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Influence of storage regimes on physicochemical traits of broiler pectoralis puperficialis muscle using mustard oil

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ABSTRACT

This study was conducted to evaluate the effectiveness of mustard oil as a natural preservative for improving the quality and shelf life of refrigerated broiler breast meat. Boneless broiler breast muscles were collected from the local market of Bangladesh Agricultural University, Mymensingh, and marinated with mustard oil at two concentrations: 1% (T_1) and 5% (T_2), while untreated meat served as the control (T_0). The samples were stored at 4 ± 1 °C for 12 days and analyzed at 0, 6, and 12 days to determine changes in physicochemical properties, proximate composition, instrumental color, water holding capacity (WHC), pH, and lipid oxidation measured by TBARS values. The results revealed that mustard oil significantly ($p< 0.05$) influenced several quality parameters of chicken meat during refrigerated storage. The treatment with 5% mustard oil (T_2) exhibited higher color stability (L^*, a^*, and b^* values), improved water holding capacity, and lower TBARS values compared with the control and 1% mustard oil treatment, indicating reduced lipid oxidation and better oxidative stability. Although dry matter and crude protein contents showed no significant differences among treatments, ether extract and ash contents varied significantly with treatment and storage duration. The pH values gradually decreased during storage, with mustard oil-treated samples maintaining more favorable pH stability than the control. Overall, the application of mustard oil, particularly at 5%, effectively improved the physicochemical stability and oxidative status of broiler breast meat during refrigerated storage. The findings suggest that mustard oil can serve as a promising natural preservative to enhance the quality and extend the shelf life of refrigerated poultry meat, offering a practical and economical preservation approach for the meat industry.

Introduction

Meat is acknowledged as a highly nutritious food, being an excellent source of high-quality protein. It also contains essential amino acids which is essential for any healthy diet. It contributes to human nutrition by delivering a wide range of micro and macro nutrients (Asghar et al., 1991). Poultry meat is chosen for consumption over other meats throughout the world, since it is economical, easily obtainable and has no religious restrictions (Prabakaran, 2012). Chicken meat is favored by consumers around the world because of its desirable nutritional qualities, such as a low-fat content and a relatively high concentration of polyunsaturated fatty acids (Patsias et al., 2008).

Fresh meat is also highly perishable product due to its biological composition (Zhou et al., 2010). In addition, meat and poultry products have frequently been found to be contaminated with microorganisms during the butchering and manufacturing process. These microorganisms produce undesirable quality changes in meats, especially in relation to lactic acid bacteria, a major bacterial group associated with meat spoilage (Doulgeraki et al., 2012).

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Meat or meat products typically spoil due to one of the two major causes; microbial growth or chemical deterioration. Lipid oxidation is considered as a major cause of chemical deterioration in the processed meat industry. It can cause adverse effects not only on sensory attributes such as flavor, color, and texture but also on nutritional quality of the products. Lipid per oxidation is a complex process occurring in aerobic cells and reflects the interaction between molecular oxygen and poly unsaturated fatty acids (Verma et al., 2009).

Food poisoning and the deterioration of meat products can be caused by microbial contamination, posing a public health risk as well as a financial loss. Lipid oxidation, which is initiated in the unsaturated fatty acids fraction in subcellular membranes, is a major cause of the deterioration and reduced shelf-life of meat products (Devatkal et al., 2010). Lipid oxidation may generate changes in meat quality parameters such as color, flavor, odor, texture, and even nutritional value (Kolakowska et al., 2013).

Nowadays, different preservation methods of meat have been developed among which refrigeration with natural preservatives is most useful over the world. For centuries, people have refrigerated meat to extend its shelf life, although most improvements in refrigeration technologies have occurred in the past century. The application of refrigeration for the preservation of meat has been practiced widely to maintain their quality and safety during storage, distribution and marketing. For this reason, the practice of freezing meat in the world has experienced a dramatic increase over the last two decades.

The texture of meat depends on the intrinsic mechanical properties and complex arrangement of protein, water, and cellular material of which it is made. Juiciness is dependent upon the amount of water held by meat proteins and within meat structural elements. Marinades consisting of salt and polyphosphates are used to improve the texture and yield of meat food products. Sodium chloride is known to cause meat to swell and increase the water holding capacity (WHC) of meat products. Polyphosphates enhance the effects of salt, and result in reduced cooking losses in poultry meat (Kerr et al., 2000) while improving the sensory properties of cooked products (Smith and Acton, 2010). Although, both biochemical (Siegel et al., 1979) and structural studies have provided information on changes in meat upon marination and mechanical action, less is understood about how these changes affect texture.

Marination was originally invented by chefs as a way to improve the flavor, juiciness, texture, and overall enjoyment of a product. Food companies have taken full advantage of marination. By integrating staged ingredient addition into the process, marination can improve product flavor and juiciness but more importantly overall yield. Marinated meat products are consumed increasingly. In addition to taste, marinating has been considered to increase product safety and shelf life. Despite growing interest in meat marination techniques, peer-reviewed studies examining the effects of oil-based marinades on the physical, chemical, organoleptic, and microbiological properties of chicken meat are still notably scarce. There was not more research so far conducted on chicken breast piece meat with mustard oil. When meat is enriched with mustard of oil, we can recommend this as natural preservative. The aim of preservation is not only to retard the food spoilage but also to control undesirable changes of wholesomeness and nutritive value. Oil is a natural preservative that prevents spoilage by isolating the food from air, providing a seal that can delay oxidation, deterioration, and molding (Lorenzo et al., 2019). Based on the above discussion the present study was conducted the effectiveness of mustard oil on preservation and nutritional quality of refrigerated meat. Another was to evaluate physico-chemical properties, proximate composition, instrumental color and oxidative status of pectoralis superficialis muscle of broiler under different storage conditions.

