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EFFECT OF COMMERCIALLY MANUFACTURED *KAPPA* SEMI-REFINED CARRAGEENAN (SRC) WITH DIFFERENT PHOSPHATE SALTS ON YIELD, TEXTURAL AND SENSORY PROPERTIES OF BEEF MEAT

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ABSTRACT

The phosphate salts such as SDP, TSP, SHMP, DSP, TPPP, TKPP and STPP were blended with semi-refined *kappa* carrageenan (SRC) individually and their aqueous solution was injected into the fresh beef meat. The highest weight gain (24%) in fresh meat was obtained from injection of blend made with SRC and STPP as compared to other blends and control sample after forzen storage. Similarly, it also showed low cooking loss (24%) with good testural and sensory proerties as compared to other blends. It can be concluded from the presnt study that blend of SRC and STPP can be used in beef meat for yield and quality improvement.

Keywords: Beef, Semi Refined Carrageenan, Phosphate salts, Sensory analysis, Texture

INTRODUCTION

Nowadays, trendy sophisticated lifestyle makes the people moving towards modern technology especially in food processing side. They are looking for the solutions which fulfil their day by day needs. As we know, perishable products like meat and dairy usage among people requires specific concentration. For this sake it has technology like infusion of hydrocolloids and salts to make the product such as beef, poultry, pork and fish with better flavour texture, tenderness and juiciness for the customer satisfaction. Generally salts having good functional properties using in meat and meat products, which acts as preservative, binding to water and fat, textural properties and increasing shelf life by controlling water activity **(Bess, 2011).** Cooking loss, texture deterioration, decrease shelf life are the important factors affected by the reduction of salt in meat products, and at the same time there were controversy in hypertension, so there was mandatory to control the salt limits in meat and meat products. Sodium phosphate is generally used to increase moisture retention and reduce oxidative rancidity in meat **(Baumert and Mandigo, 2005).** Today, the meat industry offers a variety of different formulations to meet different nutrition needs.

Wierbicki and Howker (1976) observed that phosphates and NaCl at different levels showed various effects on colour, quality and sensory characteristics of beef and found that at 3% salt, either 0.3% STPP or 0.217% TSPP with other curing ingredients was an acceptable limit for cut-and-formed smoked as well as cured ham **(Wierbicki and Howker, 1976). Baublits *et al.* (2005)** studied the effect of the addition of STPP, SHMP and TSPP at the concentration 0.2 and 0.4% along with 2% NaCl on color, quality, and sensory characteristics of beef and observed that STPP was the most effective phosphate type for improving the color at the concentration 0.4% at the injection rate 18% **(Baublits *et al.*, 2005). Torley *et al.* (2000)** had observed that TSPP (0.35%) and STPP (0.37%) on pale soft exudative (PSE) pork had small effects on the functional properties such as pH, cooking temperature and ionic strength than in normal pork meat and concluded that addition of polyphosphates only gave a lower cooking loss through texture.

Tetra sodium diphsphates are the most functional phosphates in meat products. They act on the actomyosin complex of meat protein and also have high pH value. It results in high protein solubility which induces good water binding capacity **(Molins, 1991; Zayas, 1997).** Short chain phosphates are used as improving emulsion water holding capacity and stability **(Feiner, 2006; Zayas, 1997)** whereas the long chain phosphates such as SHMP and STTP used for optimize solubility and functionality of meat products **(Alvarado and McKee, 2007; Anjaneyulu *et al.*, 1989; Offer and Trinick, 1983).** The addition of NaCl or STPP and a lower pH led to an increase in the metmyoglobin level **(Fernández-López *et al.*, 2004; Moiseev and Cornforth, 1997)** in meat. **Anjaneyulu *et al.* (1990)** had reported that application of phosphate blends on buffalo meat patties improved the level of emulsifying capacity, increased emulsion stability, yield of patties, water holding capacity and reduced cooking loss, then shrinkage of patties. The phosphates such as TSPP, STPP and SAPP with NaCl in various concentrations had played a main role on buffalo meat and that the effects of phosphate were always comparatively better than sodium blends and control **(Anjaneyulu *et al.*, 1990).** Phosphates with kappa-carrageenan salt on the low fat emulsified meatballs significantly affect the product cooking yield, adhesion, gumminess, chewiness, lipid content, hardness, viscosity, cohesiveness and brittleness. The combination of salt and polyphosphates had effects on the product's texture and overall acceptance **(Hsu and Chung, 2001).**

