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Effect of Basil Seed Gum and Tracaganth Gum as Fat Replacers on Physicochemical, Antioxidant and Sensory Properties of Low Fat Mayonnaise

Johary N[1], Fahimdanesh M[2*], Garavand F[3]
[1,2]Department of Food Science and Technology, Shahr-e-Qods Branch, Islamic Azad University, Tehran, Iran.
[3] Department of Food Science and Technology, college of Agriculture and Natural Resources, University of Tehran, Tehran, Iran.
m.fahimdanesh@shahryariau.ac.ir

ABSTRACT: *In present study, application of basil seed gum (BSG) and tracaganth gum (TG) as fat replacers were studied in low fat mayonnaise formulation. Hence, sesame seed oil (SSO) was substituted common vegetable oils at the levels of 20 and 30%. Fat was partially substituted by BSG at levels of 2.5 and 4.5% and TG at levels of 1.6 and 2.5%. FF (full fat or control with 78% oil), F1 (30% SSE, 1.6% TG), F2 (20% SSE, 2.5% TG), F3 (30% SSE, 1.6% TG and 2.5% BSG), F4 (20% SSE, 2.5% TG and 2.5% BSG), F5 (30% SSE, 1.6% TG and 2.5% BSG) and F6 (20% SSE, 2.5% TG and 4.5% BSG) are treatment used in this study. Physicochemical, antioxidant and sensory analysis of FF and Low fat treatments were evaluated. Results indicated that BSG and TG beside fat replacer and low calorie content roles can improve the viscoelastic behavior and consistency of low fat mayonnaise with their suitable water absorption properties. Also, incorporation of SSO can improves the antioxidant and anti-rancidity traits and brings health- promoting attributes to the final product because of the presence of phenolic compounds and their antioxidant properties. In view of sensory attributes, F4 showed similar textural characteristics as those of control. Likewise, all treatments have acceptable pH and acidity and no creaming was observed. According to the results of present study, it can be concluded that BSG, TG and SSOare suitable substitutions for conventional high fat mayonnaise without any adverse effects on quality attributes of mayonnaise. Nearby, employing SSE can both prevent rancidity and include antioxidant effects to mayonnaise, so that such mayonnaise can be accounted as a functional food.*

KEYWORDS: *Basil seed gum, tracaganth gum, mayonnaise, sesame seed oil.*

I. INTRODUCTION

It is well-known that fats play an important role in bodyas a source of energy and transport of vital nutrients especially fat soluble vitamins. Hence, it is essential to pay attention to both the total amount and the type of fats in the diet. An excessive consumption of oils and fats can lead to health problems such as cardiovascular diseases, high blood pressure and obesity (Zaouadi et al., 2014). Mayonnaise is traditionally prepared using egg yolk as an emulsifier and alarge volume of oil (about 65%). Therefore it is generally considered as a high-fat and high-caloric food item which dwindling consumption of low-fat or low-energy products is so important. Hence formulation of a low-fat (LF) mayonnaise is an important matter both for the food industry and for consumers. As well as, fat gives the desired flavor, color, appearance, texture, and shelf-life to mayonnaise. Thus, during the developing of a LF mayonnaise, it is hard to maintain the quality attributes of traditional mayonnaise. Mostly, no-fat components including different gums, starches, and proteins with different functionalities are incorporated into fat-reduced goods. These components may result in loss of quality properties of LF products compared to full-fat (FF) products (Worrasinchai et al., 2006; Rhabari et al., 2014).

Different formulations of mayonnaise containing lowlevels of oil have been developed by various fat replacers. Among the fat replacers polysaccharide gels containing remarkable dietary fibers are worthy substitutes for fats and oils. Polysaccharide gels, including pectin, guar gum and xanthan gum, have been increasingly studied as fat replacers in food industry (Liu et al., 2007). However, limited numbers of researches emphases on reduced-fat mayonnaise containing basil seed gum (BSG) and tracaganth gum (TG) as fat replacers, as well, sesame seed oil as healthy oil instead of common oils in mayonnaise. Rheological characteristics have close relation to textural attributes of mayonnaise. TG and BSG are polysaccharide gums applied in food products alone, or in combination to generate the desired rheological properties. They were used as a fat replacer, stabilizer and emulsifier in ice cream, non-fat concentrated yoghurt, low fat yogurt etc. (Bahramparvar et al., 2009; Aghdaei et al., 2012).