Materials and methods

The present experiment has been conducted in accordance with the following systematic programs:

Collection of raw materials

Boneless broiler breast muscle, obtained from poultry slaughtered in accordance with the halal method, was procured from local Market, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh. The muscle samples were immediately transported to the Animal Science Laboratory for further processing. Mustard oil was also sourced from the same local market located at BAU, Mymensingh.

Sample preparation

Approximately 1 kg of fresh boneless broiler breast muscle was procured for the preparation of marinated chicken samples. Initially, the muscle samples were thoroughly cleaned with fresh water, and all visible body fat, tendons, skin, and separable connective tissues were carefully trimmed using a sharp knife. The cleaned muscle was then cut into uniform small pieces. Subsequently, the samples were thoroughly mixed with mustard oil at concentrations of 1% and 5%, respectively, in accordance with the experimental design. Three treatment groups were established as follows: T_0 = Control group (without mustard oil), T_1 = 1% mustard oil, and T_2 = 5% mustard oil. The treated muscle samples were then individually packed in zipper bags, where the required portions were retained for experimental analysis and the remaining samples were stored in a refrigerator until further use.

Experiment layout

The muscle samples were divided into three experimental groups. The control group (T_0) consisted of raw muscle without any preservatives, while the other two treatments (T_1 &T_2) groups were mixed with 1% and 5% mustard oil, respectively. All samples were placed in sterile zipper bags and stored at 4 ± 1°C for 12 days under refrigeration. Analyses were performed at 6-day intervals to assess the quality attributes of the samples (Fig 1).

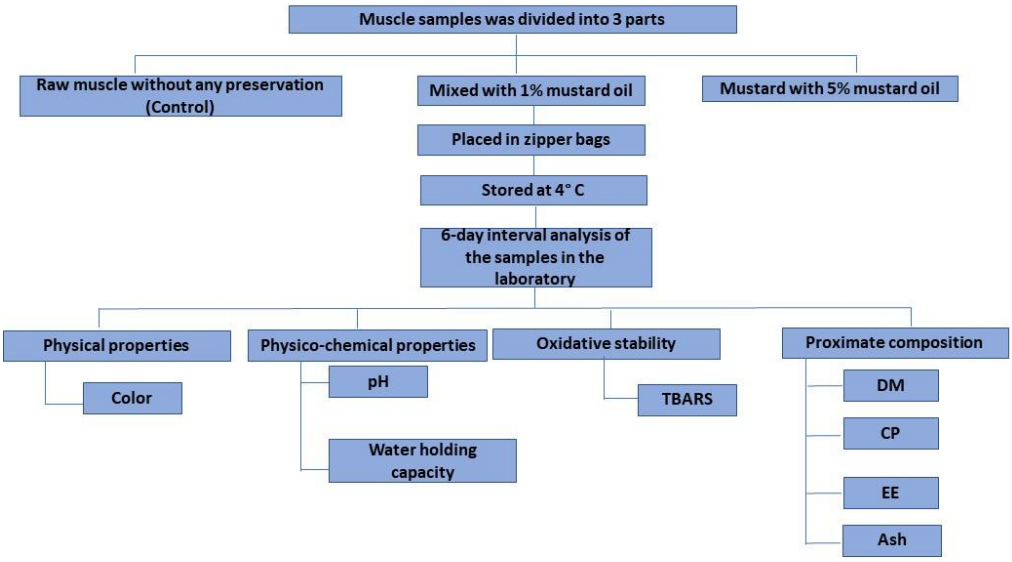

Figure 1: Illustration of the experimental design

Instrumental color measurement

Meat from the longissimus was measured for color using "The Konica Minolta Chroma Meter (CR 410, Konica Minolta Sensing, Inc., Osaka, Japan)" and a Miniscan Spectro colorimeter programmed with the CIE Lab (International Commission on Illumination) L*, a*, and b* system. The measurements, which assess L* for lightness, a* for redness, and b* for yellowness, were taken 24 hours after slaughter (CIELAB, 2014). The colorimeter was calibrated using the specific whiteboard before measurements began. Each value was an average of three measurements taken from an area of meat between 4–5 cm^2 to obtain a representative evaluation of the samples. The L* value indicates the lightness component, ranging from 0 to 100 (black to white); a* and b* both range from −60 to +60, with a* indicating green if negative and red if positive, and b* indicating blue if negative and yellow if positive. Petri dishes were used to serve each meat sample. Measurements of color parameters were made on day 0 and again on days 6 and 12, as well as until the end of the frozen storage period at 4ºC.

Proximate composition

Proximate composition such as Dry Matter (DM), Ether Extract (EE) and Crude Protein (CP) were carried out according to the methods (AOAC, 1995). All determination was done in triplicate and the mean value was reported.

Dry matter

Dry matter content determination was done by drying the sample. The differences in weight between the fresh and dried samples represent the water content. A microwave oven was used for the experiment.

