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Research Article

Effect of Rosemary Extract as an Antimicrobial and Antioxidant Agent on Chicken Breast Fillets

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ABSTRACT

With the increase in awareness among meat consumers regarding the healthiness of products, the meat safety issue has come to the spotlight in recent years. Although the processor tried their best to market healthier and safer products to the consumers and that is the reason normally fresh chicken meat is marketed under refrigerated temperature. The research was conducted with the perspective of increasing the shelf life of chicken meat at refrigerating temperature and enhancing the attributes of preservation. However, the application of rosemary on chicken breast fillet proved to be an addition in the flavor of chicken meat which varies as per the sensory attributes of consumers. The microbial growth and lipid oxidation can be retarded by using antimicrobial and antioxidant agents in chicken and its products which can lead to maintaining the overall meat quality by enhancing shelf life and reducing putrefaction. The market purchased 24 chicken breast fillets were divided into four groups. Group one was kept as the control group and the other three groups were treated with different concentrations of rosemary (0.5%, 1%, and 1.5% respectively). All the treated and untreated samples were kept in the display chiller at 4°C. Sampling for TVC, pH, color, lipid oxidation, and sensory analysis was carried out on 0, 2, 4, 8, and 10 days of storage. The pH value of the breast fillets was recorded by using a meat-grade pH meter. Color determination was carried out by using a Minolta colorimeter. For sensory analysis, the breast fillets from each treatment were marinated and deep-fried till the core temperature reached 72°C. Sensory panelists looked for the odor and taste of rosemary extract treated and untreated samples. The data was analyzed through one-way ANOVA and factorial ANOVA using SPSS (version 25). The significant treatment means were compared using Duncan's multiple range test at a significance level of $P \leq 0.05$. Based on this study it can be concluded that the use of 1% and 1.5% rosemary extract spray improved the shelf life of fresh broiler meat by reducing bacterial count. However, the 1.5% rosemary extract reduces the bacterial count but imparts a strong odor in meat due to its aromatic characteristic.

Keywords: Chicken breasts fillets; Rosemary; Antioxidant; Antimicrobial

INTRODUCTION

Poultry meat is an important source to fulfill protein needs globally [1]. The meat processors maintain the optimum conditions to ensure the quality and safety of their processed products, this is often the rationale that fresh meat and its products are marketed under refrigerated temperature. However, after 6-7 days, even under refrigeration, there are chances of microbial growth and oxidative rancidity, leading to meat putrefaction [2].

During meat processing, there is a chance of microbial contamination, which may decrease meat's shelf life; along with this, during storage, lipid oxidation occurs in meat, which also

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deteriorates the meat quality. Some significant factors, such as bacterial contamination, and oxidation ruin food's appearance. So, avoiding these factors is highly desirable to produce food with longer shelf life and health for people. Chicken meat is known for its remarkable health benefits due to its nutritional value with high protein content specifically in breast fillets (Pectoralis major) with low cholesterol, calories, and fat levels [3].

Different interventions are applied in the modern processing industries for ensuring meat safety and enhancing its shelf life [4]. The application of these substances, directly or indirectly, as anti-microbial and antioxidant agents can reduce microbial growth and lipid oxidation. The natural preservatives used for meat producers include cinnamon, clove, rosemary, basil, thyme, oregano, lemon leaf, ginger, basilica, balm, coriander, etc. recognized as safe in the food industry [5]. Rosemary (*Rosmarinus officinalis* L.), first grown in Europe, best known as a food seasoning, is one of the most popular aromatic and medicinal plants worldwide. Rosemary (*Rosmarinus officinalis* L.), from the family Lamiaceae, is a greenish, compact, perennial aromatic herb of 90–250 cm height with small (2–4 cm) narrow and sticky leaves [6].

Rosemary leaves, either fresh or dried have been used for their iconic fragrance and aroma in food cooking or used in minute amounts as herbal tea extract. In contrast, whereas rosemary extracts are being utilized as natural antioxidants to improve the shelf life of foods. European Union has approved rosemary extract (E392) as a reliable and effective natural antioxidant to improve food preservation.

This high antioxidant property of rosemary extract is associated with their phenolic diterpenes, such as carnosic acid, carnosol, rosmanol, rosmariquinone, and rosmaridiphenol, ursolic acid, and caffeic acid be used to enhance the shelf life of poultry meat and meat products [7].

Rosemary oil treatment alters cell membrane and cell wall structures proliferating, resulting in the release of cellular content [8]. It has also shown hepato-protective solid and therapeutic potential [9]. The pharmacologically checked medicinal uses of rosemary are antidiabetic, antimicrobial, antitumor cells, antioxidant, and anti-inflammatory properties [10]. Therefore, rosemary extract could be helpful as an antimicrobial and antioxidant agent in foods, and their potential in individual foods could be further checked.

