International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(2): 1081-1087

Received: 18-01-2019
Accepted: 22-02-2019

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Comparative evaluation of marination of pork chunks in STPP and / or NaCl solutions on quality of pork curry

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Abstract
In the study, effect of different levels of Sodium tripolyphosphate and / or NaCl four treatments were compared and evaluated *viz*. Control (Treatment-1), Marination in 0.4% STPP (Treatment-2), Marination in 0.4% NaCl (Treatment-3), Marination in 0.4% STPP and 0.4% NaCl (Treatment-4). The result revealed that Marination in 0.4% STPP + 0.4% NaCl resulted in significant increase in pH and moisture content and decrease in WHC values of raw meat. Marination in 0.4% STPP + 0.4% NaCl also caused increase in cooked pork pH, moisture content and cooking yield values. The Warner Bratzler Shear Force Value of cooked pork chunks decreased in all marinated samples. However, in 0.4% STPP + 0.4% NaCl had significantly (P<0.01) higher tenderising effect than 0.4% STPP or 0.4% NaCl. Although all marination improved sensory characteristics, but the combined effect of STPP + NaCl Marination on sensory attributes was significantly (P<0.05) higher compared to STPP or NaCl. From the results it can be concluded that to get the best quality pork curry, raw meat chunks should be marinated in 0.4% sodium tripolyphosphate + 0.4% sodium chloride solution.

Keywords: Pork, Curry, Marination, Tenderness, STPP and NaCl

Introduction
Marination of meat chunks is a simple and convenient method used under house-hold conditions. Use of polyphosphate is widely accepted for marinating meat chunks and preparation of processed meat products. These polyphosphates are helpful in improving the quality of products in respect to yield, WHC, pH, colour, texture, flavour etc. and in inhibiting oxidative rancidity [1]. Now-a-days many polyphosphate are available in the market either in single or in combination form. Among all the phosphates, sodium tri-polyphosphate (STPP) and tetra sodium polyphosphate (TSPP) are found to be superior. "Enhancement of fresh pork" is the process of adding non-meat ingredients to fresh pork, to improve the eating quality (juiciness, tenderness and flavour of the pork) of the final product [2]. Phosphates are also added to enhance sensory characteristics such as tenderness and overall acceptability [3]. The enhancement of pork loin significantly increased the tenderness, juiciness, flavour and overall acceptability and decreased Warner-Bratzler shear force value than the control [4]. The combination of early post-mortem enhancement and accelerated chilling may be used to improve product quality [5].
Combination of sodium chloride (NaCl) and inorganic phosphate has a synergistic effect in beef and pork products by stabilizing colour; improving water holding capacity (WHC); and increasing cooking yield [6] and sensory characteristics [7]. It was found that the enhanced products were very similar to each other and superior to the control products for sensory trait and shear force measurements [8] Tenderness and flavour significantly increased with enhancement with phosphate and salt [4]. The present study was aimed to improve the tenderness and other quality traits of pork curry by using STPP and/or NaCl. Different levels of STPP and NaCl were tried and on the basis of sensory evaluation results, optimum treatments (0.4% STPP and 0.4% NaCl) were identified. The optimum treatments and their combined effects were then compared with control for physico-chemical, functional, textural and sensory characteristics.

Materials and methods
Pork required for this study were collected from the ham portion of the carcass of pig of almost similar age (6-8 months), live weight (70-80 kg) and conformation, slaughtered in

experimental abattoir of the Livestock Products Technology Division, Indian Veterinary Research Institute, Izatnagar or in the local market of Bareilly. Meat (about 5 kg in each batch) was procured within 3-4 hrs of slaughter and brought immediately to the laboratory. External fat and fascia were trimmed off and meat was processed as per the requirement of different experiments. Meat chunks of 3.5-4.0 cm^3 size from ham of pork were used to get better and uniform product quality. Preliminary trials were conducted to select the level of sodium tripolyphosphate (STPP) and sodium chloride (NaCl) for marination of pork chunks to get the optimum effect on quality of pork curry. During preliminary trials, four levels of STPP (0, 0.3, 0.4 and 0.5%) and four levels of NaCl (0, 0.3, 0.4 and 0.5 %) were evaluated. STPP or NaCl was mixed with water @ of 10% (V/W) of meat required for marination. Meat chunks were marinated in the solution for 30 minutes. Based on the results of sensory evaluation of preliminary trials the optimum levels were selected. Finally, following four treatments were compared and evaluated.