Beside the fat replacers mentioned above, there is a little information about the usage of sesame seed oil (SSO) as a functional (unsaturated fatty acids and phenolic compounds) healthy fat in mayonnaise formulation. Thus, the purpose of the current study was to scrutinize the effects of partial fat substitution by TG and BSG on physicochemical, rheological, antioxidant and sensory properties of low fat mayonnaise.

II. MATERIALS AND METHODS

Chemicals and reagents: Soybean and sesame seed oil, egg, vinegar, salt, sugar and mustard were provided from local market. Gallic acid, DPPH (2,2-diphenyl-1-picrylhydrazyl), sodium carbonate and Folin–Ciocalteu phenol reagent were purchased from Merck (Darmstadt, Germany). BSG and TG prepared from Pars Sta (Iran, Tehran). Other chemicals were of analytical grade.

Mayonnaise preparation: Mayonnaise ingredients of full fat and low fat were shown in Table 1. To prepare different mayonnaises; at first, powder ingredients (salt, sugar, gums, guar, and mustard), water, and egg were mixed with stirrer for 4 min at 800 rpm. Then, 1/3 of vinegar was added and mixed for 2 min with the same speed. Then oil was added gently in 8 min at 1,100 rpm in to aqueous phase. The rest of the vinegar was poured into mixture (2/3 of vinegar) and mixed for 2 minutes. The obtained mixture was homogenized with the stirrer operating at 1,500 rpm for 7 min. As it is observed from Table 1 sesame seed oil (SSE) was substituted common vegetable oils at the levels of 20 and 30%.

Table 1. Formulation of different mayonnaise samples

Ingredients	Control (FF)	F1	F2	F3	F4	F5	F6
Oil	75	30	20	30	20	30	20
Egg	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Mustard	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Salt	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Sugar	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Vinegar	6	6	6	6	6	6	6
Water	9.1	52.55	61.65	50.05	59.15	48.05	57.15
Xanthan	0.05	0.05	0.05	0.05	0.05	0.05	0.05
TG	-	1.6	2.5	1.6	2.5	1.6	2.5
BSG	-	-	-	2.5	2.5	4.5	4.5

Composition analysis and calorie calculation: Moisture, protein, and ash contents were determined according to AOAC (2000) official methods. Fat content was measured by using Soxhlet apparatus, and total carbohydrate content was calculated by difference. The calorie value of samples was calculated according to the following equation:

$$\text{Calorie value} = (4 \times \text{carbohydrate}) + (9 \times \text{fat}) + (4 \times \text{protein}) \quad \text{Eq.1}$$

pH and acidity measurement : A fixed amount of each sample was diluted with 95 cc distilled water and pH of samples was measured by the pH meter (Meterohm, Ion analysis, Switzerland). Also acidity measured by titration with NaOH solution.

Color measurement: Lightness (L*), redness (a*) and yellowness (b*) values of the biscuit were measured using Lovibond Colorimeter (Virginia, USA). The positive and negative values of a* are exhibited magnitude of reddish and greenish of samples, respectively. On the other hand, a positive value of b* indicates yellowish and its negative indicates bluish of the mayonnaise samples.

Stability and creaming tests: 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. Then mayonnaise samples tested in Bostwick Consistometer which measures viscosity by measuring the flow of a product under its own weight in a specified time.

Total phenolic content: Total phenolic contents of mayonnaise were determined using the Folin–Ciocalteu test (Singleton and Rossi, 1965). The diluted samples were mixed with Folin–Ciocalteu reagent and distilled water. Samples were kept for 7 min at room temperature and then sodium carbonate solution was added. The tubes vortexed for 30 s and allowed to set in a dark place for 70 min for color outreach. Spectrophotometric measurements were performed by a spectrophotometer (New Jersey, USA). The total phenolic compounds was measured at 760 nm and calculated by a calibration curve plotted with gallic acid. Total phenolic content was expressed as mg gallic acid per 100 gram dry sample (mg GAE/100g sample).

Antioxidant activity: Antioxidant activity of samples was evaluated according to Gharibzahedi et al. (2013) with some revisions. Samples were mixed with methanolic DPPH solution and then the mixture kept for 30 min at room temperature. A DPPH solution with no added extract was considered as the control. The antioxidant activity as inhibition percentage of DPPH was measured at 517 nm according to the following equation:

$$\text{Inhibition of DPPH}(\%) = \frac{A_{control} - A_{sample}}{A_{control}} \times 100 \qquad \text{Eq. 2}$$

where A_{sample} and $A_{control}$ are the absorbance of the extract sample with DPPH and the absorbance of the DPPH solution without extract, respectively.