Crude protein (%)

CP was determined by the micro kjeldahl method. The total nitrogen content of each sample was determined in triplicate by using the kjeldahl apparatus. In this case, total nitrogen was determined by digesting the samples with 20 ml concentrated sulphuric acid (H_2SO_4) in the presence of K_2SO_4, $CuSO_4$ and selenium powder followed by distillation of ammonia liberated by alkali (NaOH) into boric acid and titrated with standard HCl. The nitrogen values thus obtained were converted to total crude protein by multiplying with a factor of 6.25.

Ether extract (%)

EE content was determined by Soxhlet apparatus using diethyl ether. At first empty flask weight was taken. Then 5g sample was taken in a thimble and added 200 ml acetone in a Soxhlet. Extraction was done at 40-45°C which took about 7-8 hours. After extraction the flask were taken out and dried in oven for 30 minutes at 100°C. The flask containing ether extract was cooled in desiccators and weighed. The calculated value for ether extract content was obtained as percent of the sample.

The formula**:**

$$\%\ of\ ether\ extract = \frac{weight\ of\ the\ sample}{weight\ of\ the\ Ether\ Extrat} \times 100\%$$

Ash (%)

The samples were weighed in porcelain crucibles and pre-ashed in an electric oven set to 100°C. After that, the crucibles along with the samples were heated for six hours at 550°C in a muffle furnace. After that, the crucibles were placed in desiccators to cool. Ash was calculated as the average weight in percentage of the residual material in each sample.

The formula:

% of Ash content = $\frac{E}{C} \times 100$

Where, E = Weight of ash; C = Weight of sample

Physico-chemical properties measurement

pH measurement

The meat pH value was measured immediately after slaughtering (ultimate pH) the animal using a pH meter. The pH was measured by placing an electrode at three different points of the meat which was calibrated before use at pH 7.0 by pH meter (Hanna HI99163). The medial part of the meat was measured 3 times at a depth of 1 cm, and the results were averaged.

Water holding capacity (WHC)

WHC was measured according to the methodology of (Choi et al. 2018). Thawed samples (1 g each) were wrapped in absorbent cotton and placed in a 1.5 ml Eppendorf tube. The tubes with samples were centrifuged in a centrifuge separator (H1650-W Tabletop high speed micro centrifuge) at 10,000 RPM for 10 min at 4º centigrade temperature, following which the samples were weighed. The WHC% of the sample is expressed as the ratio of the sample weight after centrifugation to the initial sample weight, using the following formula:

%WHC= (Weight after centrifugation ÷ Weight before centrifugation) ✕100

Biochemical analysis

Thiobarbituric acid values (TBARS) (mg-MDA/kg)

Lipid oxidation was assessed in triplicate using the 2-thiobarbituric acid (TBA) method described by Schmedes and Holmer (1989). Chicken breast piece meat samples (5 g) were blended with 25 ml of 20% trichloroacetic acid solution (200 g/L of trichloroacetic acid in 135 ml/L phosphoric acid solution) in a vortex machine for 60s. The homogenized sample was filtered with Whatman filter paper number 4, and 2 mL of the filtrate was added to 2 mL of 0.02 M aqueous TBA solution (3 g/L) in a test tube. The test tubes were incubated at 100°C for 30 min and cooled with tap water. The absorbance was measured at fixed wavelength of 532 nm using a UV-VIS spectrophotometer (UV-1200, Shimadzu, Japan). The TBA value was expressed as mg malonaldehyde per kg of chicken breast piece meat sample.

Statistical Model and Analysis

The experiment was conducted as a factorial design incorporating two factors: Factor A (Treatments) and Factor B (Days of Intervals). The proposed statistical model was as follows:

$\mathbf{y}ijk = \mu + A_i + B_j + (AB)_{ij} + \varepsilon_{ijk}$

where: $i = 1, \ldots, a$; $j = 1, \ldots, b$; $k = 1, \ldots, n$

Where:

$\mathbf{y}_{ijk}$ = the k-th observation at the i-th level of Factor A and the j-th level of Factor B, $\boldsymbol{\mu}$ = the overall population mean, $\mathbf{A}_i$ = the fixed effect of the i-th level of Factor A (Treatments), $\mathbf{B}_j$ = the fixed effect of the j-th level of Factor B (Days of Intervals), $\mathbf{(AB)}_{ij}$ = the interaction effect between the i-th level of Factor A and the j-th level of Factor B, $\boldsymbol{\varepsilon}_{ijk}$ = the random error associated with the k-th observation in the ij-th cell, assumed to be independently and normally distributed with mean zero and constant variance ($\varepsilon_{ijk} \sim NID(0, \sigma^2)$) (Steel et al., 1981)

Results and Discussion

Instrumental color value

In case of lightness (L*) of fresh broiler muscle (Table 1), the most preferable color was detected from T_2 (57.26) and the least preferable color was detected on T_0 (52.01) group among all three treatments.

The most preferable color was observed at T_2 at 0 day (60.674) and less preferable color was found at 12th day (52.02). The L* values were significantly differed at different treatment groups ($p < 0.01$), days intervals ($p < 0.01$) and the interaction between treatments and days interval ($p < 0.01$).

