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Optimization and shelf-life evaluation of mayonnaise like paste prepared using avocado pulp

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A B S T R A C T

The purpose of this study was to analyze the use of avocado pulp in place of egg yolk in the preparation of a mayonnaise-like paste. Eight formulations of mayonnaise were obtained with avocado pulp ranging from 51.2 to 70% and sunflower oil ranging from 30 to 48.68%, with all other constituents remaining constant. Sensory evaluation revealed that the mayonnaise made from 55% avocado pulp and 45% sunflower oil was the best when compared to marketed products in terms of sensory evaluation, proximate analysis, microbiological analysis, acid value, and peroxide value. The optimized product was superior in terms of color and overall acceptability than the control sample ($P < 0.05$). The chemical analysis, i.e., the moisture, fat, protein, ash and carbohydrate contents were found to be 40.54%, 51.1%, 1.22%, 1.71% and 6.23%, respectively, for the optimized product and 26.41%, 66.22%, 0.34%, 1.11% and 6.33%, respectively, for the control sample. Total plate count and yeast and mold count (cfu/g) were found to be 170.3 and 89.33, respectively, for the optimized product and 160.67 and 84, respectively, for the control product. There was an increase in both acid value and peroxide value at all temperatures during storage but a lower increase was found in the sample stored at 25°C. Using the accelerated shelf life technique, the shelf life of optimized mayonnaise like paste based on acid value was found to be 61 days, 41 days and 13 days at 25°C, 40°C and 50°C, respectively. Similarly, the shelf life based on peroxide value was found to be 35 days, 20 days and 12 days at 25°C, 40°C and 50 °C, respectively. Avocado incorporated mayonnaise with acceptable sensory quality and good spreadability can be prepared. Determinations of acid and peroxide values were carried out at regular intervals, ranging from 5 days to 30 days during the storage of mayonnaise. No chemical analysis was done for longer than 30 days, and also no microbiological analysis was performed for the entire storage period; these analyses would be necessary in further research to confirm the shelf life of mayonnaise.

Keywords: Mayonnaise, avocado, accelerated shelf life, peroxide value, acid value.

И З В О Д

Сврха ове студије била је да се анализира употреба пулпе авокада уместо жуманца у припреми пасте налик мајонезу. Добијено је осам формулација мајонеза са пулпом авокада у распону од 51,2 до 70% и сунцокретовим уљем у распону од 30 до 48,68%, при чему су сви остали састојци остали константни. Сензорна процена је показала да је мајонез направљен од 55% пулпе авокада и 45% сунцокретовог уља био најбољи у поређењу са тржишним производима у смислу сензорне оцене, микробиолошке анализе, киселинског и пероксидног броја. Оптимизовани производ је био супериорнији у погледу боје и укупне прихватљивости од контролног узорка ($P < 0.05$). Хемијском анализом утврђено је да је влажност, садржај масти, протеина, пепела и угљених хидрата 40,54%; 51,1%; 1,22%; 1,71%, односно 6,23% за оптимизовани производ и 26,41%; 66,22%; 0,34 %; 1,11% и 6,33% за контролни узорак. Утврђено је да је укупан број бактерија и квасаца и плесни (cfu/g) 170,3 и 89,33 за оптимизовани производ и 160,67 и 84 за контролни производ. Дошло је до повећања и киселинског и пероксидног броја на свим температурама током складиштења, али је мањи пораст пронађен у узорку ускладиштеном на температури од 25°C. Користећи убрзану методу одређивања рока трајања, утврђено је да је рок трајања оптимизоване пасте попут мајонеза на основу киселинског броја 61 дан, 41 дан и 13 дана на 25°C, 40°C и 50°C. Слично је утврђено да је рок трајања на основу пероксидног броја 35 дана, 20 дана и 12 дана на 25°C, 40°C и 50°C. Може се припремити мајонез са авокадом са прихватљивим сензорним квалитетом и добром мазивошћу. Одређивање киселинског и пероксидног броја вршено је у редовним интервалима, од 5. до 30. дана током складиштења мајонеза, а хемијске анализе нису рађене дуже од 30 дана, као ни микробиолошке анализе за цео период складиштења, што би било неопходно у даљим истраживањима за потврду рока трајања мајонеза.

