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Effect of Sesame Sprouts Powder on the Quality and Oxidative Stability of Mayonnaise

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Abstract Sesame (*Sesamumindicume* L.) and its oil contain antioxidative lignin polyphenols, λ-tocopherol and other bioactive compounds. The aim of present research was to investigate the effect of sesame sprouts on quality and oxidative stability of mayonnaise during storage. Antioxidant activity of sesame sprouts determined through phenolic contents and DPPH free radical scavenging activity, ABTS cation radical-scavenging activity and ferric reducing antioxidant power (FRAP), increased with increasing germination days showing maximum value at day 7. The sesame sprouts showing highest antioxidant potential were was used in mayonnaise at the concentration of 0.5%, 0.75%, 1.0% and 1.25 % along with control, EDTA (0.0075%) and BHT (0.02%). During 45 days of storage period at 25±5 °C, mayonnaise was examined at 0, 15, 30 and 45 days for oxidative potential using DPPH free radical scavenging activity, ABTS cation radical-scavenging activity and ferric reducing antioxidant power (FRAP). Antioxidant potential decreased with storage and highest potential was observed for SSP_4 at end and was comparable to the EDTA and higher than BHT. Oxidative stability was determined through peroxide, *ρ*-anisidine, iodine and FFA. Although oxidation increased with storage but sesame sprouts powder was effective in retarding the oxidation especially at higher ratios. Quality was determined through pH, viscosity and sensory evaluation. The investigation suggested that sesame sprouts powder is effective in controlling oxidation in mayonnaise but not found worthy in sensory perception. This proved that sesame sprouts powder has good antioxidant potential to be utilized in various foods to control oxidation.

Keywords: *mayonnaise, sesame sprouts, antioxidants, oxidation, germination*

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1. Introduction

Mayonnaise is basically an oil-in-water emulsion characterized by high fat contents (65-85%) usually prepared by emulsifying oil with other ingredients like egg, vinegar, oil, sugar and salt etc. It may have different shapes and color. It is one of the widely consumed food product [11]. Formation and stabilization of mayonnaise is facilitated by egg lecithin. In multiphase systems, oxidative reactions are an interfacial phenomenon, which are affected by a wide number of different factors, such as the chemical composition and the physicochemical properties of the oil and water phases, the types of surfactants, and the surface area of the oil phase [26,31]. Mayonnaise stability is generally based on different factors such as quantity of oil, quantity of egg yolk, ratio of oil phase to aqueous phase, method of mixing, water quality, and temperature [18]. Due to higher lipid contents one of the great concerns to emulsified foods like mayonnaise is phenomenon of interfacial oxidation, ultimately hampering storage stability and quality profile which is ultimately co-related to oxidative stability [35]. This phenomenon that is affected by several different factors like composition and the physicochemical properties of the lipid and aqueous phases, nature of emulsifiers, and the surface area of the lipid phase and substantial dissolved oxygen [12]. Commonly used synthetic antioxidants like TBHQ, BHA and BHT are widely incorporated to inhibit rancidity however their toxicity and increased consumer demands for natural products have diverted attention towards naturally edible plants as resources more effective and safer antioxidants [6]. Now research is concentrated on O/W emulsions as they are the basis of several innovative food products and their characteristics significantly affect the final product quality [19].

As synthetic antioxidants are of chemical nature which may pose any potential health threat if it's prescribed limit is violated. Many spices and plant materials contain noticeable amount of phenolic compounds and phytochemicals which are strongly assumed to have antioxidant potential. Spices are being used in foods as

flavoring agents from 2000 years [7]. Among natural antioxidants phenolic compounds are of greatest importance and are known to protect easily oxidizable constituents of food from oxidation [20]. One of the imperative oilseed crops of the world is Sesame (*Sesamumindicum L.*) which is a reasonable source of edible gourmet oil. It serves as a nutritious human food and extensively used in confectionery and baked products [30]. It is cultivated throughout the world; and constitutes about 55% lipid and 20% protein [1]. Sesame seeds and its different fractions are rich in natural antioxidative compounds such as lignans (sesamin, sesamolin, sesaminol) and tocopherols which are responsible for its oxidative stability and antioxidative activity. Antioxidant phenomenon, hepato-protective effects, hypo-cholesterolaemic and prevention of hypertension are some of the main nutraceutical attributes of sesame seeds [9].

Popular sprouts cultivated are legumes such as mungbean and soybean sprouts but sesame seeds are also good for sprouting. However, little is known about sesame sprouts. Sesame seed sprouts have shown increased antioxidant activity with progress in seeding days. Moreover, sprouted sesame seeds have high levels of free amino acids, γ-Aminobutyric acid and phenolic compounds; therefore it may be suggested to categorize as functional ingredient [5]. The objectives of the present study were to investigate the antioxidant activity of sesame sprouts at different days of sprouting and determine the effect of sesame sprouts powder on oxidative stability, quality and sensory attributes in mayonnaise.

2. Materials and Methods

2.1. Materials and Chemicals

Sesame seeds, ingredients for the preparation of mayonnaise and packaging material were purchased from the local market. All chemicals used were of analytical grade were purchased from Sigma Chemicals Co. Pakistan.

2.2. Preparation of Sesame Sprouts Powder (SSP)

Sprouting of sesame seeds was done in SANYO incubator at 25°C with 70% relative humidity. The sesame sprouts were collected at day-1, day-3 and day-5, day-7. Sprouts were lyophilized in Christ Alpha 1-14 LD freeze dryer and grinded into powder form.

