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HYDRATION, TEXTURAL AND ORGANOLEPTIC PROPERTIES OF CHICKEN INJECTED WITH BLEND OF SRC AND STPP IN AMBIENT, CHILLED AND FROZEN CONDITION

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The fresh chicken samples after bird was slaughtered were maintained in ambient, chilled and frozen condition and then sample was drawn every one hour interval and injected with brine solution made up of Semi Refined Carrageenan (SRC) and sodium tripolyphosphate (STPP) up to six hour storage period. Then all the treated samples along with their control were stored in frozen condition for 48 hrs and studied their hydration, textural and organoleptic properties. The maximum weight gain was observed for first three hours (20.5% to 23.5%) in chicken samples maintained in ambient temperature whereas in the case of chicken samples maintained in chilled condition, the maximum weight (22% to 24.5%) was observed in 2-4 hr and in frozen condition it was in 1 to 5 hr (21.5% to 23%) with less cooking loss when compared to their control samples. The pH values found decreased with increasing pre-storage time in all three temperatures condition studied. The MSC, moisture content, ash, WHC and ERV shown decreased with increasing pre-storage time in ambient condition. Sensory analysis was done with the help of 9-hedonic scale and found chicken samples stored in chilled condition and treated with blend of SRC and STPP yielded better textural properties as compared to those stored in ambient and frozen conditions.

Keywords: Semi Refined Carrageenan (SRC), Sodium tripolyphosphate (STPP), Sensory attributes, Water Holding Capacity (WHC), Meat Swelling Capacity (MSC), Extract Release Volume (ERV)

INTRODUCTION

Processed and frozen foods are playing an important role in advanced food processing sector. Injected meat technology such as fusion of hydrocolloids with desired salts increases their flavor, texture and juiciness. Food additives have become more prominent in recent years due to rapid growth in the processing, manufacturing, treatment, packaging, storage and transportation of certain foods. Thus, food additives are widely used and are essential in food manufacturing industries.

Hydrocolloids never interfere with the activation of meat protein, but they are very effective in forming a gel or acting as a thickener by reducing cooking loss and assisting to obtain the suitable texture and to prevent syneresis in the finished meat products (Feiner, 2006). Among all hydrocolloids, carrageenans has been used primarily to enhance functional properties of meat, it can increase yield, control purge, improve finished product sliceability and enhance juiciness. Carrageenans are often used in chicken breast products to assist in holding the injected brine which can reach 30-50% (Barbut, 2002). In addition carrageenans never interact with the meat proteins to participate in network formation, since the visco elastic nature of the carrageenan network same as pure protein (Verbeken *et al.*, 2005). Bater

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et al. (1992) reported that kappa carrageenan improved better sliceability, increased in yield and rigidity as well as a decreased in expressible juice in poultry meat. Amako and Xiong (2001) found that carrageenan actions depend upon the type of meat such as white or red and are incorporated. Ayadi *et al.* (2009) evaluated the influence of carrageenan on sensory properties of sausages made from poultry meat.

Phosphates are commonly used to enhance muscle protein extraction, reduce cooking shrink and improve water holding capacity (Barbut, 2002). Sheard *et al.* (1998) observed that polyphosphates improved water-holding, tenderness, and juiciness in pork meat. Fletcher (2002) analyzed the aging prior to deboning is the important to ensure poultry breast meat tenderness without affecting quality characteristics. Marimuthu *et al.* (2015) observed that beef injected with SRC-STTP blend yielded highest weight gain with improved texture. The combination of Semi Refined Carrageenan (SRC) with NaCl was recommended for increasing freeze/thaw stability of pork sausage, and this effect could be improved by addition of sodium tripolyphosphate (STPP) (DeFreitas *et al.*, 1997). STTP did not only increase the pH value but also strongly increased the extraction of protein in meat (Nguyen Huynh *et al.*, 2011). Combining carrageenan with sodium tripolyphosphate increased hardness in pork sausages; without sodium tripolyphosphate, carrageenan still significantly increased product hardness, although overall hardness reading were lower (Pietrasik *et al.*, 2005).