Кључне речи: мајонез, авокадо, убрзана метода, рок трајања, пероксидни и киселински број.

1. Introduction

Nepal is blessed with a variety of agroecological, as well as climatic and edaphic conditions that are ideal for producing high-quality horticulture products (CBS, 2012). Fruits and vegetables provide vitamins and minerals that are necessary for the proper maintenance of human health (Potter and Norman, 2016). Avocado varieties such as Fuerte, Hass, Ettinger, Reed, and others have been introduced in Nepal (Hasanuzzaman et al., 2003). Avocado's glory has already flourished in urban areas due to its unique acceptance among foreigners (Shrestha, 2019).

The avocado (*Persea americana*) is a fruit with a distinctive flavor, creamy texture and high nutritional content, which has attracted consumers and increased global demand (Dreher & Davenport, 2013). It has health-promoting, nutritional and economic advantages. Its cultivation benefits growers, marketers, processors, and consumers because of its economic and socio-economic importance. Adding avocado to a diet is highly desirable (Dangal et al., 2021b). Although avocados are typically eaten raw, due to their high oil content, a sizeable portion of the fruit is now more frequently used to make oil (Wang et al., 2020). Due to its potential applications in the food and cosmetics industries as well as its positive effects on human health, the demand for avocado oil has significantly surged recently (Krist, 2020). Mayonnaise is one of the world's oldest and most widely used sauces or condiments (Abu-Salem and Abou–Arab, 2008). Mayonnaise is a condiment sauce made by emulsifying edible vegetable oil, an aqueous phase of vinegar, and an oil-in-water emulsion produced by hen's egg yolk. It belongs to the food category known as salad dressings or salad cream. It is a semi-solid emulsion in which the discontinuous phase is oil and the continuous phase is water (Chukwu and Sadiq, 2008). One current food technology trend is to use plant oils as an oil phase in emulsions, with a focus on healthy oils like walnut oil, olive oil, and canola oil (Mihov et al., 2012). Avocados can be made into a mayonnaise-like spread or dressing because their healthy fats increase nutrient absorption from all greens and are also high in nutrients (Bryan, 2018).

Massive quantities of avocado are produced during a specific season in several parts of Nepal, including Dhankuta, Illam, and Panchthar, resulting in overproduction. They cause a market glut and become scarce during other seasons. They cannot all be consumed fresh, nor can they all be sold at economically viable prices. Avocados are high in monounsaturated fatty acids (MUFA), which help to protect against inflammation and cancer. They also help to lower blood sugar levels and support cardiovascular, digestive, and skin health. Because this is such a nutritious fruit, efficient utilization is critical. Because avocado is the only fruit rich in MUFA, converting it into a mayonnaise-like product is one of the best methods of efficient utilization and value addition. Avocado being a good source of lipophilic phytochemicals such as monounsaturated fatty acids, its oil contains fatty acids similar to virgin olive oil. Since it has been used as a fruit, mashed as a sandwich spread and cubed as a topping for baked products and soups, avocado pulp can be finely ground and whipped into mayonnaise deluxe along with other ingredients. Avocado mayonnaise like paste can be used in the same manner as any on salads, in sandwich spreads etc (Elsorady et al., 2016).

Since avocados are high in MUFA, one of the best ways to use them effectively and add value is to make a mayonnaise like product. It might also provide a vegan-friendly alternative to recipes that call for eggs. Being such a nutrient-dense fruit, effective utilization is crucial. The desire to replace eggs in the food system was motivated by the risk of inherent cholesterol and the need for low-cholesterol and secure foods. The study was carried out to optimize the recipe and sensory analysis of mayonnaise like paste prepared using avocado pulp and sunflower oil and to evaluate the proximate analysis and accelerated shelf-life of the product with respect to acid and peroxide values.

