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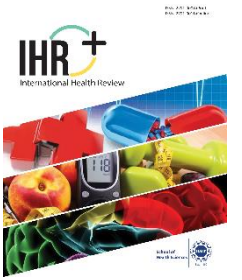

Title: **Effect of Almond and Thyme Oils on the Nutritional Profile of Broiler and Quail Meat**

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Effect of Almond and Thyme Oils on the Nutritional Profile of Broiler and Quail Meat

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ABSTRACT

Broiler and quail farming have experienced significant growth in Pakistan. Broiler chickens are primarily raised for their meat, whereas quails are raised for both their meat and eggs. This study aims to assess the quality and shelf life of broiler and quail meat when treated with thyme and almond essential oils and stored under refrigeration at 4℃. Proximate analysis was conducted on the quail and broiler meat samples, assessing moisture, ash, protein, and fat content to evaluate their nutritional value. Nanoemulsions of thyme and almond oil were prepared at two different concentrations (15% and 25%) and applied to the meat samples, which were then divided into five groups: a control group and four treatment groups. The four treatment groups were labelled as 15% thyme, 25% thyme, 15% almond, and 25% almond. The meat samples were analyzed for their proximate composition (moisture, ash, protein, and fat) and pH levels on the first, seventh, and twenty-first days of the experiment. Fresh samples of chicken and quail meat exhibited significant differences in moisture, ash, proteins, and fats, while pH levels remained relatively stable. On the 7th and 21st days, there was an observable increase in ash, protein, and fat values across all experimental groups, while pH levels remained relatively unchanged. Broiler meat had the highest protein content, while quail meat contained the highest fat levels. Among the treatments, it was observed that thyme oil at a 25% concentration yielded the best results for preserving nutritional values close to their initial levels when compared to the other experimental groups. Based on the study's findings, it is reasonable to conclude that thyme oil, in comparison to almond oil, maybe a more effective option for preserving meat and extending the shelf life of stored meat.

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Keywords: almond, chicken meat, essential oils, proximate analysis, quail meat, thyme

1. INTRODUCTION

Broiler and quail farming have experienced significant growth in Pakistan (ranking 11th globally) in recent years and represent the country's second-largest industry [1]. Broiler chickens are raised for meat production, while quails are raised for both meat and egg production [2]. The poultry sector in Pakistan has made substantial contributions to both the livestock and agricultural sectors, contributing 11.5% to the livestock sector and 6.4% to the agricultural sector [1]. This industry is well-regarded for its profitability, low capital investment requirements, and rapid turnover and for quails, the high nutrient values of meat and egg products are well-renowned [3].

Meat plays a vital role in the global food chain as a primary source of animal proteins, fats, and various inorganic products [4–6] and consumer demand remains high [7–9]. In Pakistan, consumers increasingly prefer frozen over fresh meat due to various socio-economic factors [10].

However, meat has a limited shelf life at lower temperatures (15-30°C) and remains safe for consumption for only a few days at refrigerated temperatures (0-10°C). This limited shelf life is primarily due to microbial spoilage caused by pathogenic and non-pathogenic microorganisms, as well as lipid oxidation [11]. Chicken meat, in particular, is vulnerable to spoilage due to its pH and moisture content, creating aerobic conditions conducive to microbial growth [12–14].

One of the significant challenges facing the meat industry today is extending the shelf life of meat products. Achieving this objective requires the delay of lipid oxidation and prevention of microbial growth in meat [15]. While chemicals, such as sodium nitrate, benzoic acid, and potassium sorbate can be used for this purpose, they may have adverse health consequences for consumers. Therefore, scientists are exploring the use of natural preservatives, including bacteriocins [16], organic acids [17], and essential oils (EOs) [18], which can effectively delay lipid oxidation and protein deterioration. These natural compounds are considered safe for consumption, meeting the Generally Recognized as Safe (GRAS) standards established by the FDA [19, 20]. These complex compounds are known for their antimicrobial properties, making them suitable for application in the

food industry, in which a rich content of terpenoids and phenolic components are found [16]. Extensive research and comparative studies with existing literature should be undertaken to rigorously test the efficacy of these complex compounds in extending the shelf life of both frozen and refrigerated meat products.

