**Effect of Titanium dioxide nanoparticles and Thyme essential oil on the quality of chicken fillet**

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**ABSTRACT**

This study aimed to assess the effect of titanium dioxide (TiO2), Thyme essential oil and a mixture of both on the quality of chicken fillets .Fresh chicken breast fillets samples were treated with TiO2 nanoparticles as a trial (Ⅰ ) , Thyme oil (2%) as a trial (Ⅱ ) individually and in mix of both( trial Ⅲ). All samples were examined during cold storage (4±10 c) at zero, 2, 4, 6, 8 , 10 , 12 and 14 days from examined sensory, bacteriologically and chemical point of view. The results indicated a positive effect on the shelf life of treated samples as compared to untreated ones especially in trial (Ⅱ). On the other hand, there was a good antibacterial activity of such treatment on APC, Psychrotrophic and coliform counts. Also , the results showed that pH, TBA and TVN values were increased but not reached to spoilage(6.4) in all treated samples which treated with Thyme oil 2% give the best effectiveness followed by TiO2 and combination of both.

**Keywords**

TiO2 nano-particles – Thyme essential oil – APC - Total Coliform count- Psychrotrophic count- pH ̦ TVN ̦ TBA .

**Introduction**

Chicken meat is a competitive source of animal proteins compared to red meat from other farm animals **(USDA, 2006).**

Fresh chicken meat is highly susceptible to microbial spoilage due to its high levels of moisture and nutrients **(Bazargani-Gilani et al., 2015).**

In recent years, antimicrobial packaging has attracted much attention from the food industry to the increase in consumer demand for minimally processed and preservative-free products. Use of antimicrobial substances based on nanoparticles and essential oils are of great importance and can control the microbial population and target specific microorganisms to provide higher safety and quality products **(Appendini and Hotchkis , 2002).**

Thyme (thymus sp.) has much attention due to its high content and wide spectrum of phenolic compounds, antimicrobial and antioxidant properties, and potential for use in meat and meat products **(Guttierrez et al., 2008 ; Barbosa et al., 2009 ; Gutierrez et al., 2009 ; Jayasena and Jo, 2013 ; Bensid et al., 2014).**

Nanotechnology is used as a novel approach in meat industries for enhancing the safety and quality of products **(Pradeep et al., 2016)**. Also, it can be applied throughout different aspects of the food chain processing for improving food safety and quality control and increasing shelf life **( Bošković et al., 2013).**

The metal nanomateriales that commonly used for antibacterial activity in food industry are Silver (Ag), Zinc (Zn), Magnesium (Mg), Copper (Cu) and Titanium (Ti) **(Duncan, 2011).**

Titanium dioxide (TiO2) is an inert, nontoxic, and inexpensive material with potential activity against a wide variety of microbes due to its photocatalytic activity. When Microbiological, biochemical and sensory techniques have been used to assess freshness and quality during handling and storage.

Therefore, the main target of this work was to investigate the antioxidant as well as the antibacterial effectiveness of TiO2, thyme oil and combination of both on the quality of fresh chicken fillet during cold storage.

**Material and Methods**

**Collection of Samples (chicken fillets):**

A total of 1.600 g of fresh chicken breast fillets represented by 16 portions (100 ± 10 g for each), were collected from different local markets in Toukh ̦ Qalubyia governorate ̦ Egypt.

**Preservatives used**

-Titanium dioxide nanoparticles (TiO2) (12 mM)

-Thyme oil (2%)

**Experimental applications**

The samples were placed in markets separate sterile plastic bags in an ice box and transferred to the laboratory without delay under aseptic conditions.

Fresh chicken breast meat samples were divided into two groups (treated and control group). Treated ones were subdivided into three groups (TiO2, thyme oil 2% and combination of both), (24 of each), First group samples were dipped in in 2% Thyme essential oil for 5 minutes with proper mixing ̦ Second group samples were dipped in 12mM TiO2 nanoparticles. Third group samples mixture between (2% Thyme essential oil + 12mM TiO2 nanoparticles). All samples (treated and control) were stored at 4± 10C and examined every two days (zero (after 2 hours), 2 ̦ 4, 6, 8, 10, 12, 14) days for their sensory, chemical and bacteriological profile. Experiments were conducted in triplicates.