Ethical statement

All experimental procedures were pre-approved (vide letter no. DR/74, 14 January 2021) by the Institutional ethical review committee/institutional review board in accordance with the Helsinki Declaration of 1975 on human experimentation, Office of Research, Innovation, and Commercialization (ORIC), University of Veterinary and Animal Sciences (UVAS), Lahore, Pakistan.

MATERIALS AND METHODS

Experimental site

The present study was conducted at the meat processing lab of the department of meat science and technology, food safety and hygiene lab, and Central Laboratory Complex (CLC), Ravi Campus, Pattoki.

Sources of sample

Poultry breast fillets were purchased from the local market and transported to the lab under controlled hygienic conditions. Rosemary extract was brought from a shop of herbs and spices essential oils located in the local market. Dilutions were made as per the experimental plan (v/v) and sprayed on chicken breast fillets.

Packaging of samples

The breast fillets were packed in food-grade polystyrene trays and then shrink-wrapped with cling film at the chilling temperature (0-4°C).

Study parameters

Total viable count (ISO 6222:1999): 1 ml sample was taken from a stomacher bag containing the homogenized sample, and ten-fold serial dilutions were made with 0.1% BPW for the Total Viable Count (TVC) calculation. Then 0.1 ml of the adulterated sample was transferred to petri plates carrying nutrient agar for determination of Total Viable Count (TVC). After that, the petri plates were incubated at 37°C for 48 hrs. The visible colonies were counted using the Quebec Colony Counter (WTW, bzg-28, Germany).

Color measurement: The color of broiler breast samples was measured instrumentally at days 0, 2, 4, 6, 8, and 10. Different color parameters such as lightness (L^*), redness (a^*), yellowness (b^*), hue attitude (h), and chroma (c) were measured with the help of Minolta Chroma meter (Konica Minolta® CR-410, Japan), which was calibrated each time using a white plate as recommended by the manufacturer [11].

pH measurement: The pH was measured using a pH meter (WTW, pH3210, Germany). The pH meter was calibrated using buffer sets at pH 4-7 (WTW Technical Buffers). Probes were cleaned with distilled water after every sample reading [12].

TBA measurement: A 2 g meat sample was taken in a falcon tube. 50 µl of Butylated hydroxyl-toluene was added to that tube, and then 15 ml of distilled water was added to it. After homogenization, 1 ml of that was taken in a test tube with 2 ml TBA/TCA solution. The solution was warmed up in a water bath set at 90°C for fifteen minutes. Mixing by vortex mixer centrifugation was done in a centrifuge machine for 15 minutes set at 2000 rpm at 4°C, after which supernatant was collected, and absorbance value was recorded in a spectrophotometer at a wavelength of 531 nm [13].

Sensory evaluation: Sensory evaluation was performed in the sensory analysis lab at CLC, UVAS Ravi Campus, Pattoki.

Breast fillets samples from each treatment were cooked without salt and any spices on a hot plate, until they attained the core temperature of 72°C. Each specimen was further subdivided into equal parts to be served to all sensory panel members. All the samples were tagged and served warm, and in between all samples, the panelists had the facility to clean their mouths to rinse all carry-over effects. The panelists evaluated color appearance, flavor, juiciness, tenderness, and overall acceptability by following an 8-point hedonic scale [14].

• Odor
• Tenderness
• Juiciness
• Oiliness
• Flavor
• Overall acceptability

Statistical design: The data was analyzed through two-way ANOVA using SPSS. The significant treatment means were compared by using Duncan's multiple range test at a significance level of P ≤ 0.05 (Table 1).

Table 1: Packaging of samples.

Treatments		Storage duration (Days)	Total
T0	Control	0, 2, 4, 6, 8, 10	Treatments=4, Storage duration=6, Replicates=3, Total=72
T1	Rosemary extract at 0.5%		
T2	Rosemary extract at 1%		
T3	Rosemary extract at 1.5%		

RESULTS

Meat color, pH, TBARS and sensory evaluation according to treatments

Meat color, pH, TBARS, and sensory evaluation according to treatments are given in Table 2. The L^* was lower in control as compared to the rosemary extract treatments (P<0.01). The a^* was higher in control as compared to the rosemary extract treatments (P<0.01). The b^* was increased in rosemary extract of concentration 1% and 1.5% as compared to the 0.5% followed by the control group (P<0.01). Meat pH was higher in control as compared to the rosemary extract 1.5%. Thiobarbituric acid reactive substances were increased in rosemary extract 1% as compared to the 1.5% and control (P<0.01) (Figure 1).

Table 2: Meat color, pH, TBARS and sensory evaluation according to treatments.