2.3. Preparation of Antioxidant Extracts

The freeze-dried sprout powder (3g) was extracted and sonicated twice with 50 ml of 80% methanol each time for 30 minutes. The methanol solution was filtered and then methanol was removed in an evaporator at a temperature lower than 40 °C. The residue was freeze-dried to be used for subsequent antioxidant tests.

2.4. Analysis of Sesame Sprouts Powder

2.4.1. Proximate Analysis

The moisture, crude fat, crude protein and ash content of the sesame sprouts powder samples were determined by using the standard protocol as described in [3].

2.4.2. Total Phenolic Content

The Folin-Ciocalteu method [32] was used to determine total phenolic content. A sample of 5 g was diluted to 50 ml with distilled water and filtered through filter paper. This solution (0.5 ml) was then mixed with 2.5 ml of 0.2 N Folin-Ciocalteureagent for 5 min and 2 ml of 75 g/l sodium carbonate (Na_2CO_3) was then added. After incubation at room temperature for 2 h, the absorbance of the reaction mixture was measured at 760 nm against a methanol blank (IRMECO U2020 UV/VIS spectrophotometer). Gallic (0-100 mg/l) was used as standard to produce the calibration curve. The mean of three readings was used and the total phenolic content was expressed in mg of Gallic acid equivalents (GAE)/100 g of sesame sprouts powder (SSP).

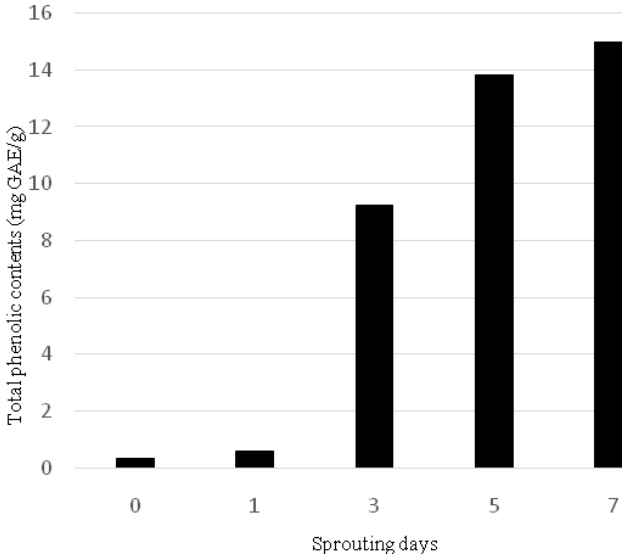

Figure 1. Total phenolic content of sesame sprouts on various days after seeding

2.4.3. Antioxidant Activity Analysis

i) DPPH radical scavenging assay

The DPPH radical scavenging assay was performed to the according to a method of [34]. A 3 ml extract sample diluted in methanol was mixed with 3 ml DPPH radical solution in methanol (2.0×10^{-4} M). The final concentration of DPPH was 1.0×10^{-4} M. The reaction mixtures were shaken vigorously and incubated in the dark for 30 min. The absorbance of the solution was measured at 517 nm.

ii) Determination of ABTS cation radical-scavenging activity

The ABTS cation radical-scavenging activity ofmethanolic extract prepared from sesame sprouts powder was determined according procedure adopted by [24]. Briefly, ABTS radical was prepared by mixing ABTS stock solution (7 mM in water) with 2.45 mM potassium persulfate. This mixture was kept for 12-24 h until the reaction was completed and the absorbance was stable (0.700±0.020 at 734 nm at 30°C). For the spectrophotometric assay, 1.48 ml of the $ABTS^+$ solution and 20 µl of the sample extract or trolox solutions were

mixed and measured immediately after 10 min at 734 nm at 30°C. Trolox (2.5 mM) was prepared in methanol to use as the standard solution.

iii) Determination of ferric reducing antioxidant power (FRAP)

The ferric ion reducing activity of methanolic extract prepared from sesame sprouts powder was measured according to the method of [36]. The FRAP reagent 2.5 mL of a 10 mmol/L TPTZ solution in 40 mmol/L HCl, 2.5 mL of 10 mmol/L $FeCl_3$ and 25 mL of 0.1 mol/L acetate buffer (pH 3.6) was prepared freshly and incubated at 40 ^oC for 15 min. Then, 0.1-0.3 mL of methanolic extracts of samples or standard solution with 2 mL of FRAP reagent were transferred into a 10-mL volumetric flask and made up to the volume with redistilled water. The obtained blue solutions were kept at room temperature for 10 min and centrifuged at 5,000 rpm for 20 min. The absorbance was measured at 593 nm using spectrophotometer.

2.5. Preparation of Mayonnaise

Mayonnaise was prepared according to the method mentioned by [22] with some modification. Different ratios of sesame sprouts powder (0.5%, 0.75%, 1% & 1.25%) will be used for the preparation of mayonnaise with artificial antioxidants for comparative study.

2.6. Storage Study

Mayonnaise was packed in plastic cups and stored at 25±5^oC. The storage study will be performed at intervals of 0, 15, 30, 45 days to investigate the oxidative stability, quality and sensory attributes.

2.7. Lipid Extraction from Mayonnaise

Lipids of all the samples of mayonnaise were extracted by using the procedure described by [21].The mayonnaise was gently mixed prior to sampling. Thirty gram portions of mayonnaise were poured into 50 ml polypropylene centrifuge tubes. The samples were frozen at -20°C for 24 h and thawed for 2 h at 4°C to break the emulsion. Two milliliters of water were added and the mixtures were centrifuged at 5000 rpm for 20 min. The lipid phase separated from the emulsion residue was stored in closed glass flasks at - 40°C until analyzed.

2.8. Physico-chemical Analysis

Free fatty acids, Iodine value, pH and Viscosity were determined by according to the standard methods from [3].

