The effect of different concentrations of vivapur MCG on the stability of fat–reduced, low–cholesterol mayonnaise emulsion

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Abstract

Mayonnaise is an oil – in – water emulsion which contains high amounts of egg and fat resulting in cardiovascular diseases as well as allergenic effects. The consumers, thus tend to use low – cholesterol, reduced – egg, reduced – fat mayonnaise. In this study, different concentrations of micro crystallized cellulose emulsifier coated with carboxy methyl cellulose (Vivapur MCG; 0, 25, 50, 70 and 100%) were substituted for different concentration of egg (0, 25, 50, 75, 100%) in the formulation of reduced – fat mayonnaise and the stability of the emulsion was examined by Ban Mary method and centrifuge. The results showed that the stability of all mayonnaise samples decreased significantly over time. By substituting 25% Vivapur MCG for egg in the formulation of mayonnaise, a low – cholesterol, reduced-fat mayonnaise could be produced which was not significantly different from the control sample after a 3- month storage.

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Introduction
Mayonnaise and dressings are semi-solid oil – in – water (O/W) emulsions which contain 70-80% fat as well as basic ingredients (vegetable oil, egg yolk, vinegar, lime juice) and additives (egg white, salt, spices, stabilizers, thickening agents, etc.) (Franco et al., 1995; Nikzade et al., 2012). Iranian national standard has specified three types of mayonnaise regarding the fat content: 1) ordinary mayonnaise with min. 66% fat, 2) reduced – fat mayonnaise with min. 25% fat reduction as compared to the ordinary one, 3) low-fat mayonnaise with 50% fat reduction as compared to the ordinary counterpart (Anonymous, 1992). Concerns about the harmful effects of taking excess amounts of certain lipids (e.g. cholesterol and saturated fats) on the consumers’ health have led to development of reduced – fat products. However, fat as a food component contributes to flavor, appearance and shelf-life of the food products. Thus, it is difficult to mimic the quality of classic products when manufacturing low-fat foods. Therefore, non-fat matters having different functional roles must be included in the formulation of reduced – fat products in replace of fats to provide the required quality properties (Mun et al., 2009).

Mayonnaise is produced by emulsifying edible vegetable oils as dispersed phase in continues liquid phase including vinegar. This o/w emulsion is stabilized by emulsifying compounds contained in egg yolk. Eggs have high nutritional value in human diet, containing proteins of high biological value, especially fatty acids, phospholipids, vitamins and minerals. Egg yolk is the most important emulsifier in mayonnaise and dressings (Laca et al., 2010). During past 30 years consumption of egg has been declined due to concerns about its high cholesterol content and allergenic effects (Paraskevopowou et al., 1997). It is important to provide egg substitutes for different groups of people. First, those people having high level of serum cholesterol because they are susceptible to increased cardiovascular diseases. Second, those people who are allergic to egg protein or any foods containing egg or its products. The third group includes vegetarians (Myers, 2005). Thus production of reduced – fat egg – free mayonnaise seems necessary. In products such as mayonnaise in which egg is used as emulsifier, using other emulsifiers along with egg yolk or as its substitutes seems useful (Nikzade et al., 2012). Emulsifier based on microcrystallized cellulose coated with carboxy methyl cellulose (Vivapur MCG) may be substituted for fat and egg. This compound is characterized by neutral taste, white or grey color or yellowish light brown powdery texture. It is also without any calories, gluten, phytic acid, and allergenic effects. This product has an 18-month self – life. It may be used in boiled sausages, cooked sausages, minced meat products, deep – freezing, ready – to – use products among others (Backe and Ungerer, 2013). To date various studies on reduced – fat mayonnaise have been carried out (Sue et al., 2009; Mun et al., 2009; Nikzade et al., 2012). However, no research has been conducted concerning the substitution of vivapur MCG. So, this study was aimed at investigating the effect of different concentration of Vivapur MCG on the stability of reduced – fat mayonnaise.

Material and methods
Liquid soy oil was obtained from Nastaran Company, eggs from Dasht – e – Eram cultivation & industry, drinking water, sugar from Amirkabir cultivation & Industry, salt from Iran zohreh salt company, mustard powder from GS – DUNN Co. Canada, Vinegar from Iran Khazar Liagol, citric acid from Jining foreign trading, china, xanthan from H-Quality Industries, China, guar from Jainsons Industries, India, cold process starch (CH₂) from Rucket Co. Germany and vivapur MCG from JRS, Germany (Table1).

