J Food Sci Technol
DOI 10.1007/s13197-012-0796-7

ORIGINAL ARTICLE

Application of Isfarzeh seed (*Plantago ovate* L.) mucilage as a fat mimetic in mayonnaise

S. S. Amiri Aghdaei · M. Aalami · Saeed Babaei Geefan · A. Ranjbar

Revised: 3 July 2012 / Accepted: 27 July 2012

Abstract In present study, application of Isfarzeh seed (*Plantago ovate* L.) mucilage as fat replacer was studied in mayonnaise formulation. Fat was partially substituted by mucilage gels (2 and 3 % suspensions) at levels of 30, 40 and 50 % which were referred to as FM2-30 % (2 % gel and 30 % substitution level), FM2-40 %, FM2-50 %, FM3-30 %, FM3-40 %, and FM3-50 % formulations, respectively and the full fat (Ff) mayonnaise with 78 % oil was used as control. Physicochemical, texture and sensory analysis of Ff and Low fat (Lf) treatments were evaluated. Results indicated that Lf samples had considerably lower energy content compared with control, but higher water content than their Ff counterpart. In view of texture, FM3-30 % showed similar textural characteristics as those of control. Both Ff and Lf samples exhibited thixotropic and shear thinning behavior through rheological studies and all samples followed the power law model except FM3-40 % and FM3-50 %. Sensory evaluation demonstrated that all of mayonnaise samples, containing 3 % mucilage, were more acceptable. It was concluded that Isfarzeh seed mucilage can be used as a suitable fat replacer in mayonnaise formulation.

Keywords Isfarzeh · Fat mimetic · Mayonnaise · Mucilage

Introduction

Traditional mayonnaise is probably one of the oldest and most widely used sauces throughout the world. Mayonnaise is a product with particular consistency and is classified as a type of oil in water emulsions. Vegetable oil, acetic acid, and egg yolk are main components of mayonnaise (Bortnowska and Makiewiewicz 2006).

In addition, mayonnaise may contain salt, sweeteners, spices, effective flavor materials, preservatives and stabilizers. It must contain at least 78.5 % of total fat and 6 % pure egg yolk (Codex Alimentarius Commission 1989). Due to high levels of oil present in mayonnaise, continuous usage of this product may result in diseases such as obesity, arteriosclerosis, hypertension and cardiovascular diseases. Therefore, consumers tend to consume low-fat products.

Genus Plantago from the plantain family (Plantaginaceae) has about 250 species. One member of this genera, *Plantago ovate* L. (known as Isfarzeh in Persian language), is found worldwide, but it is native to India, Pakistan, and Iran. It's seed contains mucilage, protein, sugar, oil and tannin (Kang et al. 2007). The outer layer of the seed husk, known as psyllium, constitutes about 25 % of the total seed and contains high amounts of mucilage and is simply separated by grinding. The milled seed Mucilage is a white fibrous material that is hydrophilic. Upon absorbing water it turns into a colorless and clear gel (Yu et al. 2003). It contains Arabinose, Xylose, and lesser amounts of other sugars. When it absorbs water, its volume increases by ten-fold or more. It has no toxicity and is chemically neutral, and cannot be decomposed by human digestive enzymes. In medicine, psyllium can help relieve both constipation and diarrhea, and has also been used to help regulate blood sugar levels in people with diabetes, and can help lower cholesterol (Moreaux et al. 2011). As psyllium is not absorbed by human body, thus it can be used in dietary food formulation.