2.8.1. Oxidative Stability Analysis

Peroxide value (PV) and *para*-anisidine value (AV) were determined by according to the standard methods from [3].

2.8.2. Antioxidant Activity Analysis

i) DPPH radical scavenging assay

The DPPH radical scavenging assay was performed to the according to a method of [34] 3 ml of oil sample diluted in methanol was mixed with 3 ml DPPH radical solution in methanol (2.0×10^{-4} M). The final concentration of DPPH was 1.0×10^{-4} M. The reaction mixtures were shaken vigorously and incubated in the dark for 30 min. The absorbance of the solution was measured at 517 nm.

ii) Ferric reducing antioxidant power (FRAP) assay

The ferric ion reducing activity of extract prepared from sesame sprouts powder was measured according to the method of [36]. The FRAP reagent 2.5 mL of a 10 mmol/L TPTZ solution in 40 mmol/L HCl, 2.5 mL of 10 mmol/L $FeCl_3$ and 25 mL of 0.1 mol/L acetate buffer (pH 3.6) was prepared freshly and incubated at 40°C for 15 min. Then, 0.1-0.3 mL of extracts of samples or standard and 2 mL of FRAP reagent were transferred into a volumetric flask and made up to the volume with distilled water. The obtained blue solutions were kept at room temperature for 10 min and centrifuged at 5,000 rpm for 20 min. The absorbance was measured at 593 nm using spectrophotometer.

2.9. Sensory Evaluation

Seven sensory attributes of the prepared mayonnaise samples were evaluated for its appearance, color, taste, flavor, mouth feel, and overall acceptability A Nine-Point Hedonic Scale was used for the evaluation of sensory attributes.

2.10. Statistical Analysis

All experiments were performed in triplicate. Comparison among the means was carried out using tukey's Multiple Range test at the 95% confidence level using Statistical Analysis System (SAS) release 9.1 (SAS Institute, Inc., Cary, NC, USA).

3. Results and Discussions

3.1. Proximate Analysis

The proximate analysis (moisture, ash, fat and protein contents) of sesame sprout powder (SSP) is presented in Table 1. The moisture contents of SSP were determined at different days of germination that's show the germination process has significant ($p<0.05$) effect on the moisture contents of sprouts. Seedlings before germination showed the lowest moisture contents (0.310 g/100 g) while that increased within germination days with maximum moisture contents (4.3 g/100 g) at day 3. Sesame seeds showed lowest moisture because seeds at the state of quiescence have low moisture content. The drop in moisture contents of sprouts at day 5 and day 7 can be attributed to increases in dry mass of the sprouts.[28], studying the nutritional modifications in sprouted legumes and rice observed that legumes seeds rapidly absorbed water during germination. Moisture contents of all the legumes under study (kidney, mung, soy bean and peanut) were increased significantly during germination.

Table 1. Chemical composition of sesame sprouts powder (Mean ± SD)

Sprouting Days	Moisture (g/100 g)	Ash (g/100 g)	Protein (g/100 g)	Fat (g/100 g)
0	0.31±0.07$^{\psi}$	5.31±0.09	24.70±0.22	54.10±1.05$^{\psi}$
1	2.70±0.08$^{\psi}$	5.25±0.10	24.40±0.17	51.16±0.76$^{\psi}$
3	4.30±0.30$^{\psi}$	5.18±0.12	24.79±0.20	43.50±1.11$^{\psi}$
5	2.59±0.11$^{\psi}$	5.32±0.17	24.66±0.30	20.96±2.15$^{\psi}$
7	2.38±0.08$^{\psi}$	5.28±0.13	24.78±0.19	15.80±1.47$^{\psi}$

ψ Values followed by different letters in the same column are significantly different ($p < 0.05$) according to Tukey's Multiple Range test.

The results showed non-significant effect of germination on SSP ash contents. Ash contents were almost stable during germination (Table 1). The mean ash content of seed, day1, 3, 5 and 7 were 5.31, 5.25, 5.18, 5.32, and 5.28 g/100 g respectively. The results of this study are in agreement with the study of [17] who studied the effect of germination on the changes in the chemical composition of sesame seeds. The changes ash contents were found insignificant up to day 5 of sprouting as germination days progressed.

The results of protein contents is presented in the Table 1 indicating that effect of days of germination was non-significant on the protein contents of germinated seeds. Seeds before germination had 24.70 g/100 g crude protein. Remained stable during germination, at day 7 protein contents were found to be 24.78 g/100 g. [23] evaluated the changes in antioxidant activity and nutritional significance of sesame sprouts. Results of the study indicated that during sprouting protein contents were not affected significantly. The free amino acid level increased with progressing germination days. There was 11% increase in free amino acids as compared to the non-germinated seeds.

During the study period, the oil content of seeds progressively decreased with the germination period, suggesting that oils are the major source of energy during germination and the early periods of seedling growth [16]. Seeds before germination had the highest lipids level with a mean value of 54.10 g/100 g. Lipid contents in the sprouts gradually diminished as germination progressed, as shown in Table 1. Fat contents were significantly reduced in sprouted soy bean, peanut, white, black, red and brown rice as compared to the non-germinated seeds [28]. Similar results occurred in study by [13,15].