Treatments-1: Control.
Treatments -2: Marination in STPP (0.4%).
Treatments -3: Marination in NaCl (0.4%).
Treatments -4: Marination in STPP (0.4%) and NaCl (0.4%).
The ingredients and their levels selected for preparation of meat curry are presented in Table-1.

Table 1: Ingredients used for preparation of pork curry

Sl. No.	Ingredients	% of Meat
1	Meat chunks	100.00
2	Turmeric powder	0.45
3	Red chilli powder	0.25
4	Salt	1.60
5	Condiments mix (onion: garlic=3:1)	20.00
6	Spice mix	1.20
7	Refined sunflower oil	8.00
8	Water	200.00

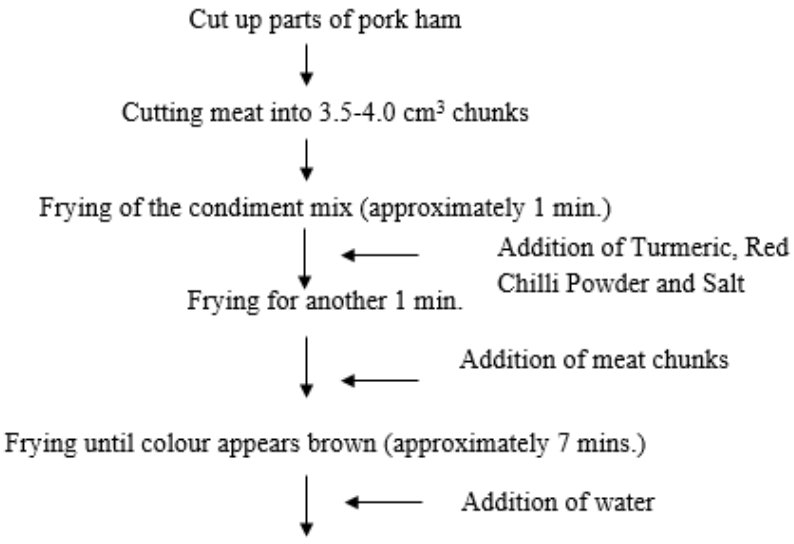
Analar grade and food grade chemicals required in this study were procured from standard firms like Qualigens, Merck, BDH, CDH and Hi-media Food grade sodium tripolyphosphate [(STPP) $Na_5O_{10}P_3$, Molecular wt. 367.86] was procured from CDH (Central Drug House, (P) Ltd., New Delhi).

Refined sun flower oil (Fortune, Adani Wilmar Ltd., Ahmedabad, India), refined iodised salt (Tata salt, Tata chemicals Ltd., Mumbai, India) and spice mix ingredients were procured from the local market. After removal of extraneous matter, all the spice ingredients were dried in an oven at 60 °C for $2^1/_2$ hours. Dried ingredients were then ground in home mixer (Jaipan, India) and sieved through a fine mesh. The powder so obtained was mixed in the required proportion (Table-2) to obtain a spice mix for pork curry.
For condiments mix, onion and garlic were procured from the local market. They were peeled, cut in to small pieces and homogenized in home mixer (Jaipan, India) in 3:1 ratio and a fine paste was obtained. Fresh paste was prepared before each trial.