There is little published data in the literature on application of hydrocolloids (gums) to partially replace fat in a mayonnaise system. Viscoelastic properties of reduced fat mayonnaise have been improved by addition of xanthan gum (Ma and Barbosa-Cánovas 1995), and addition of algal

S. S. Amiri Aghdaei
Department of Food Science and Technology,
Baharan Institute of Higher Education,
Gorgan, Iran

M. Aalami · S. Babaei Geefan (✉) · A. Ranjbar
Department of Food Science and Technology, Gorgan University
of Agricultural Sciences and Natural Resources,
Gorgan, Iran
e-mail: saeed_b63@yahoo.com

Published online: 15 August 2012

alginates to the full fat (70 % oil) mayonnaise as stabilizers resulted in an improvement of emulsion strength (Mancini et al. 2002). Worrasinchai et al. (2006) used β-glucan prepared from spent brewer's yeast as a fat replacer in mayonnaise and studied physicochemical and rheological properties of the resulted product. In another research pectin and whey protein isolate were used as fat mimetic in formulation of low fat mayonnaises (Liu et al. 2007). Some fat mimetic such as modified starch (Murphy 1999), inulin (James 1998), pectin (Pedersen and Christian 1997), microcrystalline cellulose (Grodzka et al. 2005), carrageenan (Trueck 1997) and some thickeners (Wendin et al. 1997) have been generally used to stabilize the emulsion and to increase the viscosity of light mayonnaise.

Beside the fat replacers mentioned above, there is also little information on the application of psyllium as fat mimetic in mayonnaise formulation. Therefore, the objective of present study was to investigate the effects of partial fat substitution by mucilage on physicochemical, rheological and sensory properties of low fat mayonnaise.

Materials and methods

Mucilage preparation

Separating Isfarzeh seed husk

One hundred grams (wet basis) of Isfarzeh seed with initial moisture content of 7 % were milled, using a laboratory mill. Then, the mixture was passed through a 20 mesh sieve to separate the kernel and the shell.

Hydrocolloid purification with ethanol

Using a magnetic stirrer, Isfarzeh seed husk and distilled water were mixed well at a ratio of 1:30 and at ambient temperature (25 °C). The slurry was then centrifuged (10,000 g & 25 °C) to remove insoluble impurities. The resulting clarified gel was mixed with ethanol (1:3, v/v) and centrifuged (5,000 g) to precipitate its hydrocolloid content. The sediment was washed using alcohol 2–3 times to separate water and colorant inside the hydrocolloid. The final purified hydrocolloid was freeze dried (freeze drier Operon model FDB-5503), grinded and passed through a 30 mesh sieve to uniform particles. Finally, 2 % and 3 % gel solutions were prepared.

Mayonnaise preparation

One kilogram of each mayonnaise sample was prepared. Different recipes of mayonnaise contained soybean oil and fat mimetic (as % of gel & fat substitution) including 54.5 % & 23.5 % (2–30 %), 46.8 % & 31.2 % (2–40 %), 39 & 39 (2–50 %), 54.5& & 23.5 % (3–30 %), 46.8 % & 31.2 % (3–40 %) and 39 % & 39 % (3–50 %), while full fat (Ff; Control) contained 78 % soybean oil and no fat mimetic. All formulations contained 8 % Egg yolk, 8 % Vinegar, 1 % Mustard, 2 % common salt and 3 % sugar.

Mayonnaise preparation procedure was as follows; firstly egg and vinegar were mixed together and then all other ingredients (including psyllium mucilage for the low fat mayonnaise recipes) except oil were added and mixed (Sunny, model SBG-450) well. The oil was finally poured inside the mixer very slowly and homogenized for 1 min. Sub samples (250 g) of mayonnaise were aseptically transferred to sterile 250 ml, Duran glass bottles with polypropylene screw caps and left for one-day at 5 °C.

Proximate composition analysis

Moisture, protein, and ash contents were determined according to AOAC (2005) official methods. Fat content was measured by Bligh and Dyer (1959) method, and total carbohydrate content was calculated by difference.

Rheological measurements

Rheological measurements were performed after 24 h storage using a Brookfield viscometer Model RVDV-II (Engineering Lab Inc., Stoughton, Mass., U.S.A) with a spindle no.6 at 5 °C and 25 °C. Shear stress data were plotted versus shear rate for each mayonnaise sample at a range of spindle speed (10–200 rpm). Plots of Ln shear stress versus Ln shear rate (for each sample) were then used to calculate values including flow behavior index (n) and consistency coefficient (K).