Sensory Analysis: The sensory attributes of samples including color, appearance, taste, texture, chewiness, mouth feel, spread-ability and overall acceptability were assessed based on 5-point hedonic test by semi-trained panelists and the data was analyzed statistically (Reddy et al., 2005).

Statistical analysis: The data were subjected to analysis of variance (ANOVA) and the significance of the difference between means was determined by Duncan's multiple range test (P<0.05) by using SPSS statistical software (version 18; SPSS Inc., Chicago, IL, USA).

III. RESULTS AND DISCUSSION

Composition analysis and calorie calculation: The chemical analysis and calorie value of different FF and LF mayonnaise demonstrated in Table 2. As it is evident, LF samples showed a considerable lower calorie value compared to the control (FF sample) so that the amount of generated calorie in LF samples is 30-40% of control. Substitution of TG, BSG and SSO instead of common vegetable oil cause increasing moisture content while oil content decreased significantly (P<0.05). In light of protein and ash content, there are no notable changes between FF and LF samples. But carbohydrate levels experienced higher amounts as polysaccharide gums alternate vegetable oil as fat replacers because gums have some carbohydrate in their side chain. Higher amounts of moisture content in LF mayonnaise attributed to the intrinsic traits of TG and BSG in bonding free water in their structure (Ma and Boye, 2013). These hydrocolloids which applied as fat replacers able to show some functional properties like fats by bonding water molecules into food emulsions (Razavi et al., 2009). According to Table 2, the calorie value (or energy generation) of LF mayonnaise lowered successfully compared to FF mayonnaise. In addition, applying gums in LF mayonnaise formulation result in alleviating calorie value both in case of low fat consumption and indigestibility of polysaccharide gums in human body (Aghdaei et al., 2012).

Table 2. Chemical analysis (w/w) and calorie value of FF and LF mayonnaise.

Treatments	Fat	Protein	Moisture	Carbohydrate	Ash	Calorie
Control (FF)	76.26 ± 0.30^a	1.83 ± 0.03^a	17.33 ±0.18^f	0.67 ±0.03^e	0.84 ±0.04^b	696.34
F1	31.63 ± 1.08^b	1.87 ± 0.03^a	78.12 ±1.33 ^{c}	1.85 ±0.05^d	0.82 ±0.05^b	299.63
F2	20.74 ± 0.69^c	1.85 ± 0.02^a	89.56 ±0.38^a	2.77 ±0.02^c	0.83 ±0.06^b	205.14
F3	30.94 ± 0.46^b	1.86 ± 0.02^a	73.96 ±1.00^d	3.96 ±0.12^b	0.86 ±0.03^b	301.74
F4	21.03 ± 0.27 ^{c}	1.88 ± 0.03^a	86.59 ±0.62^b	4.62 ±0.51^b	1.13 ±0.06^a	215.72
F5	30.97 ± 0.16^b	1.86 ± 0.03^a	71.13 ±0.28^e	3.92 ±0.14^b	0.87 ±0.05^b	301.85
F6	20.33 ± 0.33 ^{c}	1.90 ± 0.04^a	87.42 ±0.41^b	6.67 ±0.69^a	1.19 ±0.08^a	217.29

In each column, values with different letters mean significant differences (P<0.05). Data are expressed as mean ± standard deviation.

pH and acidity: pH and acidity are important factors in preparation of mayonnaise dressings which according to national standardsmust be below 4.1 and in the range of 0.65-0.85, respectively. The obtained results of pH value are presented in Fig. 1. Results showed that pH doesn't altered 30 days after storage but decreased gradually in 60 and 90 days during storage. As well as, the results of acidity are showed in Fig. 2. As shown all treatments are in the range of 0.7 to 0.8 and don't practiced any considerable change during storage. Also, almost all pH and acidity values are in the range of standard specifications. Increase in pH and acidity decreasing may prepare suitable condition for growth of pathogenic bacteria: *Staphylococcus aureus*, which is the main cause of mayonnaise deterioration. The pH and acidity of all FF and LF mayonnaise are constant and similarly altered because the vinegar and mustard contentof them, which are responsible for pH lowering in emulsion system, are equal. Also, Stephen et al. (2006) stated that pH decreasing may result in breakdown of ester groups and converting to carboxylic groups in the structure of hydrocolloids. These results are in consistent with Marinescu et al. (2011).