Table 2: Composition of spice mix

Sl. No.	Ingredient		% in mix (w/w)
	Common name	Local name	
1	Coriander	*Dhania*	38.0
2	Cumin seed	*Zeera*	20.0
3	Aniseed	*Saunf*	10.0
4	Black pepper	*Kali mirch*	10.0
5	Cardamom	*Badi elaichi*	8.0
6	Cinnamon	*Dalchini*	5.0
7	Mace	*Javitri*	2.5
8	Cloves	*Loung*	2.5
9	Nutmeg	*Jaifal*	2.5
10	Bay leaf	*Tejpatha*	1.5
	Total		100.0

Procedure of preparation of pork curry
The refined oil was heated in the pressure cooker and the condiments were added and fried until the colour faded. After that, turmeric, red chilli powder and salt were added and fried till golden yellow colour appeared. The meat chunks were then added and fried till the colour became brown. Water was then added and lid of the pressure cooker was closed. Cooking under steam was done for 25 mins. After opening the lid, the meat and gravy were stirred after addition of spice mix and left for simmering for 5 mins. The prepared meat curry was transferred to a plate, cooled and evaluated. The flow chart for preparation of pork curry is presented in Figure-1.



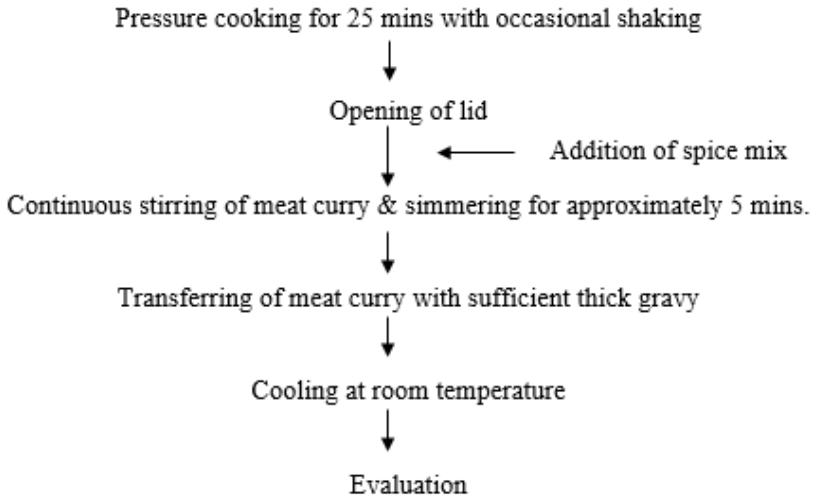


Fig 1: Flow chart for preparation of pork curry

Analytical Procedures

pH

The pH of raw meat and meat curry was determined as per the standard method. Ten grams of sample was homogenized with 50 ml of distilled water for about a minute in Ultra turrex T-18 tissue homogenizer (Janke and Kenkel, IKA Labor Technik, USA). The pH was recorded by immersing the combined glass electrode of digital pH meter (Elico, India, Model: L1 114) directly into the meat suspension.

Temperature

The temperature of raw meat and meat curry was determined by digital thermometer (Fischer Scientific, Control Company, China). For raw meat, the metal electrode was introduced deep into the chunks just before cooking. The temperature shown on the screen of the thermometer was recorded. Similarly for meat curry, temperature was recorded just after cooking and average of minimum four observations was recorded.

Water holding capacity (WHC)

The WHC of raw meat was determined by partial modification of the standard method [9]. Ten grams of finely minced meat sample was homogenized with 15 ml of 0.6M NaCl in a polycarbonate centrifuge bottle for about one minute in Ultra turrex T-18 tissue homogenizer (Janke and Kenkel, IKA Labor Technik, USA). After holding for 15 minutes at 4 ^{0}C in order to allow the 0.6M NaCl to reach equilibrium, the meat slurry was again homogenized for 1 minute and immediately centrifuged (REMI centrifuge, T23, Sl. No. GGNC 338) at 5500 rpm for 10 minutes. The supernatant volume was measured and WHC was expressed as ml of 0.6M NaCl retained by 100 g of meat.

Moisture

Moisture content of raw meat and cooked meat chunks was determined as per the standard method [10].