Table 1: Effect of different concentration mustard oil on instrumental color value (Mean ± SE) in marinated chicken breast muscle at

Color	DI	Treatments			Mean	Level of significance		
		T_0	T_1	T_2		Treat.	DI	T×DI
L*	0	56.090±3.471	59.733±4.587	60.674±1.601	59.670^{a}±3.533	**	**	**
	6	54.370±2.981	56.566±2.601	59.656±1.693	56.708^{b}±2.412			
	12	50.346±3.412	51.863±6.294	52.020±3.010	50.712^{c}±3.407			
	Mean	**52.012^{c}±2.604**	**56.054^{b}±4.494**	**57.269^{a}±3.288**				
a*	0	0.496±0.903	0.946±0.243	1.303±0.378	0.993^{c}±0.583	**	**	**
	6	1.186±1.110	1.403±0.274	1.156±0.718	1.147^{a}±0.609			
	12	0.666±1.350	0.993±0.703	2.576±0.378	1.013^{b}±2.422			
	Mean	**0.338^{c}±1.121**	**1.114^{b}±0.406**	**1.678^{a}±0.491**				
b*	0	5.636±1.614	6.280±0.587	11.496±2.718	7.783^{c}±1.694	**	**	**
	6	9.290±0.371	9.460±0.318	10.606±1.971	9.545^{a}±1.005			
	12	7.836±0.276	9.506±2.398	7.710±0.697	8.091^{b}±1.114			
	Mean	**7.588^{c}±0.753**	**8.416^{b}±1.101**	**9.938^{a}±1.735**				

4±1°C temperature

Same superscripts in different treatments groups and days of interval did not differ significantly, whereas different superscripts in different treatments groups and days of interval differ significantly. T_0 = (control group), T_1 = (1% mustard oil), T_2 = (5 % mustard oil), DI=Day Intervals, Treat= Treatment, T×DI=Interaction of Treatment and Day Interval. ** means significant at 1% level of probability.

In case of redness (a*) of fresh broiler meat, most preferable color was observed from T_2 (1.67) and less preferable color was observed from T_0 (0.338) group among all three treatments. The most preferable color was observed at T_2 at 12th day (2.57) and less preferable color was found at 0 day (1.3). The a* values were significantly differed at different treatment groups ($p < 0.01$), days intervals ($p < 0.01$) and the interaction between treatments and days interval ($p < 0.01$).

In case of yellowness (b*) of fresh broiler meat, the most desirable color was observed from T_2 (9.938) and less desirable color was obtained from T_0 (7.588) group among all three treatments. The most preferable color was observed at T_2 at 0 day (11.49) and less preferable color was found at 12th day (7.71). The b* values were significantly differed at different treatment groups ($p < 0.01$), days intervals ($p < 0.01$) and the interaction between treatments and days interval ($p < 0.01$).

The quality feature that most affects a consumer's decision to buy or reject a product is the color of the meat. The T2 treatment's L*, a* and b* values were found to be higher than the T_1 treatment and control group. All these values were found significantly differ ($p<0.01$). L*, a* and b* value decreased of increasing storage period. Meat those are kept in refrigeration at 4℃ may gradually lose color due to lipid and pigment oxidation, which causes non-enzymatic browning between lipids and amino acids. Kumar and Tanwar (2011) reported similar outcome in chicken meat nugget with ground mustard. A decrease in appearance and color scores of meat products with increase in storage period was also reported by Singh et al*.* (2011), Kandeepan et al*.* (2010), Chidanandaiah and Sanyal (2009) and Kilinc (2009), Akhter et al. (2022). Among four treatments, significantly higher color score was observed in 12% carrot group than other treatments which was similar to the findings Zargar et al*.* (2017).

Proximate analysis

Dry matter (DM)

Table 2 shows that there were no significant differences (P>0.05) among treatments, days of interval, and their interaction for the dry matter (DM) content of marinated chicken meat. The mean DM values ranged from 25.63% to 26.66% across all treatment groups. Among the three treatments, the control group (T_0) recorded the highest DM content, which may be attributed to the absence of oil-based marination. The gradual increase in DM content observed over the storage period could be associated with progressive moisture loss from the meat during refrigerated storage, which consequently reduced the overall moisture content and elevated the dry matter percentage over time. Similar results were reported for Indonesian traditional meatballs with a DM content ranged from 56.17 to 60.32% (Purnomo and Rahardiyan, 2008). Naveena et al. (2008) also reported an increase in the DM content with the increase storage period for pomegranate peel extract and pomegranate rind powder extract respectively. A decrease in the percentage of DM content investigated by Santhi and Kalaikannan (2014) in low-fat chicken nuggets with the inclusion of oat flour.

Crude protein (CP)

Table 2 shows that there were no significant differences in all treatments, days of interval and interaction between treatment and days of interval for CP parameter. The ranges for mean value of CP were 21.77 to 21.89 for all groups.

Among four treatment groups, the lowest amount of CP content was observed from T_2 group. The CP content was decreased with the increase storage period. The most preferable CP content was observed at 0 day and less preferable CP content at 12th day but in terms of consumers view it was accepted. According to Suradkar et al. (2013), bread crumbs reduced the protein content of chicken nuggets. Similar finding was reported by Bhosale et al. (2011) for carrot and mashed sweet potato incorporated chicken nuggets and also in Das et al. (2022) for different edible oil. When chicken sausage made with wheat bran (WB) and dried carrot pomace (DCP), the protein content dramatically dropped (Yadav et al., 2018), which is similar to the present findings.

Ether extract (EE)

Table 2 shows that there was significant difference in all treatments, days of interval and interaction between treatment and days of interval for EE parameter. The ranges for mean value of EE were 2.64 to 2.68 for all groups. Among three treatment groups, the most preferable EE content was observed from T_0 group. The lowest amount of EE content indicates this product is most preferable for consumers' health. Less preferable EE content was observed from T_2 group. The EE content was decreased with the increase storage period. The data shows that the EE content was decreased to 2.66%

in all treatments after 12 days of storage. Suradkar et al. (2013) also reported similar results in different meat products. Ether extract content of the products presented a significantly (p<0.05) decreasing trend with increasing levels of combining of pumpkin in chicken sausages reported by Zargar et al. (2014).