It is well-established that the inclusion of an adequate amount of meat in the diet is crucial for maintaining overall health. Proper preservation and extending the shelf-life of meat products will help to ensure that meat products are available to meet increasing demands. Therefore, understanding the precise fatty acid composition of meat is essential. The current study was designed to assess the quality of chicken and quail meat by monitoring the moisture, ash, protein, and fat contents of meat by applying thyme and almond oils and in control group (without these oils).

2. MATERIALS AND METHODS

2.1. Study design, Sample Collection, and Location

This study involved the application of thyme and almond oil nanoemulsions to fresh chicken and quail meat samples obtained from Tollinton Market, Lahore. The research was conducted at the Food and Biotechnology Research Center, PCSIR Lahore.

2.2. Categorization of Quail and Broiler Meat Samples

Both quail and broiler meat samples were categorized into five groups: one control group and four experimental groups. The experimental groups received 15% and 25% nanoemulsions of thyme oil and 15% and 25% nanoemulsions of almond oil.

2.3. Purchase of Oils and Nanoemulsion Preparation

Thyme oil from OLIM naturals (Lahore, Pakistan) and almond oil from Mundials (Spain) imported by General Food cooperation Karachi, Pakistan. The oils were purchased for this study online from draz. Nanoemulsions of both thyme and almond oil were prepared at concentrations of 15% and 25%. The 15% emulsion comprised 10% oil, 3% gelatin, 2% glycerin, and 85% water. The 25% emulsion comprised 20% oil, 3% gelatin, 2% glycerin, and 75% water. These components were mixed thoroughly on a shaker for 15 minutes.

2.4. Sample Preparation

Small pieces (4-5 cm in size and 2-3 mm in thickness) of both broiler and quail meat were immersed separately in the 15% and 25% nanoemulsions of thyme and almond oils for 15 minutes. The samples were then vacuum-sealed in polythene bags and stored at 4°C for 21 days. The proximate analysis such as moisture, ash, fat, protein, pH, and mineral content were carried out at 7^{th} and 21^{st} days.

2.5. Estimation of Ash and Moisture

The ash and moisture content of chicken and quail meat were determined using the established methods of Nielsen and Fakolade [21, 22]. The crucibles were washed, oven-dried, and 1 gram of the sample was used to determine ash and moisture content.

2.6. Estimation of Crude Proteins

To determine the protein content, 0.2 grams of samples were taken along with an equal amount of catalyst and placed in a digestion flask. Then, 20 ml of concentrated H_2SO_4 was added. The sample was heated at a high temperature until it became transparent, indicating the conversion of proteins and organic materials into ammonium sulfate. After digestion, the digestion flask was allowed to cool. The volume was adjusted to 100 ml by adding distilled water to a volumetric flask. To convert ammonium sulfate into ammonia, 20 ml of 40% NaOH was added from the top of the distillation flask. At the end of the condenser tube, a beaker containing 2% boric acid was placed. At the receiving end, 5 ml of 2% boric acid with a drop of methyl red as an indicator completely absorbed all the nitrogen produced as ammonia. Boric acid reacted with the ammonia, forming a complex of ammonium borate. The amount of nitrogen in the receiving solution was measured through titration, and the protein percentage was calculated.

2.7. Estimation of Crude Fat

The determination of crude fat content in the sample was conducted following the method outlined by Lanza [23]. A mixture of methanol and chloroform was prepared in a 3:1 ratio, combining 150 ml of chloroform with 50 ml of methanol thoroughly. Next, 10 grams of the sample were measured, and 50 ml of the prepared chloroform-methanol solution was added to the sample. This mixture was then placed on an orbit shaker for 15

minutes. A pre-weighed flask, equipped with filter paper and a funnel, was used to filter the solution. An additional 5 ml of the chloroform-methanol solution was used for rinsing. The filtrate was collected in the flask and the flask was then placed on a hot plate to allow for the evaporation of the chloroform-methanol solution. As a result, an oil layer developed at the bottom of the flask. The flask was subsequently placed in an oven for approximately 30 minutes, and its weight was determined using a measuring balance.

