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Development of Light Mayonnaise Formula Using Carbohydrate-Based Fat Replacement

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Abstract: Mayonnaise which made in traditional method contains enormous fat (70–80%). It is well known that the amount and type of fat consumed are important to the aetiology of several chronic diseases. Therefore, it is difficult to imitate traditional product quality when preparing low-fat foods. Thus, the objective of this study was to develop light mayonnaise by reducing fat content to 50% using potato powder mash as fat replacement. The full fat mayonnaise (FF) and commercial low fat (CLF) were used as a control experiment. Physicochemical, rheological, microbiological analyses and sensory evaluation of the FF and light fat mayonnaises preparing by potato powder mash (LFP) at level 5, 10 and 15% were performed. The results indicated that all light-fat mayonnaise formula had significantly lower energy content, but higher water content than their FF and CLF counterpart. In terms of colour, the low fat mayonnaise formula was higher than that of the commercial light fat mayonnaise. With regard to pH, there were no significant differences between the FF, CLF and LFP mayonnaises after one-day storage. Meanwhile, the overall acceptability scores were significantly higher when the substitution levels of potato powder mash increased. The rheological characteristics of LFP at 15% are more close to that of the commercial control CLF. Microbial loadings of all mayonnaises tested were in the acceptable limit throughout the storage time. This study shows good potential for potato powder to be used as a fat replacer in mayonnaise.

Key word: light mayonnaise, Fat replacement, potato powder, Rheological properties and Sensory evaluation

INTRODUCTION

Consumer's demand for more natural, nutritional, and healthier food products, presenting both nutritional and health benefits has increased over the years. The adverse health effects associated with over consumption of certain types of lipids has led to a trend within the food industry toward the development of reduced-fat products. It is a major challenge to produce reduced-fat foods which have the same appearance, texture, stability, and flavor as their full-fat counterparts (McClements and Demetriades, 1998). Traditional mayonnaise is a mixture of egg, vinegar, oil and spices (especially mustard). Mayonnaise made in this fashion typically contains 70–80% fat (Depree and Savage, 2001). Despite the high oil content relative to water, mayonnaise is an oil in-water emulsion. This emulsion is formed by first mixing the eggs, vinegar and mustard and then slowly blending in the oil. These results in an emulsion consisting of closely packed 'foam' of oil droplets. By contrast, if the oil and aqueous phases are mixed all at once, the result is a water in-oil emulsion similar in viscosity to the oil from which it is made (Hasenhuettl, 2008; Narsimhan and Wang, 2008).

The "light" mayonnaise products, marketed only in recent years, contain about 36% fat (McClements 2005). There is currently interest in producing reduced-fat mayonnaise and substituting fat without altering the consistency of the product. In some researches, fat replacers based on starch, protein and gum were used in reduced-fat mayonnaise or salad dressing (Aluko and McIntosh 2005). The use of a starch paste, however, requires an increase in the extent and cost of processing and tends to affect adversely the flavour and texture of the mayonnaise substitute (Dartey *et al.,* 1990). One of the major trends is to reduce the fat content of salad dressings, which has led to popular "reduced fat," "light," "low fat," or "fat free" versions of these traditional products. However, as a food component, fat contributes to the flavor, appearance, texture, and shelf life of food products. Therefore, it is difficult to imitate traditional product quality when preparing reduced-fat foods.

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Thus, to establish the formulation of reduced-fat products, it is necessary to use a combination of non-fat ingredients with different functional roles to replace the quality attributes lost when fat is removed. Biopolymers, such as gums, starches, and proteins are often incorporated into fat-reduced products to provide some of these functional attributes McClements, and Demetriades, (1998) and Mun *et al*. (2009).

Potato (*Solanum tuberosum* L.) production has significantly increased in recent years in many developing countries. Where it has become more important as a food and industrial crop. Potato flour can become the most viable value added product due to its versatility in function as a thickener and colour or flavour improver (Yadav *et al* 2006).

Potato flour is used in sauces, gravy, bakery products, extruded products or fabricated snacks and in soup mixes (Rekha *et al.,* 2004). It is prepared by drying the peeled slices in a hot air drier or by drying the cooked mash with a drum drier into flakes followed by grinding and sieving (Willard and Hix 1987).

This study was carried out to investigate the effect of intact potato powder to prepare light fat mayonnaise formulations and investigate the effects of their substitution on chemical, rheological, texture, sensory properties and microbiological of the light fat mayonnaises (LPF), using the full fat (FF) formulation and commercial low fat CLF as reference.

MATERIALS AND METHODS

Materials:

All ingredients used to prepare the mayonnaise, such as corn oil, eggs; vinegar, sugar, and salt were purchased from a local grocery store. Potato powder gift from *Teba for Food Industry Co. Egypt*, prepared by drying the cooked mash with a drum drier into flakes followed by grinding and sieving. With chemical analysis moisture, fat, protein, carbohydrate and ash were 7.5, 0.9, 7.1, 83.2 and 3.1%, respectively. Commercial low fat mayonnaise was purchased from grocery store.