Shear force value of cooked meat

Cooked pork chunks (from meat curry) were cut into 1.25 cm^3 cubes. The cut piece was then sheared in a Warner-Bratzler Shear Press (Model: No. 81031307, G. R. Elect. Mfg. Co., USA). The shear force was recorded (in kg/cm^2) as per the standard method [11]. Ten observations were recorded for each sample to get the average value.

Cooking yield

The weights of meat chunks before and after processing were recorded and cooking yield was calculated and expressed in percentage.

$$\text{Cooking yield (\%)} = \frac{\text{Weight of cooked meat chunks}}{\text{Weight of raw meat chunks}} \times 100$$

Sensory evaluation

Standard sensory evaluation method using 8-point descriptive scale was followed with modifications where 8= excellent and 1=extremely poor [12]. The experienced panel (7 members) consisted of scientists and post-graduate students of Division of Livestock Products Technology, IVRI, Izatnagar. The panellists were trained and well acquainted with different sensory attributes during their post graduate/ doctoral programme. They were briefly explained about the nature of the experiment without disclosing the identity of samples. Samples were warmed (40-45 ^{0}C) using a microwave oven (LG Electronics India Ltd., Mumbai) for 1 min and served to the panellists. Sensory evaluations were conducted between 3:30 and 4:00 pm and filtered tap water was provided to the panellists for rising their mouth in between evaluation of different samples.

Statistical analysis

The experiments were replicated a minimum of five times and the data generated for different quality characteristics were compiled and analysed using randomised block design at the institutes computer centre. The data obtained from various trials under each experiment were subjected to statistical analysis for analysis of variance (one way ANOVA) and Duncan's multiple range test (DMRT) to compare the means and to find the effects of treatments. The statistically analyzed results were tabulated and interpreted.

Results and discussion

Temperature was non-significantly different between all the treatments in raw and cooked meat samples. The mean pH value for STPP + NaCl marinated samples was significantly (P<0.05) higher than the control in raw and cooked meat samples. Higher pH values in cooked hams were reported after treatment with phosphate [13]. The mean WHC of raw meat for STPP + NaCl marinated samples was significantly

(p<0.01) lower than control, STPP and NaCl marinated samples. However, non-significant difference was observed between WHC values of STPP and NaCl marinated samples. Significantly lower WHC in all marinated samples when compared to control could be due to the absorption of added water during marination. The mean moisture content values of raw meat for STPP and STPP + NaCl marinated samples were significantly (p<0.01) higher than the control. The mean moisture content of cooked meat for STPP + NaCl marinated samples was significantly (P<0.05) higher than the control. Similar observation was also reported in enhanced pork loins [4]. In contrary to that, other worker reported that moisture content was not affected by STPP treatments [14]. All marinated samples had significantly (p<0.01) lower shear force values than control. Among treated samples, value was significantly (p<0.01) lower in STPP + NaCl than STPP and NaCl marinated samples. Lower shear force value was also observed in STPP + NaCl enhanced pork chops compared to the control [4]. In general, all marinated samples had higher cooking yield than control. However, values were significantly (p<0.01) higher in STPP and STPP + NaCl marinated samples when compared to control samples. However, there was non-significant difference between control and NaCl marinated samples. Similar reduction in cooking loss was also observed in phosphate enhanced pork. [15] In contrast to this, no significant difference between enhanced and control chops was reported by other worker [4].