Variables	Control	Rosemary extract 0.5%	Rosemary extract 1%	Rosemary extract 1.5%	P-value
L^*	51.47 ± 0.27^b	52.82 ± 0.21^a	52.94 ± 0.27^a	52.83 ± 0.45^a	<0.01
a^*	16.17 ± 0.11^a	13.33 ± 0.25^b	13.47 ± 0.11^b	13.78 ± 0.25^b	<0.01
b^*	11.62 ± 0.08^c	19.05 ± 0.39^b	21.62 ± 0.2^a	21.43 ± 0.63^a	<0.01
pH	5.65 ± 0.04^a	5.58 ± 0.06^{ab}	5.44 ± 0.04^{bc}	5.3 ± 0.04^c	<0.01
TBARS	0.34 ± 0.04^b	0.37 ± 0.03^{ab}	0.51 ± 0.06^a	0.25 ± 0.03^b	<0.01
Odor	6.81 ± 0.18^b	6.95 ± 0.12^b	7.27 ± 0.08^a	7.31 ± 0.18^a	0.04
Tenderness	6.77 ± 0.2^c	7.22 ± 0.12^{bc}	7.62 ± 0.03^{ab}	7.83 ± 0.08^a	<0.01
Juiciness	6.5 ± 0.13^c	6.81 ± 0.12^{bc}	7.21 ± 0.1^{ab}	7.57 ± 0.08^a	<0.01
Oiliness	6.29 ± 0.11^d	6.83 ± 0.1^c	7.27 ± 0.06^b	7.68 ± 0.05^a	<0.01
Mouth feel	7.41 ± 0.1^a	7.25 ± 0.04^{ab}	7.22 ± 0.05^{ab}	6.98 ± 0.12^b	<0.01
Overall acceptability	6.71 ± 0.07^d	7.08 ± 0.05^c	7.47 ± 0.05^b	7.88 ± 0.04^a	<0.01

Note: In a row, means with different superscripts indicate significant (P ≤ 0.05) difference among treatments.

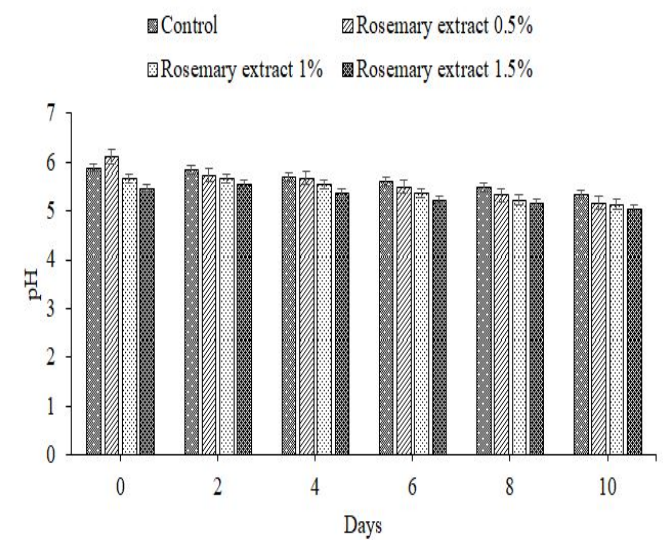

Figure 1: Meat pH according to treatment cross days interaction.

Meat odor was increased in rosemary extract 1% and 1.5% as compared to 0.5% and control (P<0.01). Tenderness and juiciness were increased in rosemary extract 1.5% as compared to control (P<0.01). Oiliness and overall acceptability were higher in rosemary extract 1.5% followed by 1%, 0.5% and control, respectively (P<0.01). Mouth feel was increased in control as compared to rosemary extract 1.5% (P<0.01) (Figure 2).

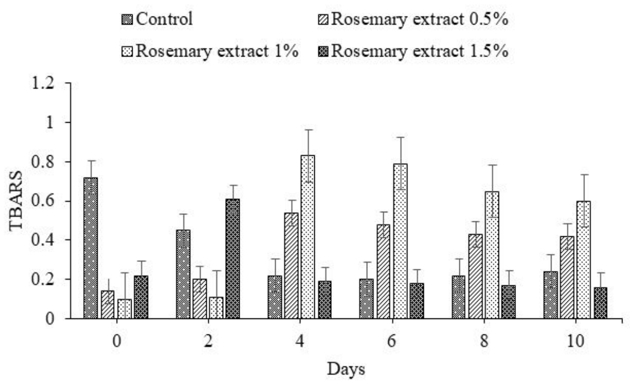

Figure 2: Thiobarbituric acid reactive substances according to treatment cross days interaction.

Meat color, pH, TBARS and sensory evaluation according to days

Meat color, pH, TBARS, and sensory evaluation according to days are given in Table 3. The L^* was higher on day 10 as compared to 8, 2 and 0 day (P<0.01). The a^* was increased on day 10 as compared to day 2 (P<0.01). The b^* was not affected among different days (P>0.05). Meat pH was higher on day 0 as compared to day 10. Thiobarbituric acid reactive substances remained unaffected on different days (P>0.05) (Figure 3).

Table 3: Meat color, pH, TBARS and sensory evaluation according to days.

