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Impact of Essential Cinnamon Oils on the Qualitative Attributes of Chicken Eggs at Different Storage Temperatures

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ABSTRACT

The experiment was conducted during during November, 2021 to January, 2023 at the Division of Livestock Products Technology, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India to investigate the suitability of cinnamon essential oils sprays for maintaining the quality of eggs during diffrent storage conditons (27±5°C and 4±1°C). The freshly laid, unwashed, chicken shell eggs were procured from local poultry farms in Bareilly and used for the experiments. The eggs immediately after collection were labeled and weighed. Fresh eggs were analyzed within 2–3 hours of laying. The Control sample eggs and Cinnamon essential oils sprays treated eggs were evaluated on day 0, 10, 20, 30, 40, 50, and 55 at refrigeration (4±1°C) and room temperature (27±5°C). The Cinnamon treated eggs samples had significantly lowered (p<0.05) egg weight loss, air cell depth, egg yolk weight, yolk index, haugh unit, lipid peroxidation value, yoik pH, albumen pH and egg surface, albumen, yolk APC value as camapre to control egg sample. The overall sensory parameters were significanty more acceptable in treaed eggs as campare to control sample. The Cinnamon essential oils played a significant role in the maintenance of the quality parameters of eggs, treated eggs should be kept at 4±1°C for up to 40 days and at 27±5°C for up to 20 days.

KEYWORDS: Cinnamon essential oils, egg quality, lipid peroxidation, APC

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1. INTRODUCTION

The Indian poultry industry has flourished at a remarkable pace recently, and it is now emerging as a sunrise sector. The total Egg production in the country is estimated as 142.77 billion nos. during 2023–24 and registered a growth of 6.8% growth over the past 10 years as compared to the estimates of 78.48 billion numbers during 2014–15. Further, the production has increased annually by 3.18% during 2023–24 over 2022–23 (BAHS, 2024). India currently produces approximately 5.65% of the world's eggs. The poultry industry's organized sector shares 70% of the overall egg production. The layer industry in India is dominated by southern states, with Andhra Pradesh accounting for the majority of the egg production (19.1%), followed by Tamil Nadu and Telangana. Animal protein consumption has risen in recent years as consumers' concerns about nutritionally balanced and healthy diets have grown. Eggs and their products are an important and necessary part of the human diet globally. Eggs are a low-cost, high-quality protein source and are considered a safe food, containing a majority of essential amino acids, vitamins, minerals, and essential fatty acids (Figueiredo et al., 2014). Eggs are perishable and begin to degrade after being laid. The world egg industry has been reported to lose more than ten million dollars per year due to egg and eggshell quality issues (Wong et al., 1996). Changes in the chemical, physical and biological composition, and the functional parameters deteriorate egg quality (Hidalgo et al., 1996), affecting not only the consumer's acceptance of the eggs but also their use in the food industry. Inadequate temperature, humidity, carbon dioxide (CO_2), and prolonged storage periods may deteriorate internal egg quality (Samli et al., 2005).

Eggs have a protective coating made up of glycoproteins and minor components including hydroxyapatite crystals, polysaccharides, and lipids that help to prevent bacterial contamination and water loss through the eggshell (Wellman et al., 2008). On prolonged storage moisture content and carbon dioxide can permeate through eggshells, resulting in changes in albumen quality and yolk along with loss of weight. Hence, to reduce water vapor and CO_2 release, the eggshell's pores must be sealed. The cuticle serves as a physical and chemical barrier, minimizing water loss through the eggshell and preventing by invasion of undesirable microorganisms. Antimicrobial activity is seen in many proteins like lysozyme C, Ovotransferin, ovocalyxin-32, cystatin, and ovoinhibitors found in the eggshell cuticle. (Rose-Martel et al., 2012).

Due to increasing concern about maintaining the quality of eggs during storage, researchers are looking for coatings that can seal the eggshell pores and reduce deteriorative changes. Essential oils are aromatic plant's secondary metabolites that have wide applications due to their inherent antimicrobial and antioxidant properties. Edible coatings along with essential oil are thought to be an efficient and novel way to maintain food quality. The essential oils Coatings are layers of essential oils mixed with biological polymers that can hold oil (protein, lipids natural gum, starch, etc.). It can help to preserve food by not only preventing the gaseous exchange of O_2, CO_2 and moisture but also by delaying the decay of food (Ju et al., 2018). The studies regarding the application of cinnamon essential oils as a coating material to increase the shelf life of eggs while maintaining their quality are limited. Therefore, the present study had envisaged the suitability of cinnamon essential oils sprays for maintaining the quality of eggs during storage (27±5°C and 4±1°C).

2. MATERIALS AND METHODS

The experiments were conducted during November, 2021 to January, 2023 at the Division of Livestock Products Technology, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India. The freshly laid, unwashed, chicken (Gallus domesticus) shell eggs were procured from local poultry farms in Bareilly and used for the experiments. The eggs immediately after collection were labeled and weighed. Fresh eggs were analyzed within 2–3 hours of laying. Cinnamon essential oils sprays treated eggs were evaluated on day 0, 10, 20, 30, 40, 50, and 55 at refrigeration (4±1°C) and room temperature (27±5°C).

2.1. Preparation of essential oil-coating solutions

The chitosan purchased from Sigma-Aldrich was dissolved in 1% (v/v) acetic acid at concentrations of 1% (w/v). The solutions were then adjusted to pH 5.6 with NaOH before adding 1.5 cinnamon essential oils. Eggs were coated with cinnamon essential oil solution using a Spray bottle, allowed to dry, and then the above procedure was repeated once more. Noncoated eggs and eggs coated with 1% acetic acid and Chitosan (pH adjusted to 5.6) were used as the control groups. All eggs were placed in cardboard egg racks and stored at different temperatures (4±1°C and 27±5°C).

2.2. Analytical procedures

The thiobarbituric acid value of the egg yolk sample was measured according to the method described by Witte et al. (1970). All the microbiological parameters were determined by APHA (2001).

2.3. Measurement of external quality

The individual eggs were weighed on a digital balance to the nearest 0.01 g accuracy. The shape index was calculated by multiplying the ratio of breadth to length with 100. The inner shell membrane was removed from the shells and the shells were kept for drying in the open air for 24 h. All the dried shells (devoid of shell membrane) were weighed and divided by the egg weight to get the total shell quantity %.