It is generally required fitting the experimental data to some forms of best-fit mathematical equation or model in order to perform a quantitative comparison of materials. The model is used to predict the viscosity of a flow as a function of shear stress or shear rate, it is named also constitutive equation of a flow. There were some useful flow models introduced to use for fitting the flow curve of mayonnaise or salad dressing as follows:

(A) Power law model

Shear thinning or shear thickening fluids obey the power law model (Ostwald-de Waele equation):

$$\tau = k(\dot{\gamma})^n \qquad (1)$$

where K is the consistency coefficient (Pa s^n), $\dot{\gamma}$ is shear rate (S^{-1}), τ is shear stress (Pa), n is the flow behavior index (−). For shear thinning fluids $n<1$ and for shear thickening fluids $n>1$.

(B) Herschel-Bulkley model (Bourne 1978)

$$\tau = \tau_0 + k\,\dot{\gamma}^n \qquad (2)$$

In this equation, τ_0 is the yield stress (Pa).

Correlation coefficient (R^2) was applied to select the best and most appropriate model for the behavior of each mayonnaise sample. The higher correlation coefficient ($0 < R^2 < 1$), the more solidarity between the values predicted by the model and values obtained from experiments.

Texture analysis

Mayonnaise samples were stored in refrigerator for 24 h until texture analysis. The measurements were carried out using a Brookfield texture analyzer (Brookfield LFRA texture analyzer model number 4500 texture pro lite) equipped with a 38 mm diameter cylindrical probe at 25 °C.

The condition of the analysis was as follows; one cycle was applied, at a constant crosshead velocity of 1 mm/s to a sample depth of 30 mm, and then returned. From the resulting force-time curve, the values for texture attributes, i.e. firmness, adhesiveness, and consistency were obtained using texture pro lit software (version 1).

pH measurement and stability test

pH was determined using AOAC standard method (AOAC 2005) at 25 °C. The samples were assessed for the stability test after 24 h storage at 35 °C. Mayonnaise stability was determined after centrifugation (10 min, 2,500 rpm), and was expressed as the volume of separated phase to the total emulsion volume.

Color measurement

Mayonnaise samples were measured for color in the L*, a*, b* system using a Lovibond Colorimeter (Lovibond CAM-System 500).

Sensory analysis

After 1 day storage Sensory characteristics including appearance, color, odor, texture, taste, and overall acceptability were evaluated by 14 semi-trained panel on 5-point hedonic scale (1 = the least or the lowest; 5 = the most or the highest).

Statistical analysis

All the tests were performed in triplicate. The data collected were analyzed by one-way analysis of variance (ANOVA), and significant differences of means were compared using Duncan test at 5 % significance level using SAS software program.

Results and discussion

Proximate composition

The proximate analysis and caloric values of the low fat (LF) mayonnaises containing psyllium, and the full fat (FF) mayonnaise are presented in Table 1. The moisture content of samples increased with increasing levels of fat mimetic substitution due to very high moisture content of such compounds which is a typical characteristic of carbohydrate-based fat replacers (Akoh 1998). Significant differences were observed between LF and FF samples in ash and carbohydrate content. Therefore, it could be concluded that increasing psyllium content in mayonnaise formulation enhances the percentage of ash and carbohydrate. Because of different amount of oil used to formulate samples, the fat content in Lf samples was much lower than control. The caloric values of low fat formulations significantly decreased with increasing levels of mucilage, because water is the main constituent of mucilage and on the other hand, being dietary fiber, mucilage cannot be digested and absorbed by human body.

Flow behavior

Flow curves of the Ff and Lf mayonnaises are shown in Fig. 1. All samples exhibited thixotropic behavior over the whole range of shear rate studied (0–50 S^{-1}) in that segments of the down curves reached values of shear stress lower than those of the up curves at the same values of shear rate. All samples showed thixotropic shear thinning behavior in which their flow properties depended on both shear rate and time. In concentrated emulsions, the droplets are close enough together to interact with each other which may lead to the formation of a three-dimensional network of aggregated droplets and consequently to a higher viscosity.

