Global Veterinaria 2 (5): 219-224, 2008
ISSN 1992-6197

Effect of Tapioca Starch and Potato Flour on Physico - Chemical, Sensory and Microbial Characteristics of Pork Sausage During Refrigerated Storage (4±1°C)

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Abstract: A study to compare the effectiveness of Tapioca Starch (TS) and Potato Flour (PF) for preparation of pork sausage with 50 per cent lean and 30 per cent low value meat (Head, Heart and Tongue in the ratio of 70:15:15) was carried out. Preliminary studies were conducted to decide upon the suitable level of inclusion of TS and PF. Sausages prepared were subjected to physico-chemical and sensory analysis. Analysis revealed that sausages with 5 per cent level of PF and 7 per cent of TS as optimum. Sausages were prepared with these optimum levels and were subjected to physico-chemical (pH, shear force, TBARS and TV), Sensory (appearance, flavor, texture, juiciness and overall palatability) and microbial analysis (TVC, Staphylococcus, Psychrophils, Yeast and mould, Lactobacillus, Streptococcus and Anaerobes) to study the keeping quality at refrigerated storage (4±1°C) for 30 days. The results revealed that during storage there was a highly significant ($P<0.01$) decrease in pH, shear force, sensory and microbial analysis and increase in TBARS and TV. Sausages prepared with 5 per cent PF and 7 per cent TS were acceptable up to 25 days of refrigerated storage (4±1°C).

Key words: Pork sausage · Tapioca starch · Potato flour · Sensory evaluation · Microbial analysis · Refrigerated storage

INTRODUCTION

Comminuted meat products, are widely consumed throughout the world, but unfortunately their cost, especially for the developing countries, is high [1]. To reduce the cost of production there is an interest in use of various non-meat ingredients [2] and edible byproducts [3] for realizing higher returns. Slaughter of animal produces a considerable amount of edible byproducts (Head meat, heart, tongue, tripe etc.) with high biological value and low palatability attributes. Comminuted meat products offer an attractive avenue for utilization of these low value cuts and edible offals by replacing a certain proportion of skeletal meat to reduce their cost of production. However products prepared with these low value cuts and offals have poor cooking yield and emulsion stability because of its poor emulsifying and water binding capacity [4-6]. These shortfalls can be rectified by addition of binders such as starches, especially those of plant origin to compensate when a nutritionally equivalent meat source of low cost and reduced functionality is used [7]. Potato has long been used by meat processors in the form of starches and flour [8-10] and several workers have tried tapioca starch as a binder for preparing sausages and other meat products [8, 10-12]. However little evidence is available about the use of Tapioca starch and potato flour in pork sausages made with low value meat. With this viewpoint, the present study was undertaken to compare the effectiveness of tapioca starch and potato flour binder in pork sausage with 50 per cent lean meat and 30 per cent low value (Head, Heart and Tongue) meat under refrigerated condition (4±1°C) over a period of 30 days.

MATERIALS AND METHODS

Pork obtained from pigs slaughtered at Department of Meat Science and Technology, Madras Veterinary College was used for the study. After slaughter pork was deboned manually to obtain lean meat. Meat from head and cheek was isolated from separable fat. Heart was cut open along its longitudinal axis and clotted blood was

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removed. The epithelial layer of tongue was scrapped off and then cut into small pieces. The lean meat, head meat, tongue, fat and heart were packed in polyethylene bags separately and frozen at -20°C until use. Commercially available Tapioca starch was used in this study. Potato Flour was prepared by scalding fresh potatoes at 80°C for 10 minutes and then peeling off the skin. Scalded potatoes were cut into small pieces and dried in an oven at 60°C overnight. The dried potatoes were ground into a fine powder using a Cyclotec of 1 mm sieve.

Preparation of Sausages: Frozen meat, (LVM- Head, Heart and Tongue) and fat were tempered at 4°C and were cut into small pieces and minced using 4.5 mm plate in Electrolux mincer (Omas, Model-16789). LVM was minced twice in order to remove additional connective tissues. The minced meat lean meat (50%), lean meat (30%) along with (STPP-0.3 per cent, Salt-2 per cent and Sodium nitrite-120 ppm) were chopped in a bowl chopper for 1 minute and fat (20%) were added and chopped for another 2 minutes then spice mix at 1.5% level (Corriander powder-20 per cent, Aniseed-15 per cent, Black pepper-13 per cent, Capsicum-15 per cent, Cumin seed-10 per cent, Dried ginger-10 per cent, Cinnamon-5 per cent, Cloves-5 per cent, Turmeric-5 per cent and cardamom-2 per cent), Green condiments at 3 percent (Onion: Garlic –3:1) and added water in the form ice at 10 % level were added and chopped for few minutes. At the final step tapioca starch and Potato flour was added at 7 and 5 per cent respectively and chopped for another 1.5 min. During chopping care was taken to maintain the emulsion temperature between 10-13°C. From this emulsion samples were taken for pH and emulsion stability. Emulsion was then stuffed in sheep casing of 19 mm diameter, using a manual sausage stuffer and linked manually. Stuffed sausages were kept in refrigerator (4±1°C) for 1 hour to ensure proper setting. Sausages were then cooked in water bath at 80°C for 15 minutes so as to reach core temperature of 72±3°C. Total of six batches of sausages were prepared. The sausages prepared were packed in polyethylene bags and kept in refrigerator (4±1°C). Samples were drawn at 5 days interval and were analyzed for pH by following the method described by [13] using a digital pH meter (Cyberscan PH 510, Merck), Emulsion Stability as per the method outlined by [14], Cooking Yield. Shear force was determined using Warner Bratzler Shear press and recorded as per [3], TBARS was determined using method of [15] and expressed as mg of malanoldehyde/ Kg of sample, Tyrosine Value (TV) was determined by the modified method of [16] and sensory (9 point hedonic scale) and microbial analysis by following the method described by [17] using readymade media from HIMEDIA over a period of 30 days. Data generated from each trial was analyzed by following standard procedure described by [18].