Ash

Table 2 shows that there were significant differences in all treatments, days of interval and interaction between treatment and days of interval for Ash parameter. The ranges for mean value of Ash were 1.35 to 1.45 for all groups. Among these three treatments, the most preferable ash content was observed from T_0 group. The lowest amount of ash content indicates this product is most preferable for consumers' health. Less preferable ash content was observed at control group. The ash content was significantly increased with the increase in storage period. This increase during storage may be associated with moisture loss from the meat samples, which concentrates the mineral components and results in relatively higher ash percentages.

Table 2: Effect of different concentration of mustard oil on proximate parameters (Mean ± SE) in marinated chicken breast piece meat at 4±1°C temperature

Parameters	DI	Treatments				Level of significance		
		T_0	T_1	T_2	Mean	Treat.	DI	T× DI
DM (%)	0	25.20±0.041	26.45±0.038	26.46±0.044	**26.03^{c}±0.05**	NS	NS	NS
	6	25.79±0.058	26.52±0.034	26.63±0.057	**26.31^{b}±0.05**			
	12	25.89±0.063	26.71±0.021	26.89±0.047	**26.49^{a}±0.05**			
	Mean	**25.63^{c}±0.05**	**26.56^{a}±0.03**	**26.66^{b}±0.05**				
CP (%)	0	21.61±0.011	21.69±0.034	21.88±0.011	**22.06^{a}±0.02**	NS	NS	NS
	6	21.57±0.017	21.59±0.010	21.75±0.012	**21.63^{b}±0.01**			
	12	21.49±0.017	21.53±0.012	21.69±0.011	**21.57^{c}±0.01**			
	Mean	**21.60^{c}±0.02**	**21.77^{b}±0.01**	**21.89^{a}±0.02**				
EE (%)	0	2.68±0.003	2.70±0.005	2.76±0.005	**2.71^{a}±0.004**	*	*	*
	6	2.61±0.003	2.66±0.005	2.66±0.004	**2.64^{b}±0.004**			
	12	2.52±0.006	2.62±0.003	2.63±0.005	**2.59^{c}±0.004**			
	Mean	**2.64^{c}±0.01**	**2.66^{b}±0.003**	**2.68^{a}±0.003**				
Ash (%)	0	1.17±0.017	1.31±0.011	1.32±0.017	**1.26^{c}±0.02**	*	*	*
	6	1.36±0.015	1.43±0.017	1.46±0.010	**1.41^{b}±0.0.2**			
	12	1.52±0.015	1.57±0.015	1.58±0.008	**1.55^{a}±0.013**			
	Mean	**1.35^{c}±0.02**	**1.43^{b}±0.02**	**1.45^{a}±0.01**				

Different superscripts in different treatments groups and days of interval did not differ significantly. T_0 = (No oil), T_1 = (1% mustard oil), T_2 = (5% mustard oil), DI=Day Intervals, Treat= Treatment, T×DI=Interaction of Treatment and Day Intervals. *means significant at 5% level of probability.

The most preferable Ash content was observed at 0 day and less preferable ash content at 12th day but in terms of consumers view it was accepted. The data showed that the highest amount of ash content was increased to 1.47% in all treatments after 12th days

of storage. Zargar et al. (2017) reported that the ash content of the products showed a significant (p<0.05) decreasing trend with increasing levels of incorporation of carrot in chicken sausages. Similar results were also reported by Serdaroglu et al. (2005) in the ash content of koefte beef meatballs, which ranged from 2.6 to 2.8%. Bhosale et al. (2011) found that, when chicken nuggets were mixed with ground carrot and mashed sweet potato, the ash content decreased, which is similar to these findings.

Physicochemical quality

pH value

The pH changes in chicken meat treated with different concentrations of mustard oil during refrigerated storage at 4°C are presented in Table 3. Across all treatment levels, the overall observed mean pH ranged from 6.25 to 6.44. The relatively higher pH values may be attributed to the proteolytic breakdown of muscle proteins, release of basic nitrogenous compounds, and the inhibition of lactic acid-producing bacteria by the antimicrobial constituents of mustard oil. Throughout the storage periods, the pH of chicken samples indicated a significant difference (p<0.001) between treatments. The various superscripts seen on the 0, 6th and 12th days of observation revealed a substantial difference. Throughout the storage period, T_2 maintained lowest pH values than control and T_1 samples. In compared to the control group, T_2 had the most preferred pH during the storage period. The pH value of meat in all treatments gradually decreased as the storage period extended. The range of overall observed mean pH value was 6.21 to 5.80 at different days of interval. The initial pH value of the control sample was 6.20 and decreased to 5.81 after 12 days of storage, significantly higher than other treatments (Table 3). The accumulation of lactic acids from microbial secretions and thaw loss of chicken meat were likely to blame for the lowering pH trend. Bacteria and mold have a tendency to diminish as storage duration increases, and they release pH lowering components. Similar findings were observed by Singh et al., (2014). The rise in the pH (p<0.05) of the control samples may be caused by bacterial consumption of acids produced during the breakdown of proteins due of the depletion of the stored glucose. The last increase in pH levels might have been caused by release of ammonia molecules from endoprotease or proteolytic microbial flora in the raw meat by Mokhtar et al. (2012).