The power law model turned out to be best fitted to the experimental shear rate – shear stress data ($R^2=0.99$) (Table 2). The consistency coefficient (K) values were markedly decreased, while the flow behavior index (n) increased when the samples were subjected to the ascending and then descending of the shear rates. Therefore, the Ff and Lf mayonnaises behaved as shear thinning fluids and their flow behavior index (n) values were less than 1.0. These findings were in agreement with the results of Ma and Barbosa-Cánovas (1995). As shown in Table 2, in samples containing 2 % mucilage (at 5 °C) the consistency coefficient values were significantly lower in down curve compared

Table 1 Chemical composition (%w/w) and caloric value of different mayonnaise samples

Sample	Moisture content	Fat	Carbohydrate	Protein	Ash	Caloric value * (Kcal/100 g)
Ff [e]	14.7±0.26[d]	80.7±0.28[a]	1.8±0.02[d]	1.9±0.010[a]	0.83±0.011[c]	741.6±2.5[a]
2–30 % [f]	40.6±0.28[c]	54.0±0.37[b]	2.5±0.08[c]	1.9±0.018[a]	0.96±0.010[b]	503.6±3.0[b]
2–40 %	47.7±0.27[b]	46.6±0.29[c]	2.7±0.04[b]	1.9±0.028[a]	0.98±0.007[b]	438.1±2.5[c]
2–50 %	56.1±0.06[a]	38.4±0.05[d]	2.8±0.05[b]	1.9±0.013[a]	0.99±0.001[b]	362.9±0.5[d]
3–30 %	40.9±0.17[c]	53.9±0.14[b]	2.9±0.03a	1.9±0.015[a]	1.00±0.015[a]	495.9±1.5[b]
3–40 %	47.5±0.31[b]	46.2±0.26[c]	2.9±0.03[a]	1.9±0.022[a]	1.02±0.025[a]	435.6±2.6[c]
3–50 %	55.4±0.16[a]	38.2±0.13[d]	2.9±0.01[a]	2.0±0.031[a]	1.01±0.003[a]	368.8±1.3[d]

Assays were performed in triplicate

Values with different letter in a column are significantly different ($p<0.05$)

[e] Full fat (mayonnaise with 78 % oil & without psyllium mucilage as fat mimetic)

[f] Percentage of gel (psyllium mucilage gel) - percentage of fat substitution (with psyllium mucilage gel)

*Caloric values = (4 × pr) + (9 × fat) + (4 × carbohydrate)

with those in up curve, while at 25 °C consistency coefficient of samples was closer to each other. These findings affirm the effect of temperature on rheological properties of mayonnaise. The highest consistency coefficient was observed in FM3-30 % at 5 °C that was noticeably higher than that of other samples. The consistency coefficient of FM 3-40 % (at 5 °C and 25 °C) was more close to control compared with other mayonnaises. In view of flow behavior index, the highest value was found in FM2-50 %; both at 5 °C and 25 °C, and the lowest was observed in FM3-30 % at 5 °C. When the flow behavior index reaches one, the flow behavior shifts from non-Newtonian to Newtonian; therefore, it can be concluded that the flow behavior of FM 2-50 % sample in down curve at both temperatures (5 °C and 25 °C) changes toward Newtonian fluid. As the shear rate is increased, the consistency reduces because the hydrodynamic forces cause aggregates to become deformed and finally disrupted (McClements 1999) which results in a reduction in the viscosity.

In conclusion, all samples showed thixotropic characteristics and shear thinning behavior, and their flow behavior was found to be dependent on temperature and shear stress.