Fig. 1. pH value of FF and LF mayonnaise during 90 days storage (values with different letters mean significant differences (P<0.05)).

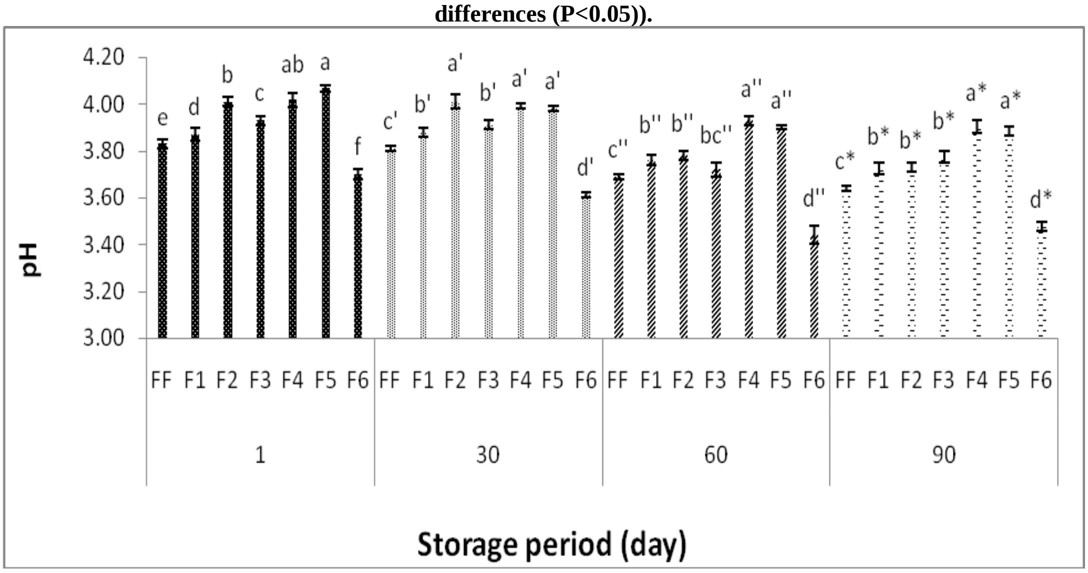
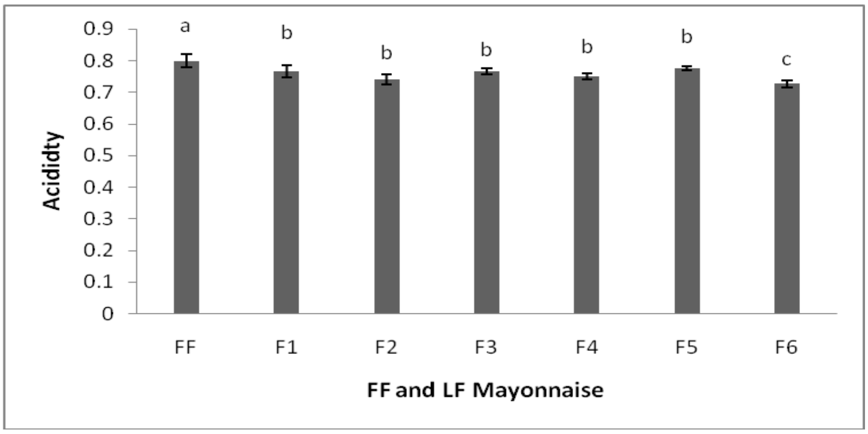
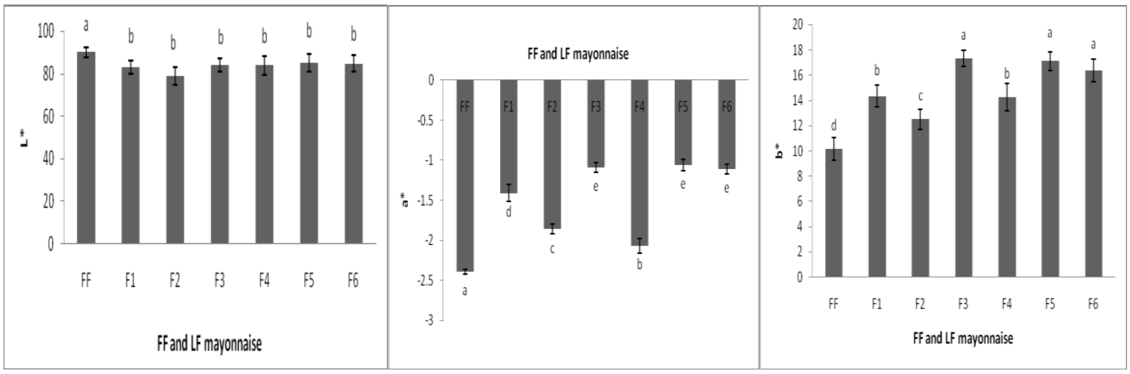