2. Materials and methods

2.1. Collection of raw materials

Avocado fruits of the Lamb Hass variety were collected from Dhankuta, while refined sunflower oil, powdered sugar, fresh lemon, salt, skim milk powder (SMP), mustard powder, and vinegar were obtained from Biratnagar's local market. Guar gum was used as a stabilizer.

2.2. Optimization of avocado pulp and sunflower oil level in mayonnaise

Eight different samples were designed by varying the avocado pulp and sunflower oil formulations shown in Table 1 and were coded as A, B, C, D, E, F, G, and H while keeping the other ingredients constant.

According to Pradhananga (2011), the other ingredients were measured (Table 2) from avocado and sunflower oil in a 100 part (55:45) ratio (2011).

Table 1.
Different proportions of avocado and sunflower oil

S.N	Avocado (g)	Sunflower oil (g)
A	70	30
B	40	60
C	55	45
D	47.561	52.439
E	62.439	37.561
F	43.781	56.219
G	66.219	33.781
H	51.321	48.679

Table 2.
Constituents used in mayonnaise preparation

Constituents	Weight (g)	% in recipe
Avocado	55	43.56
Sunflower oil	45	35.6
Skim milk powder	3.75	2.96
Vinegar	10	7.91
Lemon juice	0.625	0.49
Sugar	2.5	1.98
Salt	1.5	1.19
Mustard powder	0.375	0.3
Stabilizers	0.625	0.49
Water	6.875	5.43

The samples were prepared as shown in Figure 1. Mayonnaise-like paste was created by optimizing the proportions of avocado pulp (55%) and sunflower oil (45%) based on sensory characteristics such as taste, consistency, color, appearance, spreadability, smell, and overall acceptability.

Sugar + salt + stabilizer + avocado pulp + warm water + lemon juice + 1/3rd of vinegar

↓

Mixing in a blender for 5 minutes

↓

Addition of sunflower oil drop wise

↓

Continuous mixing to form emulsion

↓

Mixing for additional 5 minutes

↓

Addition of remaining vinegar (2/3rd)

↓

Mayonnaise

↓

Sensory analysis

Figure 1. Flowchart of *avocado* mayonnaise like paste preparation

2.3. Sensory analysis

Following the product preparation, eight mayonnaise samples were sensory evaluated. Semi-trained panelists evaluated sensory characteristics such as taste, consistency, color, appearance, spreadability, smell, and overall acceptability, on a 9-point hedonic scale, with 1 being the lowest and 9 being the highest (Ranganna, 1986).

2.4. Statistical analysis

All analyses were performed in triplicate. Microsoft Office Excel 2013 was used to perform statistical calculations. Using the statistical program IBM SPSS version 20, sensory analysis was processed using two way ANOVA, and comparison between different recipe samples was processed using one way ANOVA. Tukey's HSD post hoc test was used to separate means when there was a significant difference.

2.5. Storage stability

Optimized mayonnaise was kept in jars and stored at temperatures of 25°C, 40°C and 50°C for 30 days using the accelerated shelf life testing method (Robertson, 2016).

2.6. Analytical methods

As per KC and Rai (2007), the physicochemical analysis of sunflower oil, such as peroxide value and acid value, was performed. Moisture, crude fat, crude protein, crude fiber, ash, and carbohydrate contents were determined as per Ranganna (1986). During storage, the acid value and peroxide value were determined at regular intervals, ranging from 5 days to 30 days.

2.7. Microbiological analysis

Yeasts and molds were counted using the pour plate technique in Potato Dextrose Agar (PDA) medium according to BIS (1999). Total Plate Count (TPC) was determined using the pour plate technique in Plate Count Agar (PCA) medium in accordance with BIS (2012).

3. Results and discussions

3.1. Chemical composition of oil

The physiochemical analysis of sunflower oil was performed, and the results are shown in Table 3.

Table 3.
Physicochemical analysis of sunflower oil

Parameters	Sunflower oil *
Acid value (mgKOH g⁻¹ oil)	0.11(0.01)
Peroxide value (meq kg⁻¹ oil)	1.67(0.35)

* The values are the means of triplicates. Figures in the parentheses are the standard deviation.