Carrageenans are highly flexible molecules that form helical structure which has ability to form a variety of different gels at room temperature. Red sea weeds are the sources of carrageenan i.e., linear anionic sulphated polymer of galactose and anhydrogalactose. They are used in the food industries such as canned meat, reduced fat products for its gelling characteristic, water binding properties and thickening **(Giese, 1992; Therkelsen *et al.*, 1993; Candogan and Kolsarici, 2003a,b; Bixler and Porse, 2011).** The function of carrageenan in meat and its adding to the low-fat meat products improves water retention, consistency, slicebility and texture. **DeFreitas *et al.* (1997)** evaluated the effects of κ-, ι-, and λ-carrageenan (CGNs) on the rheological properties, water loss, and ultra structure of salt-soluble meat protein (SSMP) gels and found that κ-CGN increased gel strength and water retention of SSMP. At 0.2 to 1.5% of carrageenan in turkey meat sausage caused reduction of emulsion stability and increased water holding capacity **(Ayadi *et al.*, 2009)** also addition of carrageenan to increase emulsion stability in low fat frankfurter was reported by Candogan and Kolsarici (2003a). Influence of carrageenan on sensory properties of sausages showed that it could improve sensory scores in beef sausages **(Xiong *et al.*, 1999).**

The present study was to evaluate the effect of blends prepared with commercially manufactured semi refined carrageenan (MK-250 is brand name of AquAgri for food application) and different phosphates on yield, textural and sensory properties of beef meat with different phosphate salts.

MATERIAL AND METHODS

Sample collection

Beef *biceps femoris* (breeds: Jersey; sex: male, age: 2 years) was purchased from local meat shop and it was kept in refrigerator (4°C) for about 2 hours till it was used for the experiment, then ligaments, tendons and extraneous tissues were removed as much as possible and cut into 100g pieces with almost similar shape using a meat cutter.

SRC & Phosphate Salts

Semi-refined carrageenan (MK-250 is a brand name of AquAgri for food application) with particle mesh size of 200 mesh (0.074mm) used was from stock of Aquagri Processing Private Limited Batch No-108/2015, Manamadurai, India. The salts of Sodium Phosphate dibasic (SDP), trisodium orthophosphate (TSP), Sodium hexa meta phosphate (SHMP), Sodium dihydrogen orthophosphate dehydrate (DSP), Tetra potassium pyrophosphate (TPPP), Di sodium hydrogen orthophosphate anhydrous (TKPP), Sodium tripolyphosphate (STPP) were 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, Sony Cyber shot, GPS- DSC- HX 200 were used in the present investigation.

Preparation of Brine solution

Brine solutions were freshly prepared and used. Seven phosphate salts viz. SDP, TSP, SHMP, DSP, TPPP, TKPP and STPP were mixed separately with semi-refined carrageenan (MK-250) at 1:3 ratio in chilled water (5°C) and used.

Meat treatment

All Part of *biceps femoris* was usedpieces was injected with 30% of its initial weight with freshly prepared brine solution by using syringe and the meat piece without brine injection was treated as control sample. Both treated and control samples were stored in freezer at -18°C for two days. Then samples were taken out, allowed to thaw and weight gain was calculated after drip loss. The samples were subjected to cooking at optimum temperature level of 80° ±2°C. Each sample was tagged with the wooden card board with nylon thread for identity. The experiment was replicated and average of data obtained from two experiments was considered.