2.8. Calculation of pH

The pH of the samples was determined by homogenizing 10 grams of the sample in distilled water and measuring the pH using a pH meter at 23°C.

2.9. Statistical Analysis

Statistical analysis was performed by using SPSS version 22. A one-way ANOVA was used to compare differences among broiler and quail meat groups, and t-tests were used to assess differences between broiler and quail meat samples.

3. RESULTS

Chicken and quail meat samples were collected in triplicates from Tollinton Market, Lahore, in February 2022. Proximate analysis for moisture, ash, protein, fat, and pH, was conducted on both samples. Five groups were established for each meat type: one control group and four treatment groups with varying oil concentrations (15% thyme, 25% thyme, 15% almond, and 25% almond). All groups were assessed on 1st, 7th, and 21st days to evaluate the effects of oil nanoemulsions on storage.

3.1. Estimation of Moisture Content in at 1st, 7th, and 21st Day Old Meat Samples

Fresh samples of chicken and quail meat (without nanoemulsion) were compared with prepared samples (with nanoemulsion) to determine their moisture content at the beginning and end of the experiment. It was observed that the fresh samples had a higher percentage of moisture content as compared to the samples that were treated with oils and examined after 7 and 21 days. When comparing the moisture content of chicken and quail fresh meat samples, it was evident that quail samples had a higher percentage of moisture compared to chicken meat samples (see Table 1).

Statistical analysis using a simple t-test revealed significant differences with a P-value of 0.000 between chicken and quail fresh meat samples. Additionally, moisture content was monitored at 7 and 21 days after the treatment with the oils, revealing slight changes in moisture levels with 15% and 25% thyme oil concentrations. The 25% of concentration of thyme oil demonstrated the best results, closely resembling the readings of fresh samples (see Table 1). A statistical analysis through one-way ANOVA indicated significant differences with a P-value of 0.049 between chicken and quail meat samples.

Table 1. Proximate Analysis of Moisture Contents in Meat Samples on 1st, 7th, and 21st Day

No. of days	Sample	Chicken	Quail
1st day	Fresh sample	72.56 ± 1.67	73.23 ± 1.25
7th day	Control	69.81 ± 1.20	70.13 ± 0.28
	15% Thyme	69.16 ± 0.72	70.06 ± 1.03
	25% Thyme	69.07 ± 0.56	69.74 ± 1.00
	15% Almond	70.71 ± 1.32	70.11 ± 1.01
	25% Almond	69.67 ± 0.49	70.09 ± 0.25
21st day	Control	66.13 ± 0.28	64.21 ± 1.25
	15% Thyme	66.45 ± 0.66	64.36 ± 1.32
	25% Thyme	66.06 ± 2.55	64.16 ± 3.31
	15% Almond	66.47 ± 2.80	64.50 ± 1.04
	25% Almond	66.19 ± 2.63	64.56 ± 3.03

3.2. Estimation of Ash content at 1st, 7th, and 21st day old chicken

Chicken and quail whole meat samples were tested for ash contents both before and after the application of thyme and almond oil. It was noticed that a higher percentage of ash content was found in fresh samples as compared to samples that were fixed with oils and examined after 7 and 21st days. Higher ash content was observed in the fresh quail meat sample as compared to the chicken meat sample (see Table 2). Statistical analysis was carried out by simple t-test and significant differences were noticed at P value 0.007 between chicken and quail meat fresh samples.