Table 3: Physico-chemical and functional properties of raw and cooked pork curry (Mean ± SE)*

Parameter	Level of marination			
	Control	0.4% STPP	0.4% NaCl	0.4%STPP+ 0.4% NaCl
Raw Meat				
Temperature (^{0}C)	19.12 ± 0.13^a	19.12 ± 0.22^a	18.94 ± 0.21^a	18.94 ± 0.22 ^{a}
pH	5.93 ± 0.04^a	6.10 ± 0.06^{ab}	6.09 ± 0.07^{ab}	6.17 ± 0.06^b
WHC (ml/100g)	41.50 ± 1.00^c	33.50 ± 1.27^b	32.50± 0.79^b	26.00 ± 0.61^a
Moisture (%)	75.23 ± 0.57^a	77.60 ± 0.45^b	76.82 ± 0.34^{ab}	78.18 ± 0.71^b
Cooked Meat				
Temperature (^{0}C)	87.72 ± 0.89^a	88.04 ± 0.82^a	87.96 ± 0.81^a	87.80 ± 0.80^a
pH	5.95 ± 0.06^a	6.03 ± 0.07^{ab}	6.09 ± 0.04^{ab}	6.20 ± 0.04^b
Moisture (%)	58.08 ± 0.17^a	59.36 ± 0.95^{ab}	59.63 ± 0.64^{ab}	61.70 ± 1.19^b
W-B SFV (kg/cm^2) $^{++}$	5.43 ± 0.21^c	4.09 ± 0.11^b	3.94 ± 0.16^b	3.01 ± 0.19^a
Cooking Yield (%)	65.78 ± 0.75^a	69.21 ± 0.68^{bc}	67.64 ± 0.58^{ab}	70.51 ± 0.89^c

Mean with different superscripts in the same row indicate significant difference (P<0.05)
Number of observation: n = 5, $^{++}$n=30

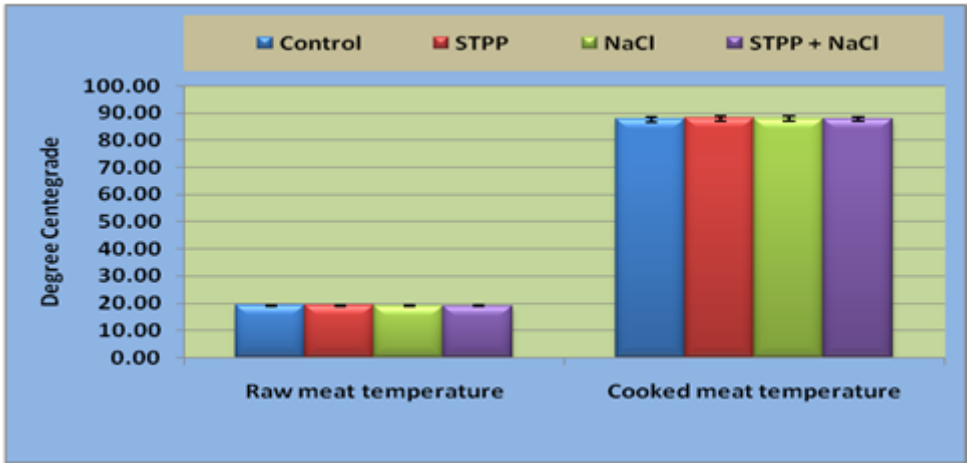


Fig 2: Raw and cooked meat temperature of control, STPP, NaCl and STPP + NaCl marinated pork