Injection treatment has shown to improve tenderness in chicken meat (Alvarado and McKee, 2007). Bauermeister and McKee (2005) suggested that the use of injection could be an effective means of relieving hardness related with deboning fillets as much as early as 2 hr post-mortem. Smith and Young (2007) found that phosphate significantly increase the cooking yield. Yoon (2002) found chicken breasts with 10% phosphate salts by immersion for 10 min, significantly decreased purge and cooking losses as well as minimized ice crystal formation and freeze induced shrinkage of myofibrils and no significant texture hardening was found in frozen chicken breasts regardless of treatments. The objective of the present study was to evaluate the effects blend made with SRC and STTP in chicken samples maintained at ambient, chilled and frozen condition.

MATERIALS AND METHODS

Sample Collection

Broiler chicken (*Gallus gallus domesticus*) breast muscles (Hybrid: sex: female, age: 5 weeks; muscle pH: 6.5) was purchased from local slaughter house, Manamadurai, India and immediately transported to the Laboratory of Food analysis. After removing the fats from meat as much as possible, it was cut into 36 parts with 50 g each with almost similar shape using a meat cutter and 36 samples were divided into 3 lots with 12 samples each and maintained at ambient (30 ± 1 ºC), chilling (5 ± 2 ºC) and freezing (-20 ± 2 ºC) separately till they were treated.

SRC and STPP

Semi Refined Carrageenan (SRC) (E407a) with particle size of 200 meshes was taken from stock of Aquagri Processing Private Limited Batch No-108/2015. Sodium tripolyphosphate (STPP) was purchased from LOBA chemicals private limited, Mumbai, India. Water bath-250 W, Sigma Scientific instrument (P) Ltd., Chennai, India; Blue Star Chest freezer, Model CHF 200 B, India, Samsung Refrigerator, Model RR19H1104RH/TL/2015; Sony Cyber shot, GPS-DSC-HX 200 were used in the present investigation.

Preparation of Brine

Brine solution with 3.33% of SRC and 1.33% of STPP in 95.34% of chilled water (3-4^{o}C) was prepared freshly and used for treatment.

Meat Treatment

Then each sample (50 g) maintained in different storage condition was drawn at 1hr interval up to 6 hr and injected with brine solution at the ratio of 20 ml, i.e., 40% of its original weight with help needle syringe and their control samples given no treatment. Then all the treated samples along with their control were wrapped with plastic film and stored in frozen condition for 48 hrs. Then meat samples were allowed to thaw at 4 °C to measure their hydration level. Then all samples were cooked at 70 °C for 40 min and studied their textural and organoleptic properties.

Determination of Hydration and Drip Loss

Chicken samples were weighed before and after injection of brine solution as explained below,

$$Hydration\ (\%) = \frac{(Wt.\ of\ \ sample - Post\ inj. - Pre\ inj.)}{Wt.\ of\ \ sample - Pre\ inj.} \times 100$$

$$Drip\ loss\ (\%) = \frac{Post\ inj. - Post\ thawing}{Post\ inj.} \times 100$$

Determination of pH

Each sample (1 g) with distilled water was homogenized using mortar and pestle. The crushed meat solution was filtered using Whatman filter paper (125 mm) and pH of homogenate was measured using an electrical automatic pH meter (Eutech Instruments, Malaysia).

Determination of Moisture

Moisture of chicken samples was determined according to AOAC method (AOAC, 1990) as below:

Weight of frozen samples was weighed after complete thawing.

$$Moisture\ (\%) = \frac{Loss\ in\ mass\ of\ sample\ (g)}{Initial\ mass\ of\ the\ sample\ (g)} \times 100$$

Determination of Ash

The ash value was determined according to AOAC method (AOAC, 2000). The sample (1 g) was weighed in pre-weighed crucibles and charred on a hot plate and then placed in a muffle furnace at 550 ^{o}C for 4 hours and total ash was measured as below,

$$Ash\ content\ (\%) = \frac{Loss\ in\ mass\ of\ sample\ (g)}{Initial\ mass\ of\ the\ sample\ (g)} \times 100$$

Determination of Cooked Yield

The cooked yield was calculated in relation to the raw meat weight (before injection) (Drummond and Sun, 2006) using the following equation:

Cooked yield (%) = Cooked weight/Raw weight*100

Textural Analysis

Extract Release Volume (ERV) of meat was determined using the method described by Jay (1964), 20 g of chicken sample was homogenized with 100 ml of distilled water for 2 minutes, and filtered through Whatman filter paper No. 1. The volume collected in 15 min was considered for calculating ERV. Meat Swelling Capacity (MSC) of chicken was determined by method of Leora *et al.* (2006), 25 g of meat was homogenized with 100 ml distilled water for 2 min. Then 35 ml of homogenate was centrifuged at 2000 rpm for 15 min and collected the supernatant (S) and calculated the MSC as below.