Variables	0 day	2 day	4 day	6 day	8 day	10 day	P-value
L^*	49.68 ± 0.27^d	52.31 ± 0.29^c	52.56 ± 0.2b^c	53.09 ± 0.15^{bc}	53.21 ± 0.15^b	54.23 ± 0.15a	<0.01
a^*	14.46 ± 0.38^{ab}	13.2 ± 0.39^b	13.64 ± 0.24^b	14.17 ± 0.34^{ab}	14.29 ± 0.33^{ab}	15.36 ± 0.35^a	<0.01
b^*	16 ± 1.04	18.58 ± 0.94	18.21 ± 1.09	18.85 ± 1.15	19.13 ± 1.17	19.8±1.24	0.24
pH	5.78 ± 0.06^a	5.7 ± 0.03^{ab}	5.57 ± 0.04^{bc}	5.42 ± 0.04^{cd}	5.3 ± 0.03^{de}	5.18 ± 0.03^e	<0.01
TBARS	0.29 ± 0.06	0.34 ± 0.05	0.45 ± 0.07	0.41 ± 0.06	0.37 ± 0.05	0.35 ± 0.04	0.49
Odor	6.81 ± 0.21	7.42 ± 0.09	7.29 ± 0.06	7.22 ± 0.14	6.83 ± 0.24	6.97 ± 0.24	0.07
Tenderness	7.67 ± 0.09^a	7.71 ± 0.04^a	7.34 ± 0.11^{ab}	7.41 ± 0.16^{ab}	7.13 ± 0.2^{ab}	6.91 ± 0.29^b	<0.01
Juiciness	7.7 ± 0.11^a	7.24 ± 0.13^{ab}	7.06 ± 0.13^{bc}	6.63 ± 0.15^{cd}	6.43 ± 0.19^d	7.08 ± 0.07^{bc}	<0.01
Oiliness	7.3 ± 0.12^a	7.36 ± 0.11^a	7.07 ± 0.1^{ab}	6.82 ± 0.17^{ab}	7.01 ± 0.18^{ab}	6.54 ± 0.21^b	<0.01
Mouth feel	7.28 ± 0.14	7.29 ± 0.1	7.25 ± 0.11	7.06 ± 0.11	7.21 ± 0.07	7.2 ± 0.12	0.73
Overall acceptability	7.38 ± 0.07	7.32 ± 0.09	7.29 ± 0.12	7.44 ± 0.12	7.08 ± 0.14	7.19 ± 0.19	0.38

Note: In a row, means with different superscripts indicate significant (P ≤ 0.05) difference among days.

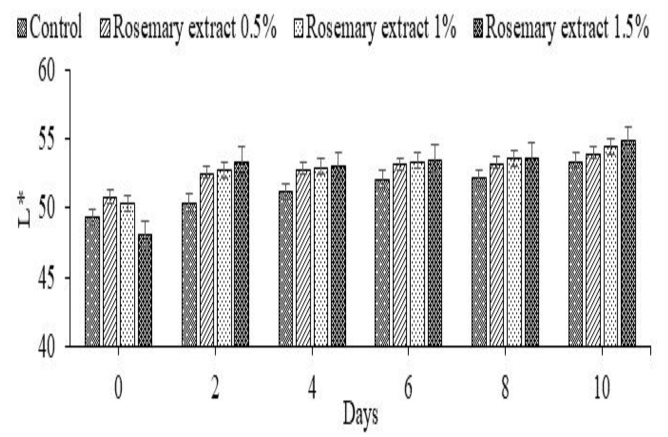

Figure 3: The L*of meat color according to treatment cross days interaction.

Meat odor was numerically higher on day 0 as compared to day 10 (P=0.07). Tenderness and oiliness were higher on day 0 and 2 as compared to day 10 (P<0.01). Juiciness was higher on day 0 as compared to day 8 (P<0.01). Mouth feel and overall acceptability were not affected on different days (P>0.05) (Figure 4).

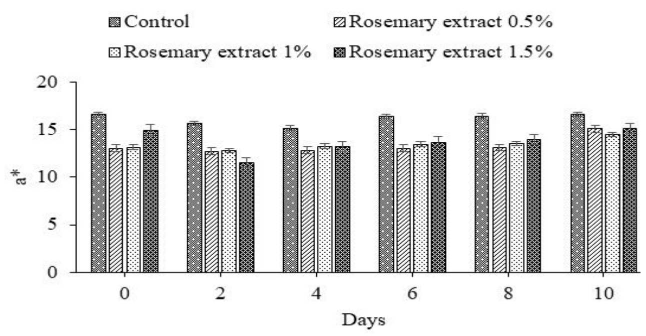

Figure 4: The a*of meat color according to treatment cross days interaction.