Fig. 2. Acidity of FF and LF mayonnaise (values with different letters mean significant differences (P<0.05)).



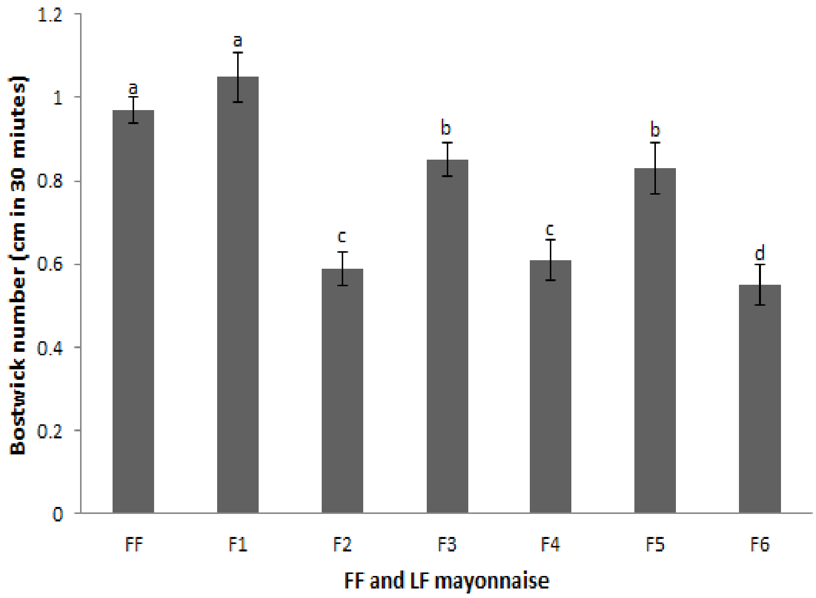
Color: Among the all color parameters lightness (L* value) plays an imperative role in consumer's acceptable. According to the Fig. 3 L* value of all LF mayonnaise was lower than that of FF mayonnaise. It can be concluded that decreasing in oil content and addition of hydrocolloids in mayonnaise formulation results darker appearance in LF mayonnaise. These results were in agreement with the results of Aghdaei et al. (2012) about the application of Isfarzeh seed mucilage as a fat mimetic in mayonnaise. Also McClements and Dimitris (1998) stated that when particle size diameter becomes smaller, the lighter color obtained because of the light fractionating. Thus, it can be said that incorporation of macromolecules like hydrocolloids (TG and BSG) in mayonnaise formulation alongside the direct effect on product's color, may create larger particle size in the emulsion system. As well as, a* and b* parameters in F3, F5 and F6 were higher than the other LF and control samples. The reason of such behavior could be related to the presence of much higher SSO (with the moderate red-like color) and hydrocolloids contentin F3 and F5 samples. F6 sample even though lower SSO content indicated more a* and b* values because of the presence of some impurities in the much higher hydrocolloids used. In addition, increase in SSO levels inclined mayonnaise samples to the yellow and red colors.

Fig. 3. Color parameters of FF and LF mayonnaise (values with different letters mean significant differences (P<0.05)).