Table 2. Proximate Analysis of Ash Contents in Meat Samples on 1st, 7th, and 21st Day

No. of days	Sample	Chicken	Quail
1st day	Fresh Sample	1.03 ± 0.31	1.46 ± 0.37
7 days	Control	0.65 ± 0.11	0.86 ± 0.29
	15% Thyme	0.85 ± 0.04	0.95 ± 0.12
	25% Thyme	0.96 ± 0.06	1.19 ± 0.30
	15% Almond	0.74 ± 0.01	0.43 ± 0.20
	25% Almond	0.77 ± 0.06	0.76 ± 0.62
21 days	Control	0.14 ± 0.09	0.06 ± 0.04
	15% Thyme	0.51 ± 0.61	0.07 ± 0.09
	25% Thyme	0.65 ± 0.44	0.21 ± 0.19
	15% Almond	0.01 ± 0.002	0.05 ± 0.04
	25% Almond	0.04 ± 0.05	0.08 ± 0.01

3.3. Estimation of Protein in fresh, 7 and 21-day-old meat samples

For estimating the protein content of chicken and quail whole meat samples, both meat samples were tested both before and after the application of thyme and almond oil. During storage, the protein content increases in all four treatment groups when compared to the fresh meat samples. In comparison to the quail fresh meat sample, the fresh chicken meat sample had a higher protein level (see Table 3). Statistical analysis was carried out by simple t-test and significant differences were noticed at P value 0.000 between chicken and quail meat fresh samples.

Table 3. Proximate Analysis of Protein Contents in Meat Samples on 1st, 7th, and 21st Day

No. of days	Sample	Chicken	Quail
1st day	Fresh	23.35 ± 0.77	20.42 ± 0.71
7th day	Control	23.26 ± 0.62	19.27 ± 0.77
	15% Thyme	23.05 ± 0.64	20.17 ± 1.62
	25% Thyme	23.29 ± 0.72	20.33 ± 0.30
	15% Almond	22.16 ± 1.16	19.73 ± 1.07
	25% Almond	22.67 ± 0.63	20.04 ± 1.02
21st day	Control	19.65 ± 1.57	17.53 ± 0.39
	15% Thyme	21.65 ± 1.73	20.08 ± 0.07
	25% Thyme	22.56 ± 1.18	20.46 ± 2.00

No. of days	Sample	Chicken	Quail
	15% Almond	20.05 ± 1.46	18.76 ± 1.11
	25% Almond	20.22 ± 0.80	18.93 ± 1.18

3.4. Estimation of Fat at 1st, 7th, and 21st Day Old Meat Samples

Along with fresh samples, chicken and quail whole meat samples were tested for fat content after the application of thyme and almond oil. A higher percentage of fat content was found in fresh samples as compared to samples that were fixed with oils and examined after 7 and 21 days. There was a great difference between the fat values of chicken and quail meat. Fat content was higher in the quail fresh meat sample as compared to the chicken meat sample (Table 4). Statistical analysis was carried out by simple t-test and non-significant differences were noticed at P value 0.101 between chicken and quail fresh meat samples.

Table 4. Proximate Analysis of Fat Contents in Meat Samples on 1st, 7th, and 21st Day

No. of days	Sample	Chicken	Quail
1st day	Fresh Sample	1.88 ± 0.14	3.68 ± 0.08
7th day	Control	1.36 ± 0.13	2.66 ± 0.45
	15% Thyme	1.65 ± 0.28	3.04 ± 0.40
	25% Thyme	1.84 ± 0.04	3.05 ± 0.22
	15% Almond	1.30 ± 0.05	2.68 ± 0.32
	25% Almond	1.57 ± 0.35	2.93 ± 0.12
21st day	Control	0.93 ± 0.19	1.85 ± 0.18
	15% Thyme	1.39 ± 0.25	2.79 ± 0.35
	25% Thyme	1.80 ± 0.02	2.83 ± 0.11
	15% Almond	1.29 ± 0.65	2.49 ± 0.64
	25% Almond	1.54 ± 0.31	2.68 ± 0.47

3.5. Estimation of pH at 1st, 7th, and 21st Day Old Meat Samples

The pH levels of both chicken and quail whole meat samples were assessed both before and after the application of thyme and almond oil. It was observed that the pH of fresh samples was lower as compared to samples treated with oils and examined after 7 and 21 days. As storage progressed, pH values increased, while moisture, ash, protein, and fat content decreased. Notably, fresh chicken meat samples exhibited higher pH levels than quail meat (Table 5). A statistical analysis utilizing a simple

t-test revealed significant differences with a P-value of 0.000 between fresh samples of chicken and quail meat.