2.4. Measurement of internal quality

The Shell thickness was calculated by taking an average of the four pieces of shells (one from each end, broad & narrow, two from the body of the eggs) with the help of screw gauze. The egg length and breadth were measured with the help of digital vernier calipers. The length and width of the albumen, yolk, and air cell depth were measured in mm with the help of a digital vernier caliper. The height of the albumen and yolk were measured at their highest point by using the spherometer on a table glass. Care was taken to balance the table and table glass with the help of a dumpy level. The height of the albumen was measured at 3 or 4 locations and the average was calculated. The pH of the albumen and the yolk were measured with a pH meter (Hanna Instrument Inc.). The Yolk index was calculated by using the Formula:

$$\text{Yolk index} = \frac{\text{Yolk height (mm)}}{\text{Yolk diameter (mm)}}$$

Haugh unit (H.U.) was calculated by using the Formula

$$\text{H.U.}=100 \log (H+7.57-1.7W^{37})$$

Where, H is albumen height (mm), measured by a spherometer and W is the observed weight of the egg in grams.

2.5. Sensory evaluation

Sensory evaluation of eggs treated with essential oil and without treated were selected for this experiment. After being cooked at 100°C for 5 min, the boiled eggs were subjected to the sensory panelists consisted of scientists and postgraduate students of the Livestock Products Technology Division of IVRI. Each boiled egg was randomly coded and presented to each panellist seated separately in a control booth. A 9-point hedonic scale ranging from “like extremely” to “dislike extremely” was used to determine the degree of acceptance of each boiled egg in terms of flavour, texture, colour, and overall liking (Meilgaard et al., 1999). The responses were then converted to numerical values ranging from 1 for “dislike extremely” to 9 for “like extremely.”

2.6. Statistical analysis

All the data obtained during the present investigation were analyzed statistically by using SPSS (Version 24.0) software. The data obtained were analysed by Randomized Block Design and subsequent one-way ANOVA except storage study parameters were analysed by Complete Randomized Design for two-way ANOVA. Further, the significance of the data was compared by Tukey’s Post Hoc Test by the SPSS-24® software package. A probability value of $p<0.05$ was described as significant.

3. RESULTS AND DISCUSSION

3.1. Egg weight loss (%)

The results for the effect of different essential oil coating on egg weight loss (%) at 27±5°C and 4±1°C changes are presented in Table 1. Regardless of treatment, a significant ($p<0.05$) weight loss was observed. The weight loss increased gradually with the advancing storage period. The control eggs showed maximum weight loss (13.78%) and T-2 (11.51%) egg samples showed minimum weight loss among all the treatment groups on the 55th day of storage. At 4±1°C , the eggs from the control group had the highest weight loss (11.52%), eggs coated with T-2 (9.45%) showed less weight loss. The essential oil coating sealed the pores of the eggs, preventing the evaporation of moisture and gases. According to Ezazi et al. (2021), eggs held at 25°C for 8 weeks lost 14.50% of their weight. Torrico et al. (2011), stated that mineral oil coating significantly reduced the weight loss (0.72 to 1.20%) of coated chicken eggs, compared to non-

Table 1: Effect of cinnamon essential oil coating on egg weight loss (%) *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	0±0.00^{g}	1.67±0.12^{fA}	4.54±0.11^{eA}	6.70±0.17^{dA}	10.83±0.09^{cA}	12.21±0.12^{bA}	13.78±0.08^{aA}
	4±1°C	0.00^{g}	1.10±0.14^{fA}	3.29±0.16^{eA}	4.10±0.11^{dA}	7.69±0.14^{cA}	9.76±0.12^{bA}	11.52±0.10^{aA}
T-1	27±5°C	0±0.00^{g}	1.52±0.14^{fB}	3.78±0.08^{eB}	5.83±0.08^{dB}	9.24±0.06^{cB}	11.02±0.14^{bB}	12.01±0.11^{aB}
	4±1°C	0.00^{g}	1.09±0.11^{fB}	3.20±0.11^{eB}	3.76±0.10^{dB}	6.54±0.12^{cB}	8.34±0.11^{bB}	9.96±0.15^{aB}
T-2	27±5°C	0±0.00^{g}	1.39±0.13^{fD}	3.33±0.15^{eC}	5.50±0.12^{dC}	8.69±0.11^{cE}	10.41±0.09^{bF}	11.51±0.15^{aE}
	4±1°C	0.00^{g}	0.93±0.08^{fF}	2.31±0.13^{eC}	3.26±0.14^{dF}	5.89±0.15^{cD}	7.41±0.13^{bF}	9.45±0.12^{aE}

n=6; *mean±S.E bearing different superscripts row-wise (small alphabet) and column-wise (Capital alphabet) significantly ($p<0.05$); T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil coated (4.17%) chicken eggs, after 5 weeks of storage at 4°C.

3.2. Egg shape index (%)

The results for the effect of different essential oil coating on egg shape index (%) at 27±5°C and 4±1°C are presented in Table 2. There was no significant difference observed in the Shape index of coated and noncoated eggs during the storage period. Similar findings were also reported by Song et al. (2000) and Tilki and Saatci (2004), who found that the storage time and temperature did not affect the egg shape index.

3.3. Eggshell weight (%)

The results for the effect of different essential oil coating on eggshell weight (%) at 27±5°C and 4±1°C are presented in Table 3. There was no significant difference observed in eggshell weight (%) of coated and noncoated eggs during the storage period. These results are consistent with the findings of Silversides and Scott (2001) and Akyurek and Okur (2009), who found that storage time, did not affect eggshell weight.

3.4. Eggshell thickness (mm)

The results for the effect of different essential oil coating on eggshell thickness (mm) at 27±5°C and 4±1°C are presented in Table 4. There was no significant difference observed in eggshell thickness of coated and noncoated eggs during