Mayonnaise Preparation:

The mayonnaise recipes and preparation methods were modified from those of Worrasinchai, *et al.,* (2006). The full fat (FF) and reduced-fat mayonnaise recipes are shown in Table I. We prepared 500 g of each mayonnaise sample for this study. The light fat mayonnaise LF samples were prepared by replacing the 50% from oil by the potato powder dissolved in water at levels of 5, 10 and 15% of substituted oil and named LFP_5, LFP_{10} and LFP_{15}. The mayonnaise samples were prepared using a standard mixer. Briefly, egg yolks, vinegar, salt, sugar and mustard were mixed together with some water. The potato powder and guar gum dissolved in the rest of water to form gel structure, then mixed with the mixture. This mixture was stirred at speed 4 for 2 min until homogeneous. The oil was added slowly to the mixture with stirring at speed 4 for 10 min, followed by an additional 3min of stirring. The mayonnaise samples were transferred to 5 glass bottles (100 ml) with polypropylene screw caps and stored 60 days at room temperature until analysis.

Table I: Percentage recipes of the mayonnaise (wt %).

Component	FF	light fat mayonnaise		
		LFP_5	LFP_{10}	LFP_{15}
Soybean oil	75	37.5	37.5	37.5
Egg yolk	6.0	6.0	6.0	6.0
Vinegar 5% (w/v)	10	10	10	10
Salt	1.10	1.10	1.10	1.10
Sugar	2.5	2.5	2.5	2.5
Water	4.5	42.85	40.95	39.05
Mustard	1.5	1.5	1.5	1.5
Guar gum	0.4	0.4	0.4	0.4
Potassium Sorbet	0.07	0.07	0.07	0.07
Sodium benzoate	0.03	0.03	0.03	0.03
Potato powder	--	1.9	3.75	5.65

Proximate Analysis:

Moisture, protein, Fat, fiber and ash contents were determined according to AOAC (2000) official methods. Carbohydrates were determined by subtracting the sum of moisture, protein, fat, and ash percentages from 100%.

Caloric values was calculated according Souci *et al.,* (2000) total calories = (4 x gm protein) + (9 x gm fat) + (4 x gm carbohydrate). pH values were measured at a temperature of 25 ^{0}C using a Denver pH meter model 225 (Denver instrument, CO, USA). Acid and peroxide value was determined according A.O.A.C (2000).

Rheological Properties:

Apparent viscosity of mayonnaise samples were measured directly using Brookfield Digital Rhometer, Model DVIII Ultra. Mayonnaise sample was placed in a beaker, and the HA-07 spindle was used for rheological measurements. Shear rate was calculated using the following equation (Brookfield manual, 1998):

$$\gamma = [\frac{2\pi R_c^{\ 2}}{60(R_c^{\ 2} - R_b^{\ 2})}]RPM$$

Where, ϒ is the shear rate, 1/sec
Rc is the radius of container, cm   Rb is the radius of spindle, cm
The shear stress was calculated using the following equation: (ϒ = μ ϒ)
ϒ is the shear stress (Pa). ***μ*** is the apparent viscosity (Pa.sec). ϒ is the shear rate (1/sec)
A thermostatic water bath provided with the instrument was use to regulate the sample temperature. The rheological parameters for mayonnaise samples were studied at 25ºC and different rotational speeds (10-60 rpm).

Microbiological Analysis:

Total viable count, total yeast and mold and the presence of salmonella were determined according to Smith and Cirigliana (1992).

Colour Measurement:

Mayonnaise samples were measured for colour in the L*, a*, b* system using a Minolta Colorimeter CR-300 (Konica Minolta Business Technologies, Inc., Langenhagen Hannover, Germany).

Emulation Stability:

We transferred 15 g (F_0) of each sample to test tubes (internal diameter 15mm, height 125mm) that were then tightly sealed with plastic caps and stored at 50 ºC for 48 h. After storage, the emulsions were placed in centrifuge tubes and processed for 10 min at 3000 rpm to remove the top oil layer according Mun *et al.,* (2009). The weight of the precipitated fraction (F_1) was measured, and the emulsion stability was characterized as (%) = (F_1/F_0) ×100.

Texture Measurements:

Mayonnaise texture measurements were carried out with the TA.XT2i Texture Analyser (Stable Micro Systems Ltd,Surrey, UK) with a 5 kg load cell. Back extrusion cell with 35 mm diameter compression disc was used. The samples were carefully scooped into acrylic cylindrical containers (50 mm internal diameter and 75 mm height) to a depth of 55 mm. One cycle was applied, at a constant crosshead velocity of 1 mm/s, to a sample depth of 40 mm, then returned. From the resulting force–time curve, the values for texture attributes, i.e. firmness and adhesiveness, were obtained using the Texture Expert for Window Version 1 equipment software. Firmness was the maximum force as the test cell penetrated into the sample as described by Mohamed and Morris (1987). Adhesiveness was the negative force area representing the work necessary to pull the compressing plunger away from the sample as defined by Bourne (1978).

Sensory Evaluation:

Sensory evaluation was conducted on the mayonnaise samples after one-day storage at room temperature. Sensory characteristics: appearance, colour, odour, texture, taste, and overall acceptability were evaluated by 10 trained panel on 9-point hedonic scale, 1 = the least, the lowest; 9 = the most, the highest (Worrasinchai *et al.,* 2006).

Statistical Analysis:

A one-way analysis of variance (ANOVA) and Tukey's test (P > 0.05) were used to establish the significance of differences in the physicochemical properties, proximate analysis and sensory evaluation of mayonnaise samples. The result was performed using the SPSS version 9.0 windows program (SPSS, Inc., 1998, Chicago, IL).