According to the Codex Alimentarius Commission Standard (CODEX-STAN 210—1999), maximum acid values for refined sunflower oil are 0.6 mgKOH g^{-1} oil and the peroxide value was 10 meq kg^{-1} oil. Based on the results of the analysis, the used sunflower oil was of high quality, with a peroxide value of 1.67 meq kg^{-1} oil and an acid value of 0.11 mg KOH g^{-1} oil, and it was used to make mayonnaise. The acid value of sunflower oil was reported to be 0.22 ±0.03 by Dangal et al. (2021a).

3.2. Effect of formulation on sensory characteristics

The developed products were evaluated based on taste, color/appearance, spreadability, consistency, smell, and overall acceptability, as shown in Figure 2. The values in Figure 2 are the panelists' mean scores. The values at the top of the bars with similar superscripts are not significantly different at the 5% level of significance.

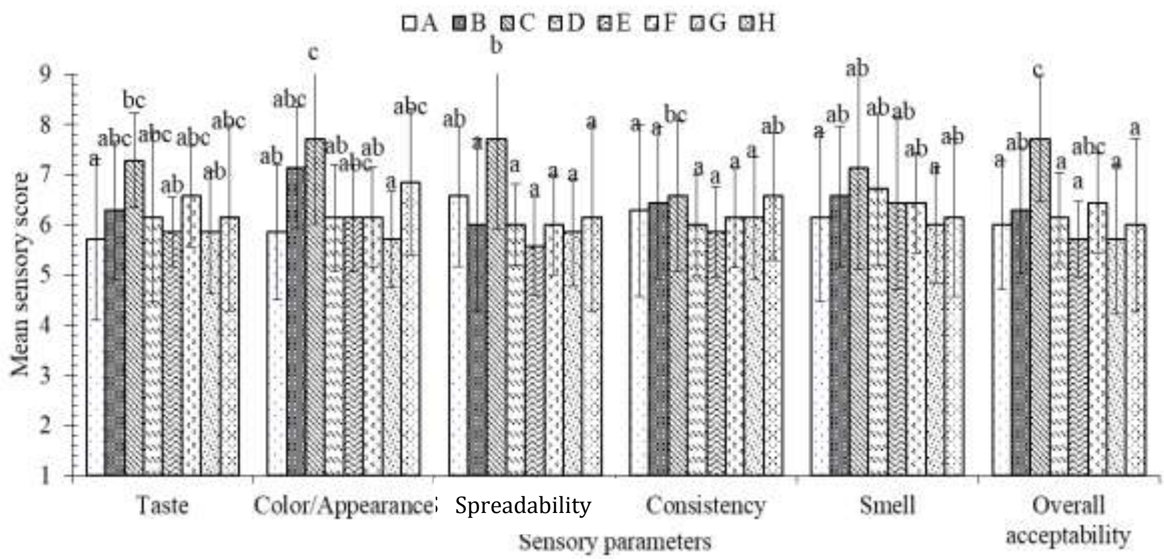

Figure 2. Sensory analysis of final product mayonnaise as compared to control

3.2.1. Color/appearance

Figure 2 depicts the results of sensory evaluation based on product color/appearance. At the 5% level of significance, the product made by blending 55% avocado and 45% oil was significantly superior to the other samples prepared.

3.2.2. Spreadability

Figure 2 depicts the sensory evaluation results based on the product's spreadability. In this case, Sample C had the highest mean score of the samples, indicating that the product made by blending 55% avocado and 45% oil was significantly superior to the other samples prepared, at the 5% level of significance.

3.2.3. Consistency

Figure 2 depicts the sensory evaluation results based on product consistency. The mean sensory score for sample C was found to be the highest among the samples, indicating that the product made by blending 55% avocado and 45% oil was significantly superior to other samples prepared, at the 5% level of significance.