Table 2: Effect of cinnamon essential oil coating on egg shape index (%) *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	81.41±0.34	80.89±0.31	81.23±0.36	81.15±0.21	81.25±0.29	80.78±0.31	81.21±0.28
	4±1°C	81.24±0.32	81.17±0.28	81.18±0.33	80.91±0.17	80.85±0.33	81.17±0.43	81.11±0.23
T-1	27±5°C	81.45±0.21	81.36±0.25	80.78±0.32	81.36±0.32	81.21±0.27	81.01±0.34	80.59±0.17
	4±1°C	81.11±0.19	81.28±0.24	80.69±0.25	81.21±0.24	80.73±0.41	81.21±0.36	80.83±0.33
T-2	27±5°C	81.34±0.32	81.10±0.43	81.24±0.34	80.89±0.24	80.85±0.31	80.71±0.28	81.33±0.31
	4±1°C	81.30±0.21	80.81±0.26	81.12±0.28	80.76±0.23	81.09±0.37	81.09±0.27	81.14±0.28

n=6; T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

Table 3: Effect of cinnamon essential oil coating on eggshell weight (%) *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	11.50±0.21	11.47±0.24	11.51±0.24	11.48±0.22	11.50±0.27	11.51±0.19	11.49±0.24
	4±1°C	11.51±0.19	11.51±0.33	11.49±0.18	11.49±0.31	11.48±0.27	11.48±0.21	11.47±0.32
T-1	27±5°C	11.46±0.25	11.50±0.19	11.47±0.26	11.51±0.28	11.46±0.24	11.48±0.27	11.51±0.21
	4±1°C	11.49±0.23	11.53±0.26	11.50±0.21	11.47±0.22	11.53±0.22	11.46±0.26	11.52±0.18
T-2	27±5°C	11.48±0.26	11.46±0.23	11.50±0.27	11.47±0.19	11.46±0.32	11.50±0.24	11.48±0.32
	4±1°C	11.46±0.27	11.47±0.24	11.48±0.25	11.51±0.19	11.50±0.18	11.49±0.19	11.50±0.23

n=6; T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

Table 4: Effect of cinnamon essential oil coating on eggshell thickness (mm) *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	0.40±0.004	0.40±0.005	0.40±0.003	0.39±0.004	0.39±0.003	0.39±0.002	0.39±0.005
	4±1°C	0.40±0.002	0.40±0.005	0.40±0.003	0.40±0.006	0.40±0.004	0.39±0.003	0.39±0.005
T-1	27±5°C	0.40±0.005	0.40±0.002	0.40±0.004	0.40±0.003	0.40±0.002	0.39±0.005	0.39±0.002
	4±1°C	0.40±0.003	0.40±0.002	0.40±0.006	0.40±0.002	0.39±0.003	0.39±0.004	0.39±0.003
T-2	27±5°C	0.40±0.002	0.40±0.003	0.40±0.002	0.40±0.004	0.40±0.003	0.39±0.004	0.39±0.003
	4±1°C	0.40±0.005	0.40±0.004	0.40±0.005	0.40±0.002	0.40±0.005	0.39±0.003	0.39±0.004

n=6; T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil the storage period. Saleh et al. (2020) observed that the eggs stored at refrigerated temperature maintain their shell thickness as compared to those stored at room temperature, whose shell thickness decreases with increased storage time.

3.5. Egg air cell depth (mm)

The results for the effect of different essential oil coating on egg air cell depth (mm) at 27±5°C and 4±1°C are presented in Table 5. Regardless of treatment, a significant (p<0.05) increase in air cell depth was observed. The air cell depth increased gradually with the increase of storage periods, the control eggs showed maximum air cell depth (12.85 mm) and T-2 (11.23 mm) eggs showed minimum air cell depth s on 55th day of storage. At 4±1°C, the control group had the highest air cell depth (10.24 mm), and eggs coated with T-2 showed minimum air cell depth (9.23 mm). The depth of the air cell is a rough indication of the age of the eggs and there is often a relation between this depth and the internal quality. Results showed that the depth of the air cell for the coated eggs was significantly (p<0.05) lower than that of the control group. Nongtaodum et al. (2013) reported that after three weeks of storage at 25°C, oil coating greatly slowed the rise in air cell height, and oil-coated eggs exhibited considerably lower air cell height after 5 weeks of storage than uncoated and glycerol-coated eggs (2.55 to 2.97 mm versus 4.10 to 4.15 mm).

Table 5: Effect of cinnamon essential oil coating on egg air cell depth (mm) *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	0.19±0.013^{g}	2.67±0.017^{fA}	6.42±0.013^{eA}	8.07±0.015^{dA}	10.13±0.009^{cA}	11.43±0.014^{bA}	12.85±0.008^{aA}
	4±1°C	0.19±0.012^{g}	1.94±0.013^{fA}	4.24±0.016^{eA}	6.71±0.011^{dA}	7.87±0.012^{cA}	9.76±0.009^{bA}	10.24±0.016^{aA}
T-1	27±5°C	0.19±0.017^{g}	1.87±0.015^{fB}	4.34±0.017^{eB}	6.25±0.014^{dB}	8.41±0.012^{cB}	9.54±0.016^{bB}	11.51±0.012^{aB}
	4±1°C	0.19±0.018^{g}	1.79±0.014^{fB}	3.45±0.009^{eB}	4.72±0.017^{dB}	6.43±0.014^{cB}	8.31±0.011^{bB}	9.67±0.009^{aB}
T-2	27±5°C	0.19±0.012^{g}	1.54±0.017^{fC}	4.21±0.011^{eC}	5.78±0.016^{dF}	8.03±0.012^{cF}	9.21±0.014^{bD}	11.23±0.009^{aC}
	4±1°C	0.19±0.009^{g}	1.45±0.011^{fD}	3.22±0.014^{eD}	4.34±0.009^{dC}	6.13±0.011^{cF}	7.78±0.014^{bF}	9.37±0.011^{aC}

n=6; *mean±S.E bearing different superscripts row-wise (small alphabet) and column-wise (Capital alphabet) significantly (p<0.05); T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

3.6. Egg yolk weight (g)

The results for the effect of different essential oil coating on egg yolk weight (g) at 27±5°C and 4±1°C are presented in Table 6. The yolk weight increased significantly (p<0.05) during storage and the eggs from the control group had the highest yolk weight (24.03 g) and eggs coated with T-2 (22.44 g) showed a minimum increase in yolk weight. At 4±1°C, the yolk weight increased gradually with the increase of storage period the control eggs showed maximum yolk weight (22.68 g) and T-2 (20.28 g) eggs had minimum yolk weight among all the treatment groups on the 55th day of storage. The increased yolk weight may be the result of albumen liquefaction and the yolk absorbing water during storage as a result of water and carbon dioxide loss from the albumen through the eggshell. The yolk weight increased from 26.28 to 29.12 for the control noncoated eggs and from 28.76 to 29.28 for edible oil-coated eggs after 5 weeks of storage at 25°C (Wardy et al., 2010).