RESULTS AND DISCUSSION

3.1. Chemical Composition:

The proximate analysis of the full fat (FF) mayonnaise; the commercial low fat (CLF) mayonnaises and low fat mayonnaise containing potato powder mash by concentration 5, 10 and 15% ($LFP_{5,\ 10\ and\ 15}$) are presented in Table 1. The moisture content of FF mayonnaise was significant lower than CLF. Meanwhile, low fat mayonnaise containing potato powder mash (LFP) by concentration 5, 10 and 15% were significantly higher than FF and CLF and these had values 54.19, 53.05 and 51.75; which is a typical characteristic of carbohydrate-based fat replaces (Akoh, 1998). No significant difference between the FF, CLF and LFP mayonnaises in protein contents was found. While carbohydrate content in CLF samples were higher than the FF and LFP mayonnaise, The add of potato powder mash by different concentration 5 and 10 to mayonnaise was no significant difference in total carbohydrate content, meanwhile, add potato powder mash by concentration 15% to produced low fat mayonnaise was significantly higher in total carbohydrate content with values 5.68%. Recent trends show the demand of reduced fat, low fat, or fat free versions of traditional food products. Ford *et al.,* (2004) reported that the total fat content of emulsified products could be reduced by replacing the fat droplets with non-fat ingredients. These ingredients are usually biopolymers, such as gums, starch and proteins (Clegg 1996).

Table 1: Proximate analysis of mayonnaise samples.

Samples	Moisture	Fat	Protein	Ash	Fiber	Carbohydrate
Full Fat mayonnaise (FF)	17.65±1.14[d]	77.43±2.12[a]	1.04±0.32[a]	0.75±0.11[b]	0.26±0.11[c]	2.87±0.42[d]
Commercial Low Fat (CLF)	47.31±2.35[c]	36.23±1.96[b]	1.16±0.28[a]	2.17±0.23[a]	1.14±0.31[a]	11.99±1.26[a]
*Low fat potato mayonnaise (LFP_5)	54.19±2.49[a]	39.76±1.38[b]	1.25±0.35[a]	0.76±0.34[b]	0.49±0.20[bc]	3.55±0.37[c]
Low fat potato mayonnaise (LFP_{10})	53.05±2.07[a]	39.73±1.85[b]	1.32±0.46[a]	0.84±0.27[ab]	0.61±0.23[b]	4.45±0.41[c]
Low fat potato mayonnaise (LFP_{15})	51.75±2.16[a]	39.45±1.16[b]	1.52±0.41[a]	0.86±0.31[ab]	0.74±0.28[b]	5.68±0.40[b]
LSD	3.18	2.87	0.89	0.40	0.37	1.15

Assays were performed in triplicate. Mean ±SD values followed by the same letter in each column are not significant different at $P < 0.05$.
*(LF_5, $LF_{7.5}$ and LF_{10}) low fat mayonnaise content the potato powder concentrations were 5, 10 and 15%.
[a] Carbohydrates were determined by subtracting the sum of moisture, protein, fat, and ash percentages from 100%.

3.2. Caloric Values:

According to USDA (2005), traditional mayonnaises present 717 kcal/100 g while the light versions contain 324 kcal/100 g. The caloric values of FF, CLF and LFP are presented in Fig. 1. It can be observed that the caloric values for FF and CLF mayonnaise had values 712.51 and 378.67 kcal/100 g, respectively. Meanwhile, even the formulations base on potato powder presented less calories with ranged from 383.85 to 377.04 (kcal/100 g). The apparent relationship between dietary fat and development of cardiovascular diseases, hypertension and obesity has prompted a consumer to be more trends to demand reduced fat products and the demand for low-fat mayonnaise has been rising (Worrasinchai *et al.,* 2006). Largely influenced by health-related concerns, there has been pressure on the food industry to reduce the amount of fat, sugar, cholesterol, salt and certain additives in the diet. Food manufacturers have responded to consumer demand, there has been rapid market growth of products with a healthy image (Liu *et al.,* 2007), and the mayonnaise added to GBP when compared to the commercial mayonnaise showed that had great potential in food industry and for consumers that are more readily adhere to nutritional guidelines concerning fat consumption.

3.3. Colour and Texture:

The lightness (L-value) of mayonnaise has a major impact on the perceived appearance of the product. The L-value of the full fat (FF) mayonnaise was higher than that of the commercial light fat mayonnaises (CLF) and low fat mayonnaise containing potato powder mash (LFP) formulation. Meanwhile, it was higher in low fat mayonnaise (LFP) than that of the commercial light fat mayonnaise (CLF). Chantrapornchai, *et al.,* (1999), McClements, and Demetriades (1998) reported that the emulsion changed from a grey colour to an increasingly bright white colour as the droplet size decreased due to an increase in light scattering. Therefore, the L-value of low fat mayonnaise (LFP) was decreased with increasing the level of potato powder. The a-values (redness) increased, whereas the b-values (yellowness) decreased with increasing the effects of colour of potato powder mash in the light fat mayonnaises, especially the 15% formulation. In general, FF mayonnaise exhibited a shiny bright yellow colour, whereas low fat mayonnaises was evaluated as too pale and dense, mainly due to fat replacers, which is confirmed by the previous finding (Karas *et al.,* 2002).