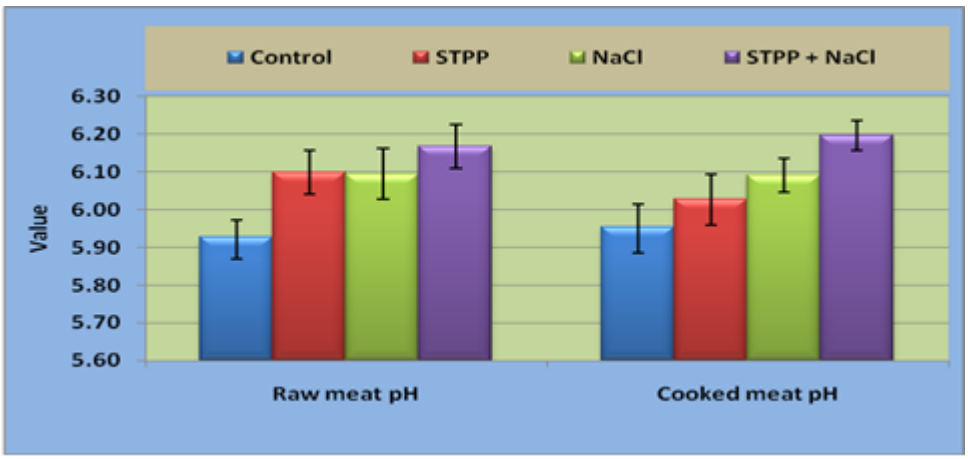


Fig 3: Raw and cooked meat pH of control, STPP, NaCl and STPP + NaCl marinated pork

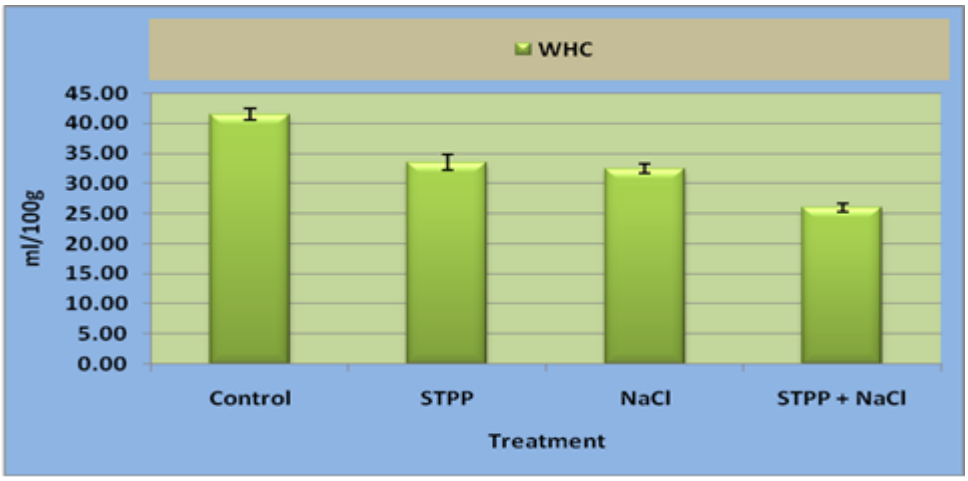


Fig 4: WHC of control, STPP, NaCl and STPP + NaCl marinated pork

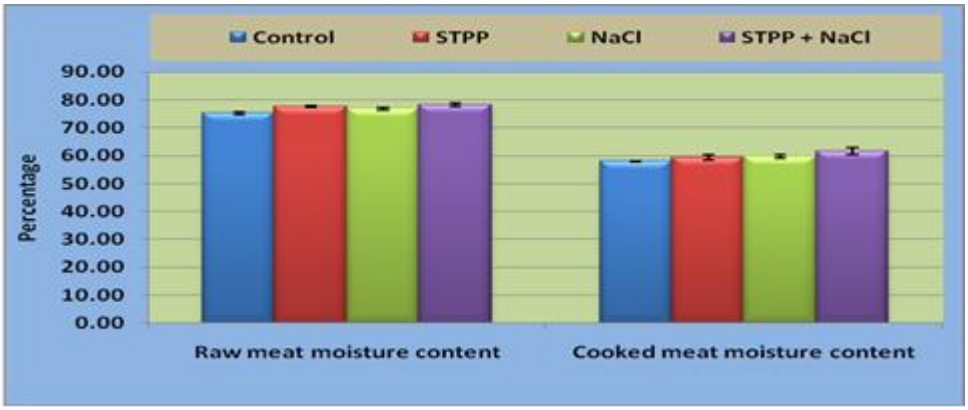


Fig 5: Raw and cooked meat moisture content of control, STPP, NaCl and STPP + NaCl marinated pork