3.2.4. Taste

Figure 2 depicts the sensory evaluation results based on the product's taste. Sample C, the product made by blending 55% avocado and 45% oil, had the highest mean score and was significantly superior to the other samples.

3.2.5. Smell

Figure 2 depicts the results of sensory evaluation based on the smell of the product. The smell of the samples was similar, but the mean sensory score for sample C was found to be the highest, indicating that the product made by blending 55% avocado and 45% oil was significantly superior to the other samples prepared, at the 5% level of significance.

3.2.6. Overall acceptability

Figure 2 depicts the sensory evaluation results based on the overall acceptability of the product. The mean sensory score for sample C was found to be the highest; the sample product (55% avocado pulp and

45% oil) was distinct and significantly superior to the other samples, at the 5% level of significance.

3.3. Comparison of best optimized product with marketed product

3.3.1. Chemical analysis

Table 4 shows the proximate analysis of the final product, i.e., the best obtained product from sensory analysis as compared to the control (marketed product). A preliminary analysis of the final product and the control sample was performed. On the basis of carbohydrate content, the mayonnaise prepared was comparable to the control ($P > 0.05$). However, it had a lower crude fat content and higher moisture, protein, and total ash contents when compared to the control ($P < 0.05$). Crude fiber was not detected in either the optimized product or control mayonnaise samples.

Table 4.
Proximate analysis of final product mayonnaise as compared with the control product

SN.	Parameters	Values	
		Optimized mayonnaise	Control
1	Moisture (%, wb)	$40.54^a \pm 0.66$	$26.41^b \pm 0.28$
2	Crude fat (%, db)	$51.11^a \pm 0.09$	$66.22^b \pm 0.08$
3	Protein (%, db)	$1.22^a \pm 0.02$	$0.34^b \pm 0.02$
4	Total ash (%, db)	$1.71^a \pm 0.28$	$1.11^b \pm 0.05$
5	Carbohydrate (%, db)	$6.23^a \pm 0.24$	$6.33^b \pm 0.28$
6	Crude fiber(%, db)	ND	ND

* values are the means of three determinations and their standard deviations. Different alphabets in a row shows the values are significantly different ($P < 0.05$)

Bukya et al*.* (2018) found that a vegan mayonnaise made with chilli had a nearly identical protein and ash content, a lower carbohydrate but a similar fat and moisture content when compared to the results obtained in this study. Shiby et al. (2016) stated that as avocado content increased, the amount of oil required to form an emulsion decreased. As a result, when compared to egg mayonnaise, our study found a lower fat content. The low protein content in avocado mayonnaise may be due to the lack of an egg, which is high in protein content, and the high moisture content may be due to the high moisture content of fresh avocado.

3.3.2. Microbiological analysis

Table 5 compares the microbiological analysis of the final product, which was best obtained from sensory analysis (made by blending 55% avocado and 45% oil), to the control (marketed sample).

Table 5.
Microbiological analysis of final product mayonnaise as compared with the control

SN	Parameters	Values*	
		Optimized mayonnaise	Control
1	Yeast and mold (cfu g^{-1})	$89.33^a \pm 4.04$	$84^b \pm 4.58$
2	Total plate count (cfu g^{-1})	$170.3^a \pm 7.50$	$160.67^a \pm 6.11$

* values are the means of three determinations and their standard deviations. Different alphabets in a row shows the values are significantly different ($P < 0.05$)

The total plate count of optimized mayonnaise was similar to the control sample ($P > 0.05$), but the yeast and mold count of optimized mayonnaise was significantly different from the control sample ($P < 0.05$). Because they do not contain eggs, which are more susceptible to microbial contamination, both optimized and control mayonnaise contained a lower total plate count as compared to 6.4×10^2cfu g^{-1} as prepared by Abu-salem and Abou-Arab (2008). According to Pradhananga (2011), yeast and mold levels were found to be lower than 100. Tabu-salem and Abou-Arab (2008) found no yeast or mold in the mayonnaise samples after the first 5 weeks. However, Brocklehurst and Lund (1984) stated that microorganisms are introduced into products through ingredients, equipment, and air, and that, with the exception of aciduric microorganisms, most others will die, especially when stored at room temperature for long periods of time.