**Results**

**Sensory Examination**

It is obvious from results obtained in table (2)that‚ the sensory characteristics of different treated chicken fillet samples were enhanced in compared to untreated ones (control) at all time of storage. Shelf life of samples were extended in the three trials as following trial(Ⅱ)(Thyme oil 2%) then trial(Ⅰ) (TiO2)followed by trial(Ⅲ)(mix of both).

**Chemical indices ꞉**

Table (1) revealed that the initial mean pH value 5.71± 0.02 of control ‚ and in treated samples with Thyme oil 2% ‚ Titanium dioxide 12 mM ‚ Mix(Thyme oil 2% - TiO2) were 5.69±0.03‚ 5.70± 0.03 and 5.71± 0.02 ‚ respectively at zero day (after two hours) .

Finally at 14th day of cold storage the pH value were 6.24 ± 0.05 ‚ 6.32± 0.03 and 6.42± 0.05 in thyme oil 2% ‚ TiO2 12 mM ‚ Mix(Thyme oil 2% - TiO2)‚ respectively where control samples were spoiled.

Also ‚ the initial mean TVN value (2.86± 0.10 mg % ) of control ‚ and in treated samples with Thyme oil 2% ‚ Titanium dioxide 12 mM ‚ Mix(Thyme oil 2% - TiO2 were 2.74± 0.08 ‚2.78± 0.08 and 2.81± 0.09 mg % at zero day ‚ respectively(table 2)

Finally at 14th day of cold storage TVN value were 18.63± 0.37 and 19.38± 0.32 in Thyme oil 2% ‚ Titanium dioxide 12 mM ‚ Mix(Thyme oil 2% - TiO2)‚ respectively where control samples were spoiled.

Moreover , the initial mean TBA value was 0.08± 0.01 mg/Kg of control ‚ and in treated samples with Thyme oil 2% ‚ Titanium dioxide 12 mM ‚ Mix (Thyme oil 2% - TiO2) were 0.06± 0.01 ‚0.07± 0.01 and 0.07± 0.01 at zero day (after two hours) ‚ respectively .

Finally at 14th day of cold storage TBA value were 0.72± 0.04 mg/Kg ‚0.83± 0.04 and 0.90± 0.04 in Thyme oil 2% ‚ Titanium dioxide 12 mM ‚ Mix (Thyme oil 2% - TiO2)‚ respectively where control samples were spoiled.(Table 3)

**Bacteriological Examination**

The results achieved in table(4) noticed that the initial mean count of total aerobes in control group ‚ was 1.25×107 ± 2.5×106 .Such count was slightly decreased to 1.25×107 ± 5×105 ‚ 1.05×107 ± 5×105 and 1.55×107 ± 5×105 after treatment with Thyme oil 2% ‚ TiO2 (12 m M) and Mix (Thyme oil 2% ‚ TiO2 (12 m M) ‚ respectively‚ with reduction percentage of 10.00% ‚ 16.00% and 24.00 ‚respectively.

Finally at 14th day of refrigeration storage at 40 C ‚ ‚ the samples of untreated control group its mean count of total aerobes ‚ was 5.51×108 ± 6.1×107 such count was slightly decreased to 3×106 ± 1×106 ‚ 1.15×107 ± 3.5×106 and 1.25×107 ± 5×105 after treatment with Thyme oil 2% ‚ TiO2 (12 m M) and Mix (Thyme oil 2% ‚ TiO2 (12 m M) ‚ respectively‚ with reduction percentage of 99.46%‚97.91% and 97.73 ,respectively.

The results achieved in table(5) cleared that the mean total coliform count in control group was 1.25×107 ± 2.5×106 . Such count was slightly decreased to 1.7×107 ± 6×106 ‚ 1.65×107 ± 5.5×106 and 5.25×107 ± 4.45×107 after treatment with Thyme oil 2% ‚ TiO2 (12 m M) and Mix (Thyme oil 2% ‚ TiO2 (12 m M) ‚ respectively‚ with reduction percentage of 36%‚32% and 32% ‚ respectively.

Finally at 14th day of refrigeration storage at 40 c ‚Mean total Coliform count of control group samples was 5.33×108 ± 5.3×107 such count was slightly decreased to 2. 5×106 ± 5×105 ‚ 6×106 ± 2×106 and 7×106 ± 2×106 after treatment with Thyme oil 2% ‚ TiO2 (12 m M) and Mix (Thyme oil 2% ‚ TiO2 (12 m M) ‚ respectively‚ with reduction percentage of 99.53%‚98.87% and 98.69‚ respectively.