3.2. Antioxidant Activity of Sesame Sprouts Powder (SSP)

Pheonlic compounds present in the sesame seeds are lignans (sesamin, sesamolin and sesaminol) and tocopherol, which are responsible for its antioxidant potential. Sesame lignans can be effective in controlling oxidation in vegetable oils [4]. The effect of days on the phenolic content is highly significant. In this study, it was observed that the total phenolic level improved as seeding days progressed as show in Table 2. The total phenolic content in the seeds was only 0.36 mg Gallic Acid Equivalents per gram (GAE/g) while the phenolic content sharply increased at day 5 and reached to the 13.80 mg GAE/g. At day 7 phenolic levels further increased to 14.96 mg GAE/g. The increase in total phenolic content in sesame sprouts is attributed to the increase in phenolic compounds such as sesamol and alpha-tocopherol which are potent antioxidant compounds. Total phenolics in tested faba bean cultivars were significantly different and greatly influenced by seed form. Among test cultivars, phenolics in raw, green and sprouts are in the range 8.38 - 14.01 mg GAE/g, 20.89- 46.58 mg GAE/g and 8.72-13.61 mg GAE/g, respectively. The greatest accumulation of phenolic compounds occurred in the green seeds. Since, the mean value of phenolics in green seeds for all tested cultivars was 35.6 mg GAE/g compared with 11.43 and 10.42 mg GAE/g for sprouts and raw seeds, respectively [14].

The DPPH radical is a stable organic free radical with an adsorption peak at 517 nm. It loses this adsorption when accepting an electron or a free radical species, which results in a visually noticeable discolouration from purple to yellow [29]. The effect of germination days on DPPH radical scavenging activities of the sesame sprouts powder is highly significant. The DPPH in the seeds was only 15%, at day 1 it changed to 18% while the DPPH radical scavenging activity sharply increased at day 3 after seeding to the 87 % mg. At day 7 phenolic levels further increased to 93.33%. The free radical scavenging activity germination at day 3 improves significantly. The activities of sprouts powder were found to increase in the following order: day7 > 5 day > 3 day> 1 day > seed. Increase in the DDPH activity of sprouts is due to changes in phenolic composition during germination. Greatest accumulation of phenolic compounds occurred at day 7 in the sprouts as compared to seeds is responsible for increased antioxidant activity. An increase in the antioxidant activity during the sprouting was also evaluated in the reaction with DPPH free radical. However, in this case the sunflower sprouts exhibited the highest antioxidant capacity, followed by radish, broccoli and mung bean. It was also observed that the values of antioxidant activity increased almost twelve-fold for mung bean, twice for radish and sunflower, and by one-fifth in the case of broccoli sprouts, in comparison to the seeds [37].

Table 2. Antioxidant activity of sesame sprouts powder (Mean ± SD)

Sprouting days	DPPH activity (%)	ABTSactivity (µmoleTE/g)	FRAP activity (µmoleTE/g)
0	15.00±0.41$^{\psi}$	0.94±0.12$^{\psi}$	0.83±0.17$^{\psi}$
1	18.33±0.15$^{\psi}$	3.38±0.19$^{\psi}$	0.92±0.10$^{\psi}$
3	87.24±0.62$^{\psi}$	11.39±0.18$^{\psi}$	1.25±0.53$^{\psi}$
5	89.46±0.35$^{\psi}$	21.53±0.35$^{\psi}$	1.32±0.18$^{\psi}$
7	93.37±0.25$^{\psi}$	33.71±0.21$^{\psi}$	1.50±0.35$^{\psi}$

ψ Values followed by different letters in the same column are significantly different ($p < 0.05$) according to Tukey's Multiple Range test.

Generation of the ABTS (2, 2′-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid)) radical cation is the base of one of the spectrophotometric methods used to measure the total antioxidant activity of samples. The results of ABTS assay of all sesame sprouts powder samples is presented in Table 2. Analysis of variance shows that effect of different seeding days is highly significant in affecting the ABTS cation radical-scavenging activity of sesame sprouts powder. As shown in Table 2, the ABTS value of sesame sprouts powder increased with increasing sprouting says. Sesame seeds had ABTS value of 0.86 mg Trolox/g d.m. which increased to 3.25 at day 1.sharp increase in the ABTS activity was observed at day3, 5 and 7 with 11.33, 21.26, 33.45 mg Trolox/g D.M. respectively. ABTS value is an indicator of antioxidant activity and sesame sprouts showed to have good antioxidant potential [27].

In FRAP assay an electron is transferred from antioxidant compound (usually phenolic compounds) to the oxidant specie to. In this reaction antioxidant is oxidized and oxidant specie (Fe^{3+}). Any compound having ability to reduce the Fe^{+3} to Fe^{+2} can show a reduction in the redox potential [38]. The results of FRAP assay are presented in Table 2. Analysis of variance shows that effect of different seeding days is highly significant in affecting the Ferric Reducing Antioxidant Power (FRAP) of sesame sprouts powder. As shown in Table 2, the

FRAP value of sesame sprouts powder increased with increasing sprouting days. Sesame seeds had FRAP value of 0.83 m M Fe^{2+}/g D.M. which increased to 0.83 at day 1. Sharp increase in the ferric reducing antioxidant power was observed at day3, 5 and 7 with 0.92, 1.25, 1.32 and 1.5 respectively. [2], authors found that FRAP antioxidant power increased in significantly in the sprouts as compared to the seeds under study. FRAP power of seeds of amaranth (55.3), quinoa (92.1), buckwheat (436) and wheat (110), which increased to 122, 164, 739 and 210 mg TE/100g DW respectively.

3.3. Storage Study of Mayonnaise

3.3.1. Physico-chemical Analysis of Mayonnaise

Free fatty acids were determined in oil separated from mayonnaise at regular intervals in 45 days storage period at 25°C. The treatments and storage period had significant effect on free fatty acids of mayonnaise. Free fatty acids increased in all the samples with increasing storage days. At day 45 all the treatments showed their maximum values but highest mean value was observed in the control sample (2.79%). Although FFA content increased with storage, fatty acid increase was low in sesame sprouts treated samples. This study is in agreement with study of [39], who prepared the mayonnaise with groundnut and soybean oil. The free fatty acid content went on increasing in all the samples with progressing storage days. Free fatty acid ranged from 0.69-87 in week 1 while its level increased to range of 4.55-5.22 in week 6.