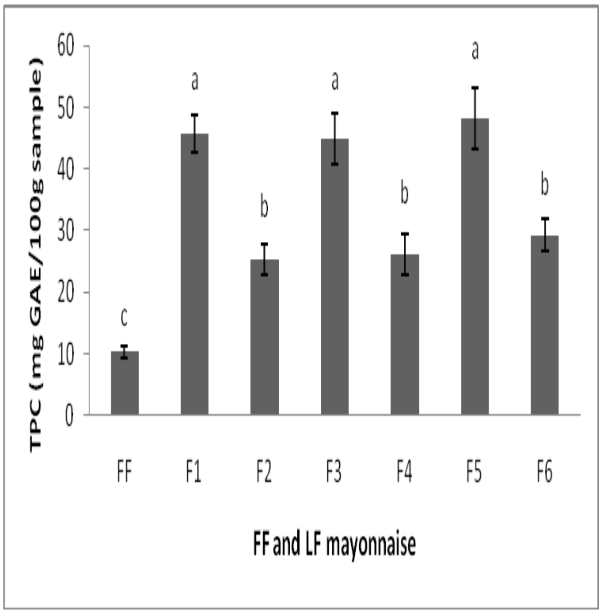
Stability: According to the obtained results neither creaming nor phase separation were occurred in all emulsion systems. It is concluded that the presence of various hydrocolloids (e.g. Xanthan, TG and BSG) in mayonnaise formulation as fat replacers cause this phenomena. Basically, more hydrocolloid incorporation increases the viscosity in continuous phase and provides emulsions with smaller particle size and more stability (Nikzade et al., 2012). As illustrated in Fig. 4, addition of more hydrocolloids in mayonnaise formulation results lower Bostwick number i.e. more emulsion consistency. F6 sample revealed the maximum consistency because of greater hydrocolloid content compared to other samples (0.05% Xanthan, 2.5% TG and 4.5% BSG). The acquired findings of Bostwick number for control sample which is about 0.97 cm/s were in agreement with the Sahin and Ozdemir (2004). Likewise Amirkavei et al. (2004), and Liu et al. (2007) reported more viscos and consistent LF mayonnaise using maltodextrin, pectin and other gums.

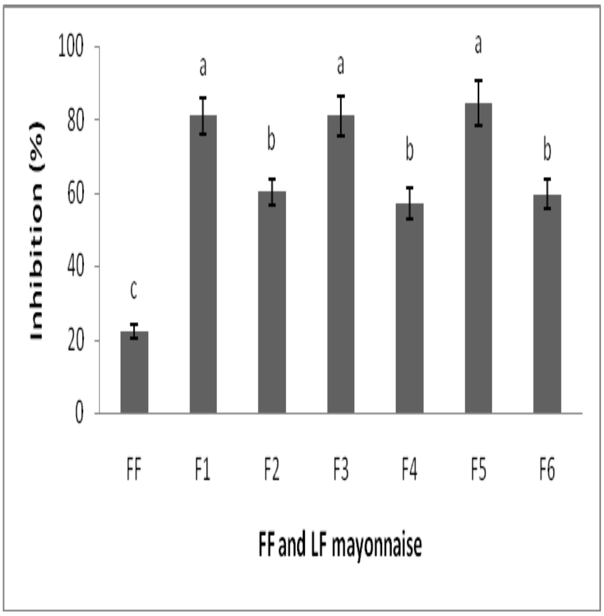
Fig. 4.Bostwick number of FF and LF mayonnaise (values with different letters mean significant differences (P<0.05)).



Total phenolic compounds and antioxidant activity: It is remarkable that phenolic compounds show potent antioxidant and antimicrobial activities that recommend them as extremely valuable components in the formulation of health-promoting functional food products (Garavand and Madadlou, 2014). As reported in Fig. 5, exploiting SSO in formulation donate considerable phenolic compounds and radical scavenging capacity to LF mayonnaise. According to the Fig. 5, more SSO incorporation (30%) in F1, F3 and F5 samples cause 4-5 fold increase in TPC content and inhibition of free radicals. This is because of the presence of numerous phenolic compounds in SSO especially sesamol which its antioxidant and anti-cancer was approved by several researchers (Espín et al., 2000; Kapadia et al., 2002; Shahidi et al., 2006). Also, Dimitrios (2006) attributed the antioxidant properties of SSO to the lignans compounds including sesamin, sesamolin, sesaminol, sesangolin and 2-episalatin. SSO contain considerable amounts of vitamin E which provide antioxidant activity. On the other hand, presence of mustard in the formulation of all mayonnaise samples cause antioxidant attributes because of possessing phenolics like kaempferol, quersetin and hydroxycynnamic acids (Cartea et al., 2010).