The results achieved in table(6) revealed that the mean total psychrotrophic count in control group ‚ was 1.15×107 ± 1.5×107 such count was slightly decreased to 1.75×107 ± 5.5×106 ‚ 1.5×107 ± 5.5×106 and 1.8×107 ± 5×106 after treatment with Thyme oil 2% ‚ TiO2 (12 m M) and Mix (Thyme oil 2% ‚ TiO2 (12 m M) ‚respectively‚ with reduction percentage of 52.17%‚34.78% and 56.52 ‚respectively.

Finally at 14th day of refrigeration storage at 40 c ‚ Mean total psychrotrophic count of control group was 6.81×108 ± 3.9×107 such count was slightly decreased to 1.5×106 ± 5×105 ‚ 4×106 ± 1×106 and 8×106 ± 1×106 after treatment with Thyme oil 2% ‚ TiO2 (12 m M) and Mix (Thyme oil 2% ‚ TiO2 (12 m M) ‚respectively‚ with reduction percentage of 99.78%‚99.41% and 98.83‚ respectively.

**Discussion**

The obtained results indicated that the best acceptable quality was attained at thyme oil-treated samples, then TiO2 treated sample while slight improvement in acceptability of mixture samples as compared with control samples.

Natural products and naturally derived compounds from plants may have applications in controlling pathogens in foods **(Davidson, 1997 and Bowles and Juneja, 1998).**

Thyme EOs have gained greater acceptance among food technologists due to their better sensory evaluation and antimicrobial properties **(Fischer and Phillips, 2006).**The major active compound of thyme is thymol, which exerted its antimicrobial action through binding to membrane proteins by hydrophobic bonding and hydrogen bonding, and then changing the permeability of the membranes **(Burt, 2004).**

These results agree with those obtained by **Sasse et al. (2009)** who reported that spices as thyme contain antioxidant components that improve both color and flavor stability in meat. Also, **Sallem-Amany et al. (2010)** indicated that sensory properties of meat samples during cold storage (4°C)were enhanced by treatment meat by thyme oil as compared to the untreated (control) samples, however,

**Shaltout et al. (2017)** whose results were that meat samples containing 2% thyme oil, demonstrated the highest enhancement of sensory attributes.

Accordingly, the changes in microbial count in the fresh chicken fillet samples during storage especially aerobic bacterial count ‚ coliform count and psychrotrophic count were decreased with addition of thyme essential oil than other treated groups.

**Conclusion**

Thyme essential oil 2% maintained the sensory qualities of fresh chilled chicken fillet meat sample, due to have amounts of phenolic compounds exhibiting potent antioxidant ‚ antibacterial effects enabling to increase quality and shelf life. Thyme essential oil 2% had been shown to cause significant decrease in pH‚ TVN ‚TBA values compared to control sample.

Thus‚ one can suggest that addition of this essential oil to meat as natural preservative could improve the overall quality and serve consumer needs.

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**Chemical indices of control and treated chicken fillet samples꞉**

**Table(1) pH values of control and treated chicken fillet samples**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Trials** | **Experimental Period** | | | | | | | |
| **Zero day** | **2nd day** | **4th day** | **6th day** | **8th day** | **10th day** | **12th day** | **14th day** |
| **Control** | 5.71±0.02Ab | 6.57±0.30Aa | 6.12±0.04Aab | 6.40±0.04Aa | Spoiled | Spoiled | Spoiled | Spoiled |
| **Trial T** | 5.70±0.03Af | 5.80±0.02Be | 5.91±0.03Bd | 6.04±0.04BCc | 6.04±0.04ABc | 6.14±0.03Ab | 6.25±0.04Aa | 6.32±0.03Aba |
| **Trial O** | 5.69±0.03Ad | 5.77±0.02Bcd | 5.85±0.03Cc | 5.97±0.04Cb | 5.97±0.04Bb | 6.06±0.03Ab | 6.17±0.04Aa | 6.24±0.05Ba |
| **Trial M** | 5.71±0.02Ae | 5.81±0.01Be | 5.96±0.03Bd | 6.11±0.03Bc | 6.11±0.03Ac | 6.17±0.04Ac | 6.29±0.04Ab | 6.42±0.05Aa |