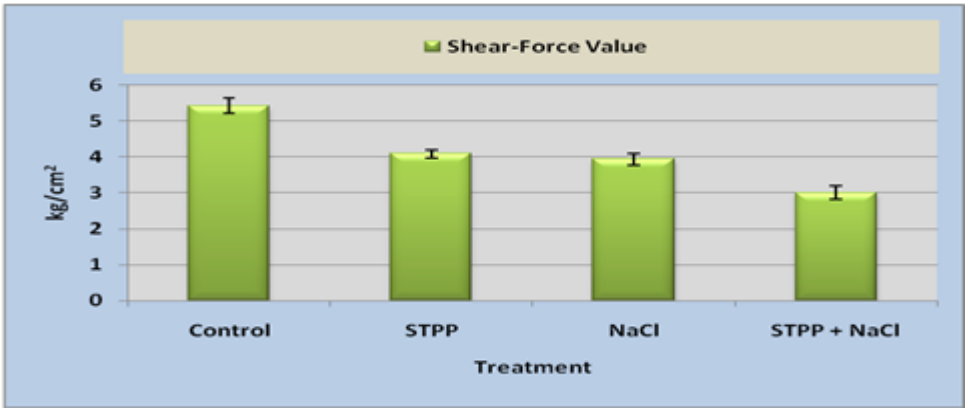


Fig 6: Shear force value of control, STPP, NaCl and STPP + NaCl marinated cooked pork chunks

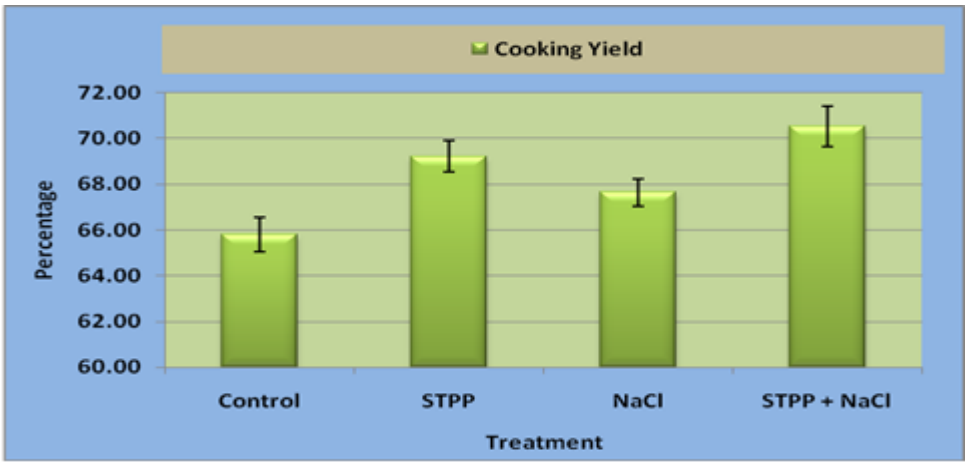


Fig 7: Cooking Yield of control, STPP, NaCl and STPP + NaCl marinated pork curry

Sensory attributes

Among sensory attributes, significantly ($P<0.01$) higher tenderness, juiciness and overall palatability scores were observed in all marinated samples than control. Among marinated samples, significantly ($P<0.01$) higher value was observed in STPP + NaCl marinated sample. Similar observation was reported in pork chop enhanced with STPP + NaCl [4]. It was also reported that the use of STPP/NaCl solution increase tenderness in enhanced sample compared to non-enhanced control [16]. On the other hand, no tenderness difference was observed in phosphate enhanced pork roasts as compared to control [3] Pork loins enhanced with phosphate and salt had a higher overall flavour rating in comparison to the control [4] However, it was also reported that pork flavour was masked by addition of 0.4-0.475% STPP, i.e., had lower flavour intensity when compared to the control [14] Further it was also reported that the overall eating quality of pork markedly improved by needle injection of a brine solution, containing STPP and salt [17].