Analysis of Physicochemical parameters

pH of sample was measured by using an electrical automatic pH meter (Eutech Instruments, Malaysia). A few drops of distilled water was sprayed on meat and measured the pH by direct contact between the sensitive diaphragm of the electrode and meat tissue.
Moisture of meat samples was determined according to AOAC method **(AOAC, 1990).** Meat sample was weighed in pre-weighed crucibles and charred on a hot plate and then placed in a muffle furnace at 550°C for 4 hours and total ash was measured as below:
Ash Content (%) = weight of residue after ashing (g)/ Weight of sample (g) *100

Yield calculation

The cooked yield was calculated in relation to the raw meat weight (before injection) **(Drummond and Da-Wen 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).** 20g of meat was homogenised with 100 ml of distilled water for 2 minutes. Then poured the homogenate directly into the funnel lined with Whatman filter paper No.1, folded thrice as to make eight sections and allowed the homogenate to seep between the folds. The volume collected in 15 min was considered for calculating ERV.
Meat swelling capacity (MSC) of meat was determined by method of **Leora *et al.* (2006).** 25g of meat was homogenised with 100 ml distilled water for 2 minutes. Then 35 ml of homogenate was centrifuged at 2000 rpm for 15 minute 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 using the method described by **Kauffman *et al.* (1986) and Trout (1998).** 0.5g of meat sample was weighed and placed in between filter papers and this in turn was placed between glass sheets weighing 1.58kg. Over it, a weight of 4.0kg weight was place, thus total weight including glass sheet was 5.58kg for 5min. 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:

WHC % = (Area marked borderline – Area meat) * 100 / Area marked borderline

Sensory analysis

Ten panellists were chosen for the assessment of the sensory attributes of the cooked beef meat samples. The samples were coded with alphabets and served to the panellists in individually partitioned booths. Sensory property was evaluated using standard evaluation score card (9 hedonic scales). Statistical analysis was done according to method described by **Steel *et al.* (1996).**

RESULTS AND DISCUSSION

The weight extension in brine injected meat samples ranged between 16 to 24%. The highest weight gain was observed in brine prepared with STPP and injected in meat i.e. 24% and it was 21%, 20%, 19%, 17%, and 16% in TPPP, SHMP, TSP, SDP & TKPP and DSP blended with MK-250 and injected in meat samples respectively, thus the response of different phosphates in weight extension of beef meat follows as: TPPP >TPPP>SHMP>TSP>SDP & TKPP>DSP. In the control sample there was 4% weight loss was recorded. Similarly lowest cooking loss i.e. 34% observed with beef sample treated with STPP followed by TPPP (26%), TSP (28%), SHMP (30%), SDP & TKPP (34%) and DSP (35%) (Table 1). **Garcia *et al.* (2013)** and **Lee *et al.* (2014)** had reported that addition of kappa carrageenan improved the yield and textural characteristics of beef and similar effect was observed in pork by **Patrascu *et al.* (2013).** Blend of STPP also showed lowest cooking loss of 38.70% followed by TSP (39.49%) and in other phosphates, the cooking loss ranged between in 40.49% to 43.58% .and in control it was 47.91%. The net weight loss from raw meat to after cooking ranged from 24% to 35% in treated samples with STPP being lowest weight loss (24%) and in control meat sample the weight loss was 50% (Table 1). It has been reported in literature that decreasing cooking loss was observed when treating muscle with a brine solution **(Sheard *et al.*, 1999; Walsh *et al.*, 2010).**

Table 1 Yield improvement and cooking loss of beef meat injected with blend of SRC (MK- 250) and different phosphates *

Blend	Initial weight(g)	Weight after injection (g)	Weight after storage (after drip loss) (g)	Weight post cooking (g)	Weight after cooking loss (%)	Net loss for initial weight of 100g (%)
MK-250 + SDP	100	130	117	66	43.58	34
MK-250 + TSP	100	130	119	72	39.49	28
MK-250 +SHMP	100	130	120	70	41.66	30
MK-250 + DSP	100	130	116	65	43.96	35
MK-250 + TPPP	100	130	121	72	40.49	28
MK-250 + TKPP	100	130	117	66	43.58	34
MK-250 + STPP	100	130	124	76	38.70	24
Control	100	100	96	50	47.91	50

*Each value is a mean of duplicates

The pH of brine made with different phosphates ranged from 6.53 to 11.67 with the order of TSP (11.67) > TKPP (10.75) > SDP (10.20), STPP (10.17), TPPP (10.09), SHMP (7.75 and slight acidic pH in DSP (6.53). The pH of raw meat was 5.54 and phosphate salts ranged from slight acidic (DSP pH 6.53) to high alkali condition of TSP (pH 11.67). The pH of brine injected meat and cooked increased from pH of its raw meat samples but all within acidic condition (Table 2) including TSP injected meat. The pH of meat improves little after injection of phosphate salts, thereby structure of muscle protein is opened as to increase the water holding capacity in order to yield extended weight gain and decreasing cooking losses **(Knipe, 2003 and Molins, 1991).** It has also been reported by **Xiong *et al.* (1999)** that an increase in pH sharply enhanced the water binding strength in beef sausage when injected with some gums including carrageenans along with salts.