The texture parameters determined are shown in Table 2. The commercial light fat mayonnaises and low fat mayonnaise (LFP_{15}) formulate were similar for firmness and cohesiveness values and significantly lower

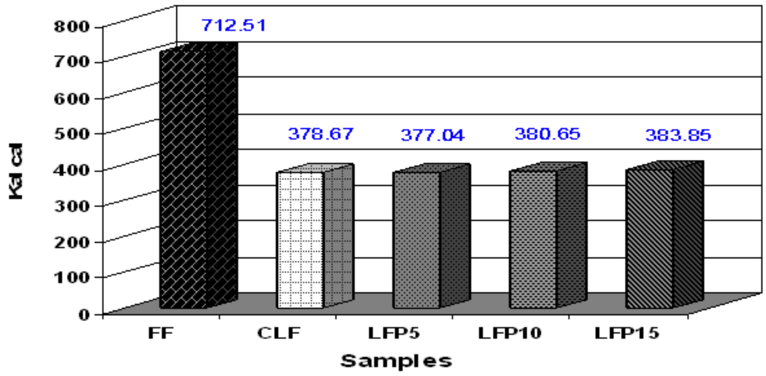

Fig. 1: Caloric values of full fat and low fat mayonnaise samples.

Table 2: Colour measurement of low fat mayonnaise samples.

Samples	Colour			Texture	
	L	A	B	Firmness (N)	Adhesiveness ($\times 10^{-3}$ Nm)
Full Fat mayonnaise (FF)	87.02±1.67^{a}	-4.87±0.20^{c}	21.78±0.57^{a}	2.06±0.26^{a}	19.56±1.23^{a}
Commercial Low Fat (CLF)	83.30±1.15^{b}	-2.90±0.15^{a}	16.36±0.54^{d}	1.46±0.22^{b}	13.72±1.01^{c}
Low fat potato mayonnaise (LFP_5)	86.82±1.46^{a}	-4.37±0.31^{b}	20.72±0.65^{b}	0.62±0.17^{d}	7.15±0.98^{e}
Low fat potato mayonnaise (LFP_{10})	85.45±1.10^{ab}	-4.11±0.25^{b}	19.43±0.34^{c}	1.03±0.19^{c}	9.68±1.13^{d}
Low fat potato mayonnaise (LFP_{15})	85.27±1.44^{ab}	-4.01±0.22^{b}	19.49±0.58^{c}	1.75±0.23^{ab}	15.96±1.27^{b}
LSD	2.25	0.41	0.99	0.36	1.36

Assays were performed in triplicate. Mean ±SD values followed by the same letter in each column are not significant different at P < 0.05.

than the full fat (FF) mayonnaise. In mayonnaise, the large contact surface area between oil droplets leads to important friction force, which oppose to the free flowing of the emulsion in a shear field, hence increasing its viscosity. In terms of texture, Worrasinchai *et al* (2006) found that the low fat mayonnaise was partially substituted by β-glucan at levels of 50% and 75% formulations showed similar firmness and adhesiveness values as those of the FF sample.

Rheological Properties:

Determining the rheological properties may provide us with information on the texture and flow characterization of the different formulate (Wendin and Hall, 2001). The flow curves in Fig (2) showed that the all samples of mayonnaise exhibit non-Newtonian Bingham equation, $\Upsilon = {}_0 + K\,\Upsilon^n$ where, ${}_0$ is the yield stress =value, n is the flow index = 1. In this equation, Υ is the shear stress (Pa), Υ is the shear rate(s^{-1}), K is the consistency index (Pa s^n). It was noticed that FF sample had the higher value of shear stress compared with those of the other mayonnaise samples at the same shear rates. The values of shear stress for LFP_{15} are more or less similar to the values for commercial one (Fig. 2). Our data are consistent with Ma *et al* (2006) who reported that the addition of fat mimetics made the rheology properties of low fat mayonnaise close to that of the high fat mayonnaise.

As shown in table (3) the apparent viscosity (μ) of FF sample represented the highest value. When the fat content was reduced to form the low fat mayonnaises, the apparent viscosity was decreased by 39.7%, 55.8%, 82% in LFP_{15}, LFP_{10}, LFP_5 respectively. However as the percentage of fat replacer (potato mash) was increased, the viscosity of mayonnaise increased to 40.8 *Pa.sec*, which was close to that of commercial mayonnaise (control). Also, showed the model-fitting flow equation parameters of different mayonnaise samples. The yield stress (Υ_0) and the consistency coefficient (K) of the FF mayonnaise was the largest one in all the mayonnaise samples. When used as the salad dressing the yield stress was an important character for it must have properly ability to keep non-fluid on the salad surface (Liu *et al.,* 2007). The yield stress and the consistency coefficient of the mayonnaise LFP_{15} was more or less similar to the control sample (CLF). The current study was confirmed by Mun *et al.,* (2009) he yield stress value would increase proportionally with increases in the disperse-phase volume fraction and the strength of the attractive forces between the oil droplets. However, in the present study, this effect was counterbalanced by increasing the potato mash to 15 % replacing the fat in the formulation that otherwise strengthens the gel structure of mayonnaises sample.

