of separated oil was measured. Oil separation percentage was calculated using the following equation: [(weight of separated oil / 25 g of mayonnaise sample) x 100].

pH: Sample (10 g) was placed in a beaker and measured by using a pH-meter (Model 320, Mettler-Toledo Ltd., Essex, UK).

Table 1. The formulations of celery mayonnaise.

Ingredients	Percentage by total weight			
	Control	M1	M2	M3
Vegetable oil	72.0	36.0	28.8	21.6
Egg yolk	5.0	5.0	5.0	5.0
Fermented vinegar	1.0	1.0	1.0	1.0
Distilled vinegar	3.0	5.0	5.0	5.0
Lemon juice	2.0	3.0	3.0	3.0
Sugar	6.0	6.0	6.0	6.0
Mustard	0.5	0.5	0.5	0.5
Salt	1.0	1.0	1.0	1.0
Pepper	0.1	0.1	0.1	0.1
Celery (chopped)	6.0	6.0	6.0	6.0
Xanthan gum	0.3	0.3	0.3	0.3
Water	3.1	35.7	42.9	50.1
Konjac flour	0	0.4	0.4	0.4

Control = a full fat celery mayonnaise.
M1 = a celery mayonnaise with the replacement of 50% vegetable oil with water incorporated with 0.4% konjac flour.
M2 = a celery mayonnaise with the replacement of 60% vegetable oil with water incorporated with 0.4% konjac flour.
M3 = a celery mayonnaise with the replacement of 70% vegetable oil with water incorporated with 0.4% konjac flour.

Sensory Evaluation

Twelve undergraduate students of the University of the Thai Chamber of Commerce were selected on the basis of their interest as participants and trained before assessment. A quantitative descriptive analysis (QDA) was used to evaluate sensory attributes for thickness, meltability, color, flavor and oiliness (Lawless and Heymann 1998). All tests were held in the UTCC sensory laboratory within separate booths.

Statistical Analysis

The statistical design for physical properties was a completely randomized design (CRD) while sensory data was conducted using the randomized complete block design (RCBD). Statistical treatment of the data was done by analysis of variance (ANOVA) using Statistical SPSS for Windows version 11.0. When data were significant at a level of 5%, Duncan's New Multiple Range Test (Cochran and Cox 1992) was used.

Results and Discussion

Physical Analysis

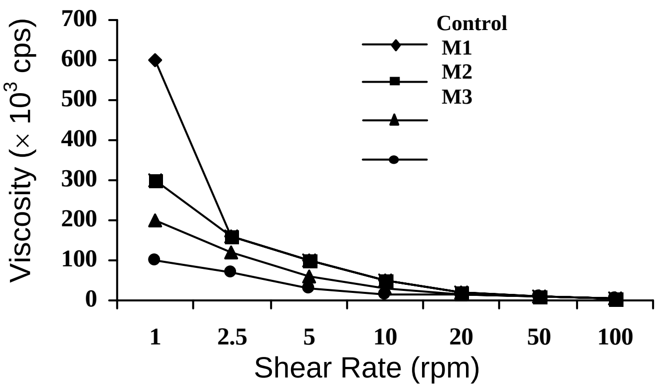
The physical properties of celery mayonnaise samples (control, M1, M2 and M3) are shown in Table 2. There were no significant differences ($p > 0.05$) on L^* values, a^* values and emulsion stability whereas significant differences ($p < 0.05$) were founded in b^* values, firmness and pH among all the samples. The control is the most yellowish in appearance while an increase in the percentage of oil replacement resulted in lower b^* values in the 'light' samples. M3 had the highest penetrometer value ($p < 0.05$), indicating a less viscous consistency or firmness, this was because of the dilution effect of water on thickness of the samples. The pH of the control sample was significantly higher ($p < 0.05$) than that of M1, M2 and M3, due to less vinegar and lemon juice content while the variation in pH among the 'light' samples is probably as a result of the buffering effect of the other ingredients.

Table 2. Physical properties of celery mayonnaises.