Table 6: Effect of cinnamon essential oil coating on egg yolk weight (g) *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	16.24±0.12^{g}	17.99±0.15^{fA}	20.38±0.12^{eA}	21.45±0.14^{dA}	22.35±0.09^{cA}	22.96±0.13^{bA}	24.03±0.16^{aA}
	4±1°C	16.23±0.07^{g}	17.26±0.09^{fA}	19.79±0.11^{eA}	20.24±0.09^{dA}	21.37±0.12^{cA}	21.73±0.08^{bA}	22.68±0.121^{aA}
T-1	27±5°C	16.23±0.11^{g}	17.73±0.13^{fB}	18.93±0.14^{eB}	20.03±0.11^{dB}	20.95±0.13^{cB}	21.53±0.12^{bB}	22.65±0.12^{aB}
	4±1°C	16.24±0.09^{g}	17.05±0.11^{fB}	17.56±0.13^{eB}	17.97±0.07^{dB}	19.11±0.09^{cB}	19.42±0.13^{bB}	20.53±0.11^{aB}
T-2	27±5°C	16.22±0.11^{g}	17.54±0.16^{fF}	18.71±0.11^{eE}	19.78±0.09^{dF}	20.67±0.08^{cD}	21.31±0.14^{bF}	22.44±0.14^{aE}
	4±1°C	16.23±0.11^{g}	16.89±0.08^{fD}	17.32±0.11^{eF}	17.68±0.09^{dE}	18.87±0.11^{cF}	19.19±0.09b^{DE}	20.28±0.14^{aF}

n=6; *mean±S.E bearing different superscripts row-wise (small alphabet) and column-wise (Capital alphabet) significantly (p<0.05); T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

3.7. Egg albumen weight (g)

The results for effecting different essential oil coating on egg yolk albumen(g) at 27±5°C and 4±1°C are presented in Table 7. The lowest albumen weight was recorded on the 55th day of storage in both control and treated eggs. Albumen weight loss was significantly (p<0.05) higher in control eggs (23.15 g) than in reated samples. T-2 egg samples showed higher albumen weight on the 55th day of the storage period. At 4±1°C, the uncoated eggs had significantly (p<0.05) lower albumen weight (26.54 g) than fresh eggs. For all eggs, the albumen weight decreased significantly (p<0.05) during storage and the eggs from the T-2 (27.94) had the highest albumen weight 55th day of storage. During the storage of eggs at room temperature, a decline in egg albumen weight was observed with increased storage time by Uyanga et al. (2020).

3.8. Egg yolk index

The results for the effect of different essential oil coatings on egg yolk index at 27±5°C and 4±1°C are presented in Table 8. The coated egg sample had a significantly (p<0.05) higher yolk index compared to the control eggs. After 40 days of storage, the yolk index of the uncoated eggs was not detected due rupture of vitelline membrane. T-2 eggs had highest yolk Index on 55th day of storage period. Pires et al. (2020) observed that the yolk index of uncoated eggs decreased from 0.49 (1st wk) to 0.33 (4th wk) and from 0.49 (1st wk) to 0.40 (4th wk) during storage at room and refrigeration temperature respectively in RPC enriched essential oil coating.

3.9. Egg yolk colour

The results for the effect of different essential oil coating on egg yolk colour at 27±5°C and 4±1°C are presented in Table 9. Colour of egg yolk is important to consumers and effects their purchasing decisions. There was no significant difference observed in yolk colour score of coated and noncoated eggs during the storage period. Caner and Cansiz (2008), also reported no significant differences in color-appearance of yolk between coated and uncoated egg samples. The yolk color during storage did not significantly differ across coating treatments (with beeswax and Gammalu Latex coating) and storage periods . Throughout the study period, the coating materials did not alter the yolk color, indicating that storage duration, gas penetration, and water penetration have no bearing on the color of the yolk (Homsaard et al., 2021).

Table 7: Effect of cinnamon essential oil coating on egg albumen weight (g) *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	31.11±0.21^{a}	29.49±0.26^{bF}	28.19±0.19^{cF}	27.56±0.23^{dF}	26.14±0.21^{eF}	24.98±0.25^{fF}	23.15±0.19^{gF}
	4±1°C	31.11±0.19^{a}	30.27±0.24^{bF}	29.07±0.21^{cF}	28.51±0.27^{dF}	27.73±0.19^{eF}	27.13±0.23^{fF}	26.54±0.21^{gF}
T-1	27±5°C	31.10±0.19^{a}	30.56±0.23^{bE}	29.51±0.25^{cE}	28.73±0.27^{dE}	27.32±0.19^{eE}	26.20±0.24^{fE}	25.74±0.23^{gE}
	4±1°C	31.10±0.25^{a}	31.41±0.19^{bE}	30.17±0.24^{cE}	29.75±0.23^{dE}	28.96±0.24^{eE}	28.32±0.27^{fE}	27.73±0.24^{gE}
T-2	27±5°C	31.11±0.23^{a}	30.72±0.25^{bC}	29.68±0.19^{cC}	28.95±0.25^{dC}	27.63±0.23^{eAB}	26.43±0.19^{fAB}	25.91±0.19^{gB}
	4±1°C	31.11±0.21^{a}	31.53±0.25^{bB}	30.31±0.19^{cC}	29.93±0.25^{dD}	29.21±0.27^{eC}	28.60±0.21^{fA}	27.94±0.19^{gA}

n=6; *mean±S.E bearing different superscripts row-wise (small alphabet) and column-wise (Capital alphabet) significantly (p<0.05); T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

3.10. Egg yolk TBARS value

The results of different essential oil coating on egg yolk TBARS value (mg malonaldehyde kg^{-1}) at 27±5°C and 4±1°C changes are presented in Table 10. A significant (p<0.05) change in TBARS value was observed among different treatments. The TBARS value gradually increased during storage and the control egg showed maximum TBARS value (0.894) while T-2 showed minimum TBARS value of 0.851 at 27±5°C and at 4±1°C the eggs from the control group showed the highest TBARS value (0.768) while eggs coated with T-2 showed lower TBARS value of 0.727 on 55th day of storage. The results agree with the findings of Lakins et al. (2009) who reported that the TBARS values are affected by surrounding storage temperature and duration.