3.3.3. Sensory analysis comparison with control

Figure 3 compares the sensory analysis of the final product, i.e., the best obtained from sensory analysis (made by blending 55% avocado and 45% oil), to the control (marketed product).

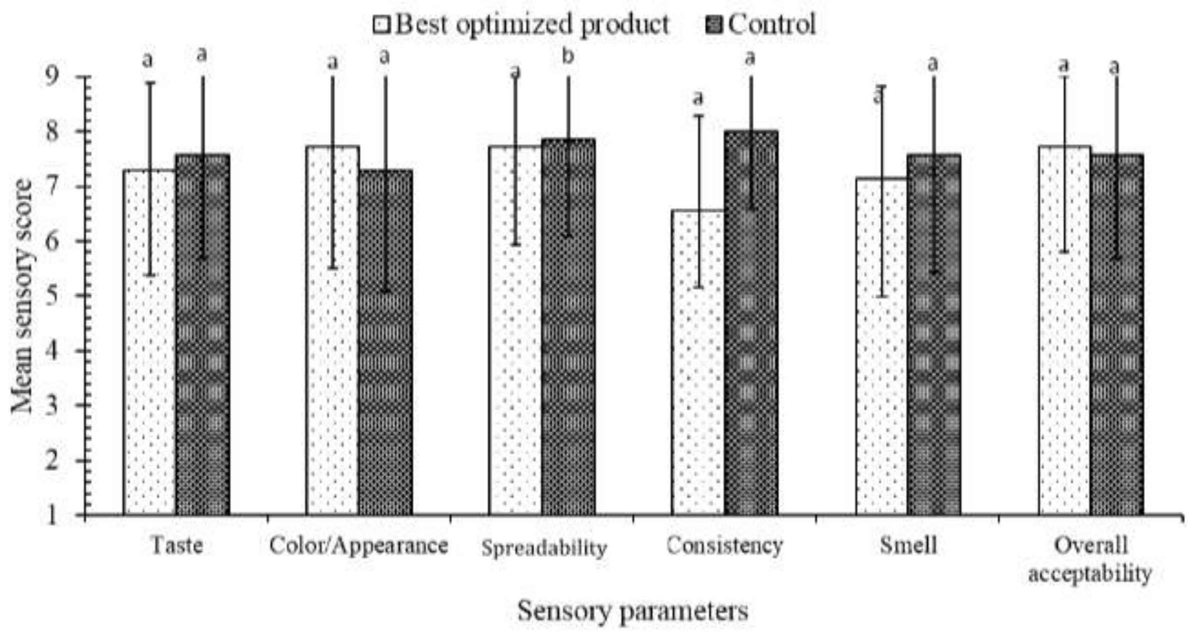

Figure 3. Sensory analysis of final product mayonnaise as compared to control

The values in Figure 3 are the panelists' mean scores. At the 5% level of significance, the values on the top of the bars with similar superscripts are not significantly different. The mean sensory score for overall acceptability for the optimized product was found to be higher than the control. The optimized product and the control product did not differ significantly ($P > 0.05$).

3.4. Shelf life of the product

The best optimized mayonnaise product was stored at a temperature of 25°C, 40°C and 50°C, and acid value and peroxide value were observed at the interval of 5th, 10th, 15th, 20th, 25th and 30th days.

3.4.1. Effect of temperature on acid value of mayonnaise

At 25°C, acid value increased continuously from initial 0.5 to 0.748 at 30th day of storage. The coefficient of determination (R^2) was observed to be 0.9969. On the other hand, at 40°C, the acid value of mayonnaise increased continuously from initial 0.5 to 0.841 at 30th day of storage. The coefficient of determination (R^2) was observed to be 0.9981. Similarly, at 50°C, the acid value increased continuously from 0.5 to 1.965 at 30th day of storage. The coefficient of determination (R^2) was observed to be 0.9392. As shown in Figure 4, the acid value of mayonnaise at 50°C increased faster than that at 40°C, and the acid value of mayonnaise at 40°C increased faster than that at 25°C. This shows that the acid value increases as the temperature rises. Pradhananga (2011) found a similar increase in the acid value of mayonnaise with increasing temperature during storage.