Fig. 5. Total phenolic compounds and antioxidant activity of FF and LF mayonnaise (values with different letters mean significant differences (P<0.05)).





Sensory evaluation: Table 3 indicated the sensory scores for different mayonnaise formulations. The greatest scores for appearance and color were related to FF and F1 samples clearly because of their lighter color compared to other LF mayonnaise which are in agreement with the results of colorimeter. Another reason may associate with the higher moisture content in LF mayonnaise formulations (Aghdaei et al., 2012). In case of better taste, FF, F1, F4, F5 and F6 have statistically significant differences (P<0.05) in comparison with the other samples. FF and F1 samples also give superior texture, while it is expected that the samples with more hydrocolloids incorporation contribute better texture. This can be ascribed to the insufficient dispersion or inhomogeneous hydration of hydrocolloids in water which cause grainy texture in the final product. F6 sample acquired the highest score in consistency which these results are in agreement with the results of stability and viscosity tests. The main reason is also combination of three gums in the mayonnaise formulation. F4 sample attained the best score in light of spread-ability and mouth feel. Finally, the overall acceptability showed that the control and F4 samples obtained the uppermost scores.

Table 3. Sensory evaluation of FF and LF mayonnaise.

Treatments	Appearance	Color	Taste	Texture	Consistency	Spread-ability	Mouth feel	Overall acceptability
Control (FF)	4.71 ± 0.06^{a}	4.41 ± 0.13^{a}	4.01 ± 0.18^{a}	4.54 ± 0.15^{a}	3.35 ± 0.11^{e}	3.51 ± 0.15^{b}	4.02 ± 0.18^{b}	4.44 ± 0.04^{a}
F1	4.63 ± 0.18^{a}	4.32 ± 0.06^{a}	4.12 ± 0.13^{a}	4.25 ± 0.09^{a}	2.52 ± 0.05^{b}	2.85 ± 0.15^{c}	4.21 ± 0.09^{b}	3.92 ± 0.16^{b}
F2	3.74 ± 0.09^{b}	3.85 ± 0.19^{b}	2.76 ± 0.08^{b}	3.37 ± 0.04^{b}	3.88 ± 0.06^{c}	3.07 ± 0.08^{b}	3.83 ± 0.16^{b}	3.77 ± 0.06^{c}
F3	1.94 ± 0.26^{d}	3.71 ± 0.16^{b}	2.90 ± 0.09^{b}	1.86 ± 0.12^{b}	3.44 ± 0.13^{e}	2.66 ± 0.12^{c}	2.25 ± 0.15^{b}	2.16 ± 0.13^{e}
F4	4.03 ± 0.27^{b}	4.01 ± 0.15^{b}	4.12 ± 0.22^{a}	4.02 ± 0.21^{a}	4.00 ± 0.06^{b}	4.02 ± 0.11^{a}	4.33 ± 0.06^{a}	4.13 ± 0.06^{b}
F5	3.81 ± 0.16^{b}	4.05 ± 0.10^{b}	4.24 ± 0.18^{a}	3.92 ± 0.14^{a}	3.27 ± 0.09^{b}	2.30 ± 0.14^{c}	3.77 ± 0.11^{b}	3.27 ± 0.14^{d}
F6	3.33 ± 0.11^{c}	4.02 ± 0.14^{b}	4.21 ± 0.11^{a}	3.00 ± 0.09^{a}	4.40 ± 0.08^{a}	3.16 ± 0.19^{b}	2.90 ± 0.08^{a}	3.39 ± 0.09^{d}

In each column, values with different letters mean significant differences (P<0.05). Data are expressed as mean ± standard deviation.

IV. CONCLUTIONS

The results of the present study showed that TG and BSG beside the fat replacer and decreasing calorie value also able to increase viscosity in LF mayonnaise samples due to moisture absorption. Thus more stable emulsion obtained. Also SSO incorporation instead of common vegetable oils in addition to anti-rancidity effects brings health-promoting characteristics due to the presence of phenolic compounds. Generally, decreasing in the oil content of mayonnaise and addition of hydrocolloids as fat replacers cause decreasing in desirable color parameters and some sensory scores, but provides positive changes especially in case of lessening fat consumption and calorie generation. Finally, it can be concluded that TG and BSG are appropriate fat replacers so that we can exploited them in the preparation of low-fat low-calorie mayonnaise.

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