RESULTS

The mean values on physicochemical sensory and Microbiological characteristics of sausages with 7 per cent inclusion of Tapioca starch and 5 per cent potato flour upto 30 days of storage at (4±1°C) are presented in Tables (1-3).

Physicochemical Characteristics: The pH of sausages and the interaction between treatments and storage days showed a highly significant ($P<0.01$) difference between treatments with sausages with potato flour having higher value. There was a rise in pH from day 0 to day 20 and day 25 in tapioca starch and potato flour incorporated sausages, respectively.

A highly significant ($P<0.01$) and higher shear force value was observed in sausages prepared using potato flour compared to tapioca starch. Upon storage there was a reduction in shear values in both the treatments.

There was a progressive increase ($P<0.01$) in TBARS number between treatment, between storage and interaction between storage period and treatment. Sausages with Potato flour had lower values compared to that of tapioca starch incorporated sausage and there was a progressive increase in both treatments during storage and is a reflection of the advance in oxidative changes in pork sausage during storage.

Tyrosine value showed a linear and highly significant ($P<0.01$) increase with the increase in storage days in both the treatments. Potato flour incorporated sausages had higher values compared to tapioca starch containing.

Sensory Characteristics: A highly significant ($P<0.01$) reduction in scores was observed in all sensory characteristics with increase in storage days in both the treatments. There was no significant difference between the treatments with respect to appearance and flavor. But potato incorporated sausages had a slower reduction in flavor compared to tapioca starch. A highly significant ($P<0.01$) difference existed between the treatments in terms of texture, juiciness and overall palatability. Potato flour incorporate sausages had higher values for texture, juiciness and overall palatability compared to tapioca starch incorporated sausages.

Table 1: Mean±S.E for Physico-chemical (pH, Shear force value, TBARS and Tyrosine Value) and of Pork sausage with 7 per cent Tapioca starch and 5 per cent Potato flour during Refrigerated Storage at 4±1°C

	Storage Days							
Parameter	0	5	10	15	20	25	30	Mean±S.E
pH								
Tapioca Starch	6.32±0.01^{a}	6.40±0.01^{b}	6.49±0.01^{c}	6.52±0.01^{cd}	6.60±0.01^{f}	6.55±0.02^{def}	6.51±0.01^{cd}	6.48±0.01^{x}
Potato Flour	6.32±0.01^{a}	6.42±0.01^{b}	6.53±0.02^{cd}	6.56±0.01^{def}	6.59±0.02^{ef}	6.73±0.01^{g}	6.54±0.01^{cde}	6.53±0.01^{y}
Days mean±S.E.	6.32±0.01^{A}	6.41±0.01^{B}	6.51±0.01^{C}	6.54±0.01^{C}	6.59±0.01^{D}	6.64±0.01^{E}	6.53±0.01^{C}	
Shear Force Value								
Tapioca Starch	0.57±0.02^{a}	0.56±0.05^{b}	0.55±0.08^{b}	0.55±0.06^{b}	0.54±0.08^{b}	0.52±0.12^{c}	0.51±0.05^{c}	0.54±0.07^{x}
Potato Flour	0.60±0.13^{a}	0.59±0.07^{a}	0.58±0.09^{a}	0.58±0.12^{a}	0.57±0.09^{ab}	0.55±0.06^{abc}	0.53±0.05^{c}	0.57±0.09^{y}
Days mean±S.E.	0.59±0.08^{A}	0.57±0.06^{B}	0.56±0.09^{B}	0.56±0.09^{B}	0.56±0.09^{B}	0.53±0.05^{C}	0.52±0.08^{C}	
TBARS (mg of malanoldehyde/Kg)								
Tapioca Starch	0.29±0.05^{b}	0.34±0.06^{c}	0.54±0.05^{e}	0.59±0.06^{g}	0.69±0.08^{h}	0.86±0.09^{i}	1.14±0.07^{j}	0.63±0.07^{x}
Potato Flour	0.22±0.03^{a}	0.24±0.06^{a}	0.45±0.16^{d}	0.50±0.08^{ef}	0.56±0.08^{fg}	0.66±0.05^{h}	0.89±0.10^{i}	0.50±0.09^{y}
Days mean±S.E.	0.25±0.04^{A}	0.29±0.06^{B}	0.49±0.06^{C}	0.54±0.07^{D}	0.62±0.08^{E}	0.76±0.07^{F}	1.01±0.09^{G}	
Tyrosine Value (mg/100g of sample)								
Tapioca Starch	2.29±0.10	3.17±0.10	4.29±0.20	6.58±0.19	8.58±0.07	11.13±0.06	18.08±0.38	7.73±0.16^{x}
Potato Flour	2.50±0.06	3.46±0.03	4.50±0.15	7.58±0.17	9.08±0.15	11.29±0.05	18.33±0.44	8.11±0.15^{y}
Days mean±S.E.	2.40±0.08^{A}	3.31±0.06^{B}	4.40±0.17^{C}	7.08±0.18^{D}	8.83±0.11^{E}	11.20±0.16^{F}	18.21±0.41^{G}	