According to the results, in all mayonnaises, the Power law model showed the highest correlation coefficient (R^2) and this revealed that the Power low compared with other models (Casson and Herschel-Bulkley) can better predict

Table 2 Values of power law model parameters (K, n and R^2) at 5 and 25 °C

	Up curve			Down curve		
	K	*n*	R^2	*K*	*n*	R^2
Sample (5 °C)						
Ff [a]	70.10541	0.208	0.994	42.819774	0.339	0.995
2–30 % [b]	50.80527	0.218	0.997	24.878401	0.435	0.998
2–40 %	36.12554	0.314	0.996	20.186216	0.444	0.997
2–50 %	27.34009	0.33	0.995	13.585459	0.561	0.996
3–30 %	94.91612	0.146	0.993	59.73989	0.282	0.998
3–40 %	65.69321	0.188	0.996	35.23359	0.355	0.997
3–50 %	46.52011	0.25	0.996	27.11264	0.359	0.993
Sample (25 °C)						
Ff	38.47467	0.272	0.992	24.53253	0.377	0.998
2–30 %	34.39805	0.281	0.999	19.96538	0.438	0.997
2–40 %	32.98325	0.299	0.996	17.374437	0.445	0.996
2–50 %	32.42728	0.32	0.997	11.634793	0.521	0.999
3–30 %	61.25221	0.141	0.991	32.98325	0.312	0.997
3–40 %	62.80282	0.137	0.992	28.78919	0.356	0.993
3–50 %	52.72027	0.201	0.99	25.25439	0.364	0.996

Assays were performed in triplicate

[a]Full fat (mayonnaise with 78 % oil & without psyllium mucilage as fat mimetic)

[b]Percentage of gel (psyllium mucilage gel) - percentage of fat substitution (with psyllium mucilage gel)

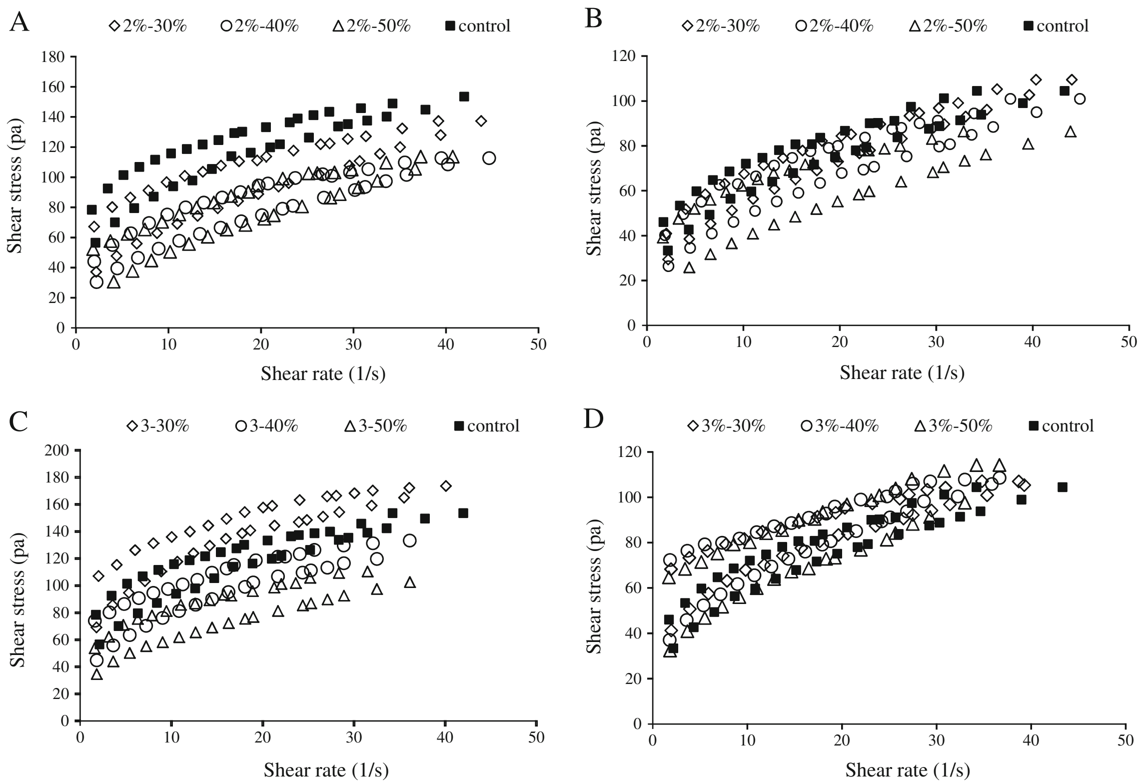

Fig. 1 Flow curves of different mayonnaise samples; **a** 2 % mucilage (5 °C), **b** 2 % mucilage (25 °C), **c** 3 % mucilage (5 °C) and (**d**) 3 % mucilage (25 °C). Each observation is a mean ± SD of 3 replicates

the flow behavior of samples, except for two (FM3-40 % and FM3-50 %) which followed the Casson Model.