The results showed that storage period and treatments significantly changed the iodine value of the mayonnaise samples. The IV decreased with increasing storage days. At day 45 lowest values were found in control sample (55.33). The unsaturated bonds of fatty acids in the control sample were reduced because more unsaturated fatty acids were oxidized in this study indicating highest level of oxidation. At day 45 all the treatments showed their maximum values, but lowest mean value was observed in the control sample (86.73). Increasing percentage of sesame sprouts powder showed slower decrease in iodine value. Sesame sprouts powder slowed the drop of iodine value, thus maximizing the stability of unsaturated fatty acids in the product. The results of this analysis are in agreement with study of [22], when purple corn extract was applied on the mayonnaise, the iodine value ranged from 137 in week 0 which reduced to 50 in week 10 when mayonnaise was stored at 25°C.

The effect of treatment and storage is highly significant, The results in the Table 3 means values for pH for treatment and storage intervals shows that the pH of all the samples decrease with increasing storage days. The addition of sesame sprouts powder increased the mean pH value of mayonnaise, highest pH value was observed for SSP_4 (4.47) at day 0. The pH of all the samples decreased with increasing storage days. Sesame sprouts powder added samples showed lower pH decrease than other but it was not significant. At day 45, the pH of SSP_0, T_{EDTA}, T_{BHT} and SSP_4 was 3.41, 3.45, 3.44 and 3.61 respectively.

Table 3. Physico-chemical analysis of mayonnaise (Mean ± SD)

0 Day					15 Day			
Treatments	**FFA (%)**	**Iodine value**	**pH**	**Viscosity (Pa.s)**	**FFA (%)**	**Iodine value**	**pH**	**Viscosity (Pa.s)**
SSP_0	0.67±0.04$^{\psi}$	139.0±0.58$^{\psi}$	4.32±0.02$^{\psi}$	49.23±0.06$^{\psi}$	1.83±0.06$^{\psi}$	104.67±1.45$^{\psi}$	3.95±0.03$^{\psi}$	48.75±0.12$^{\psi}$
T_{EDTA}	0.69±0.04$^{\psi}$	140.00±1.15$^{\psi}$	4.33±0.03$^{\psi}$	49.25±0.06$^{\psi}$	1.53±0.05$^{\psi}$	126.33±0.88$^{\psi}$	3.92±0.02$^{\psi}$	48.82±0.07$^{\psi}$
T_{BHT}	0.67±0.05$^{\psi}$	138.67±0.88$^{\psi}$	4.30±0.01$^{\psi}$	49.24±0.11$^{\psi}$	1.59±0.15$^{\psi}$	108.67±1.20$^{\psi}$	3.95±0.02$^{\psi}$	48.78±0.09$^{\psi}$
SSP_1	0.70±0.04$^{\psi}$	140.67±1.33$^{\psi}$	4.33±0.02$^{\psi}$	49.86±0.07$^{\psi}$	1.64±0.06$^{\psi}$	120.67±1.76$^{\psi}$	4.05±0.06$^{\psi}$	49.25±0.12$^{\psi}$
SSP_2	0.68±0.04$^{\psi}$	139.33±1.45$^{\psi}$	4.37±0.02$^{\psi}$	52.25±0.13$^{\psi}$	1.66±0.06$^{\psi}$	131.00±0.58$^{\psi}$	4.12±0.03$^{\psi}$	51.55±0.14$^{\psi}$
SSP_3	0.70±0.01$^{\psi}$	140.33±1.20$^{\psi}$	4.41±0.02$^{\psi}$	52.78±0.11$^{\psi}$	1.58±0.03$^{\psi}$	136.33±1.45$^{\psi}$	4.22±0.03$^{\psi}$	52.06±0.14$^{\psi}$
SSP_4	0.69±0.03$^{\psi}$	142.00±1.15$^{\psi}$	4.47±0.01$^{\psi}$	53.43±0.18$^{\psi}$	1.48±0.05$^{\psi}$	122.33±1.45$^{\psi}$	4.35±0.03$^{\psi}$	52.61±0.13$^{\psi}$
30 Day					**45 Day**			
Treatments	**FFA (%)**	**Iodine value**	**pH**	**Viscosity (Pa.s)**	**FFA (%)**	**Iodine value**	**pH**	**Viscosity (Pa.s)**
SSP_0	2.96±0.03$^{\psi}$	72.33±1.20$^{\psi}$	3.63±0.45$^{\psi}$	47.50±0.13$^{\psi}$	3.42±0.10$^{\psi}$	62.33±1.20$^{\psi}$	3.51±0.02$^{\psi}$	46.22±0.09$^{\psi}$
T_{EDTA}	2.61±0.06$^{\psi}$	115.33±2.73$^{\psi}$	3.64±0.35$^{\psi}$	47.48±0.14$^{\psi}$	2.91±0.07$^{\psi}$	109.00±1.15$^{\psi}$	3.54±0.02$^{\psi}$	46.24±0.18$^{\psi}$
T_{BHT}	2.71±0.08$^{\psi}$	82.00±1.15$^{\psi}$	3.65±0.36$^{\psi}$	47.45±0.17$^{\psi}$	3.31±0.20$^{\psi}$	72.00±1.53$^{\psi}$	3.55±0.02$^{\psi}$	46.20±0.14$^{\psi}$
SSP_1	2.80±0.05$^{\psi}$	109.00±1.73$^{\psi}$	3.68±0.35$^{\psi}$	47.78±0.19$^{\psi}$	3.12±0.10$^{\psi}$	102.67±1.76$^{\psi}$	3.56±0.01$^{\psi}$	47.46±0.17$^{\psi}$
SSP_2	2.77±0.03$^{\psi}$	117.67±0.88$^{\psi}$	3.72±0.35$^{\psi}$	51.87±0.07$^{\psi}$	3.25±0.09$^{\psi}$	113.67±1.86$^{\psi}$	3.57±0.02$^{\psi}$	49.65±0.16$^{\psi}$
SSP_3	2.67±0.05$^{\psi}$	120.33±1.45$^{\psi}$	4.83±0.30$^{\psi}$	51.23±0.15$^{\psi}$	3.30±0.06$^{\psi}$	115.67±2.40$^{\psi}$	3.59±0.02$^{\psi}$	50.58±0.10$^{\psi}$
SSP_4	2.51±0.03$^{\psi}$	123.00±1.73$^{\psi}$	3.93±0.35$^{\psi}$	51.47±0.18$^{\psi}$	3.11±0.11$^{\psi}$	119.67±0.67$^{\psi}$	3.73±0.02$^{\psi}$	50.75±0.11$^{\psi}$