Table 3: Effect of different concentrations of mustard oil on physicochemical parameters (Mean ± SE) in marinated chicken breast piece meat at 4±1°C temperature

Parameters	DI	Treatments				Level of significance		
		T_0	T_1	T_2	Mean	Treat.	DI	T×DI
pH	0	6.70±0.035	6.21±0.023	6.22±0.016	6.21^{a}±0.022	**	**	**
	6	5.82±0.023	5.85±0.014	5.86±0.006	5.84^{b}±0.013			
	12	5.79±0.023	5.80±0.008	5.81±0.008	5.80^{c}±0.011			
	Mean	**5.93^{c}±0.01**	**5.95^{b}±0.015**	**5.96^{a}±0.026**				
Water holding capacity	0	92.66±0.333	93.66±0.333	94.33±0.333	93.58^{a}±0.391	*	*	*
	6	90.66±0.88	92.33±0.333	93.00±0.577	91.91^{b}±0.668			
	12	89.66±0.666	91.66±0.008	93.66±0.023	91.66^{c}±0.257			
	Mean	**91.00^{c}±0.626**	**92.55^{b}±0.224**	**93.66^{a}±0.311**				

Same superscripts in different treatments groups and days of interval did not differ significantly, whereas different superscripts in different treatments groups and days of interval differ significantly. T_0 = (No oil), T_1 = (1% mustard oil), T_2 = (5% mustard oil), DI=Day Intervals, Treat= Treatment, T×DI=Interaction of Treatment and Day Intervals. ** means significant at 1% level of probability; *means significant at 5% level of probability.

Water holding capacity (WHC)

Table 3 shows the WHC of chicken meat combined with various oils as well as the control group after 12 days of refrigerated storage. On days 0, 6 and 12,

there was a substantial variation between the different treated batches. The range of overall observed WHC from the meat was 92.66 to 94.33 at different treatment levels. The range of overall observed of different days of intervals of WHC value was 92.66 to 93.66. Among four treatments, the WHC in the control sample was significantly lower than in the samples treated with different types of oil respectively. WHC was gradually declined during storage in various treatments as storage days increased. Among these three treatments, the most preferable WHC value was observed from T_2 group. The higher amount of WHC value indicates the product is most preferable for consumer's health. These findings are consistent with previous studies reporting that poultry meat exhibiting low pH values tends to show reduced water holding capacity, ultimately resulting in increased drip loss and cook loss (Owens et al., 2000; Zhang and Barbut, 2005).

Biochemical properties

Thiobarbituric acid value (TBARS)

Table 4 shows that there was significant difference in all treatments, days of interval and interaction between treatment and days of interval for TBARS parameter. The ranges for mean value of TBARS were 0.140-0.116 for all groups. Among these three treatments, the most preferable TBARS value was observed from T_2 group. The lowest amount of TBARS value indicates that the product is most desirable for consumer's health. The TBARS values increased significantly (p<0.001) during storage in all treatments. Similar findings were reported by Chidanandaiah et al. (2009) in meat patties during storing them in the refrigerator. Another author found a significant increase in TBARS value of control and fiber-enriched sausage with an increase in storage period (Yadav et al., 2018). Similar findings were reported by Nassu et al. (2003) in goat meat sausage during refrigerated storage.

Table 4: Effect of different types of oil on biochemical parameters (Mean ± SE) in marinated chicken breast piece meat at 4±1°C temperature

Parameters	DI	Treatments				Level of significance		
		T_0	T_1	T_2	Mean	Treat.	DI	T×DI
TBARS (mgMDA/kg)	0	0.140±0.003	0.120±0.005	0.101±0.004	0.125^{c}±0.004	**	**	**
	6	0.105±0.001	0.116±0.002	0.128±0.001	0.142^{b}±0.001			
	12	0.314±0.012	0.273±0.003	0.266±0.005	0.284^{a}±0.005			
	Mean	**0.211^{c}±0.003**	**0.173^{b}±0.007**	**0.167^{a}±0.003**				

Different superscripts in different treatments groups and days of interval differ significantly. T_0 = (No oil), T_1 = (1% mustard oil), T_2= (5% mustard oil), DI=Day Intervals, Treat= Treatment, T×DI=Interaction of Treatment and Day Intervals. ** means significant at 1% level of probability. TBARS = Thiobarbituric acid reactive substances.

Conclusion

The present study demonstrated that mustard oil can be used as a natural preservative to improve the quality and extend the refrigerated shelf life of broiler chicken breast meat. The results indicated that different levels of mustard oil significantly influenced several quality parameters, including instrumental color, physicochemical characteristics, and oxidative stability during storage at 4 °C for 12 days. Among the treatments, chicken meat treated with 5% mustard oil (T_2) showed comparatively better-quality attributes, including higher water holding capacity, lower TBARS values, and more desirable color characteristics compared with the control and 1% mustard oil treatments. Although some quality parameters changed gradually during storage, the mustard oil treatments helped maintain acceptable physicochemical and biochemical properties of the meat throughout the storage period. Therefore, the findings suggest that 5% mustard oil marination could be an effective, natural, and economical method for preserving chicken breast meat during refrigerated storage, while maintaining its nutritional and quality characteristics.