% Meat Swelling Capacity = (35-S-7)/7*100

Water Holding Capacity (WHC) of meat was measured according to the method of Kauffman *et al.* (1986) 0.5 g of meat sample was weighed and placed in between filter papers and this in turn was placed between glass sheets weighing 1.58 kg. Over it, a 4.0 kg weight was placed, thus total weight including glass sheet was 5.58 kg for 5 min. The water from the meat was then absorbed on the filter paper and filter paper was dried. Then area of the filter paper marked with and meat was later determined using a compensatory planimeter. Taking the differences from the resulting areas of the sample from marked borderline on the filter paper (moisture) and meat and a ratio area marked borderline was expressed as Water Holding Capacity (WHC) of the meat as below:

$$WHC\% = \frac{Area\ marked\ borderline - Area\ meat}{Area\ marked\ borderline} \times 100$$

Sensory Analysis

Sensory analysis was done according to method described by Pavelková *et al.* (2013). Ten panellists were chosen for the assessment of the sensory attributes of the cooked chicken samples. The samples were coded with letters (A, B, C, D, E, F, G and H) and served to the panellists individually partitioned booths. Samples were portioned in to plate with fork. Sensory was evaluated using standard evaluation score card (9 hedonic scales).

RESULTS AND DISCUSSION

The effect of brine solution made up of SRC and STPP on chicken samples maintained in ambient, chilled and frozen temperature has been shown in Tables 1-3 and Figures 1-3 shows the textural characteristics of cooked chicken samples.

Weight Gain and Cooking Loss

The weight gain of the chicken meat after the injection of brine ranged from 16% to 24.5%. The hydration level of chicken sample maintained in ambient temperature and injected with brine solution was 23.5%, 21.5%, 20.5%, 19%, 18.5% and 16.5% from 1 hr to 6 hr storage respectively, therefore, the hydration level decrease gradually as storage time increases before injection, i.e., in first three hrs, the hydration level is more than 20%. In the case of chicken samples maintained in chilling temperature and injected with brine, the highest weight gain was found from pre-storage period 2 hr to 4 hr, i.e., 22%, 24.5% and 22% respectively. In the case of chicken samples maintained in frozen condition, the hydration level was found increasing first three hrs, i.e., 20%, 21.5% and 23% respectively then slowly got reduced till 6th hr of storage before injection of brine solution.

Table 1: Hydration and Textural Properties of Chicken Maintained in Ambient Temperature and Injected with Blend of SRC-STPP*

Pre-storage (hr)	Weight Gain (%)		Cooking Loss (%)		pH	MC (%)	Ash (%)	WHC (%)	MSC (%)	ERV (ml)
	Injected	Control	Injected	Control						
1	23.5	-	12	32	6.4	8.86	3.05	69.73	42.9	33
2	21.5	-	13	34	6.38	8.8	2.9	68.17	42.9	31
3	20.5	-	14	35	6.33	8.33	2.8	67.92	28.6	26.5
4	19	-	16.5	36	6.29	8.11	2.9	67	28.6	25
5	18.5	-	17.5	38	6.25	7.89	2.8	63.25	7.14	21.5
6	16	-	19.5	42	6.21	7.66	2.74	62.04	7.14	20.5

Note: *Average of two trials conducted in duplicates.

Table 2: Hydration and Textural Properties of Chicken Maintained in Chilled Temperature and Injected with Blend of SRC-STPP*

Pre-storage (hr)	Weight Gain (%)		Cooking Loss (%)		pH	MC (%)	Ash (%)	WHC (%)	MSC (%)	ERV (ml)
	Injected	Control	Injected	Control						
1	18.5	-	14	30	6.87	6.82	2.69	55.25	39.3	47.5
2	22	-	11	30	6.73	7.13	2.79	58.27	35.7	46
3	24.5	-	9.5	31	6.64	7.25	3.21	61.71	35.7	42.5
4	22	-	12	32	6.41	7.44	3.23	58.94	35.7	46
5	20.5	-	14	31	6.21	7.06	3.18	57.61	21.44	46.75
6	20	-	15.5	32	6.18	6.9	2.885	56.93	14.29	46.75

Note: *Average of two trials conducted in duplicates.