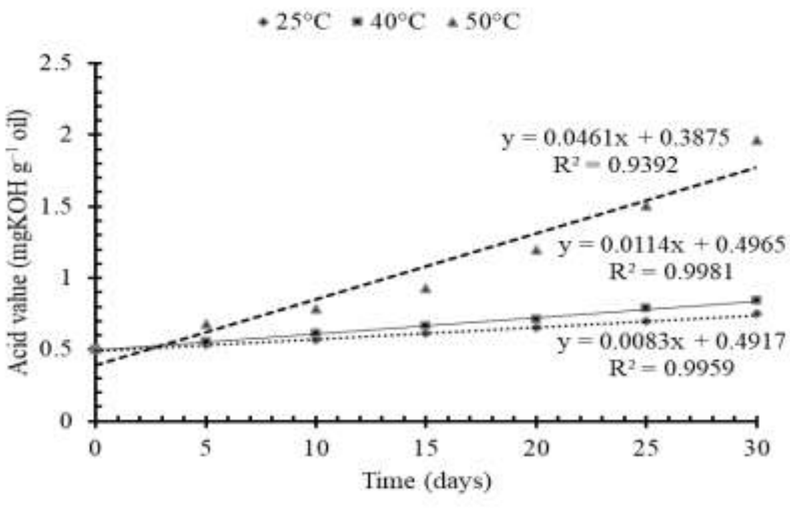

Figure 4. Effect of temperature on acid value of mayonnaise during storage period

3.4.2. Shelf life based on acid value

The shelf life of each sample was determined using a linear regression equation and the maximum limit of acid value as 1. The results are shown in Table 6.

Table 6.
Acid value test for difference between 3 temperatures and the effect on shelf life of mayonnaise

Temperature (°C)	R^2 value of plot	Shelf-life (days)
25	0.9959	61.24
40	0.9981	44.17
50	0.9392	13.29

The shelf life based on acid value (Table 6) revealed that the shelf life of mayonnaise decreased with increasing temperature, as predicted by Chukwu and Sadiq (2008). As a result of the increase in free fatty acid level, as measured by the acid value, mayonnaise's extent or proneness to rancidity increases, resulting in a decrease in shelf life. According to Pradhananga (2011), the storage stability of mayonnaise is greater at refrigerated temperatures than at room temperatures, indicating that storage stability increases as temperature decreases.

It is necessary to notice that the determination of the acid values was carried out from 5 to 30 days during the storage of mayonnaise, and no chemical analysis was done after 30 days of storage at 25°C and 40°C, and also no microbiological analysis was performed for all samples. The mentioned analyses would be necessary in order to confirm the shelf life of mayonnaise.

3.4.3. Effect of temperature on peroxide value of mayonnaise

The values obtained were observed to increase as the days progressed at all three temperatures (25°C, 40°C and 50°C) in which mayonnaise was stored. At 25°C, peroxide value increased continuously from initial 1.26 to 8.89 meq kg^{-1} at 30th day of storage (Figure 5). The coefficient of determination (R^2) was observed to be 0.9869. On the other hand, at 40°C, peroxide value of mayonnaise increased continuously from initial 1.26 to 15.81 meq kg^{-1} at 30th day of storage. The coefficient of determination (R^2) was observed to be 0.9888. Similarly, at 50°C, the peroxide value increased continuously from 1.26 to 25.77 meq kg^{-1} at 30th day of storage. The coefficient of determination (R^2) was observed to be 0.9892.