3.11. Yolk pH

The results for effect of different essential oil coatings on egg yolk pH at 27±5°C and 4±1°C are presented in Table 11. Yolk pH increased significantly (p<0.05) during storage. The yolk pH at 0 day was 6.12 but during storage of eggs, the pH gradually increased to 8.21 for coated eggs, and it reached 8.17 for T-2 at 27±5°C. At 4±1°C, the pH of the uncoated eggs increased significantly (p<0.05) from 6.12 to 6.98. However, the coatings were effective in maintaining the pH of the yolk and eggs coated with T-2 had significantly (p<0.05) lower yolk pH values after 55 days. Caner and

Table 8: Effect of cinnamon essential oil coating on yolk index *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	0.46±0.03^{a}	0.40±0.04^{bF}	0.34±0.05^{cF}	0.28±0.02^{dF}	N.D	N.D	N.D
	4±1°C	0.46±0.03^{a}	0.43±0.02^{bF}	0.40±0.05^{cF}	0.36±0.03^{dF}	0.33±0.05^{eF}	0.26±0.02^{fF}	N.D
T-1	27±5°C	0.46±0.05^{a}	0.41±0.02^{bE}	0.36±0.03^{cE}	0.30±0.04^{dE}	0.28±0.03^{eE}	N.D	N.D
	4±1°C	0.46±0.05^{a}	0.44±0.02^{b4E}	0.41±0.03^{cE}	0.38±0.04^{dE}	0.34±0.03^{eE}	0.27±0.04^{fE}	N.D
T-2	27±5°C	0.46±0.02^{a}	0.42±0.05^{bCD}	0.38±0.02^{cBCD}	0.31±0.02^{dBCD}	0.29±0.05^{eB}	N.D	N.D
	4±1°C	0.46±0.02^{a}	0.45±0.05^{bA}	0.43±0.03^{cAB}	0.41±0.02^{dABC}	0.36±0.03^{eAB}	0.29±0.05^{fA}	N.D

n=6; *mean±S.E bearing different superscripts row-wise (small alphabet) and column-wise (Capital alphabet) significantly (p<0.05); T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

Yuceer, (2015) reported that the eggs when coated with Whey Protein Isolate, Whey Protein Concentrate, Shellac or Zein had lower pH as compared to non-coated eggs, coatings act as barrier to prevent escape of carbon dioxide inside eggs.

3.12. Albumen pH

The results for effect of different essential oil coatings on egg albumen pH during storage at 27±5°C and 4±1°C are presented in Table 12. The albumen pH of all the eggs samples increased significantly (p<0.05) with storage period.

Table 9: Effect of cinnamon essential oil coating on yolk colour *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	8.95±0.21	8.94±0.19	8.91±0.23	8.93±0.18	8.93±0.24	8.78±0.20	8.64±0.22
	4±1°C	8.95±0.19	8.94±0.21	8.92±0.18	8.93±0.22	8.94±0.19	8.96±0.24	8.87±0.19
T-1	27±5°C	8.95±0.18	8.94±0.23	8.92±0.21	8.94±0.23	8.94±0.21	8.80±0.23	8.66±0.24
	4±1°C	8.95±0.21	8.95±0.23	8.91±0.21	8.94±0.18	8.95±0.21	8.95±0.18	8.91±0.21
T-2	27±5°C	8.95±0.19	8.93±0.25	8.91±0.19	8.92±0.24	8.93±0.23	8.79±0.18	8.63±0.19
	4±1°C	8.95±0.19	8.94±0.22	8.95±0.24	8.96±0.23	8.94±0.24	8.94±0.21	8.89±0.25

n=6; T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

The albumen pH values were higher for uncoated eggs than for the coated eggs during storage. The albumen pH for uncoated eggs changed from 8.74 initially to 10.26 at the end of storage. For coated eggs, albumen pH values reached 10.20 for T-2 at 27±5°C. The albumen pH increased gradually at 4±1°C, the initial average albumen pH of the

Table 10: Effect of cinnamon essential oil coating on TBA value (mg malonaldehyde/kg) *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	0.204±0.03^{g}	0.443±0.02^{fA}	0.622±0.05^{eA}	0.689±0.04^{dA}	0.742±0.03^{cA}	0.812±0.04^{bA}	0.894±0.02^{aA}
	4±1°C	0.204±0.03^{g}	0.261±0.02^{fA}	0.403±0.04^{eA}	0.483±0.05^{dA}	0.567±0.03^{cA}	0.672±0.05^{bA}	0.768±0.04^{aA}
T-1	27±5°C	0.204±0.05^{g}	0.431±0.04^{fB}	0.610±0.03^{eB}	0.674±0.02^{dB}	0.724±0.05^{cB}	0.795±0.02^{bB}	0.872±0.02^{aB}
	4±1°C	0.204±0.03^{g}	0.249±0.02^{fB}	0.378±0.04^{eB}	0.456±0.02^{dB}	0.548±0.02^{cB}	0.651±0.04^{bB}	0.745±0.02^{aB}
T-2	27±5°C	0.204±0.02^{g}	0.413±0.06^{fF}	0.594±0.03^{eC}	0.662±0.03^{dD}	0.714±0.02^{cC}	0.774±0.03^{bC}	0.851±0.04^{aF}
	4±1°C	0.204±0.02^{g}	0.231±0.04^{fD}	0.363±0.02^{eD}	0.442±0.03^{dD}	0.526±0.02^{cF}	0.638±0.02^{bF}	0.727±0.03^{aF}

n=6; *mean±S.E bearing different superscripts row-wise (small alphabet) and column-wise (Capital alphabet) significantly (p<0.05); T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

eggs was 8.74 and this value increased to 9.83 after 55 days in the uncoated eggs. The T-2 showed significantly (p<0.05) less increases in pH at the end of storage time Pires et al. (2020) observed that the initial albumen pH of the eggs was 8.05 and it increased to 9.48 and 9.26 after 6 weeks in the uncoated eggs and rice protein+tea tree EO coating respectively.

3.13. *Haugh unit*

The results for effect of different essential oil coatings on Haugh unit at 27±5°C and 4±1°C are presented in Table 13. Haugh unit found to be significantly (p<0.05) declined with the increasing storage period in both control and treated egg samples. In control eggs, the HU decreased from 81.48 12.6 (27±5°C and 4±1°C) are presented in Table 14. The APC of all treated egg sample was significantly (p<0.05) lower than control irrespective of storage period and temperature. The eggs stored at 4±1°C showed less increase in count throughout the storage period as compared to the eggs stored at 27±5°C. Treated eggs stored at 27±5°C were acceptable up to 20 days and those under refrigeration (4±1°C) were acceptable up to 40 day. Egg shell matrix has components that has antibacterial activity thus preventing the entry of various microorganisms inside egg. Similar results were reported by Chousalkar et al. (2021) who showed that the bacterial replication was limited on the egg shell surface when eggs were stored at refrigeration temperature. Eggs stored at refrigeration temperature had negligible bacterial growth on their surface when stored for 21 weeks (Saleh et al., 2020). Eggs that had been oiled and stored at refrigerator temperature exhibited lower levels of bacteria, yeast, and mold than those stored at ambient temperature (Eke et al., 2013).