Table 3: Hydration and Textural Properties of Chicken Maintained in Frozen Temperature and Injected with Blend of SRC-STPP*

Pre-storage (hr)	Weight Gain (%)		Cooking Loss (%)		pH	MC (%)	Ash (%)	WHC (%)	MSC (%)	ERV (ml)
	Injected	Control	Injected	Control						
1	20	-	12	28	6.9	6.9	2.69	60.92	35.75	48
2	21.5	-	10.5	28	6.8	7.17	2.77	62.42	32.15	46
3	23	-	9	27	6.59	7.42	3.12	64.6	32.2	44
4	21.5	-	12.5	28	6.39	7.25	3.09	62.56	35.8	43.5
5	21.5	-	13.5	30	6.3	7.13	2.88	62.22	24.99	44
6	20.5	-	16	31	6.17	6.84	2.77	60.98	14.29	46.5

Note: *Average of two trials conducted in duplicates.

Cooking loss of chicken samples injected with of brine solution in different temperature condition is given in Tables 1-3. It is observed that hydration level is indirectly proportionally to the cooking loss in all the samples investigated. The cooking in samples maintained in ambient temperature before brine injection ranged between 12% and 19.5% against their control samples between 32% and 42%. It was observed that as time increases in storage before brine injection, the more cooking loss was also more, i.e., the lowest cooking loss was in 1 hr stored sample (12%) whereas it was 19.5% in 6 hr stored chicken samples. Same trend was observed in samples stored chilled and frozen temperature before injection of brine solution. The lowest cooking loss, i.e., 9% was observed with sample with highest hydration level (24.5%) in 3 hr stored product in chilled condition, in frozen sample the highest hydrated sample at 3 hr led to lowest cooking loss (9%). The cooking loss in control samples of chilled and frozen stored samples ranged between 30 to 32% and 27-31% respectively (Tables 1-3). Candogan and Kolsarici (2003) observed that samples containing carrageenan showed cooking yield and higher water holding capacity and lower purge loss than normal one. These effects improved by increasing carrageenan concentration.

Figure 1: Effect of SRC-STPP Blend Injected in Chicken Pre-Stored at Different Temperature Conditions

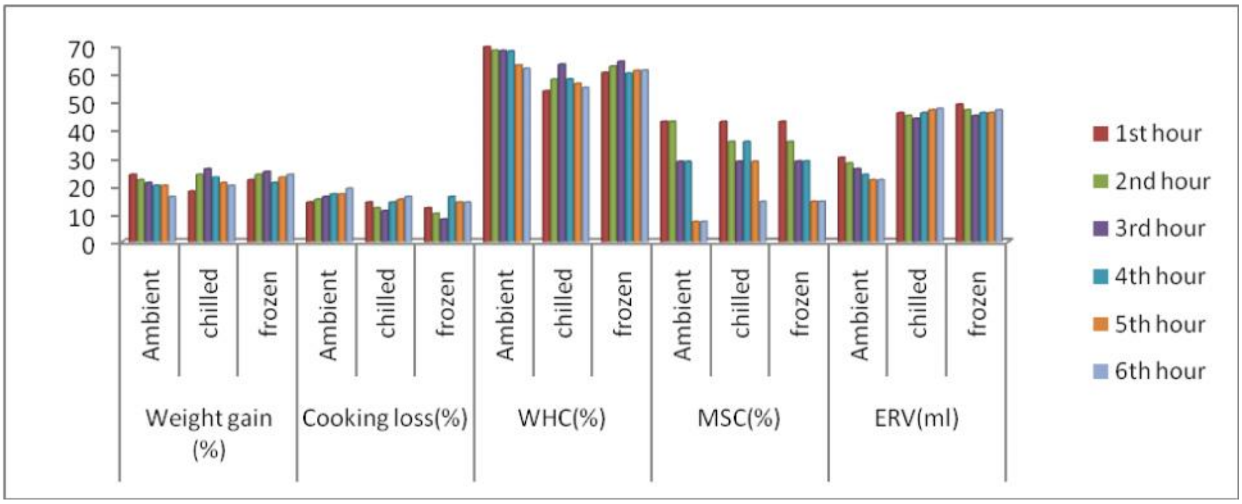


Figure 2: Sensory Analysis of Chicken Meat with Blend of SRC and STTP Stored in Three Types of Stored Conditions