Table 5. A pH of Chicken and Quail Meat Samples on 1st, 7th, and 21st Day

No. of days	Sample	Chicken	Quail
1st day	Fresh Sample	6.58 ± 0.02	6.40 ± 0.02
7th day	Control	6.8 ± 0.113	6.87 ± 0.16
	15% Thyme	6.62 ± 0.21	6.45 ± 0.01
	25% Thyme	6.6 ± 0.28	6.58 ± 0.07
	15% Almond	6.69 ± 0.50	6.70 ± 0.12
	25% Almond	6.65 ± 0.05	6.73 ± 0.01
21st day	Control	6.92 ± 0.05	6.91 ± 0.12
	15% Thyme	6.63 ± 0.09	6.54 ± 0.26
	25% Thyme	6.61 ± 0.17	6.55 ± 0.15
	15% Almond	6.68 ± 0.36	6.79 ± 0.03
	25% Almond	6.76 ± 0.04	6.82 ± 0.15

4. DISCUSSION

The nutritional value of meat has long been recognized [4, 24]. According to this research involving the application of thyme and almond oil nanoemulsions, broiler meat was found to be rich in proteins but comparatively lower in other nutrients as compared to quail meat. Quail meat samples, on the other hand, exhibited higher fat content. Chicken meat contained fewer inorganic compounds, as evidenced by its lower ash content. Similarly, [25] conducted a study on the proximate composition of red and white meat, revealing that turkey meat had the highest protein content, while lamb had the highest fat percentage. Ostrich meat, in contrast, had the lowest protein content but the highest ash percentage as compared to other meats. Tougan et al. [26] investigated factors affecting broiler meat quality and found that broiler breast meat was nutritionally superior in terms of moisture and protein as compared to thigh meat, which had higher fat content. The mean moisture and protein content 73.3% and 23.7%, respectively, in their study somewhat align with the results of this research.

In a study by [27], three different edible oils were employed to assess their impact on increasing the shelf life of broiler meat during refrigeration storage. Their fresh samples exhibited slightly lower protein content (22.62%) and slightly higher fat content (2.52%) than the findings,

although the differences were not significant. However, the ash content (1.1%) closely resembled the results of this research. Another study by [28] reported a high percentage of moisture (76.5%) and a lower percentage of protein (20.9%), while fat and ash percentages in fresh samples were near to this study's findings.

Glinkina et al. [29] explored different quail genotypes for proximate analysis, revealing a mean moisture content of 74.16%, mean ash content of 1.16%, mean protein content of 21.95%, and mean fat content of 4.03%. In this study, slightly lower moisture (73.21%), protein (20.42%), and fat (3.68%) percentages, with a higher ash percentage (1.41%) compared to their research was observed.

A study by [30] focused on the proximate analysis of quail meat after treatment with a mega floral booster addition, their control group displayed higher moisture (74.59%) and protein (22.28%) percentages but lower ash (1.24%) and fat percentages (1.78%) in Japanese quail meat. A greater difference was observed in fat percentage as compared to this study. Khalifa et al. [31] found protein content ranging from 21%-25%, which was relatively higher than this study, while the fat percentage (3.80%) closely resembled the results of this research. The moisture percentage in their study ranged from 69%-72%, which was lower than the results of this study.