Preparation of mayonnaise samples
To prepare reduced – fat mayonnaise samples, five treatments including control, 25%, 50%, 75% and 100% samples were developed. As shown in Table 1 all ingredients amounts used in all five samples were the same but water, egg yolk, and Vivapur MCG. The
control sample contained 100% egg yolk, 25% sample contained 75% egg yolk, and 25% Vivapur MCG. 50% sample consisted of 50% egg yolk and 50% Vivapur MCG. 75% sample contained 25% egg yolk and 75% Vivapur MCG and 100% Vivapur MCG. First different mayonnaise samples containing different concentrations of Vivapur MCG along with the control sample were prepared following the given formulation and Iranian National standard No. 2454. After 24 h of sample manufacture (5 samples), the test on the stability of emulsion was used. Two re-tests were performed after 1 and 2 months of production respectively. In order to produce mayonnaise samples, powdery components (salt, sugar, xanthan, citric acid, mustard, potassium sorbate, starch, sodium benzoate, guar and emulsifier Vivapur MCG) were weighed using a scale. Then egg was added to the laboratory mixer to which powdery ingredients and about one – third of water phase of the emulsion were added. Next oil was added gradually and in the mid – process, another one – third of water phase was added to the mixer (ultratharax, model T 810, Germany) at 10000 rpm, and finally the last one – third of water phase was added. Total oil amount was gradually added to the emulsion within 7 min. Each treatment, thus, was prepared after 7 min.

**Stability of emulsion**

According to Nikzade et al., with some modifications, first 15g of each sample was weighed into falcon of interest the falcons were placed in Ban Mary at 85°C for 30 min, and then they were placed in the rotor and centrifuged at 7500 rpm for 15 min at ambient temperature to separate the oil. The stability of emulsion was finally calculated using the following relation and expressed as percentage (Nikzade et al., 2012):

\[
\text{Stability of emulsion} \% = \frac{\text{centrifuge precipitate weight}}{\text{sample initial weight}} \times 100.
\]

**Statistical analysis**

Data was analyzed by software Minitab based on completely randomized design at probability level of 0.05%. First the samples were investigated to determine whether they were normal. If they were normal they would be analyzed by ANOVA parametric test. Otherwise, they were analyzed by kruscal – wallis non-parametric test as well as p-value to determine any significant difference.

**Results and discussion**

The results of measuring the stability of emulsion are presented in Table 2. As shown in Table 2 after 24 h of production the stability values of control 25%, 50%, 75% and 100% samples were 95.97 , 94.24 , 79.88 , 55.51 and 53.85 respectively where the control and 100% samples showed the highest and the lowest values of stability respectively. As the 1 st month, in the 2 nd and 3 rd months there was no significant difference between the control and 25% samples (p<0.05). The sample containing 100% emulsifier showed a falling trend of stability with the variations being significant (p<0.05). The stability values of 53.87% and 54.85% were found in the 1 st and 2 nd month respectively, being statistically similar however in the 3 rd month it decreased significantly reached 45.80% (p<0.05). The highest value of stability was observed for the control sample (Figure 1). As the concentration of emulsifier increased and the content of egg yolk decreased the stability showed a significant (p<0.05) decrease.

Stability of emulsion commonly includes inhibition of flocculation and creaming. Creaming generally does not pose any problems in high – fat (80%) mayonnaise because the globules are so compact that they are not allowed to move. In low-fat products, however, addition of thickening agents such as gums or starch to water phase may prevent creaming via retarding the globules movement (Mun et al., 2009). Although flocculation is considered as instability in dispersions it is not necessarily an undesirable phenomenon because if it does not make a visible separation and coalescence, it may be useful since it increases viscosity and confers gel-like characteristics due to formation of a 3D network of the aggregated particles thereby making the manufacturing process economic (Mun et al., 2009; Mc clement, 1999). As the concentration of Vivapur MCG increased to 50%
and 75% the stability of emulsion decreased over time. The stability of 100% sample decreased to about half of the initial value. It should be noted that 25% sample was not significantly different from the control sample \((p<0.05)\) however as the concentration of the emulsifier increased to 50% the stability showed a significant decrease.

Table 1. Formulation of mayonnaise samples containing Vivapur MCG.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Sample control</th>
<th>Sample 25%</th>
<th>Sample 50%</th>
<th>Sample 75%</th>
<th>Sample 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>1400</td>
<td>1400</td>
<td>1400</td>
<td>1400</td>
<td>1400</td>
</tr>
<tr>
<td>Vinegar</td>
<td>168</td>
<td>168</td>
<td>168</td>
<td>168</td>
<td>168</td>
</tr>
<tr>
<td>Sugar</td>
<td>182</td>
<td>182</td>
<td>182</td>
<td>182</td>
<td>182</td>
</tr>
<tr>
<td>Salt</td>
<td>59.5</td>
<td>59.5</td>
<td>59.5</td>
<td>59.5</td>
<td>59.5</td>
</tr>
<tr>
<td>Egg yolk</td>
<td>175</td>
<td>131.25</td>
<td>87.5</td>
<td>43.75</td>
<td>0</td>
</tr>
<tr>
<td>Cold starch</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Mustard</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Xanthan</td>
<td>1.75</td>
<td>1.75</td>
<td>1.75</td>
<td>1.75</td>
<td>1.75</td>
</tr>
<tr>
<td>Guar</td>
<td>4.9</td>
<td>4.9</td>
<td>4.9</td>
<td>4.9</td>
<td>4.9</td>
</tr>
<tr>
<td>Citric acid</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Vivapur MCG</td>
<td>0</td>
<td>4.375</td>
<td>8.75</td>
<td>13.125</td>
<td>17.5</td>
</tr>
<tr>
<td>Water</td>
<td>1421.35</td>
<td>146.725</td>
<td>1500.1</td>
<td>1539.475</td>
<td>1578.85</td>
</tr>
</tbody>
</table>