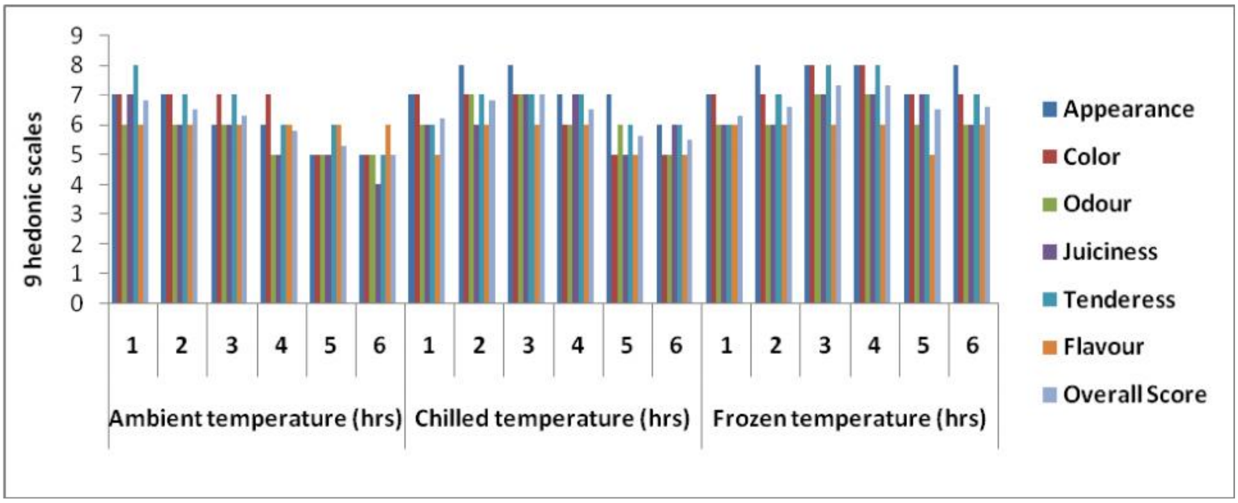
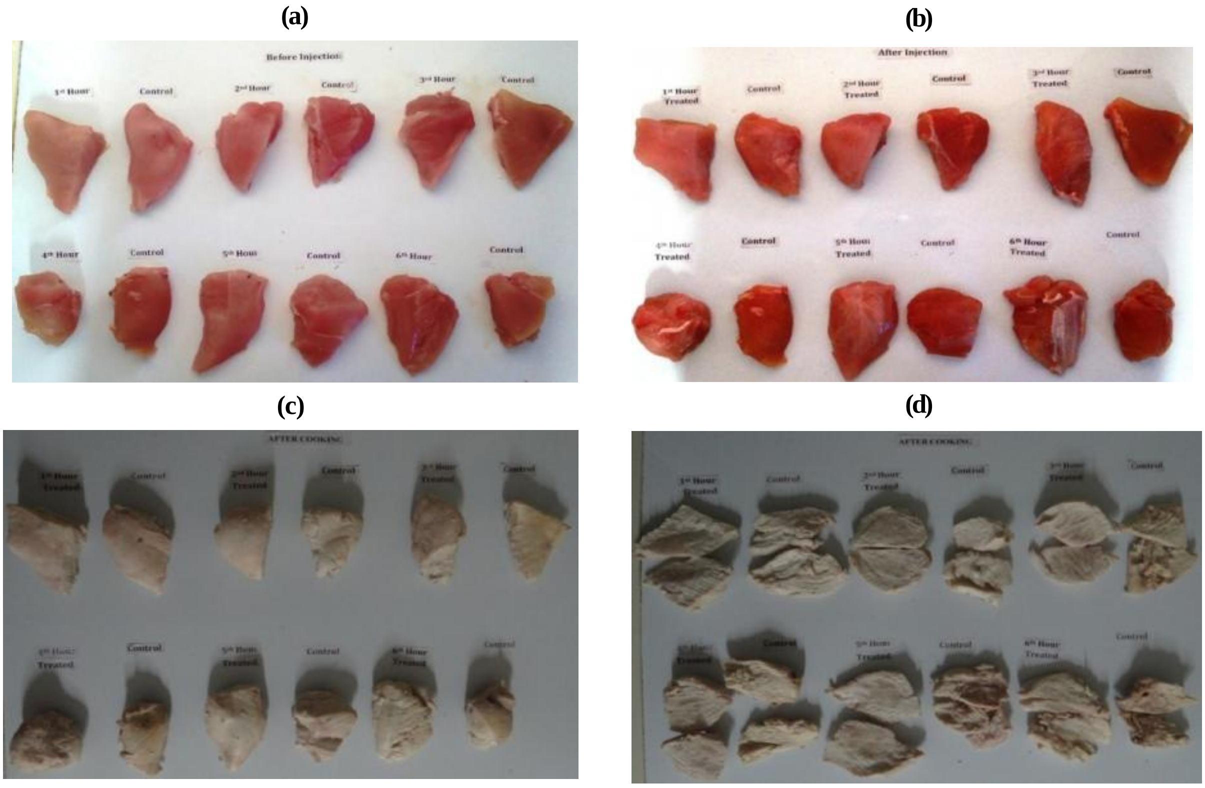