References

Akhter, M.S., Khatun, H., Hashem, M.A., Rahman, M.M. and Khan, M., 2022. Effect of storage periods on the quality and shelf life of beef liver

at refrigerated temperature. Meat Res. *2*(2). https://doi.org/10.55002/mr.2.2.17

Allen, C.D., Russell, S.M. and Fletcher, D.L., 1997. The relationship of broiler breast meat color and pH to shelf-life and odor development. Poultry Sci. *76*(7), 1042-1046. https://doi.org/10.1093/ps/76.7.1042

Asghar, A., Gray, J.I., Booren, A.M., Gomaa, E.A., Abouzied, M.M., Miller, E.R. and Buckley, D.J., 1991. Effects of supranutritional dietary vitamin E levels on subcellular deposition of α-tocopherol in the muscle and on pork quality. J. Sci. Food. Agric, *57*(1), 31-41. https://doi.org/10.1002/jsfa.2740570104

Bhosale, S.S., Biswas, A.K., Sahoo, J., Chatli, M.K., Sharma, D.K. and Sikka, S.S., 2011. Quality evaluation of functional chicken nuggets incorporated with ground carrot and mashed sweet potato. Food Sci. Technol. Int. *17*(3), 233-239. https://doi.org/10.1177/1082013210382339

Chidanandaiah, Keshri, R.C. and Sanyal, M.K., 2009. Effect of sodium alginate coating with preservatives on the quality of meat patties during refrigerated (4±1C) storage. J. Muscle Foods. 20(3), 275-292. https://doi.org/10.1111/j.1745-4573.2009.00147.x

Choi, M.J., Abduzukhurov, T., Park, D.H., Kim, E.J., Hong, G.P., 2018. Effects of deep-freezing temperature for long-term storage on quality characteristics and freshness of lamb meat. Korean J. Food Sci. Anim. Resour. 38(5), 959. https://doi.org/10.5851/kosfa.2018.e28

Das, A., Hashem, M.A., Azad, M.A.K. and Rahman, M.M., 2022. Edible oil marination in broiler meat for short term preservation. Meat Res. *2*(3). https://doi.org/10.55002/mr.2.3.22

Devatkal, S.K., Narsaiah, K. and Borah, A., 2010. Anti-oxidant effect of extracts of kinnow rind, pomegranate rind and seed powders in cooked goat meat patties. Meat Sci, *85*(1), 155-159. https://doi.org/10.1016/j.meatsci.2009.12.019

Doulgeraki, A.I., Ercolini, D., Villani, F. and Nychas, G.J.E., 2012. Spoilage microbiota associated to the storage of raw meat in different conditions. Int. J. Food Microbiol., 157(2), 130-141. https://doi.org/10.1016/j.ijfoodmicro.2012.05.020

Froning, G.W., Babji, A.S. and Mather, F.B., 1978. The effect of preslaughter temperature, stress, struggle and anesthetization on color and textural characteristics of turkey muscle. Poultry Sci. *57*(3), 630-633. https://doi.org/10.3382/ps.0570630

Horwitz, W., & Latimer, G. W., Jr., 2005. Official methods of analysis of AOAC International (18th ed.). Gaithersburg, Maryland, USA: AOAC International.

Kandeepan, G., Anjaneyulu, A.S.R., Kondaiah, N. and Mendiratta, S.K., 2010. Quality of buffalo meat keema at different storage temperature. Afri. J. Food Sci. *4*(6), 410-417.

Kerr, W.L., Li, R. and Toledo, R.T., 2000. Dynamic mechanical analysis of marinated chicken breast meat. J. Texture Stud. *31*(4), 421-436. https://doi.org/10.1111/j.1745-4603.2000.tb00300.x

Kilinc, B., Cakli, S., Cadun, A. and Sen, B., 2009. Effects of phosphate dip treatments on chemical, microbiological, color, textural, and sensory changes of rainbow trout (Onchorhyncus mykiss) fillets during refrigerated storage. J. Aquat. Food Prod. Technol. *18*(1-2), 108-119. https://doi.org/10.1080/10498850802581807

Kolakowska, A., Bartosz, G., 2013. Oxidation of food components: an introduction. In: Bartosz G. (Eds.), Food oxidants and antioxidants: chemical, biological, and functional properties, CRC Press, Boca Raton (FL), pp. 1–20. https://doi.org/10.1201/b15062-6

Kumar, D. and Tanwar, V.K., 2011. Effects of incorporation of ground mustard on quality attributes of chicken nuggets. J. Food Sci. Technol. *48*(6), 759-762. https://doi.org/10.1007/s13197-010-0149-3

Lorenzo, J. M., Mousavi Khaneghah, A., Gavahian, M., Marszałek, K., Eş, I., Munekata, P. E. S., … Barba, F. J. (2019). Understanding the potential benefits of thyme and its derived products for food industry and consumer health: From extraction of value-added compounds to the evaluation of bioaccessibility, bioavailability, anti-inflammatory, and antimicrobial activities. Critical Reviews in Food Science and Nutrition, 59(18), 2879–2895. https://doi.org/10.1080/10408398.2018.1477730

Mokhtar, S., Mostafa, G., Taha, R. and Eldeep, G.S.S., 2012. Effect of different starter cultures on the biogenic amines production as a critical control point in fresh fermented sausages. Eur. Food Res. and Technol. *235*(3), 527-535. https://doi.org/10.1007/s00217-012-1777-9

Nassu, R.T., Gonçalves, L.A.G., da Silva, M.A.A.P. and Beserra, F.J., 2003. Oxidative stability of fermented goat meat sausage with different levels of natural antioxidant. Meat Sci. *63*(1), 43-49. https://doi.org/10.1016/S0309-1740(02)00051-7