Table 2 Physiochemical properties beef meat injected with blend of SRC (MK- 250) and different phosphates*

Meat Blends	Moisture			Ash			pH				
	Raw Meat	Injected Meat	Cooked Meat	Raw Meat	Injected Meat	Cooked Meat	Raw meat	Salts	Salts with MK-250	Injected Meat	Cooked Meat
MK-250 + SDP	56.80	64.07	63.92	0.58	0.63	0.98	5.54	8.98	10.20	6.17	6.55
MK-250 + TSP	56.78	69.34	67.09	0.58	0.68	0.97	5.54	11.86	11.67	6.48	6.78
MK-250 +SHMP	56.12	66.21	67.12	0.58	0.65	0.96	5.54	5.43	7.75	6.01	6.44
MK-250 + DSP	56.74	60.69	64.72	0.57	0.74	0.98	5.54	4.41	6.53	5.75	6.25
MK-250 + TPPP	56.86	60.46	63.09	0.58	0.62	0.97	5.54	10.01	10.09	6.04	6.42
MK-250 + TKPP	56.22	60.76	64.78	0.57	0.63	0.97	5.54	8.93	10.75	6.24	6.74
MK-250 + STPP	56.54	60.81	65.18	0.58	0.61	0.98	5.54	8.94	10.17	6.06	6.45
Control	56.80	56.80	60.02	0.58	0.58	0.97	5.54	-	-	5.56	6.04

*Each value is a mean of duplicates

Moisture and Ash content

The ash and moisture content of meat injected with brine and its respective control is given in Table 2. Moisture of raw meat ranged between 56.12 to 56.86% and ash content was 0.57 to 0.58%. Because of specificity of the blend created with SRC (MK-250), the injected meat and cooked meat had shown increasing the moisture and ash level when compare to the raw meat due to its higher water holding capacity. The moisture level in control sample was 56.80% and 60.02% and ash content was 0.58% and 0.97% in raw and cooked meat respectively. In the treated meat, TSP had highest moisture content of 69.34% and lowest moisture level was observed in meat injected with TPPP (60.46%). The range of ash content in treated meat was very short i.e. 0.61% to 0.74% with lowest level in STPP and highest in DSP treated meat. Similarly, in the case of respective cooked meat, SHMP treated meat showed highest moisture level of 67.12% and lowest moisture was observed with meat treated by TPPP i.e. 63.09%. The ash content of all the samples treated with different phosphate salts and control was within the range from 0.97 to 0.98%.

Textural properties

The textural properties of raw, injected and cooked beef meat are presented in Table 3 and Figure1-2. The average ERV values of raw beef were 54 ml, while water holding capacity was 28.34 % and meat swelling capacity was 40%. For injected beef meat, highest ERV value was observed with STPP treated meat i.e. 53% followed by TKPP (52%), control (52%), TPPP (51%), TSP (50%), DSP (49%), SDP (48%) and SHMP (48%) treated meat samples (Table 3 and Figure 3). Water holding capacity of the beef meat refers to its ability of retain water and it is affected by space in muscle and pH of the tissue. The WHC of injected meat ranged from 26.12 % to 44.89 % with the order of STPP (44.89%) > TPPP (43.52%) > SHMP (43.22%) and the lowest range as TSP (42.16%) > SDP (41.94%) >TKPP (40.71%) >DSP (40.50%) and control (26.12%) (Figure 4). **Verbeken (2003)** reported that increasing the concentration of carrageenan from 0 to 2% led to an increase in WHC of about 5% and most studies reported a better water retention in the presence of carrageenan **(Pietrasik and Duda, 2000; Pietrasik and Li-Chan, 2002; Pietrasik, 2003).** it was 52%, 51%, 50%, 49%, and 48% in