Table 4: Sensory evaluation scores of pork curry marinated with STPP and/or NaCl (Mean ± SE)

Parameter	Level of marination			
	Control	0.4% STPP	0.4% Salt	0.4%STPP+ 0.4% Salt
Appearance	6.69 ± 0.09^{a}	6.74 ± 0.09^{a}	6.80 ± 0.09^{a}	6.96 ± 0.08^{a}
Flavour	6.35 ± 0.14^{a}	6.64 ± 0.11^{a}	6.46 ± 0.13^{a}	7.05 ± 0.10^{b}
Tenderness	6.32 ± 0.09^{a}	6.81 ± 0.09^{b}	6.68 ± 0.10^{b}	7.21 ± 0.06^{c}
Juiciness	6.33 ± 0.13^{a}	6.81 ± 0.11^{b}	6.67 ± 0.12^{bc}	7.15 ± 0.09^{c}
Overall Palatability	6.31 ± 0.09^{a}	6.76 ± 0.09^{b}	6.60 ± 0.11^{b}	7.13 ± 0.08^{c}

Mean with different sup erscripts in the same row indicate significant difference ($P<0.05$)
Number of observation: n = 30
8-point descriptive scale (1 = Extremely undesirable, 8= Extremely desirable)

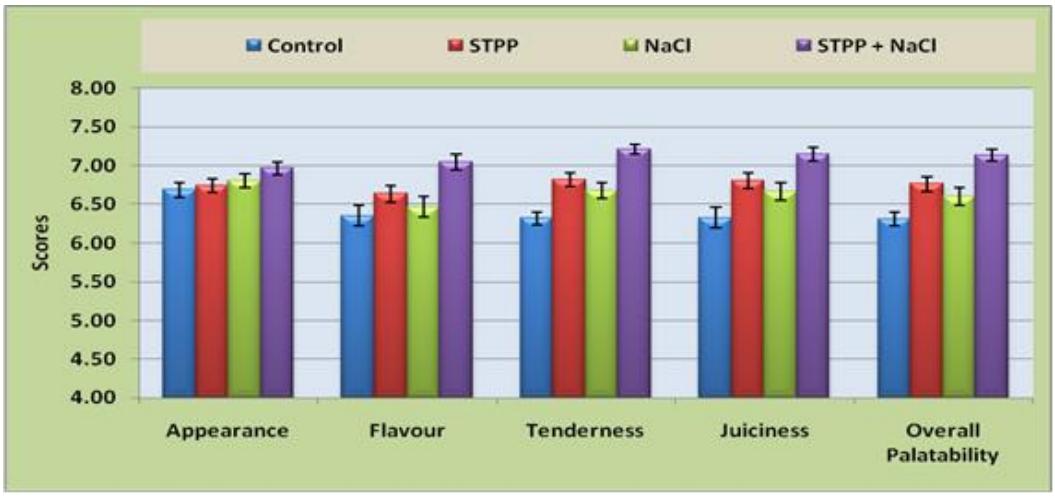


Fig 8: Sensory attributes of control, STPP, NaCl and STPP + NaCl marinated pork curry chunks

Conclusions

Marination in 0.4% STPP + 0.4% NaCl resulted in significant increase in pH and moisture content and decrease in WHC values of raw meat. Marination in 0.4% STPP + 0.4% NaCl also caused increase in cooked pork pH, moisture content and cooking yield values. The Warner Bratzler Shear Force Value of cooked pork chunks decreased in all marinated samples. However, the effect was significantly ($P<0.01$) higher in 0.4% STPP + 0.4% NaCl treated samples. Thus marination in 0.4% STPP + 0.4% NaCl had significantly ($P<0.01$) higher tenderising effect than 0.4% STPP or 0.4% NaCl. Although all marination improved sensory characteristics, but the combined effects of STPP + NaCl marination on sensory attributes was significantly ($P<0.05$) higher compared to STPP or NaCl. To get best quality pork curry, raw meat chunks should be marinated in 0.4% sodium tripolyphosphate + 0.4% sodium chloride solution before cooking. From these results, it can be concluded that among the four treatments compared for effects of pork curry, STPP + NaCl was found to be the best.

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