Table 11: Effect of cinnamon essential oil coating on yolk pH *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	6.12±0.12^{g}	7.23±0.06^{fA}	7.86±0.11^{eA}	7.92±0.05^{dA}	8.07±0.06^{cA}	8.23±0.11^{aA}	8.21±0.05^{bA}
	4±1°C	6.12±0.07^{g}	6.31±0.08^{fA}	6.52±0.05^{eA}	6.60±0.08^{dA}	6.91±0.12^{cA}	6.95±0.06^{bA}	6.98±0.09^{aAB}
T-1	27±5°C	6.12±0.04^{g}	7.19±0.03^{fB}	7.62±0.08^{eB}	7.87±0.07^{dB}	8.02±0.12^{cB}	8.16±0.08^{abB}	8.19±0.05^{aB}
	4±1°C	6.12±0.11^{g}	6.25±0.05^{fB}	6.30±0.11^{eB}	6.51±0.05^{dB}	6.83±0.06^{cB}	6.90±0.04^{bB}	6.97±0.05^{aC}
T-2	27±5°C	6.12±0.08^{g}	7.16±0.05^{fD}	7.56±0.03^{eE}	7.84±0.11^{dC}	7.98±0.05^{cD}	8.13±0.04^{bD}	8.17±0.06^{aE}
	4±1°C	6.12±0.06^{g}	6.20±0.03^{fF}	6.27±0.09^{eC}	6.46±0.03^{dC}	6.75±0.04^{cF}	6.85±0.03^{bF}	6.95±0.07^{aE}

n=6; *mean±S.E bearing different superscripts row-wise (small alphabet) and column-wise (Capital alphabet) significantly (p<0.05); T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

3.15. *Egg albumen APC value*

The results for effect of different essential oil coatings on egg albumen APC under different storage conditions (27±5°C and 4±1°C) are presented in Table 15. APC was observed in control sample from 10th day onward at room temperature (27±5°C) and 20th day onward at refrigeration temperature (4±1°C). In treated egg samples the APC value was observed from 20th day at room temperature and from 30th day at refrigeration temperature. T-2 significantly (p<0.05) less

Table 12: Effect of cinnamon essential oil coating on albumen pH *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	8.74±0.10^{g}	9.45±0.08^{fA}	9.76±0.11^{eA}	9.97±0.06^{dA}	10.12±0.08^{cA}	10.22±0.11^{bA}	10.26±0.06^{aA}
	4±1°C	8.74±0.09^{g}	9.11±0.14^{fA}	9.23±0.06^{eA}	9.26±0.12^{dA}	9.32±0.09^{cA}	9.56±0.12^{bA}	9.83±0.08^{aA}
T-1	27±5°C	8.74±0.07^{g}	9.41±0.06^{fB}	9.71±0.13^{eB}	9.93±0.09^{dB}	10.05±0.06^{cB}	10.18±0.09^{bB}	10.25±0.08^{aB}
	4±1°C	8.74±0.13^{g}	9.07±0.09^{fB}	9.16±0.04^{eB}	9.22±0.09^{dB}	9.28±0.13^{cB}	9.51±0.06^{bB}	9.82±0.14^{aB}
T-2	27±5°C	8.74±0.09^{g}	9.39±0.04^{fE}	9.68±0.16^{eE}	9.88±0.04^{dE}	10.00±0.04^{cD}	10.11±0.10^{bD}	10.21±0.11^{aE}
	4±1°C	8.74±0.11^{g}	8.87±0.13^{fD}	9.08±0.06^{eE}	9.14±0.07^{dE}	9.21±0.08^{cE}	9.48±0.09^{bE}	9.78±0.12^{aF}

n=6; *mean±S.E bearing different superscripts row-wise (small alphabet) and column-wise (Capital alphabet) significantly (p<0.05); T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

Table 13: Effect of cinnamon essential oil coating on Haugh unit *(Mean±S.E.)

Treatments		Storage day						
		0	10th	20th	30th	40th	50th	55th
Control	27±5°C	81.48±0.23[a]	65.83±0.31[bF]	46.93±0.24[cF]	31.78±0.26[dF]	N.D	N.D	N.D
	4±1°C	81.48±0.23[a]	78.14±0.25[bF]	72.18±0.27[cF]	64.79±0.23[dF]	49.76±0.36[eF]	N.D	N.D
T-1	27±5°C	81.48±0.23[a]	66.75±0.25[bD]	52.56±0.25[cE]	37.34±0.23[dE]	31.34±0.24[eE]	N.D	N.D
	4±1°C	81.48±0.23[a]	78.69±0.27[bE]	72.36±0.25[cE]	64.83±0.27[dE]	49.82±0.23[eE]	38.56±0.25[fDE]	N.D
T-2	27±5°C	81.48±0.23[a]	66.78±0.24[bA]	53.59±0.27[cC]	38.51±0.21[dB]	32.51±0.26[eA]	N.D	N.D
	4±1°C	81.48±0.23[a]	79.14±0.32[bD]	72.43±0.21[cC]	64.87±0.32[dB]	49.91±0.26[eC]	38.63±0.22[fA]	N.D

n=6; *mean±S.E bearing different superscripts row-wise (small alphabet) and column-wise (Capital alphabet) significantly (p<0.05); T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

increases in APC value at end of storage period. Mesophilic bacterial growth was retarded at cold storage temperature thus increasing the shelf life of eggs (Chousalkar et al., 2021). Eke et al. (2013) reported that the eggs that had been oiled and stored at refrigerator temperature exhibited lower levels of bacteria, yeast, and mold than eggs that had been stored at ambient temperature.

3.16. Egg yolk APC value

The results for effect of different essential oil coatings on egg yolk APC under different storage conditions (27±5°C and 4±1°C) are presented in Table 15. Initially the egg content is sterile and APC was observed in control sample from 10th day at room temperature and from 20th day at refrigeration temp. In treated eggs the APC value was observed from 20th day at room temperature and 30th day at refrigeration temperature. T-2 showed significantly (p<0.05) less increases in APC value at end of storage period. Eke et al. (2013) compared the eggs that had been oiled and had been stored at refrigerator temperature with eggs that had been stored at ambient temperature and reported that the eggs at ambient temperature exhibited greater levels of bacteria, yeast, and mold. The main reason for more APC at room temperature may be that most of bacteria that grow on eggs and in its contents are mesophilic in nature so room temperature promotes their growth.