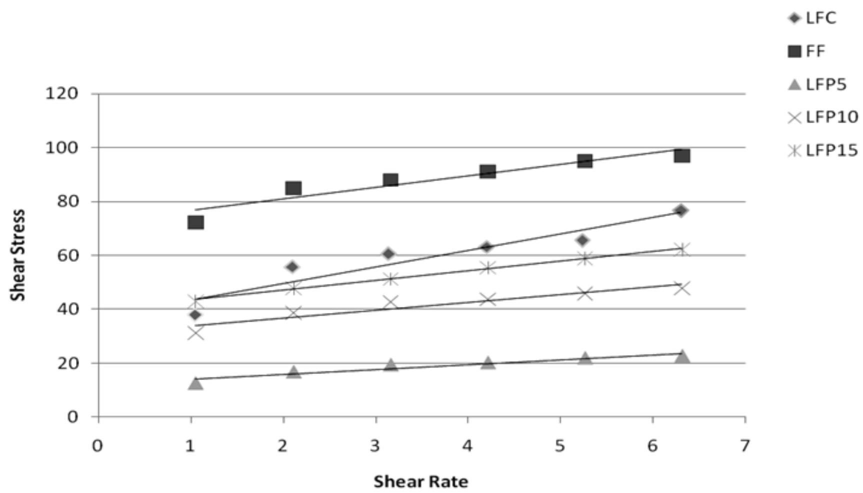

Fig. 2: Flow curves of mayonnaises.(■)FF mayonnaise,(♦) LFC mayonnaise, (*)LFP_{15} mayonnaise,(x)LFP_{10} mayonnaise, (▲)LFP_5 mayonnaise

Table 3: Model-fitting flow equation parameters of mayonnaise samples.

parameters	FF	LFC	LFP_5	LFP_{10}	LFP_{15}
Υ_0	72.31	37.21	12.26	31.07	39.78
K	6.16	4.27	1.81	2.90	3.64
R^2	0.89	0.88	0.91	0.89	0.99
μ	68	36	12	29.6	40.8

Emulsion Stability of Mayonnaise:

To compare the stability of the FF and light mayonnaise samples, we stored the mayonnaise samples at 50 ºC for 48 h and then centrifuged to separate the oil component. The commercial low fat mayonnaise CLF exhibited higher stability characteristics than FF mayonnaise sample (Fig.3). Meanwhile, the low fat mayonnaise (LFP_5 and LFP_{10}) had emulsion stability values 88.36 and 79.95, which are lower than both FF and CLF. Nevertheless, the low fat mayonnaise containing 15% potato powder mash (LFP_{15}) was had a higher stability (95.48) than FF mayonnaise and similar with commercial low fat mayonnaise. Emulsion stability usually involves preventing droplet coalescence, flocculation, and creaming. Creaming is not usually problem in mayonnaises that have high fat contents (~80%) because the droplets are so closely packed together so that they cannot move. However, in products with low fat content, creaming is usually prevented by adding a thickening agent such as a gum or a starch to the aqueous phase to slow down the droplet movement. Thus, LFP mayonnaise samples showed a higher stability than FF samples because of the increased viscosity of the aqueous phase from the addition of potato powder mash, which slowed down oil droplet movement Manoj *et al.,* (2000). Thus, these results suggested that the potato powder mash might be used in manufacturing LF mayonnaise as a stabilizing fat replacement.

Sensory Evaluations of Mayonnaise:

Sensory evaluation scores of the FF, CLF and LFP mayonnaises are shown in Table 4. The full fat mayonnaise was have scores significantly (P>0.05) increased than commercial light mayonnaise in all sensory characteristics. The appearance scores of light mayonnaise samples significantly (P>0.05) increased with increasing the substitution levels of potato powder mash. The colour of the full fat sample was better than the commercial light mayonnaise samples. Meanwhile, no significant difference between the light mayonnaises prepared by potato powder mash (LFP) and full fat sample. In general, FF mayonnaises exhibited a shiny bright yellow colour, whereas CLF mayonnaises were evaluated as too pale and dense, mainly due to fat replacers, which is confirmed by the previous finding (Karas *et al.,* 2002). The lowest colour score which might be due to the white colour of the fat mimetic resulting in the colour of the CLF (Liu *et al.,* 2007). On the other hand, the odour attribute, did not significantly influenced by addition of potato powder substitution. The LFP_{15} samples showed no significant difference in texture and taste scores from the FF, whereas the LFP_5 sample gave lower scores for these attributes. Štern, *et al*. (2001) found no significant correlation between the

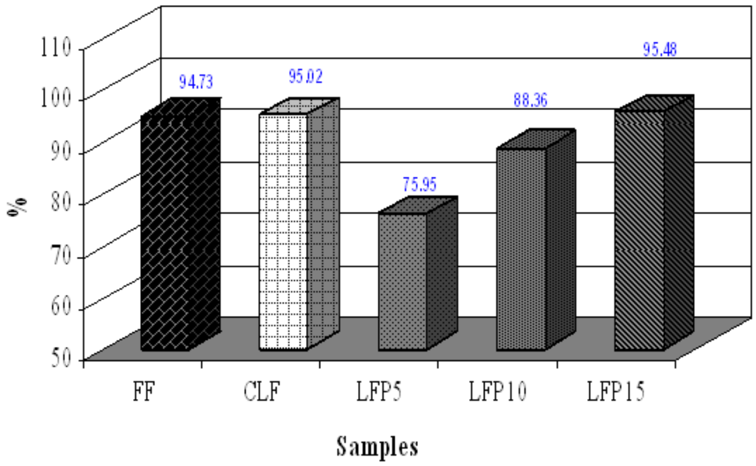

Fig. 3: Emulsion stability of low fat and low fat mayonnaise samples.