ψ Values followed by different letters in the same column are significantly different ($p < 0.05$) according to Tukey's Multiple Range test.

Viscosity increased with increasing ratio of sesame sprouts powder and it ranged from 49.86-53.43 Pa.s at day 0. With passing days of storage viscosity values decreased in all the mayonnaise samples. Addition of sesame sprouts powder did not resisted decrease in viscosity. SSP_0, T_{EDTA}, T_{BHT}had viscosity in range of47.40-47.43 Pa.s. Sesame sprouts powder containing samples were in range of 48.07-51.62 Pa.s. Viscosity is an indicator to the emulsion stability. Higher the viscosity higher will be the stability. Viscosity decreased as the emulsion was disturbed.

3.3.2. Oxidative Stability of Mayonnaise

Peroxide value (POV) of sesame sprouts powder added mayonnaises are significantly lower than that of control sample. At day 45 peroxide value order of all mayonnaise samples was SSP_4< SSP_3< SSP_2< T_{BHT}< SSP_1< T_{EDTA}< SSP_0. The POV of sesame sprouts powder added treatments (SSP_2, SSP_3 and SSP_4) were reduced as compared to the synthetic antioxidants (BHT and EDTA) containing mayonnaise samples. Sesame sprouts powder antioxidant had significantly affected the peroxides in all mayonnaise treatments. The antioxidant extracts of sesame and its fractions have shown inhibiting effect on

the peroxide value of vegetable oils during storage and frying [8,25,33].

The sesame sprouts powder added samples had significantly lower scores than the control sample throughout the storage period. Oxidation stability of the mayonnaise increased during storage as the amount of added sesame sprouts powder increased, and the mayonnaise samples with 0.75, 1.0, and 1.25 % sesame sprouts powder exhibited stronger oxidative stability effects than those with synthesized antioxidants such as BHT and EDTA. Results obtained were in agreement with results of [22] who studied the effect of purple corn extract on stability of mayonnaise. The *ρ*-anisidine increased with increasing storage days. The *ρ*-anisidine value ranged from 2.9-3.0 in week 0 which increased to 4.9-8.8 in week 10 when mayonnaise was stored at 25°C.

3.3.3. Antioxidant Activity of Mayonnaise

The DPPH radical is a stable organic free radical which gives an adsorption peak at 517 nm in spectrophotometer. Its adsorption is reduced when it accept an electron or a free radical specie, resulting in a visually perceptible change in color from purple to yellow (Sánchez-Moreno, 2002). In mayonnaise containing sesame sprouts powder DDPH activity increased with increasing percentage of powder. SSP_4 showed DPPH activity comparable to the T_{EDTA} and higher than T_{BHT} at day 0. Free radical scavenging potential decreased with increasing storage days. At the end of storage period SSP_0 showed lowest values of 4.0 while T_{EDTA} (13.15) and SSP_4 (26.21) showed the highest mean values.

Maximum Ferric Reducing Antioxidant Power (FRAP) for all mayonnaise samples were obtained at 0 day. Control treatment (SSP_0) containing no antioxidant showed lowest FRAP value of 30.07 µmol TE/mL as compared to treated samples. Among the samples prepared with sesame sprouts powder highest values were observed for SSP_4 (50.10) which were comparable to the T_{EDTA} (50.40). FRAP value of all mayonnaises decreased with increasing storage time and lowest ferric reducing antioxidant power was observed at the end of storage period. At day 45, smallest FRAP value was obtained for SSP_0 (8.96), and largest for SSP_4 (27.07). The treatments containing sesame sprouts powder at concentration of 1.0 and 1.25 % displayed better ferric reducing power than synthetic antioxidants EDTA and BHT over the storage period of 45 days. Antioxidative compounds in the sesame sprouts powder prevented the formation of reactive oxygen species by scavenging the ferrous ions and significantly delayed the oxidation of mayonnaise.