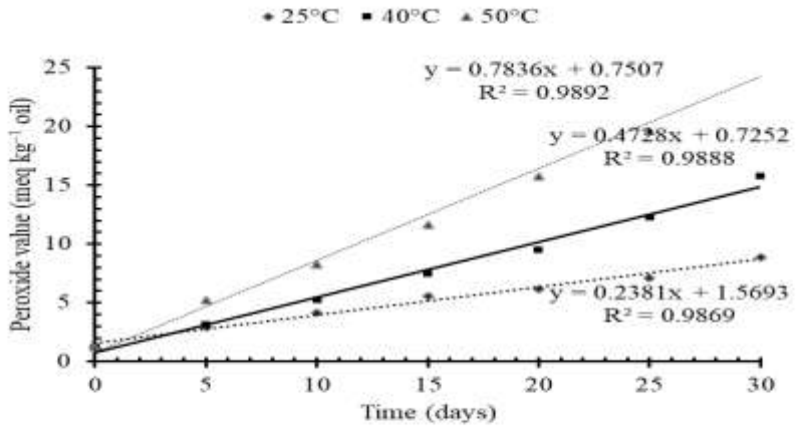

Figure 5. Effect of temperature on peroxide value of mayonnaise during storage period

From Figure 5, the peroxide value of mayonnaise at 50°C increased at a faster rate than that at 40°C and the peroxide value of mayonnaise at 40°C increased at a faster rate than that at 25°C. This indicates that the peroxide value increases with the increase in temperature. Similarly, Pradhananga (2011) reported an increase in the peroxide value of mayonnaise with increasing temperature during the storage period. Since the bioactive components of solvent extracted oil are supposed to be damaged by heat, its peroxide value increased at a highers rate to a higher value.

3.4.4. Shelf life based on peroxide value

The shelf life of each sample was determined using a linear regression equation and a maximum limit of acid value of 10 meq kg^{-1}, as shown in Table 7.

Table 7.
Peroxide value test for difference between 3 temperatures and the effect on shelf life of mayonnaise

Temperature (°C)	R^2 value of plot	Shelf-life (days)
25	0.9869	35.41
40	0.9888	19.62
50	0.9892	11.80

The peroxide value-based shelf life (Table 7) revealed that the shelf life of mayonnaise decreased as temperature increased, which is consistent with Chukwu and Sadiq (2008). The peroxide value indicates the degree of rancidity and provides an estimate of the oil's potential life. It shows the effect of air, light, and time on the oil and calculates the amount of oxidation caused by these factors at any given time. Peroxides are thought to form in vegetable oils as a result of oxygen attacking the -CH- group between carbon double bonds. Peroxides are formed when these two hydrogen atoms react. Peroxide breakdown can be catalyzed by acids or heat and produces a number of other breakdown products that contribute to the flavor or lack thereof of oxidized oils. This could be due to triglyceride hydrolysis to free fatty acids, which could be caused by moisture in the oil and the activity of the contaminating microorganism's lipase enzyme (Pradhananga, 2011).

Using an accelerated method, the shelf life of mayonnaise was determined mathematically for temperatures at which no chemical analyses were performed. Therefore, the chemical analysis of the product stored for longer than 30 days at 25°C, and also microbiological analysis for all samples should be done.

4. Conclusion

Mayonnaise made with 55% avocado and 45% sunflower oil was found to be statistically superior in sensory evaluations for color/appearance, taste, spreadability, consistency, smell, and overall acceptance. Crude fiber was not detected in both control and optimized sample of mayonnaise. During 30 days of storage, acid value and peroxide value increased. These changes under the lowest temperature storage condition (25°C) were found to be lower as compared to the high temperature storage condition (40°C and 50°C). The acid value and peroxide value increased after 30 days of storage. These changes were found to be lower at the low storage temperature (25°C) than at high storage temperatures (40°C and 50°C). Avocado incorporated mayonnaise with acceptable sensory quality and good spreadability can be prepared. Determinations of acid and peroxide values were carried out at regular intervals, ranging from 5 days to 30 days during the storage of mayonnaise. No chemical analysis was done after 30 days of storage, and also no microbiological analysis was performed for the entire storage period; these analyses would be necessary in further research to confirm the shelf life of mayonnaise.

Conflict of Interest

The authors declare no conflict of interest.

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