Treatment cross day comparison of meat color, pH, and TBARS

Meat color, pH, and TBARS according to treatment cross day interaction is given in Table 4. The L^*, a^* and b^* were highest on day 10 in rosemary extract 1.5% as compared to other treatment cross days (P<0.01). Meat pH was lowest on day 10 in rosemary extract 1.5% as compared to other treatment cross days (P<0.01). Thiobarbituric acid reactive substances were increased on day 4 in rosemary extract 1% as compared to other treatment cross days (P<0.01) (Figure 5).

Table 4: Meat color, pH, and TBARS according to treatment cross day's interaction.

Treatments	Days	L^*	a^*	b^*	pH	TBARS
Control	0	49.4	16.61	11.53	5.89	0.72
	2	50.41	15.68	12.44	5.84	0.45
	4	51.25	15.2	11.14	5.7	0.22
	6	52.11	16.43	11.43	5.61	0.2
	8	52.22	16.46	11.5	5.49	0.22
	10	53.44	16.65	11.66	5.35	0.24
Rosemary extract 0.5%	0	50.84	13.09	15.06	6.11	0.14
	2	52.61	12.75	19.43	5.73	0.2
	4	52.89	12.84	19.31	5.67	0.54

	6	53.23	13.04	19.54	5.49	0.48
	8	53.3	13.13	20.03	5.33	0.43
	10	54.03	15.12	20.96	5.17	0.42
Rosemary extract 1%	0	50.35	13.17	22.56	5.67	0.1
	2	52.82	12.83	20.61	5.67	0.11
	4	52.99	13.27	20.27	5.55	0.83
	6	53.41	13.49	21.55	5.37	0.79
	8	53.61	13.56	21.9	5.23	0.65
	10	54.49	14.53	22.82	5.14	0.6
Rosemary extract 1.5%	0	48.13	14.99	14.87	5.46	0.22
	2	53.42	11.53	21.86	5.56	0.61
	4	53.11	13.24	22.13	5.36	0.19
	6	53.6	13.73	22.9	5.22	0.18
	8	53.74	14.02	23.1	5.17	0.17
	10	54.97	15.16	23.74	5.05	0.16
SEM		0.06	0.26	0.08	0.02	0.006
Treatment × Days		<0.01	<0.01	<0.01	<0.01	<0.01

Note: In a column, P ≤ 0.05 indicate significant difference among treatment cross days interaction

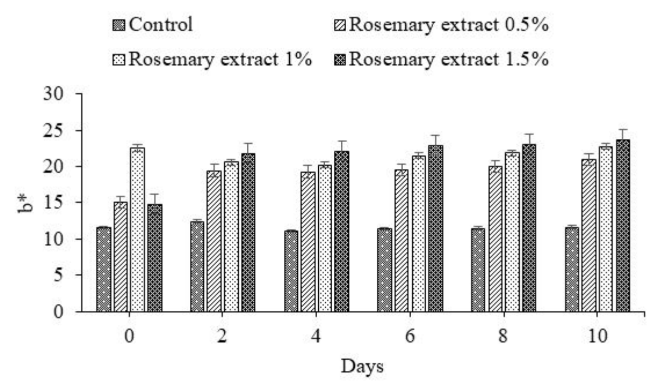

Figure 5: The b^* of meat color according to treatment cross days interaction.

Treatment cross day comparison of meat sensory parameters

Meat sensory evaluation according to treatment cross day interaction is given in Table 5. Meat odor and tenderness were highest on day 10 in rosemary extract 1.5% as compared to other treatment cross days (P<0.01). Juiciness and oiliness were higher on day 0 in rosemary extract 1.5% as compared to other treatment cross days (P<0.01). Mouth feel was highest on day 0 of control group as compared to other treatment cross days (P<0.01). Overall acceptability was increased on day 10 in rosemary extract 1.5% as compared to other treatment cross days (P<0.01) (Figure 6).

Table 5: Meat sensory evaluation according to treatment cross days interaction.

Treatments	Days	Odor	Tenderness	Juiciness	Oiliness	Mouth feel	Overall acceptability
Control	0	7.65	8	7.28	6.65	7.9	7.08
	2	7.6	7.7	6.68	6.75	7.73	6.93