Naveena, B.M., Sen, A.R., Vaithiyanathan, S., Babji, Y. and Kondaiah, N., 2008. Comparative efficacy of pomegranate juice, pomegranate rind powder extract and BHT as antioxidants in cooked chicken patties. Meat Sci. *80*(4), 1304-1308. https://doi.org/10.1016/j.meatsci.2008.06.005

Owens, C. M., Hirschler, E. M., McKee, S. R., Martinez-Dawson, R., & Sams, A. R. (2000). The characterization and incidence of pale, soft, exudative turkey meat in a commercial plant. *Poultry Science*, 79(4), 553–558. https://doi.org/10.1093/ps/79.4.553

Patsias, A., Badeka, A.V., Savvaidis, I.N. and Kontominas, M.G., 2008. Combined effect of freeze chilling and MAP on quality parameters of raw chicken fillets. Food Microbiol. *25*(4), 575-581. https://doi.org/10.1016/j.fm.2008.02.008

Prabakaran, R., 2012. Overview of poultry production in India vis-à-vis global scenario. Proc. of XXIX IPSACON. *5*, 7.

Purnomo, H., Rahardiyan, D., 2008. Indonesian traditional meatball. Int. Food Res. J. 15(2), 101-108.

Santhi, D., and Kalaikannan, A., 2014. The effect of the addition of oat flour in low-fat chicken nuggets. J. Nutr. & Food Sci. 4(1), 1. https://doi.org/10.4172/2155-9600.1000260

Schmedes A, Hølmer G 1989: A new thiobarbituric acid (TBA) method for determining free malondialdehyde (MDA) and hydroperoxides selectively as a measure of lipid peroxidation. J. Am. Oil Chem. Soc. 66(6), 813-817. https://doi.org/10.1007/BF02653674

Serdaroglu, M., Yıldız-Turp, G. and Abrodímov, K., 2005. Quality of low-fat meatballs containing legume flours as extenders. Meat Sci. *70*(1), 99-105. https://doi.org/10.1016/j.meatsci.2004.12.015

Siegel, D.G., Tuley, W.B., Norton, H.W. and Schmidt, G.R., 1979. Sensory, textural and yield properties of a combination ham extended with isolated soy protein. J. Food Sci, *44*(4), 1049-1051. https://doi.org/10.1111/j.1365-2621.1979.tb03443.x

Singh, P., Sahoo, J., Chatli, M.K. and Biswas, A.K., 2014. Shelf life evaluation of raw chicken meat emulsion incorporated with clove powder, ginger and garlic paste as natural preservatives at refrigerated storage (4±1° C). Int. Food Res. J. 21(4).

Singh, V.P., Sanyal, M.K., Dubey, P.C. and Mendirtta, S.K., 2011. Quality assessment of vacuum packaged chicken snacks stored at room temperature. J. Stored Prod. Postharvest Res. *2*(6), 120-126. https://doi.org/10.3923/crpsaj.2011.66.76

Smith, D.P. and Acton, J.C., 2000. Marination, cooking, and curing of poultry products. In: Poultry Meat Processing. CRC Press, pp. 267-290. https://doi.org/10.1201/9781420042177-18

Steel, R. G. D., Torrie, J. H., & Dickey, D. A. (1981). Principles and Procedures of Statistics: A Biometrical Approach (3rd ed.). McGraw-Hill Book Co., New York, USA.

Suradkar, U.S., Bumla, N.A., Maria, A., Zanjad, P.N. and Sofi, A.H., 2013. Effect of incorporation of bread crumbs on the physicochemical and sensory quality of chicken nuggets. Int. J. Food Nutr. and Saf. 3(1), 1-6.

Verma, A.R., Vijayakumar, M., Mathela, C.S. and Rao, C.V., 2009. In vitro and in vivo antioxidant properties of different fractions of Moringa oleifera leaves. Food Chem. Toxicol. *47*(9), 2196-2201. https://doi.org/10.1016/j.fct.2009.06.005

Yadav, S., Pathera, A.K., Islam, R.U., Malik, A.K. and Sharma, D.P., 2017. Effect of wheat bran and dried carrot pomace addition on quality characteristics of chicken sausage. Asian-Australas. J. Anim. Sci. *31*(5), 729. https://doi.org/10.5713/ajas.17.0214

Zargar, F.A., Kumar, S., Bhat, Z.F. and Kumar, P., 2014. Effect of pumpkin on the quality characteristics and storage quality of aerobically packaged chicken sausages. SpringerPlus. 3(1), 39. https://doi.org/10.1186/2193-1801-3-39

Zargar, F.A., Kumar, S., Bhat, Z.F. and Kumar, P., 2017. Effect of incorporation of carrot on the

quality characteristics of chicken sausages. Indian J. Poult. Sci. *52*(1), 91-95. https://doi.org/10.5958/0974-8180.2017.00019.8

Zhang, L., & Barbut, S. (2005). Effects of regular and modified starches on cooked pale, soft, and exudative; normal; and dry, firm, and dark breast meat batters. *Poultry Science*, 84(5), 789–796. https://doi.org/10.1093/ps/84.5.789

Zhou, G.H., Xu, X.L. and Liu, Y., 2010. Preservation technologies for fresh meat–A review. Meat Sci. 86(1), 119-128.

https://doi.org/10.1016/j.meatsci.2010.04.033