Table 4: Sensory evaluation of mayonnaise samples.

Samples	Appearance (10)	Colour (10)	Odour (10)	Texture (10)	Taste (10)	Overall acceptability (10)
Full Fat mayonnaise (FF)	9.55±0.50[a]	9.36±0.45[a]	9.38±0.48[a]	9.45±0.51[a]	9.50±0.42[a]	9.45±0.33[a]
Commercial Low Fat (CLF)	8.95±0.36[b]	8.34±0.36[b]	8.98±0.45[a]	8.56±0.49[b]	9.24±0.54[a]	8.81±0.46[b]
Low fat potato mayonnaise (LFP_5)	7.65±0.57[c]	9.16±0.44[a]	8.87±0.62[a]	7.53±0.35[c]	8.22±0.42[c]	8.16±0.55[c]
Low fat potato mayonnaise (LFP_{10})	8.95±0.43[b]	9.28±0.51[a]	9.10±0.51[a]	8.25±0.47[b]	8.75±0.51[b]	8.99±0.61[ab]
Low fat potato mayonnaise (LFP_{15})	9.23±0.45[a]	9.22±0.42[a]	9.12±0.57[a]	8.98±0.41[a]	9.40±0.44[a]	9.19±0.50[a]
LSD	0.551	0.635	0.510	0.525	0.542	0.623

Assays were performed in triplicate. Mean ±SD values followed by the same letter in each column are not significant different at P < 0.05.

apparent viscosity and sensory characteristics of mayonnaise. The overall acceptability scores were significantly higher when the substitution levels of potato powder mash increased. This is mainly contributed by the performance of appearance and colour attributes. These data agree with Karas *et al.,* 2002 the standard mayonnaise containing 75 % of oil as opposed to low-fat mayonnaise (light mayonnaise containing 49 % of oil) gained higher grades for most sensory attributes.

Effect of Storage on Ph, Acid Value and Peroxide Value of Mayonnaise:

The pH, acid value and peroxide of the FF and LF mayonnaises after storage for one-day, 30 days and 60 days at room temperature (25–30 °C) are shown in Table 5. The pH of mayonnaise can have a dramatic effect on the structure of the emulsion. The viscoelasticity and stability of the mayonnaise should be at its highest when the pH is close to the average isoelectric point of the egg yolk proteins and hence the charge on the proteins is minimized (Depree and Savage 2001). There was no significant (P>0.05) difference in pH values (3.69–3.84) of all formulations mayonnaise prepared by potato powder LFP and full fat FF at one-day storage. Meanwhile, the commercial low fat mayonnaise was significantly (P<0.05) lower in pH values. On the other hand, the pH values decreased continuously in all mayonnaise samples during storage. These data agree with Worrasinchai *et al*. (2006) who found that, no significant differences in pH values between the FF and reduce fat mayonnaises after one-day storage. However, pH values of the reduced fat samples decreased with an increasing degree of β-glucan substitution after 2 months storage. Meanwhile, Pons, *et al.* (1994) found that commercial mayonnaises had pH 3.1–3.9 values.

From the same table, it could be also observed that no significane difference in acid value of FF mayonnaise as compared with the acid value of the other low fat mayonnaises except CLF samples at one-day storage. All samples of mayonnaise had gradual increment in acid value with increased the storage time, this increase could be mainly attributed to greater water content contained more microbial loadings, which might be the growth of acid tolerant microorganisms such as lactic acid bacteria (Karas, *et al.,* 2002; Pourkomailian, 2000).

There was no significant (P<0.05) difference in peroxide values (0.71 - 0.77) of all formulations at one-day storage. While, peroxide values slightly increased in commercial light mayonnaise CLF, the full fat FF and

Table 5: Effect of storage on pH, acid value and peroxide value on mayonnaise.

Samples	pH			Acid value (mL NaOH /g)			Peroxide value (mmol O2/kg)		
	1 day	30 days	60 days	1 day	30 days	60 days	1 day	30 days	60 days
Full Fat mayonnaise (FF)	3.74±0.27[a]	3.61±0.31[a]	3.59±0.30[a]	5.43±0.35[b]	5.69±0.28[a]	5.84±0.31[a]	0.71±0.12[a]	1.48±0.22[b]	2.03±0.26[b]
Commercial Low Fat (CLF)	3.05±0.21[b]	3.01±0.25[b]	3.01±0.22[b]	5.85±0.29[a]	6.02±0.31[a]	6.13±0.27[a]	0.75±0.08[a]	1.15±0.18[c]	1.38±0.16[c]
Low fat potato mayonnaise (LFP_5)	3.69±0.28[a]	3.51±0.33[a]	3.45±0.34[a]	5.64±0.37[ab]	5.83±0.36[a]	6.01±0.25[a]	0.73±0.10[a]	1.85±0.20[a]	2.78±0.24[a]
Low fat potato mayonnaise (LFP_{10})	3.76±0.31[a]	3.71±0.36[a]	3.54±0.38[a]	5.52±0.25[ab]	5.72±0.25[a]	5.96±0.33[a]	0.76±0.12[a]	1.76±0.16[a]	2.54±0.26[a]
Low fat potato mayonnaise (LFP_{15})	3.84±0.30[a]	3.65±0.39[a]	3.59±0.32[a]	5.35±0.27[b]	5.92±0.22[a]	5.98±0.24[a]	0.77±0.8[a]	1.77±0.24[a]	2.16±0.20[b]
LSD	0.35	0.42	0.42	0.41	0.39	0.36	0.14	0.28	0.30