	4	7.5	6.9	6.45	6.7	7.78	6.65
	6	6.58	6.48	6.05	6.05	7.5	6.85
	8	5.73	6.13	5.75	6.08	6.93	6.45
	10	5.83	5.43	6.8	5.5	6.63	6.3
Rosemary extract 0.5%	0	7.28	7.85	7.45	7.25	7.43	7.25
	2	7.5	7.78	7.18	7.38	7.43	7.13
	4	7.3	7.25	6.83	6.88	7.38	7.2
	6	7.1	7.45	6.38	6.48	7.18	7.33
	8	6.13	6.68	6.08	6.8	7.1	6.78
	10	6.43	6.3	6.95	6.18	7.03	6.78
Rosemary extract 1%	0	6.55	7.53	7.83	7.5	7.33	7.43
	2	7.35	7.73	7.45	7.5	7.18	7.38
	4	7.25	7.48	7.33	7.25	7.13	7.5
	6	7.45	7.7	6.83	7.1	7	7.68
	8	7.5	7.65	6.63	7.35	7.3	7.35
	10	7.53	7.63	7.23	6.93	7.38	7.5
Rosemary extract 1.5%	0	5.75	7.3	8.25	7.8	6.45	7.75
	2	7.23	7.65	7.68	7.8	6.83	7.85
	4	7.1	7.73	7.63	7.45	6.73	7.83
	6	7.75	8	7.28	7.65	6.58	7.9
	8	7.95	8.05	7.25	7.8	7.53	7.73
	10	8.1	8.28	7.33	7.55	7.78	8.2
SEM		0.14	0.12	0.17	0.13	0.109	0.09
Treatment × Days Days		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Note: In a column, $P \leq 0.05$ indicate significant difference among treatment cross days interaction

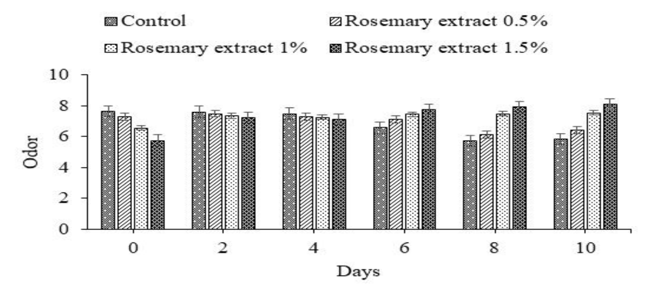

Figure 6: Meat odor according to treatment cross days interaction.

Total viable count according to treatments, days and treatment cross days or dilutions

The total viable count according to treatments, days, and treatment cross days or dilutions is given in Table 6. The total viable count was not affected among different treatments (P>0.05). Among different days, TVC was increased on day 10 in the 8th dilution as compared to day 8, 6, 4, 2, 0, and 7th, 6th, 5th, 3rd, and 2nd dilutions, respectively (P<0.01). Overall, TVC was highest in the control group on day 10 in the 8th dilution as compared to other treatment cross days and dilutions (P<0.01) (Figure 7).

Table 6: Total viable count according to treatments, days and treatment cross days or dilutions.

Treatments			Control	Rosemary extract 0.5%	Rosemary extract 1%	Rosemary extract 1.5%	P-value
TVC			7.51 ± 0.43	7.43 ± 0.42	7.38 ± 0.42	7.3 ± 0.42	0.98
Days, dilutions	0, 2nd	2, 3rd	4, 5th	6, 6th	8, 7th	10, 8th	P-value
TVC	4.33 ± 0.02^f	5.33 ± 0.02^e	7.29 ± 0.02^d	8.22 ± 0.02^c	9.11 ± 0.02^b	10.15 ± 0.03^a	<0.01
Treatment × Days, dilutions	0, 2nd	2, 3rd	4, 5th	6, 6th	8, 7th	10, 8th	P-value
Control	4.4	5.4	7.4	8.33	9.23	10.3	<0.01
Rosemary extract 0.5%	4.38	5.35	7.3	8.23	9.13	10.2	
Rosemary extract 1%	4.3	5.3	7.28	8.2	9.1	10.1	
Rosemary extract 1.5%	4.23	5.28	7.2	8.13	9	10	
SEM	0.016						

Note: In a row, means with different superscripts indicate significant (P ≤ 0.05) difference among treatments and days. P ≤ 0.05 indicate significant difference among treatment cross days or dilutions.

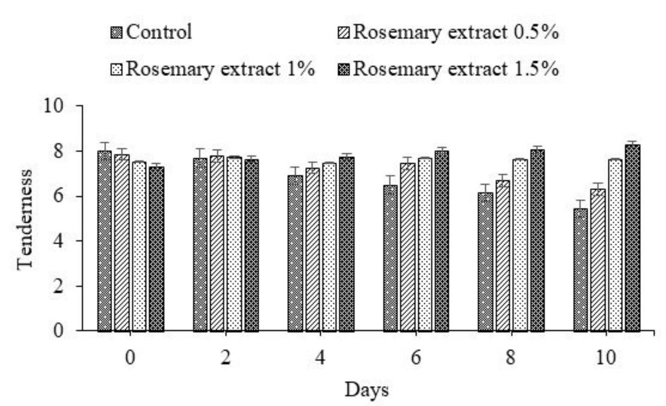

Figure 7: Tenderness according to treatment cross days interaction.