Table 3 Textural properties beef meat injected with blend of semi-refined carrageenan (MK- 250) and different phosphates*

Meat Blends	Raw meat			Injected meat			Cooked Meat		
	ERV (ml)	WHC (%)	MSC (%)	ERV (ml)	WHC (%)	MSC (%)	ERV (ml)	WHC (%)	MSC (%)
MK-250 + SDP	54	28.34	40	48	41.94	45.71	20	38.94	20.00
MK-250 + TSP	54	28.34	40	50	42.16	42.85	18	39.16	17.14
MK-250 +SHMP	54	28.34	40	48	43.22	45.71	17.5	40.12	22.85
MK-250 + DSP	54	28.34	40	49	40.50	48.57	18	37.50	14.28
MK-250 + TPPP	54	28.34	40	51	43.52	51.42	21	39.25	17.14
MK-250 + TKPP	54	28.34	40	52	40.71	48.57	18.5	37.71	18.57
MK-250 + STPP	54	28.34	40	53	44.89	42.85	20	40.82	28.57
Control	54	28.34	40	52	26.12	34.28	36.5	24.46	11.42

*Each value is a mean of duplicates

The MSC of injected beef meat as follows from highest to lowest TPPP (51.42%), DSP and TKPP (48.57%), SDP and SHMP (45.71), STPP and TSP (42.85%) and control (34.28%) (Figure 5). The cooked beef meat had lowest ERV value (18%) was found using DSP and TSP added with MK-250 while the highest ERV value is found in control 36.5 %. The highest WHC obtained for cooked meat using STPP with MK-250 (40.82%) and while the lowest WHC is for control (24.46). STPP had highest MSC value is 28.57% for STPP with MK-250 and lowest MSC is 11.42% for control. The TSP and TPPP has similar MSC value (17.14%).

Figure 1 Texture of beef meat injected with blend of semi-refined carrageenan (MK- 250) and different phosphates

Figure 2 Texture of cooked beef meat treated with blend of semi-refined carrageenan (MK- 250) and different phosphates

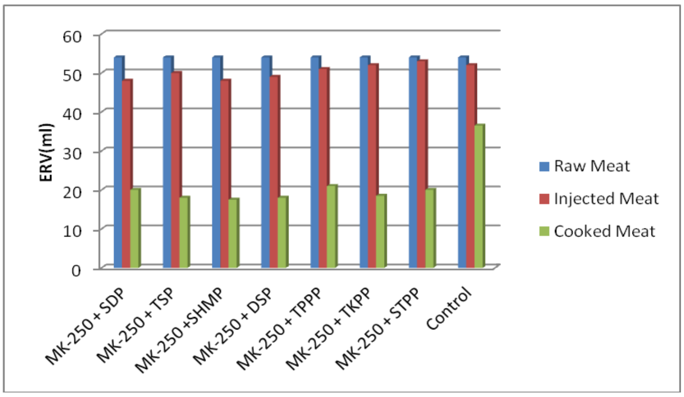

Figure 3 Effect of semi-refined carrageenan (MK- 250) and different phosphates on Extract Release Volume of beef meat

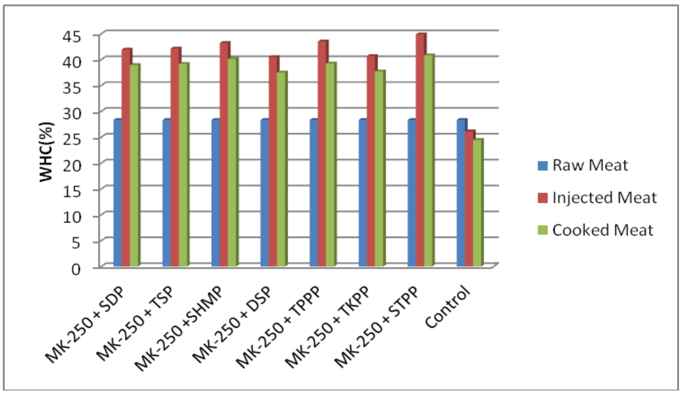

Figure 4 Effect of semi-refined carrageenan (MK- 250) and different phosphates on Water Holding Capacity of beef meat