In this study, crude protein content was higher in broiler meat as compared to quail meat, aligning with the findings of [25]. Broiler meat contains 23.35% protein. In comparison, lower protein content was observed in studies by [32], Yaghoubi et al. [28], and Mohammed et al. [33], while [29] reported higher protein levels in different quail species, which is consistent with the results of this study. Lukanov et al. [34] also observed findings similar to this research.

During storage after treatment with two different oils, protein percentages decreased in both broiler and quail meat. The decline in protein content could be attributed to protein denaturation, changes in the chemical composition ratio, protein breakdown, or a combination of both these factors. Denaturation results in the loss of secondary, tertiary, and quaternary protein structures, leading to the presence of straightforward polypeptide chains. Multiple factors, including inadequate freezing and inconsistent storage conditions, contributed to this denaturation. Freezing temperatures significantly affected denaturation rates. The sample without

any oil treatment exhibited a higher protein loss. Decreases in protein content during refrigerated storage have also been reported in studies by [35, 36], and [27].

Variations in fat content have long been recognized as a factor influencing meat eating quality. Additionally, meat serves as a significant energy source and its energy value is greatly influenced by the quality of fat it contains. When comparing the fat content of fresh meat samples of chicken and quail meat, quail meat was found to be fattier, with a fat content of 3.86% as compared to chicken meat, which had a fat content of 1.88%, respectively. However, [25] found a high fat content in quail meat (5.02%). The fat content of fresh broiler meat of approximately 1.88% is noticed in this study closely resembled the fat content of 1.82% that was reported by [25] and [37], whose research indicated a fat content of 1.75% in fast-growing broiler chicken meat.

In the findings, it was observed that broiler meat had a pH of 6.58%, which was higher than the pH of quail meat (6.40%). The fresh chicken meat samples had a lower pH value than the quail meat, as indicated in Table 5. A simple t-test revealed significant differences with a P-value of 0.000 between fresh chicken and quail meat samples. This discrepancy in pH values may be attributed to the accumulation of lactic acids from microbial secretions and chicken meat degradation, leading to a lower pH in chicken meat. In contrast, [32] reported lower pH values in fresh chicken meat, while [27] observed pH decreases in all treatments during the storage period. Rising pH values during storage can be attributed to the accumulation and proteolytic breakdown of metabolites resulting from bacterial action on meat. [38] Studied different traits of quail meat and observed a maximum pH of 6.58%, which closely resembled our results. A decrease in pH values was also noted in quail meat.

The role of different essential oils in preserving food items and extending their shelf life was examined by [39]. They compared the antimicrobial properties of various essential oils, including thyme, oregano, rosemary, sage, clove, and cinnamon on different food items, selecting essential oils based on the specific food product. Different essential oils exhibited varying abilities to control the growth of different microbial species. For fruits, the shelf life of strawberries and table grapes was extended using cinnamon, sage, and thyme essential oils, which inhibited fungal growth. These findings were consistent with previous results for

strawberry oils [40]. In the case of meat products, thyme exhibited the best results in controlling gram-negative bacteria species, thus prolonging the shelf life of meat products, which is why it has been selected for this study. Sage, chrysanthemum, and rosemary essential oils showed minimal ability to inhibit microorganisms [41].

There has been limited research in the food industry regarding almond oil. Almond oil has been extensively used in cosmetics and medical applications [42]. In this study, the efficacy of thyme and almond oil in preserving the nutrients in meat products and extending their shelf life was compared. Prior literature has highlighted the exceptional effectiveness of thyme oil among several essential oils for preserving nutrients in meat [43].

4.1. Conclusion

This study found that both chicken and quail meat are rich in nutrients, even after refrigerated storage. Thyme and almond oil nanoemulsions effectively extended the shelf life of these meats, and higher oil concentrations particularly of 25% showing better results. Thyme oil out performed compared to almond oil in preserving nutrients. Moreover, it was identified that broiler meat had higher protein and pH levels, while quail meat had higher fat and moisture levels. This research highlighted the potential of natural preservatives like thyme and almond oil for enhancing shelf life and quality of meat.

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