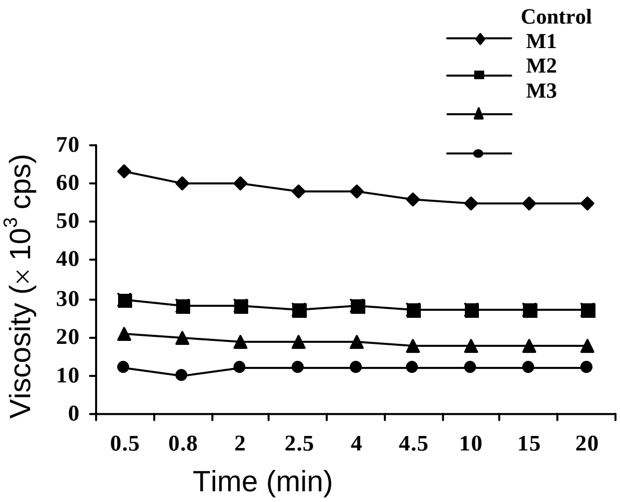
Vegetable oil reduction (%)	CIE color scales			Penetrometer value (mm)	pH	Emulsion stability
	L^{*ns}	a^{*ns}	b^*			
0 (Contr.)	83.66 ± 0.21	-2.43 ± 0.24	26.15 ± 0.16^a	143.00 ± 1.73^d	3.30 ± 0.02^a	NSO
50 (M1)	85.47 ± 0.3	-2.53 ± 0.23	23.18 ± 0.25^b	155.67 ± 0.58^c	3.25 ± 0.01^c	NSO
60 (M2)	84.72 ± 0.47	-2.46 ± 0.25	22.93 ± 0.28^b	170.67 ± 1.15^b	3.13 ± 0.01^d	NSO
70 (M3)	83.27 ± 0.18	-2.44 ± 0.20	22.45 ± 0.11^b	212.00 ± 6.93^a	3.27 ± 0.00^b	NSO

$^{a, b, c, d}$ Means in the same column with different superscripts are different (p < 0.05).
^{ns} = non-significant.
NSO = no separated oil.
CIE color scales: L^* =lightness (0 = black, 100 = white)
a^* = redness / greenness (+ = red,-= green)
b^* = yellowness / blueness (+ = yellow,-= blue)

According to the data shown in Fig. 1, the control had higher viscosity than the other samples. This shows that the reduction in oil content and the addition of water incorporated with konjac flour has a marked effect on this property. When the shear rate was increased, the viscosity of all the samples decreased, showing pseudoplastic behavior (Parede *et al.* 1989). This process can be explained by flocculation-deflocculation of the oil droplets in the aqueous continuous phase. As the shear rate was increased, the reaction shifts towards deflocculation thus lowering the apparent viscosity (Cheung *et al.* 2002).



(a) Viscosity changes at various shear rates.



(b) Viscosity changes at constant shear rate (20 rpm) with an increasing time.

Fig. 1. Viscosity changes of celery mayonnaises.

Results of Sensory Evaluation

The results of sensory analyses are given in Table 3. The control had the highest sensory score for thickness, meltability and oiliness, showing that the oil reduction have had an influence on the specific characteristic of mayonnaise. However, up to 60% of the oil reduction (M2), the sensory score for thickness was not significant difference ($p < 0.05$) compared with the control. This was because of water-holding capacity and thickening effect of konjac flour (Tye 1991).

The control had significantly more meltability than the other samples (p < 0.05). M1, M2 and M3 also were significantly different (p < 0.05) from each other in which the scores were subsequently reduced when percentage of the oil replacement was increased.

Table 3. Sensory scores of reduced-fat celery mayonnaises.

Vegetable oil reduction (%)	Sensory scores*				
	Thickness	Meltability	Color	Flavor[ns]	Oiliness
0 (Control)	6.94±1.57[a]	6.21±1.34[ab]	2.78±1.49[b]	4.71±2.72	7.10±1.07[a]
50 (M1)	5.98±1.35[a]	5.05±1.47[bc]	4.92±1.90[a]	4.82±1.83	5.02±1.44[b]
60 (M2)	5.68±1.92[a]	4.68±1.92[c]	5.92±1.74[a]	4.78±1.69	4.74±2.03[b]
70 (M3)	3.99±2.26[b]	4.48±2.27[c]	5.83±1.80[a]	5.03±1.91	4.00±2.42[b]

[a, b, c] Means in the same column with different superscripts are different ($p < 0.05$).
[ns] = non-significant.
* Based on a quantitative descriptive analysis (QDA) test (1 = none, 10 = strong).

Among the 'light' samples, the replacement of vegetable oil at the level of 50% and 60% showed no significant difference ($p > 0.05$) from each other in the scores of all attributes, except for meltability as mentioned above.

Panelists perceived that M3, with the highest percentage of the oil replacement, exhibited less quality eating, especially texture and fat-like mouth-feel. Also, it was observed that M3 produced a moist texture, affecting on the shelf life of the product (data not shown).

Conclusion

From the result obtained in this work it may be concluded that added water in conjunction with konjac flour could be used as fat replacer for producing light celery mayonnaises which have 60% of oil reduction.

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