Figure 3: Texture of Treated and Control Chicken Stored in Ambient Temperature: A) Raw Meat; B) Injected Meat; C) Cooked Meat; D) Meat Texture



pH, Ash and Moisture Content

The pH value ranged from 6.17 to 6.90 in all chicken samples maintained in different temperature condition before brine injection. Generally it decreased with the increase of time storage before injection of brine and it could be due to release of amino acids and fatty acids. The values such as 6.40, 6.38, 6.33, 6.29 6.25 and 6.21 were found in chicken samples maintained ambient temperature for 1hr to 6hr respectively before injection of brine solution. Similar results were found in both chilling and freezing storage condition of chicken meat i.e. pH 6.87, 6.73, 6.64, 6.41, 6.21, 6.18 and 6.90, 6.80, 6.59, 6.39, 6.30, 6.17 respectively. Won Sik An (2008) studied during the brine salting in meat, the pH value of all maintained temperature condition of both of the experiments showed decreasing trends at lower temperature.

The moisture content varied in the all chicken samples maintained in different temperature condition before injection of brine solution. High values showed in chicken samples maintained in ambient temperature ranged 7.66% to 8.86%, it found decreasing from 1st to 6th hr as showed in Table 1. In chilled and frozen storage condition the moisture content increased for 3 hours and gradually decreased in 4th, 5th and 6th hour. The moisture contents were 6.82%, 7.13%, 7.25%, 7.44%, 7.06% and 6.90% for 1 to 6hr respectively for samples stored in chilled condition and 6.9 %, 7.17%, 7.42%, 7.25%, 7.13% and 6.84% for frozen samples. The brining and marinating processes decreased the moisture contents. Similarly the water content of whole herring at -2 and -8 °C decreased rapidly during the first three days becoming more stable after 10 days. In contrast, the water content of fillets increased at first, but started decreasing after 7 days, whereas the weight increase stabilized (Sallam *et al.,* 2006).

Ash content in food determines the presence of dietary minerals in a particular food sample. In ambient temperature, the ash content found decreased with the increasing storage time before injection of brine solution, i.e., in first 3 hrs, ash content was 3.05% to 2.80% and slowly it got increased to 2.90% reduced again as 2.80% and 2.74%. Chicken samples stored in both chilled and frozen condition, the ash content directly proportional to the storage time till four hours and decreased to 3.18% and 2.88 % in chilled storage condition and 2.88% and 2.77% at frozen storage condition. Statistical analyses of the result indicated that ash contents of the samples were significantly ($p<0.05$) affected by gum addition. Ash contents increased with more gum addition in all temperature (Yýlmaz and Daðlýoðlu, 2003).