Texture analysis

All the texture parameters determined are shown in Table 3. The control and FM3-30 % were similar in firmness and consistency, and their values were significantly higher than those of other samples. The highest firmness was observed in control and the lowest was found in FM 2-50 % sample, and this was because of reduction in emulsion concentration. FM3-30 % and FM3-40 % samples had the highest consistency that can be mainly contributed to their higher mucilage content. There was no significant difference between the consistency of control, FM3-30 %, FM2-40 %, and FM2-50 %. The highest adhesiveness was observed in FM2-50 % that had higher amount of lower concentrated mucilage (2 % gel solution) compared with 3 % mayonnaises, and this resulted in a higher adhesiveness which is considered as an unsuitable trait. The low score that attributed to FM3-50 % might be because of high adhesiveness of this sample.

Table 3 Instrumental texture quality of different mayonnaise samples

Sample	Adhesiveness	Firmness	Consistency
Ff [e]	−1871.7±5.8^{d}	184.7±1.4^{a}	2033.3±4.4^{b}
2–30 % [f]	−1371.1±4.3^{c}	156.5±4.8^{b}	1943.4±3.9^{c}
2–40 %	−1103.9±6.2^{b}	130.8±0.9^{c}	2023.9±4.3^{b}
2–50 %	−768.9±4.4^{a}	79.2±3.3^{d}	1914.6±5.6^{bc}
3–30 %	−1901.7±3.4^{d}	179.5±2.9^{a}	2019.5±4.4^{b}
3–40 %	−1223.4±5.2^{bc}	144.8±1.7^{bc}	2179.7±5.3^{a}
3–50 %	−854.4±4.3^{a}	123.6±2.9^{c}	2286.8±5.3^{a}

Assays were performed in triplicate

Values with different letter(s) in a column are significantly different ($p<0.05$)

[e] Full fat (mayonnaise with 78 % oil & without psyllium mucilage as fat mimetic)

[f] Percentage of gel (psyllium mucilage gel) - percentage of fat substitution (with psyllium mucilage gel)

Color measurement

The lightness (L-value) of mayonnaise has major effect on the perceived appearance of the product. The color measurement results are listed in Table 4. The L-value of the control had no significant difference compared with FM3-30 %, FM 3-40 % and FM3-50 % samples. The highest lightness was recorded for control and the lowest was observed in FM 2-50 % sample. It seems that the color of the mucilage preparation used in mayonnaise formulation reduces the

Table 4 Instrumental color values of mayonnaise samples

Sample	*L**	*a**	*b**
Ff [d]	76.0±0.39^{a}	0.36±0.03^{a}	4.4±0.06^{a}
2–30 % [e]	73.4±0.14^{b}	−0.36±0.33^{b}	4.3±0.17^{a}
2–40 %	73.3±0.38^{b}	−0.36±0.03^{b}	4.4±0.12^{a}
2–50 %	72.8±0.46^{c}	−0.36±0.03^{b}	3.4±0.07^{b}
3–30 %	75.4±0.21^{a}	−0.40±0.02^{c}	2.5±0.14^{c}
3–40 %	75.5±0.17^{a}	−0.36±0.03^{b}	2.5±0.08^{c}
3–50 %	75.1±0.15^{a}	−0.36±0.04^{b}	2.5±0.18^{c}

Assays were performed in triplicate

Values with different letter in a column are significantly different ($p<0.05$)

[d] Full fat (mayonnaise with 78 % oil & without psyllium mucilage as fat mimetic)