3.16. Salmonella and listeria monocytogenes count

No Salmonella and Listeria monocytogenes colonies were detected in all control and treated egg samples throughout 55 days of storage. Pujols et al. (2014) also found no Salmonella in both noncoated or coated eggs on the first day or after 5 weeks of storage at 25°C. The results of the experiment showed that both coated and uncoated eggs were microbiologically safe for the entire five weeks they were kept at 27°C.

Table 14: Effect of cinnamon essential oil coating on egg surface APC value *(Mean±S.E.)

Treatments	Storage day							
	0		10th		20th		30th	
	27±5°C	4±1°C	27±5°C	4±1°C	27±5°C	4±1°C	27±5°C	4±1°C
Control	3.36±0.01[m]	3.66±0.03[m]	4.78±0.01[kA]	3.76±0.04[lA]	6.36±0.02[iA]	4.25±0.01[jA]	7.50±0.02[gA]	4.38±0.04[hA]
T-1	3.34±0.02[m]	3.66±0.02[m]	4.52±0.01[kB]	3.73±0.02[lB]	6.14±0.01[iB]	4.09±0.02[jB]	7.36±0.03[gB]	4.19±0.02[hB]
T-2	3.36±0.03[m]	3.66±0.01[m]	3.47±0.02[kF]	3.68±0.01[lF]	5.45±0.03[iF]	3.79±0.01[jF]	6.85±0.02[gF]	4.02±0.01[hF]

Treatments	Storage day					
	40th		50th		55th	
	27±5°C	4±1°C	27±5°C	4±1°C	27±5°C	4±1°C
Control	8.42±0.01[eA]	6.25±0.03[fA]	8.73±0.04[cA]	7.34±0.02[dA]	9.16±0.03[aA]	7.61±0.02[bA]
T-1	8.19±0.02[eB]	6.11±0.01[fB]	8.46±0.02[cB]	7.12±0.01[dB]	8.79±0.04[aB]	7.53±0.02[bB]
T-2	7.74±0.03[eF]	5.87±0.02[fF]	8.05±0.03[cF]	6.87±0.01[dF]	8.41±0.02[aF]	7.32±0.01[bF]

n=6; *mean±S.E bearing different superscripts row-wise (small alphabet) and column-wise (Capital alphabet) significantly (p<0.05); T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

Table 15: Effect of cinnamon essential oil coating on egg yolk APC value *(Mean±S.E.)

Treatments	Storage day							
	0		10th		20th		30th	
	27±5°C	4±1°C	27±5°C	4±1°C	27±5°C	4±1°C	27±5°C	4±1°C
Control	N.D	N.D	2.25±0.01^{kA}	N.D	2.63±0.03^{iA}	2.14±0.02^{jA}	3.27±0.01^{gA}	2.42±0.02^{hA}
T-1	N.D	N.D	N.D	N.D	2.41±0.02^{iB}	N.D	3.04±0.02^{gB}	2.29±0.04^{hB}
T-2	N.D	N.D	N.D	N.D	2.18±0.04^{iF}	N.D	2.75±0.03^{gF}	2.17±0.02^{hF}

Treatments	Storage day					
	40th		50th		55th	
	27±5°C	4±1°C	27±5°C	4±1°C	27±5°C	4±1°C
Control	4.54±0.01^{eA}	3.16±0.02^{fA}	5.24±0.01^{cA}	4.33±0.03^{dA}	6.61±0.02^{aA}	5.13±0.01^{bA}
T-1	4.30±0.02^{eB}	3.05±0.04^{fB}	4.89±0.03^{cB}	4.19±0.02^{dB}	6.44±0.04^{aB}	5.02±0.02^{bB}
T-2	3.93±0.02^{eF}	2.88±0.01^{fF}	4.53±0.02^{cF}	4.11±0.04^{dF}	6.07±0.01^{aF}	4.73±0.03^{bF}

n=6; N.D: Not detected; *mean±S.E bearing different superscripts row-wise (small alphabet) and column-wise (Capital alphabet) significantly (p<0.05); T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

3.17. Sensory evaluation

The results for effect of essential oil coating on sensory quality of eggs stored at 27±5°C and 4±1°C are presented in Table 16. At 27±5°C, the colour, aroma and taste were gradually decreasing with the increase in storage period and the colour of control egg sample stored at room temperature decreased its score from 7.52 to 3.58 at end of storage. Among all treated eggs T-1 scored lower sensory score at the end of storage. Overall quality of control eggs decreased from 7.25 to 3.52 at end of storage period. At 20th day of storage, control and T-1 egg sample were slightly unacceptable but all other treated egg sample were acceptable. At 4±1°C, all the sensory parameters were gradually decreasing with the increase of storage periods. The control and T-1 showed significantly higher decrease in its sensory score as compared to other treated egg samples. Overall quality of control egg samples decreased from 7.25 at 0 day to 3.83 at end of storage period. Control and T-1 eggs were slightly acceptable up to 30th and T-2 egg sample are slightly acceptable up to 40th day at refrigeration temperature. Caner, (2005) observed that the surface odour of eggs coated with chitosan was the highest, followed by

Table 16: Effect of cinnamon essential oil coating on sensory evaluation of stored egg *(Mean±S.E.)