Table 4. Antioxidant activity of mayonnaise (Mean ± SD)

0 Day					15 Day			
Treatments	**PV (meq/kg oil)**	**AV**	**DPPH (%)**	**FRAP (µmol TE/mL)**	**PV (meq/kg oil)**	**AV**	**DPPH (%)**	**FRAP (µmol TE/mL)**
SSP_0	0.59±0.06$^{\psi}$	3.12±0.31$^{\psi}$	28.06±0.35$^{\psi}$	30.06±0.15$^{\psi}$	1.50±0.21$^{\psi}$	4.72±0.13$^{\psi}$	23.00±0.42$^{\psi}$	26.46±0.26$^{\psi}$
T_{EDTA}	0.61±0.05$^{\psi}$	3.21±0.36$^{\psi}$	40.10±0.32$^{\psi}$	50.40±0.30$^{\psi}$	1.25±0.08$^{\psi}$	3.60±0.07$^{\psi}$	38.10±0.26$^{\psi}$	51.00±0.53$^{\psi}$
T_{BHT}	0.53±0.13$^{\psi}$	3.00±0.33$^{\psi}$	28.90±0.44$^{\psi}$	46.86±0.32$^{\psi}$	0.79±0.09$^{\psi}$	4.45±0.10$^{\psi}$	27.00±0.06$^{\psi}$	47.96±0.52$^{\psi}$
SSP_1	0.60±0.01$^{\psi}$	2.89±0.31$^{\psi}$	31.00±0.53$^{\psi}$	47.03±0.52$^{\psi}$	0.71±0.09$^{\psi}$	3.64±0.08$^{\psi}$	30.00±0.06$^{\psi}$	42.23±0.41$^{\psi}$
SSP_2	0.54±0.07$^{\psi}$	2.91±0.25$^{\psi}$	37.00±0.53$^{\psi}$	45.14±0.32$^{\psi}$	0.72±0.06$^{\psi}$	3.54±0.10$^{\psi}$	36.00±0.58$^{\psi}$	42.66±0.44$^{\psi}$
SSP_3	0.59±0.01$^{\psi}$	2.97±0.35$^{\psi}$	39.70±0.25$^{\psi}$	47.17±0.43$^{\psi}$	0.68±0.06$^{\psi}$	3.23±0.15$^{\psi}$	37.20±0.12$^{\psi}$	41.90±0.49$^{\psi}$
SSP_4	0.60±0.01$^{\psi}$	2.89±0.34$^{\psi}$	40.00±0.58$^{\psi}$	50.10±0.44$^{\psi}$	0.69±0.06$^{\psi}$	3.24±0.18$^{\psi}$	37.50±0.12$^{\psi}$	45.94±0.53$^{\psi}$
30 Day					**45 Day**			
Treatments	**PV (meq/kg oil)**	**AV**	**DPPH (%)**	**FRAP (µmol TE/mL)**	**PV (meq/kg oil)**	**AV**	**DPPH (%)**	**FRAP (µmol TE/mL)**
SSP_0	3.70±0.12$^{\psi}$	6.54±0.42$^{\psi}$	19.00±0.17$^{\psi}$	24.83±0.15$^{\psi}$	5.63±0.09$^{\psi}$	7.64±0.15$^{\psi}$	15.03±0.03$^{\psi}$	14.18±0.12$^{\psi}$
T_{EDTA}	2.10±0.35$^{\psi}$	3.86±0.35$^{\psi}$	37.00±0.06$^{\psi}$	38.74±0.14$^{\psi}$	4.27±0.09$^{\psi}$	4.37±0.08$^{\psi}$	26.21±0.36$^{\psi}$	32.06±0.31$^{\psi}$
T_{BHT}	1.93±0.58$^{\psi}$	5.26±0.35$^{\psi}$	24.03±0.29$^{\psi}$	36.10±0.10$^{\psi}$	3.44±0.09$^{\psi}$	5.38±0.10$^{\psi}$	20.03±0.43$^{\psi}$	30.11±0.31$^{\psi}$
SSP_1	1.88±0.07$^{\psi}$	4.08±0.07$^{\psi}$	28.03±0.35$^{\psi}$	29.99±0.53$^{\psi}$	3.30±0.18$^{\psi}$	4.70±0.13$^{\psi}$	20.86±0.09$^{\psi}$	23.00±0.53$^{\psi}$
SSP_2	1.20±0.12$^{\psi}$	3.68±0.12$^{\psi}$	27.96±0.55$^{\psi}$	30.96±0.50$^{\psi}$	2.59±0.54$^{\psi}$	4.12±0.14$^{\psi}$	21.00±0.12$^{\psi}$	27.03±0.57$^{\psi}$
SSP_3	1.72±0.12$^{\psi}$	3.38±0.17$^{\psi}$	31.41±0.21$^{\psi}$	40.64±0.11$^{\psi}$	1.43±0.17$^{\psi}$	3.52±0.10$^{\psi}$	25.06±0.03$^{\psi}$	31.05±0.11$^{\psi}$
SSP_4	0.93±0.27$^{\psi}$	3.35±0.26$^{\psi}$	31.40±0.30$^{\psi}$	42.61±0.29$^{\psi}$	1.29±0.08$^{\psi}$	3.44±0.10$^{\psi}$	26.26±0.03$^{\psi}$	34.18±0.36$^{\psi}$

ψ Values followed by different letters in the same column are significantly different ($p < 0.05$) according to Tukey's Multiple Range test.