Textural Properties

Water Holding Capacity

The Water Holding Capacity (WHC) of the chicken meat determines the ability of meat to retain water even through external pressure. The chicken meat in the ambient temperature showed better result of ability to retain water. As time increasing, water holding capacity of the chicken meat decreased. It was found decreasing from 69.73%, 68.17%, 67.92%, 67.00% and 63.25% and 62.04% for 1st to 6th hour respectively. The WHC was directionally proportional to the hydration level of chicken samples stored in chilled and frozen temperature. The highest WHC, i.e., 61.71% was found with 3 hr stored sample where highest hydration (24.5%) achieved in sample stored in chilled condition and similarly at frozen stored sample maximum WHC (64.60%) was observed in sample with highest hydration level was achieved 23%). In frozen condition, the value got increased from 60.92%, 62.42% and 64.60% for 1st hour to 3rd hour then it showed decreased for last three hours as 62.56% to 60.98% respectively. Frozen and thawed deboned or sliced poultry is more susceptible to higher thaw loss lead to less water holding capacity because of the greater surface area (Hui, 2006).

Meat Swelling Capacity

In ambient temperature stored condition, the MSC of sample ranged from 42.9% to 7.14% for all six hours and here also the MSC is directionally proportional to hydration level in the samples, i.e., highest MSC (42.9%) was in 1 hr stored sample and gradually reduced 7.14% in 6 hr. Samples stored in chilled condition, the highest MSC was observed in 1hr stored sample (39.3%) and it reduced to 35.7% and stable up to 4 hr then further reduced to 14.29%. In the case frozed stored sample before treatment of brine solution, the MSC was 32.15 to 35.8 for first 4 hr and it reduced to 14.29 at 6th storage. Goll *et al.* (1977) and Offer (1984) suggested that water holding in muscle tissue is due to changes in the intensity of swelling of the myofibrils. The increase in WHC is related to swelling of the myofibrils caused by expansion of the filament lattice. Increase in the myofibril volume caused by extensive swelling is mostly responsible for water binding in meat and for water losses during meat processing. An important factor influencing WHC is swelling of the protein matrix when shrinkage of the protein matrix, for example during heat treatment, results in decreasing WHC.

Extract Release Volume

The Extract Release Volume (ERV) phenomenon of chicken meat inversely proportional to the bacterial number tends to the spoilage of meat. ERV appears to have a considerable possibility in assessing the spoilage of beef (Jay *et al.*, 2005). The ERV was found more in samples stored frozen condition before treating with brine solution with range of 43.5 ml to 48 ml. The ERV found inversely proportional to the hydration level chicken samples stored in chilled and frozen conditions whereas in ambient stored sample, no such trend was observed. Moreover, ERV was found much less in ambient stored sample (20.5 ml to 33 ml) than ones chilled (42.5 ml to 47.5 ml) and frozen condition. The following report agreed with our study shows 19.3 ml of ERV value was reported in buffalo meat on 4th day of chilled temperature, which was significantly lower than the zero day value of 24 ml, was observed by Kandeepan (2007).

Sensory Properties

Palatability of chicken samples was evaluated by 10 panellists. On the basis of 9 hedonic scales the sensory analysis score card of SRC-STPP blend injected in poultry meat is given in the Figure 2. Chicken samples maintained in chilled condition before injection of brine solution showed greater sensory attributes than samples maintained in ambient and frozen condition before treating them with brine solution. The score found decreased in samples maintained in ambient temperature from 6.8 to 5.0 for 1st to 6th hour. In the case of sample maintained in chilled condition, for first 3 hrs, the score found increasing (score 7 at 3rd hr) and in last 3 hrs it decreased (5.5 at 6th hr). The feed-back of panellists frozen sample was that it was little chewing when compared to samples stored in other two temperature condition. It is supported by literature reports that juiciness of meat increased when it was added with salt (McGee *et al.*, 2003; and Baublits *et al.*, 2005) and an enhanced flavour in beef and pork (Scanga *et al.*, 2000; and Smith *et al.*, 1984).

CONCLUSION

Though maximum weight gain with less cooking loss can be achieved in all three cases studied by effectively managing the injection time, more desirable organoleptic properties has been observed in chicken stored in chilled temperature followed by ambient and frozen condition, therefore it is recommended that optimum temperature for injecting of brine solution into chicken for better yield and textural properties is chilled condition, i.e., 7±2 °C.

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