[e] Percentage of gel (psyllium mucilage gel) - percentage of fat substitution (with psyllium mucilage gel)

lightness (for 2 % mucilage: L=53.3, b=5.9, =−1.2 and for 3 % mucilage: L=52.5, b=5.1, a=−1.2). As the a-value is negative in low fat samples, their color changes to greenness, and this can be due to the effect of mucilage substitution. The highest b-value was observed in control, but there was no significant difference between the control and FM2-30 % and FM2-40 % samples. The b-value decreased by increasing the concentration of mucilage and the percentage of substitution, and this may be because of the effect of mucilage.

pH measurement and stability test

No significant difference was observed in pH values of all formulations after one-day storage. Since the amount of water significantly increased with increasing percentage of mucilage substitution, one might expect that the pH of the low fat formulations would be higher than that of full fat sample due to dilution of acetic acid in the aqueous phase of the low fat samples. After 60 days storage, no significant change was observed in pH values. All mayonnaise samples were stable after one-day storage, and after 60 days only one sample (FM 2-50 %) creamed. The instability of FM2-50 % sample can be due to its lower viscosity. Emulsion stability often decreases by lowering viscosity that allows the movement of oil droplets through the aqueous phase (Ramachandra-Rao and Hemantha-Kumar 1998).

Sensory evaluation

Sensory evaluation scores of mayonnaise samples are shown in Table 5. The color, mouth feel, texture and total acceptability scores of 3–50 % were significantly ($P<0.05$) lower than the others. Ff sample showed the highest score in appearance, but it had no significant difference compared with other samples, except FM3-50 %. The odor and taste did not influence by mucilage substitution. The color of FM2-30 % was better than full fat mayonnaise, but the difference was not significant. The FM3-50 % had the lowest score in view of color and that was because of increase in the moisture content of samples. The texture of FM3-30 % attained the highest score, and according to the results of texture analysis the highest firmness belonged to FM3-30 % sample. This indicates that the mayonnaise with higher firmness and consistency was better for sensory evaluation group. As shown in Table 5, in term of texture, there was no significant difference between low fat and full fat samples except for FM3-50 %. The FM3-30 % compared with other samples showed the highest score in total acceptability, but it had no significant difference in comparison to other samples, except for FM3-50 % which attained the lowest score. This result confirmed the other results obtained for sensory evaluation.

Table 5 Sensory quality of different mayonnaise samples

Sample	Appearance	Color	Odor	Texture	Taste	Mouth feel	Overall acceptability
Ff [c]	4.5±0.20^{a}	4.3±0.17^{ab}	3.6±0.23^{a}	3.8±0.23^{ab}	3.6±0.12^{a}	3.9±0.22^{ab}	4.1±0.10^{ab}
2–30 % [d]	4.3±0.16^{ab}	4.3±0.14^{a}	3.6±0.20^{a}	3.8±0.29^{ab}	3.9±0.22^{a}	3.4±0.24^{b}	3.9±0.14^{ab}
2–40 %	4.1±0.19^{ab}	4.0±0.20^{ab}	3.8±0.23^{a}	3.9±0.24^{ab}	3.7±0.22^{a}	3.8±0.18^{ab}	3.9±0.16^{ab}
2–50 %	4.0±0.20^{ab}	3.8±0.23^{ab}	4.1±0.19^{a}	3.8±0.23^{ab}	3.8±0.33^{a}	3.8±0.18^{ab}	3.8±0.16^{ab}
3–30 %	4.3±0.16^{ab}	4.2±0.15^{ab}	3.8±0.28^{a}	4.4±0.17^{a}	3.8±0.33^{a}	4.1±0.35^{a}	4.1±0.19^{a}
3–40 %	4.0±0.16^{ab}	4.2±0.18^{ab}	3.8±0.28^{a}	4.2±0.14^{ab}	3.7±0.28^{a}	4.1±0.35^{a}	4.0±0.14^{ab}
3–50 %	3.7±0.12^{b}	3.7±0.28^{b}	3.7±0.30^{a}	3.6±0.23^{b}	3.4±0.25^{a}	3.4±0.23^{b}	3.6±0.16^{b}