Assays were performed in triplicate. Mean ±SD values followed by the same letter in each column are not significant different at P < 0.05.

light fat mayonnaise LFP during storage period. The increment rate in that value was decreased with increasing of potato powder. This increment may be due to the percentage of water content of mayonnaise content.

Effect of Storage on Total Count and Yeast Count on Mayonnaise:

The total count, yeast, mold and salmonella count on mayonnaise of the FF and LF mayonnaises after storage for one-day, 30 days and 60 days storage at room temperature (25–30 °C) are shown in Table 6. After one-day storage, the total plate counts of FF formulation presented the highest value ($45x10^2$cfu/g) while the CLF sample had the lowest value ($8x10^2$ cfu/g). Whereas, the LFP_5 had the highest total plate counts among the LFP_{10} and LFP_{15} formulations. This was possibly due to the higher oil content of the FF formulation gave the higher possibility that microorganisms may reside in the oil phase and do not see the acid and pH effect in the aqueous phase and hence the levels are not reduced (Pourkomailian, 2000). After 64 days storage, the total plate count of the FF sample decreased, whereas those of the LFP and CLF increased. The reduction of microbial loadings of the FF sample was probably due to the effect of undissociated acetic acid solubilized into the oil phase. In contrast, the low fat mayonnaise samples LFP with greater water content contained more microbial loadings, this is attributed to the growth of acid tolerant microorganisms such as lactic acid bacteria (Karas *et al*., 2002). With respect to yeast and mold count, the same trend was also observed. The CLF had lowest value among all samples. This may be due to pasteurization process or the concentration of acetic acid was higher than the other mayonnaise sample. After storage period, the yeast and mold count increased gradually in all samples. Abu-Salem and Abou –Arab, (2008) Found that after 20 weeks of storage the counts of molds and yeast were higher in unpasteurized mayonnaise than pasteurized mayonnaise made from ostrich and chicken eggs. The result indicates that all mayonnaise samples were free from salmonella species. Our results confirmed by Abou-Zeid, 2006 who found that, for preventing salmonelosis transmission by home-mayonnaise the use of vinegar as an acidulants in order achieve a pH between 3.6-4.0 and storage in a worm place is recommended.

Table 6: Effect of storage on total count and yeast count on mayonnaise.

Samples	Total count plat (cfu/g)			Yeast and mold(cfu/g)			Salmonella
	1 day	30 days	60 days	1 day	30 days	60 days	
Full Fat mayonnaise (FF)	$45x10^2$	$30x10^2$	$20x10^2$	$1x10^2$	$1x10^2$	$1x10^2$	ND
Commercial Low Fat (CLF)	$8x10^2$	$12x10^2$	$18x10^2$	Zero	$1 x10^2$	$3 x10^2$	ND
Low fat potato mayonnaise (LFP_5)	$30x10^2$	$35x10^2$	$44x10^2$	$1x10^2$	$6x10^2$	$10x10^2$	ND
Low fat potato mayonnaise (LFP_{10})	$15x10^2$	$32x10^2$	$46x10^2$	$3x10^2$	$11x10^2$	$19x10^2$	ND
Low fat potato mayonnaise (LFP_{15})	$17x10^2$	$35x10^2$	$50x10^2$	$5x10^2$	$19x10^2$	$24x10^2$	ND

Conclusions:

From the results of the present work, it can be concluded that potato powder mash played a multiple role as a fat replacer and which resulted in the LF mayonnaises with lower calorie as their FF counterpart. However, the addition of the potato powder mash by 5 and 10% adversely affected mayonnaise appearance and colour leading to the significantly lower sensory quality. Nevertheless, the substitution levels by potato powder mash by 15% with 50% of oil used was found to be acceptable as compared with the full fat FF control and commercial low fat CLF sample.

REFERENCES

Akoh, C.C., 1998. Fat replacers. Food Technology, 52: 47-53.

Aluko, R.E. and T. McIntosh, 2005. Limited enzymatic proteolysis increases the level of incorporation of canola proteins into mayonnaise. Innovative Food Science and Emerging Technologies, 6: 195-202.

AOAC, 2000. (17th ed.) Official methods of analysis of the association of official analytical chemists, Vol. II. Arlington, VA: Association of Official Analytical Chemists.

Bourne, M.C., 1978. Texture profile analysis. Food Technology, 32: 62-66 see also page 72.

Chantrapornchai, W., F. Clydesdale and D. McClements, 1999. Influence of droplet characteristics on the optical properties of colored oil-in-water emulsions. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 155: 373-382.

Clegg, S.M., 1996. The use of hydrocolloid gums as mimetics. In: Roller S, Jones SA, editors. Handbook of fat replacers. Boca Raton: CRC Press, pp: 191.