Table 5. Sensory evaluation of mayonnaise (Mean ± SD)

0 Day					15 Day			
Treatments	**Color**	**Taste**	**Mouth feel**	**Overall acceptability**	**Color**	**Taste**	**Mouth feel**	**Overall acceptability**
SSP_0	8.99±0.17$^{\psi}$	8.80±0.34$^{\psi}$	8.50±0.21$^{\psi}$	8.00±0.15$^{\psi}$	7.66±0.25$^{\psi}$	7.66±0.28$^{\psi}$	6.75±0.12$^{\psi}$	6.90±0.11$^{\psi}$
T_{EDTA}	9.20±0.14$^{\psi}$	9.00±0.23$^{\psi}$	8.80±0.20$^{\psi}$	8.70±0.25$^{\psi}$	7.88±0.21$^{\psi}$	7.99±0.11$^{\psi}$	7.20±0.23$^{\psi}$	7.20±0.11$^{\psi}$
T_{BHT}	9.00±0.21$^{\psi}$	8.90±0.23$^{\psi}$	8.70±0.05$^{\psi}$	8.30±0.17$^{\psi}$	7.66±0.16$^{\psi}$	7.66±0.11$^{\psi}$	7.00±0.17$^{\psi}$	7.40±0.11$^{\psi}$
SSP_1	8.10±0.23$^{\psi}$	7.80±0.11$^{\psi}$	7.50±0.11$^{\psi}$	7.90±0.27$^{\psi}$	6.90±0.13$^{\psi}$	7.00±0.17$^{\psi}$	6.20±0.11$^{\psi}$	6.30±0.11$^{\psi}$
SSP_2	7.80±0.21$^{\psi}$	7.50±0.11$^{\psi}$	7.20±0.11$^{\psi}$	7.30±0.50$^{\psi}$	6.33±0.15$^{\psi}$	6.90±0.17$^{\psi}$	5.90±0.05$^{\psi}$	5.80±0.11$^{\psi}$
SSP_3	7.44±0.09$^{\psi}$	7.20±0.17$^{\psi}$	6.90±0.11$^{\psi}$	7.20±0.05$^{\psi}$	6.33±0.15$^{\psi}$	6.70±0.11$^{\psi}$	5.00±0.11$^{\psi}$	4.30±0.05$^{\psi}$
SSP_4	7.33±0.19$^{\psi}$	6.90±0.11$^{\psi}$	6.30±0.17$^{\psi}$	6.90±0.24$^{\psi}$	6.10±0.10$^{\psi}$	6.50±0.17$^{\psi}$	4.70±0.11$^{\psi}$	3.60±0.24$^{\psi}$
30Day					**45Day**			
Treatments	**Color**	**Taste**	**Mouth feel**	**Overall acceptability**	**Color**	**Taste**	**Mouth feel**	**Overall acceptability**
SSP_0	6.66±0.09$^{\psi}$	6.70±0.28$^{\psi}$	6.00±0.11$^{\psi}$	5.70±0.05$^{\psi}$	5.70±0.16$^{\psi}$	4.50±0.11$^{\psi}$	3.90±0.05$^{\psi}$	4.50±0.05$^{\psi}$
T_{EDTA}	7.00±0.62$^{\psi}$	6.90±0.17$^{\psi}$	6.20±0.05$^{\psi}$	6.60±0.11$^{\psi}$	5.90±0.08$^{\psi}$	4.70±0.11$^{\psi}$	4.50±0.11$^{\psi}$	5.80±0.11$^{\psi}$
T_{BHT}	6.50±0.79$^{\psi}$	6.70±0.23$^{\psi}$	5.90±0.11$^{\psi}$	6.70±0.11$^{\psi}$	5.70±0.13$^{\psi}$	4.40±0.23$^{\psi}$	4.40±0.05$^{\psi}$	5.80±0.05$^{\psi}$
SSP_1	5.50±0.01$^{\psi}$	6.10±0.11$^{\psi}$	5.50±0.17$^{\psi}$	5.30±0.05$^{\psi}$	4.80±0.08$^{\psi}$	3.70±0.05$^{\psi}$	4.00±0.05$^{\psi}$	4.50±0.11$^{\psi}$
SSP_2	5.30±0.89$^{\psi}$	5.70±0.17$^{\psi}$	4.80±0.11$^{\psi}$	4.60±0.05$^{\psi}$	4.60±0.14$^{\psi}$	3.40±0.05$^{\psi}$	2.90±0.05$^{\psi}$	3.90±0.17$^{\psi}$
SSP_3	5.20±0.99$^{\psi}$	5.40±0.11$^{\psi}$	4.20±0.11$^{\psi}$	3.80±0.11$^{\psi}$	4.20±0.09$^{\psi}$	3.30±0.05$^{\psi}$	2.90±0.05$^{\psi}$	3.20±0.11$^{\psi}$
SSP_4	4.90±0.24$^{\psi}$	5.00±0.05$^{\psi}$	3.50±0.00$^{\psi}$	3.00±0.05$^{\psi}$	4.00±0.09$^{\psi}$	3.00±0.11$^{\psi}$	2.40±0.05$^{\psi}$	2.80±0.05$^{\psi}$

ψ Values followed by different letters in the same column are significantly different ($p < 0.05$) according to Tukey's Multiple Range test.

3.4. Sensory Evaluation of Mayonnaise

The mayonnaise samples prepared by various concentrations of sesame sprouts powder were analyzed for its sensory parameters (color, taste, mouth feel, and overall acceptability) and the results presented in Table 5. Score of all parameters of sensory evaluation were significantly (P >0.05) affected by sesame powder at different levels and storage days. Storing of sesame mayonnaise significantly affected for 45 days period. Overall acceptability of mayonnaise made with different ratios of sesame sprouts powder assessed by sensory testing. The judges observed a decline in overall acceptability of mayonnaise during storage by giving lower scores. The results showed highly significant effects of treatments and storage intervals were also significant on overall acceptability of mayonnaise.

4. Conclusion

Extract of sesame sprouts powder showed good antioxidant activity which increased with days of germination. Sesame sprouts powder added to the mayonnaise was found effective in retarding the oxidation. The present investigation suggested that sesame sprouts powder have good antioxidant potential and can be utilized in different foods to control oxidation where suitable.

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