Assays were performed in triplicate

Values with different letter(s) in a column are significantly different ($p<0.05$)

[c] Full fat (mayonnaise with 78 % oil & without psyllium mucilage as fat mimetic)

[d] Percentage of gel (psyllium mucilage gel) - percentage of fat substitution (with psyllium mucilage gel)

Conclusions

From the results of the present work, it can be concluded that Isfarzeh seed mucilage can successfully replace 50 % of the oil content in mayonnaise formulation. In different replacement levels, the samples containing 3 % mucilage showed better results compared with 2 % samples. In sensory evaluation, FM3-30 % sample had the highest score; however, other samples were also accepted by sensory evaluation group in view of odor, taste and appearance. Addition of mucilage adversely affected the mayonnaise texture which led to a lower sensory quality compared with control. However, in some parameters such as color, mouth feel and overall acceptability, low-fat mayonnaises acquired higher scores, which indicate Isfarzeh seed mucilage can be used as a suitable fat replacer in mayonnaise formulation.

References

Akoh CC (1998) Fat replacers. Food Technol Int 52:47–53

AOAC (2005) Offficial methods of analysis of the association of official analytical chemists, vol II, 15th edn. Arlington, VA: Association of Official Analytical Chemists

Bligh EG, Dyer WJ (1959) A rapid method of total lipid extraction and purification. Can J Biochem Physiol 37:911–917

Bortnowska G, Makiewiewicz A (2006) Technological utility of guar gum and xanthan for the production of low fat inulin-inriched mayonnaise. Acta Sci Poland Tecnol 5(2):135–146

Bourne MC (1978) Texture profile analysis. Food Technol Int 32:62–66

Codex Alimentarius Commission (1989) Codex standard for mayonnaise (Regional European Standard) CODEXSTAN 168-1989. Codex Coordinating Committee for Europe

Grodzka K, Maciejec A et al (2005) Attempts to apply microcrystalline cellulose as a fat replacer in low fat mayonnaise emulsions. Zywnosc 12:52–61

James SM (1998) Method for producing fat-free and low-fat viscous dressings using inulin. United States of American Patent No. 5721004

Kang DH, Jung EY et al (2007) Psyllium husk combined with hydroxycitrate reduces body weight gain and body fat in diet-induced obese rats. Nutr Res 27(6):349–355

Liu H, Xu XM et al (2007) Rheological, texture and sensory properties of low-fat mayonnaise with different fat mimetics. LWT-Food Sci Technol 40(6):946–954

Ma L, Barbosa-Cánovas GV (1995) Rheological characterization of mayonnaise. Part II: flow and viscoelastic properties at different oil and xanthan gum concentrations. J Food Eng 25(3):409–425

Mancini F, Montanari L et al (2002) Influence of alginate concentration and molecular weight on functional properties of mayonnaise. Lebensm Wiss Technol 35(6):517–525

McClements DJ (1999) Food emulsions; principles, practice, and techniques. CRC Press, Boca Raton

Moreaux SJJ, Nichols JL et al (2011) Psyllium lowers blood glucose and insulin concentrations in horses. J Equine Vet Sci 31(4):160–165

Murphy P (1999) Low fat developments with speciality starches. Food Technol Int 22:24

Pedersen A, Christian H (1997) No and low fat mayonnaise compositions. United States of American Patent No. 5641533

Ramachandra-Rao HG, Hemantha-Kumar HR (1998) Emulsion stability in food products. Indian Food Ind 17:77–88

Trueck HU (1997) A mayonnaise-like product. European Patent Application No. EP0768042A1

Wendin K, Aaby K et al (1997) Low-fat mayonnaise: influences of fat content, aroma compounds and thickeners. Food Hydrocolloids 11(1):87–99

Worrasinchai S, Suphantharika M et al (2006) b-Glucan prepared from spent brewer's yeast as a fat replacer in mayonnaise. Food Hydrocolloids 20:68–78

Yu L, Perret J et al (2003) Enzymatic modification to improve the water-absorbing and gelling properties of psyllium. Food Chem 82(2):243–248