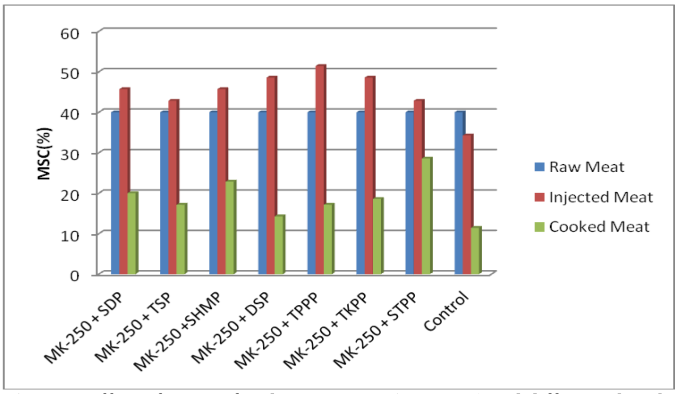

Figure 5 Effect of semi-refined carrageenan (MK- 250) and different phosphates on Meat Swelling Capacity of beef meat

Sensory properties

Palatability of treated along with control meat samples were evaluated by 10 panellists. Panellists gave feedback that acceptability all treated meat samples were very good as compared to control sample. On the basis of 9 hedonic scales the sensory analysis score card of SRC (MK-250) added with different phosphate salts on beef meat are showed in the Table 4. Brine injected samples had higher values in all sensory attributes like appearance, colour, odour, juiciness, texture, tenderness and flavour than control sample.

Table 4 Appearance and sensory analysis of beef meat injected with blend of SRC (MK- 250) and different phosphates

Blend/Traits	Appearance	Color	Odour	Juiciness	Texture	Tenderness	Flavor	Overall Palatability
MK-250 + SDP	6	6	6	5	8	7	7	6.4
MK-250 + TSP	6	7	6	6	7	7	7	6.5
MK-250 +SHMP	7	8	8	6	8	5	7	7
MK-250 + DSP	6	6	7	6	7	5	7	6.2
MK-250 + TPPP	6	7	7	6	7	6	8	6.7
MK-250 + TKPP	6	6	5	6	5	7	7	6
MK-250 + STPP	7	8	8	7	8	7	8	7.5
Control	6	6	5	6	5	6	6	5.7

In the aspects of appearance of meat injected with brine made up of STPP and TPPP got maximum scores among other treated samples and control was the least cored product. The brine made with salts such as TSP, SHMP and TPPP accounted very good status in colour, while brine of TKPP treated sample and control were in the last level. Odour and flavour was commonly shared the same level in the score card i.e. there was no such hyper variations among brine made with all the phosphate salts tested. In juiciness, mostly panellist preferred SHMP, TPPP and STPP over the other salts and the control product. These results are in agreement with literature reports that juiciness of meat increased when it was phosphated **(Baublits *et al.*, 2005; Miller and Harrison, 1965; McGee *et al.*, 2003)** an enhanced flavour in beef and pork **(Smith *et al.*, 1984; McGee *et al.*, 2003; Scanga *et al.*, 2000).** Texture and tenderness were mostly in the friendly zone as STPP scored recorded maximum level of point for both texture and tenderness followed by TSP, SHMP, TPPP, other phosphates and control. In the overall acceptability, panelists given maximum score to meat treated with brine made up of STPP and SRC (KM-250) followed by other brines SHMP, TPPP, TSP, SDP, DSP, TKPP and finally control. Therefore, STPP among all seven salts used for making brine with SRC (MK-250) performed well in terms of weight gain and improvements in texture and sensory when injected into beef meat.

CONCLUSIONS

Beef injected with blend of semi-refined carrageenan (MK-250) and phosphates like SDP, TSP, SHMP, DSP, TPPP, TKPP and STPP yielded higher weight gain with improved sensory properties like tenderness, juiciness, color and flavour as compared to control sample. Among seven phosphates tested, STPP performed well in terms of weight gain i.e. 24%, improved quality parameters and less cooking loss as compared to other phosphate salts, therefore, it can be concluded from the present investigation that there is potential use of blend made with STPP and semi-refined carrageenan (MK-250) in the beef processing industry.

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