DISCUSSION

In the modern processing, various interventions are applied to ensure meat safety and enhance shelf life. Application of natural antimicrobial and antioxidant substances to enhance the shelf life of meat is preferred compared to synthetic. The natural preservatives used by meat producers include cinnamon, clove, rosemary, basil, thyme, oregano, lemon leaf, ginger, basilica, balm, and coriander etc., were recognized as safe in the food industry. The application of these substances, directly or indirectly, as antimicrobial and antioxidant agent can reduce microbial growth and lipid oxidation. Rosemary essential oil holds the plant's core component and is being focused for its potential health benefits and uses in food items to explore its effects on quality and safety. Therefore, the present study was planned to investigate the effect of rosemary extract of different concentrations as an antimicrobial and antioxidant agent on chicken breast fillets. In this study, rosemary extract of 0.5%, 1% and 1.5% concentrations were sprayed on chicken breast fillets to analyze its effects on total viable count, meat color, pH, lipid oxidation and sensory parameters as compared to control group (Figure 8).

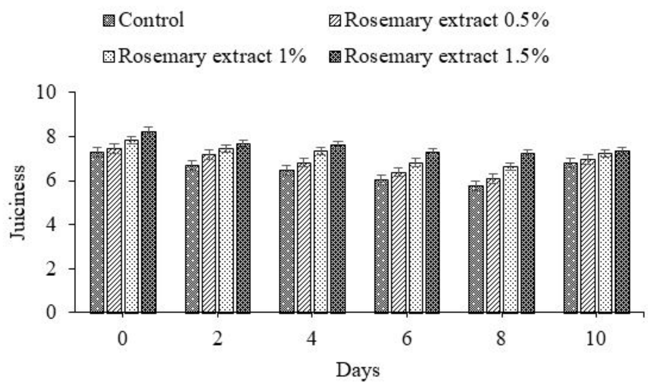

Figure 8: Meat juiciness according to treatment cross days interaction.

The a* was higher in control as compared to rosemary extract treatments. The a* was increased on day 10 as compared to day 2. The b* was increased in rosemary extract 1% and 1.5% as compared to 0.5% followed by control group. The L*, a* and b* were highest on day 10 in rosemary extract 1.5% as compared to other treatment cross days. Meat color is affected when meat is oxidized. In a study, Rosemary has shown potent activity by reducing the color loss and postponing lipid oxidation in meat and meat products [15]. In our study, Meat pH was higher in control as compared to rosemary extract 1.5%. Meat pH was higher on day 0 as compared to day 10. Meat pH was lowest on day 10 in rosemary extract 1.5% as compared to other treatment cross days. Meat pH is decreased by increasing lactic acid concentration. In our study, meat pH was lowered in rosemary extract 1.5%, which helped to prevent bacterial contamination. In a previous study, it was reported that lactic acid accumulation along with delayed lipid oxidation improved shelf life of meat [16]. Thiobarbituric acid reactive substances were increased in rosemary extract 1% as compared to 1.5% and control. Thiobarbituric acid reactive substances were increased on day 4 in rosemary extract 1% as compared to other treatment cross days. Delayed lipid oxidation in rosemary extract 1.5% effectively controlled the TBARS concentration in meat which could be due to higher concentration of antioxidant compounds such as phenolic acids, flavonoids, and diterpenoids (Figure 9) [17].

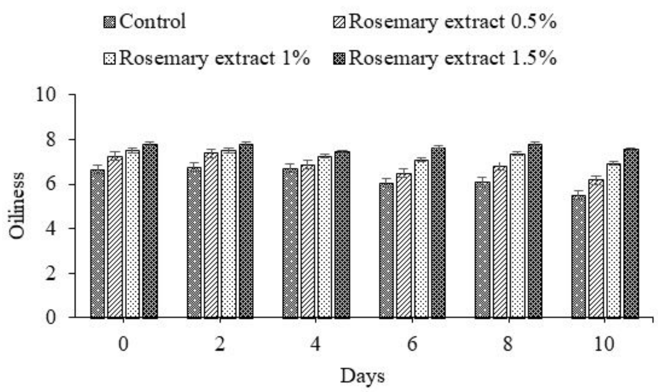

Figure 9: Meat oiliness according to treatment cross days interaction.