Dartey, K., M. Trainor and R. Evans, 1990. Low cholesterol mayonnaise substitute and process for its preparation. United States Patent 4948617.

Depree, J.A. and G.P. Savage, 2001. Physical and flavour stability of mayonnaiseTrends in Food Science & Technology, 12: 157-163.

Abu-Salem, M. Ferial and Azza A. Abou-Arab, 2008. Chemical, microbiological and sensory evaluation of mayonnaise prepared from ostrich eggs. Grasas y Aceites, 59(4): 352-360.

Ford, L.R. Borwankar D. Pechak and B. Schwimmer, 2004. Dressings and sauces. In: Friberg S, Larsson K, Sjoblom J, editors. Food emulsions . 4th ed. New York: Marcel Dekker.

Hasenhuettl, G.L., 2008. Overview of food emulsifiers. In: Hasenhuettl, G.L., Hartel, R.W. (Eds.), Food Emulsifiers and their Applications. Springer Science + Business Media, USA, pp: 1-7.

Karas, R., M. Skvarc and B. Žlender, 2002. Sensory quality of standard and light mayonnaise during storage. Food Technology and Biotechnology, 40: 119-127.

Liu, H.X.M. Xu and Sh.D. Guob, 2007. Rheological, texture and sensory properties of low-fat mayonnaise with different fat mimetics. LWT-Food Science and Technology, 40: 946-954.

Ma, Y., C. Cai J. Wang and D.W. Sun, 2006. Enzymatic hydrolysis of corn starch for producing fat mimetics. J Food Eng., 73: 297-303.

Manoj, P., A.J. Fillery-Travis, A.D. Watson, D.J. Hibberd and M.M. Robins, 2000. Characterization of a Polydisperse Depletion-Flocculated Emulsion III. Oscillatory Rheological Measurements Journal of Colloid and Interface Science, 228: 200-206.

McClements, D.J., 2005. Food Emulsions: Principles, Practice, and Techniques, 2nd ed., CRC Press, Boca Raton, FL, 2005.

McClements, D.J. and K. Demetriades, 1998. An integrated approach to the development of reduced-fat food emulsions. Critical Reviews in Food Science and Nutrition, 38: 511-536.

Abou-Zeid, M.B., 2006. Sensory, physico-chemical and microbial characteristics of new light mayonnaise formulations. M.Sc. Thesis, Faculty of Agric. Cairo University. Egypt.

Mohamed, M.O. and H.A. Morris, 1987. Textural and microstructural properties of rennet-induced milk coagulum as affected by the addition of soy protein isolate. Journal of Texture Studies, 18: 137-155.

Mun, S., Y. Lim Kim C. Gil Kang, K. Hwa Park J. Yong Shim Y. Ro Kim, 2009. Development of reduced-fat mayonnaise using 4_GTase-modified rice starch and xanthan gum. International Journal of Biological Macromolecules, 44: 400-407.

Narsimhan, G. and Z. Wang, 2008. Guidelines for processing emulsion-based foods. In: Hasenhuettl, G.L., Hartel, R.W. (Eds.), Food Emulsifiers and their Applications. Springer Science + Business Media, USA, pp: 349-389.

Pons, M., M.J. Galotto and S. Subirats, 1994. Comparison of the steady rheological characteristics of normal and light mayonnaise. *Food Hydrocolloids*, 8(3-4): 389-400.

Pourkomailian, B., 2000. Sauces and dressings. In D. Kilcast, & P. Subramaniam (Eds.), The stability and shelf-life of food. Washington, DC: CRC Press.

Rekha, M., A. Chauhan A. Yadav G. Manisha and S. Ramteke, 2004. A process for the preparation of instant soup mix from Indian Dill (*Anethum sowa*) CSIR patent. Government of India, New Delhi. DEL/501/2004.

Smith, R.B. and M.C. Cirigliano, 1992. Salad dressing .PP.975-983. In:Compendium of Methods for the Microbiological Examinations of Foods , 3d ed., Vanderzant,C.and Splittostoesser,D.F (eds),American Public Health Association,Washington, D.C.

Souci, S.W., W. Fachman and H. Kraut, 2000. Food composition and nutrition tables (6th ed.). Stuttgart: Medpharm.

Štern, P., H. Valentová and J. Pokorný, 2001. Rheological properties and sensory texture of mayonnaise. European Journal of Lipid Science and Technology, 103: 23-28.

USDA-NASS. 2005. Agricultural Statistics.

Wendin, K. and G. Hall, 2001. Influences of Fat, Thickener and Emulsi"er Contents on Salad Dressing: Static and Dynamic Sensory and Rheological Analyses. LWT- Food Science and Technology, 34: 222-233.

Willard, M.J. and V.M. Hix, 1987. Potato processing, (Talburt WF and Smith O) 4th edn., Van Nostrand Reinhold, New York.

Worrasinchai, S.M. Suphantharika S. Pinjai P. Jamnong, 2006. b-Glucan prepared from spent brewer's yeast as a fat replacer in mayonnaise. Food Hydrocolloids, 20(1): 68-78.

Yadav, A.M. Guha R. Tharanathan and S. Ramteke, 2006. Influence of drying conditions on functional properties of potato flour. Eur. Food Res. Technol., 223: 553-560.