**Table(2) TVN values of control and treated chicken fillet samples**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Trials** | **Experimental Period** | | | | | | | |
| **Zero day** | **2nd day** | **4th day** | **6th day** | **8th day** | **10th day** | **12th day** | **14th day** |
| **Control** | 2.86±0.10Ad | 5.72±0.10Ac | 11.55±0.22Ab | 18.83±0.38Aa | Spoiled | Spoiled | Spoiled | Spoiled |
| **Trial T** | 2.78±0.08Ah | 4.07±0.06BCg | 6.27±0.21Bf | 9.59±0.23Be | 12.55±0.39ABd | 14.76±0.22Ac | 16.14±0.25ABb | 18.63±0.37ABa |
| **Trial O** | 2.74±0.08Ah | 3.92±0.07Cg | 5.52±0.17Cf | 8.57±0.22Ce | 11.43±0.26Bd | 13.73±0.34Bc | 15.09±0.46Bb | 17.71±0.55Ba |
| **Trial M** | 2.81±0.09Ah | 4.21±0.06Bg | 6.51±0.28Bf | 10.18±0.37Be | 13.04±0.39Ad | 15.32±0.24Ac | 16.77±0.26Ab | 19.38±0.32Aa |

**Table(3) TBA values of control and treated chicken fillet samples**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Trials** | **Experimental Period** | | | | | | | |
| **Zero day** | **2nd day** | **4th day** | **6th day** | **8th day** | **10th day** | **12th day** | **14th day** |
| **Control** | 0.08±0.01Ad | 0.29±0.03Ac | 0.47±0.03Ab | 0.80±0.04Aa | Spoiled | Spoiled | Spoiled | Spoiled |
| **Trial T** | 0.07±0.01Ae | 0.17±0.02Be | 0.28±0.04BCd | 0.37±0.04BCd | 0.50±0.05Ac | 0.63±0.04ABb | 0.75±0.03Aba | 0.83±0.04Aa |
| **Trial O** | 0.06±0.01Af | 0.14±0.01Bef | 0.21±0.02Cde | 0.29±0.03Cd | 0.44±0.07Ac | 0.55±0.03Bb | 0.68±0.03Ba | 0.72±0.04Aa |
| **Trial M** | 0.07±0.01Af | 0.19±0.02Be | 0.35±0.03Bd | 0.45±0.03Bc | 0.55±0.05Ac | 0.70±0.04Ab | 0.81±0.03Aa | 0.90±0.04Aa |

**Table(4)Reduction percentage of Aerobic Plate Count (cfu\g) in control and treated chicken fillet samples**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Trials** | **Experimental Period** | | | | | | | |
| **Zero day** | **2nd day** | **4th day** | **6th day** | **8th day** | **10th day** | **12th day** | **14th day** |
| **Trial T** | 16.00 | 11.61 | 47.68 | 70.69 | 82.20 | 93.98 | 96.18 | 97.91 |
| **Trial O** | 10.00 | 50.89 | 68.87 | 84.91 | 93.18 | 96.90 | 98.68 | 99.46 |
| **Trial M** | 24.00 | 49.11 | 74.17 | 85.34 | 92.58 | 95.80 | 97.76 | 97.73 |

**Table(5)Reduction percentage of Coliform Count (cfu\g) in control and treated chicken fillet samples**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Trials** | **Experimental Period** | | | | | | | |
| **Zero day** | **2nd day** | **4th day** | **6th day** | **8th day** | **10th day** | **12th day** | **14th day** |
| **Trial T** | 32.00 | 4.62 | 25.35 | 78.65 | 92.31 | 96.58 | 98.04 | 98.87 |
| **Trial O** | 36.00 | 35.38 | 47.89 | 84.83 | 96.55 | 96.96 | 98.88 | 99.53 |
| **Trial M** | 32.00 | 9.23 | 49.30 | 81.46 | 92.04 | 95.26 | 97.48 | 98.69 |

**Table(6)Reduction percentage of Psychrotrophic Count (cfu\g) in control and treated chicken fillet samples**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Trials** | **Experimental Period** | | | | | | | |
| **Zero day** | **2nd day** | **4th day** | **6th day** | **8th day** | **10th day** | **12th day** | **14th day** |
| **Trial T** | 34.78 | 4.93 | 81.65 | 89.77 | 94.59 | 97.52 | 99.35 | 99.41 |
| **Trial O** | 52.17 | 75.35 | 84.18 | 90.70 | 97.57 | 98.18 | 99.19 | 99.78 |
| **Trial M** | 56.52 | 71.83 | 81.65 | 86.51 | 92.97 | 96.53 | 98.62 | 98.83 |