Meat odor was increased in rosemary extract 1% and 1.5% as compared to 0.5% and control. Meat odor was numerically higher on day 0 as compared to day 10. Meat odor was highest on day 10 in rosemary extract 1.5% as compared to other treatment cross days. In a previous study, Rašković et al., reported that rosemary extract contains different aromatic compounds which increase meat odor. Tenderness and juiciness were increased in rosemary extract 1.5% as compared to control. Tenderness was higher on day 0 and 2 as compared to day 10. Juiciness was higher on day 0 as compared to day 8 (Figure 10). Tenderness was highest on day 10 in rosemary extract 1.5% as compared to other treatment cross days. Juiciness was higher on day 0 in rosemary extract 1.5% as compared to other treatment cross days. Meat shear force is increased due to various factors however, it was reported that rosemary extract, and essential oils showed high antioxidant properties due to phenolic diterpenes, such as carnosic acid, carnosol, rosmanol, rosmariquinone and rosmaridiphenol, ursolic acid, and caffeic acid, which helped to improve meat tenderness in our study (Figure 11). Oiliness and overall acceptability were higher in rosemary extract 1.5% followed by 1%, 0.5% and control, respectively. Oiliness was higher on day 0 and 2 as compared to day 10. Oiliness was higher on day 0 in rosemary extract 1.5% as compared to other treatment cross days. Mouth feel was increased in control as compared to rosemary extract 1.5%. Mouth feel was highest on day 0 of control group as compared to other treatment cross days. Overall acceptability was increased on day 10 in rosemary extract 1.5% as compared to other treatment cross days. Rosemary extract contains oily compounds which enhance the oiliness, juiciness, mouth feel and overall acceptability of meat due to its aromatic compounds [18]. Among different days, TVC was increased on day 10 in 8th dilution as compared to day 8, 6, 4, 2, 0 and 7th, 6th, 5th, 3rd, 2nd dilutions, respectively. Overall, TVC was highest in control group on day 10 in 8th dilution as compared to other treatment cross days and dilutions. Previous studies reported the antimicrobial action of rosemary extract against *E. coli, Bacillus cereus, Salmonella choleraesuis, Staphylococcus aureus* and *Aeromonashydrophila* (Figure 12) [19,20].

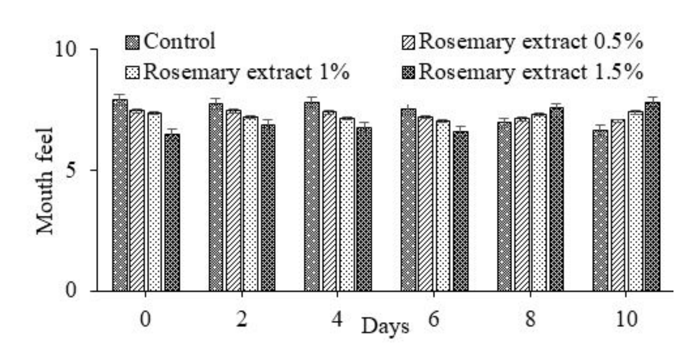

Figure 10: Mouth feels according to treatment cross days interaction.

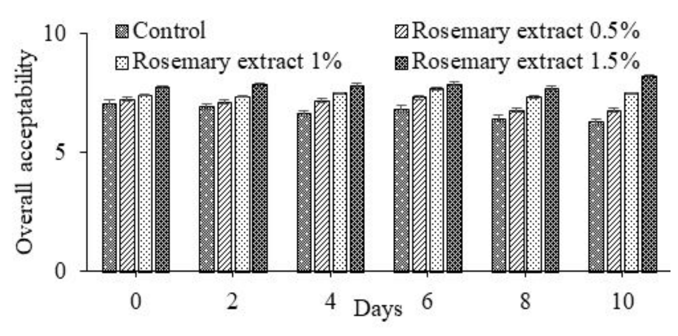

Figure 11: Overall acceptability according to treatment cross days interaction.

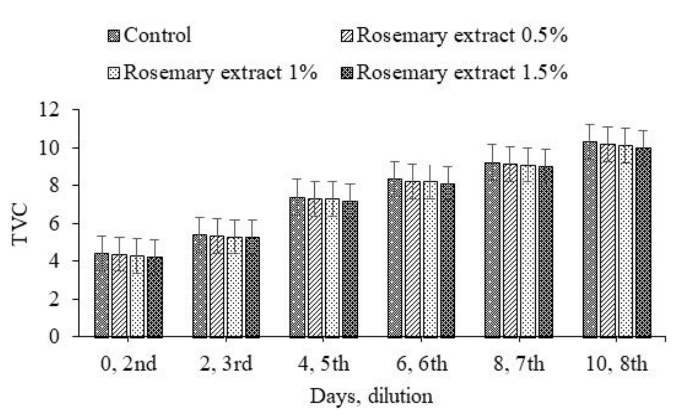

Figure 12: Total viable count according to treatment cross days and dilutions.

CONCLUSION

Based on this study it can be concluded that the use of 1% and 1.5% rosemary extract spray improve the shelf life of fresh broiler meat by reducing bacterial count. However, the 1.5% rosemary extract reduce the bacterial count but imparts strong odor in meat due to its aromatic characteristic.

RECOMMENDATIONS

The cost of rosemary extract amalgam *i.e.*, less than 50 rupees per 100 ml while it reduces the bacterial growth, oxidative rancidity and enhance the shelf life of chilled broiler meat so it should be introduced in the local market. Similarly, the effect of different concentrations of rosemary extract on broiler meat can be investigated. Moreover, effect of rosemary in further processing and value-added products can also be assessed. Furthermore, the combination of rosemary extract with different concentrations can also be effective.

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