1) Control sample (100%EY)
2) Sample25% (25%vivapur & 75%EY)
3) Sample50% (50%vivapur & 50%EY)
4) Sample75% (75%vivapur & 25%EY)
5) Sample100% (100%vivapur)
6) Vivapur MCG: Microcrystallized cellulose – based emulsifier · EY:(Egg Yolk).

Similar results were obtained for the stability of emulsion in the 2nd and 3rd months. For example, in the 2nd month the highest value of stability was found for the control sample (96.99%) and it decreased to 54.85% as the concentration of emulsifier increased to 100%. In the 3rd month, the stability reached to its minimum value (45.80) for 100% emulsifier.

Table 2. Results of tests on stability of emulsion.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Stability of emulsion (%)</th>
<th>24 hour after production</th>
<th>Month 2</th>
<th>Month 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (100%EY)</td>
<td>95.57±0.63a</td>
<td>96.99±0.94a</td>
<td>98.74±0.84a</td>
<td></td>
</tr>
<tr>
<td>25% (25% vivapur &amp; 75% EY)</td>
<td>94.24±0.09ab</td>
<td>95.79±0.46ab</td>
<td>96.01±0.56ab</td>
<td></td>
</tr>
<tr>
<td>50% (50% vivapur &amp; 50% EY)</td>
<td>79.88±0.80f</td>
<td>82.78±0.87f</td>
<td>87.83±0.98f</td>
<td></td>
</tr>
<tr>
<td>75% (75% vivapur &amp; 25% EY)</td>
<td>55.31±0.27cA</td>
<td>55.78±0.58cA</td>
<td>52.66±3.75cA</td>
<td></td>
</tr>
<tr>
<td>100% (100% vivapur)</td>
<td>53.85±0.07cA</td>
<td>54.85±0.95cA</td>
<td>45.80±0.57cA</td>
<td></td>
</tr>
</tbody>
</table>
1) Results are expressed as mean ± SD
2) a-d: Values represented by different letters in each column are significantly different \((p<0.05)\)
3) A-B: Values represented by different letters between columns are significantly different \((p<0.05)\)
4) EY: egg yolk ; vivapur MCG: microcrystallized cellulose – based emulsifier.

Nikzade et al., (2012) added soy milk and different gums to the formulation of low – cholesterol low – fat mayonnaise in replace of egg yolk. They showed that as the concentration of these compounds increased the stability of emulsion tended to increase. Their results are not in agreement with our findings.

Thaibudom and Khantarat (2011) used sodium octenyl succinate starch of (SOS) at concentrations of 25%, 50%, 75% as fat substitute in the formulation of...
reduced – fat mayonnaise. The stability showed an increase as the concentration of the emulsifier increased. Their results are not consistent with our results. The results of measuring stability during storage period are as follows.

As the time of storage extended, the stability value of the control and 25% samples showed an insignificant difference ($p<0.05$) implying that the sample had desirable stability over 3-month storage. For instance the stability value of the control sample was 95.57% after 24 h of production and reached 96.99% and 98.74% in the 2 nd and 3 rd months, respectively. The stability of 25% sample was 94.24% after 24 h of manufacture and reached 95.79 and 96.01 in the 2 nd and 3 rd months, respectively.

**Fig. 1.** Falcon of samples for test on stability of emulsion.

**Conclusion**

Stability of food emulsions is a relative concept as all emulsions are thermodynamically instable due to high interface energy between their two phases and in the case of sufficient time the phases will be separated. Thus, it is impossible to develop a sauce with indefinite shelf-life. However through controlling different processes we are able to develop products with desirable shelf – life, appearance texture and flavor. In the present study the stability of samples decreased over time as the stability of sample containing 75% Vivapur MCG decreased significantly ($P<0.05$) as compared to the control and 25% samples. It may be concluded that using emulsifier Vivapur MCG up to 25% allows us to produce a reduced – fat mayonnaise with rheological, sensory and texture properties similar to those of the ordinary mayonnaise.

**References**


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