Sample		0	10th	20th	30th	40th	50th
Colour							
Control	27±5°C	7.52±0.21^{a}	6.53±0.22^{b}	4.72±0.19^{c}	3.58±0.42^{d}	N.P	N.P
	4±1°C	7.52±0.2^{1a}	7.16±0.25^{b}	6.21±0.23^{c}	5.58±0.31^{d}	4.72±0.27^{e}	3.70±0.19^{f}
T-1	27±5°C	7.41±0.23^{a}	6.47±0.18^{b}	4.65±0.27^{c}	3.73±0.26^{d}	N.P	N.P
	4±1°C	7.27±0.19^{a}	6.52±0.22^{b}	6.53±0.31^{c}	5.65±0.26^{d}	4.74±0.32^{e}	3.75±0.27^{f}
T-2	27±5°C	6.63±0.26^{a}	6.53±0.32^{b}	5.57±0.24^{c}	4.45±0.21^{d}	N.P	N.P
	4±1°C	7.19±0.23^{a}	7.11±0.26^{b}	6.67±0.18^{c}	6.47±0.19^{d}	5.27±0.26^{e}	4.59±0.34^{f}
Aroma							
Control	27±5°C	7.54±0.34^{a}	6.23±0.25^{b}	4.69±0.22^{c}	3.54±0.31^{d}	N.P	N.P
	4±1°C	7.54±0.34^{a}	7.14±0.16^{b}	6.19±0.28^{c}	5.55±0.33^{d}	4.69±0.22^{e}	3.69±0.22^{f}
T-1	27±5°C	7.32±0.41^{a}	6.41±0.39^{b}	4.72±0.31^{c}	3.75±0.28^{d}	N.P	N.P
	4±1°C	7.32±0.41^{a}	6.55±0.19^{b}	6.47±0.36^{c}	5.74±0.28^{d}	4.72±0.31^{e}	3.72±0.31^{f}
T-2	27±5°C	6.25±0.26^{a}	6.58±0.36^{b}	5.60±0.34^{c}	4.47±0.23^{d}	N.P	N.P
	4±1°C	7.25±0.26^{a}	7.13±0.41^{b}	6.76±0.23^{c}	6.41±0.23^{d}	5.32±0.34^{e}	4.60±0.34^{f}

Table 16: Continue...

Sample		0	10th	20th	30th	40th	50th
Taste							
Control	27±5°C	7.57±0.45^{a}	6.24±0.32^{b}	4.49±0.28^{c}	3.61±0.27^{d}	N.P	N.P
	4±1°C	6.78±0.45^{a}	6.27±0.22^{b}	6.21±0.16^{c}	5.58±0.31^{d}	4.57±0.18^{e}	3.64±0.32^{f}
T-1	27±5°C	6.83±0.37^{a}	6.29±0.31^{b}	4.72±0.42^{c}	3.82±0.31^{d}	N.P	N.P
	4±1°C	6.83±0.37^{a}	6.68±0.35^{b}	6.45±0.25^{c}	5.74±0.24^{d}	4.65±0.21^{e}	3.67±0.27^{f}
T-2	27±5°C	6.76±0.42^{a}	6.69±0.29^{b}	5.66±0.31^{c}	4.52±0.19^{d}	N.P	N.P
	4±1°C	6.76±0.42^{a}	6.72±0.23^{b}	6.47±0.19^{c}	6.36±0.18^{d}	5.27±0.32^{e}	4.62±0.31^{f}
Flavor							
Control	27±5°C	7.52±0.37^{a}	6.27±0.29^{b}	4.73±0.24^{c}	3.61±0.27^{d}	N.P	N.P
	4±1°C	7.52±0.37^{a}	6.37±0.24^{b}	6.29±0.22^{c}	5.61±0.26^{d}	4.54±0.32^{e}	3.69±0.24^{f}
T-1	27±5°C	7.10±0.25^{a}	6.38±0.31^{b}	4.76±0.37^{c}	3.82±0.26^{d}	N.P	N.P
	4±1°C	7.10±0.25^{a}	6.41±0.28^{b}	6.37±0.18^{c}	5.69±0.22^{d}	4.63±0.18^{e}	3.76±0.21^{f}
T-2	27±5°C	6.76±0.42^{a}	6.73±0.35^{ab}	5.72±0.28^{c}	4.63±0.31^{d}	N.P	N.P
	4±1°C	6.76±0.42^{a}	6.74±0.31^{ab}	6.49±0.26^{c}	6.29±0.19^{d}	5.28±0.34^{e}	4.61±0.43^{f}
Mouth feel							
Control	27±5°C	7.43±0.21^{a}	6.22±0.32^{b}	4.68±0.19^{c}	3.62±0.31^{d}	N.P	N.P
	4±1°C	7.43±0.21^{a}	6.39±0.22^{b}	6.31±0.26^{c}	5.56±0.23^{d}	4.62±0.17^{e}	3.72±0.22^{f}
T-1	27±5°C	7.12±0.32^{a}	6.36±0.26^{b}	4.73±0.31^{c}	3.74±0.26^{d}	N.P	N.P
	4±1°C	7.12±0.32^{a}	6.41±0.21^{b}	6.36±0.19^{c}	5.71±0.21^{d}	4.57±0.26^{e}	3.69±0.27^{f}
T-2	27±5°C	6.52±0.28^{a}	6.48±0.31^{db}	5.74±0.26^{c}	4.61±0.36^{d}	N.P	N.P
	4±1°C	6.52±0.28^{a}	6.49±0.19^{db}	6.47±0.24^{c}	6.35±0.16^{d}	5.26±0.32^{e}	4.65±0.23^{f}
Overall quality							
Control	27±5°C	7.25±0.33^{a}	6.29±0.29^{b}	4.53±0.25^{c}	3.52±0.18^{d}	N.P	N.P
	4±1°C	7.25±0.33^{a}	6.48±0.26^{b}	6.36±0.18^{c}	5.57±0.22^{d}	4.71±0.26^{e}	3.83±0.27^{f}
T-1	27±5°C	6.82±0.52^{a}	6.33±0.34^{ab}	4.65±0.34^{c}	3.67±0.29^{d}	N.P	N.P
	4±1°C	6.82±0.52^{a}	6.52±0.24^{b}	6.39±0.24^{c}	5.75±0.19^{d}	4.68±0.23^{e}	3.79±0.23^{f}
T-2	27±5°C	7.23±0.43^{a}	6.49±0.24^{b}	5.71±0.29^{c}	4.54±0.32^{d}	N.P	N.P
	4±1°C	7.23±0.43^{a}	6.59±0.17^{db}	6.49±0.31^{c}	6.34±0.17^{d}	5.37±0.22^{e}	4.64±0.21^{f}

n=6; *mean±S.E bearing different superscripts row-wise (small alphabet) and column-wise (Capital alphabet) significantly (p<0.05); T-1: 1% acetic acid and 1% chitosan; T-2: 1% acetic acid and 1% chitosan incorporated with 1.5% cinnamon essential oil

those coated with shellac; and concluded that these coatings have been found to produce positive sensory analysis results, coating materials might be utilized to prevent deterioration of internal quality of eggs while also extending their shelf life.

4. CONCLUSION

The quality characteristics of Cinnamon essential oils sprays treated eggs significenty improved at 27±5°C and 4±1°C temperature. The storage of shell eggs at room temperature control eggs found to negatively influence the internal egg quality. Thus the Cinnamon essential oils treated eggs should be kept at 4±1 °C for up to 40 days and at 27±5°C for up to 20 days.

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