Overall means bearing different superscripts between rows (x,y) and between columns (A,B,C,D,E,F,G) differ significantly (P<0.01 or P<0.05). Interaction means bearing different superscripts (a,b,c,d,e,f,g,h,i,j) differ significantly (P<0.01 or P<0.05)

Table 2: Mean±S.E for Sensory characteristics of Pork sausage with 7 per cent Tapioca starch and 5 per cent Potato flour during Refrigerated Storage at 4±1°C

	Storage Days							
Parameter	0	5	10	15	20	25	30	Mean±S.E
Appearance								
Tapioca Starch	7.83±0.13^{g}	7.69±0.17^{f}	7.40±0.25^{e}	7.28±0.14^{d}	6.92±0.07^{bc}	6.83±0.13^{b}	6.53±0.12^{f}	7.21±0.14^{NS}
Potato Flour	7.69±0.15^{f}	7.61±0.21^{f}	7.38±0.08^{de}	7.35±0.16^{de}	7.00±0.14^{c}	6.87±0.09^{b}	6.57±0.28^{f}	7.21±0.16^{NS}
Days mean±S.E.	7.76±0.14^{A}	7.65±0.19^{B}	7.39±0.17^{C}	7.31±0.15^{C}	6.96±0.11^{D}	6.85±0.11^{E}	6.55±0.20^{F}	
Flavor								
Tapioca Starch	7.76±0.08^{i}	7.61±0.07^{gh}	7.37±0.12^{f}	7.11±0.15^{e}	6.91±0.13^{c}	6.73±0.09^{b}	6.51±0.05^{a}	7.14±0.10^{NS}
Potato Flour	7.67±0.12^{h}	7.54±0.15^{g}	7.35±0.04^{f}	7.18±0.05^{e}	7.02±0.06^{d}	6.83±0.05^{c}	6.57±0.04^{a}	7.16±0.07^{NS}
Days mean±S.E.	7.71±0.10^{A}	7.58±0.11^{B}	7.36±0.08^{C}	7.15±0.10^{D}	6.96±0.10^{E}	6.78±0.07^{F}	6.54±0.05^{G}	
Texture								
Tapioca Starch	7.86±0.04	7.68±0.06	7.60±0.06	7.28±0.12	6.91±0.05	6.73±0.21	6.16±0.14	7.24±0.10^{x}
Potato Flour	7.88±0.04	7.72±0.15	7.62±0.21	7.35±0.06	7.01±0.08	6.89±0.15	6.78±0.12	7.32±0.12^{y}
Days mean±S.E.	7.87±0.04^{A}	7.70±0.11^{B}	7.61±0.14^{C}	7.32±0.09^{D}	6.96±0.07^{E}	6.81±0.18^{F}	6.70±0.13^{G}	
Juiciness								
Tapioca Starch	7.30±0.08^{g}	7.24±0.05^{g}	7.08±0.02^{ef}	6.93±0.02^{d}	6.73±0.05^{c}	6.60±0.08^{b}	6.49±0.09^{a}	6.91±0.06**
Potato Flour	7.60±0.05^{h}	7.32±0.12^{g}	7.13±0.05^{f}	6.99±0.16^{de}	6.78±0.05^{c}	6.63±0.09^{b}	6.55±0.07^{ab}	7.00±0.08**
Days mean±S.E.	7.45±0.07^{A}	7.28±0.09^{B}	7.10±0.04^{C}	6.96±0.09^{D}	6.75±0.05^{E}	6.61±0.09^{F}	6.52±0.08^{G}	
Overall Palatability								
Tapioca Starch	7.58±0.08	7.43±0.17	7.37±0.15	7.10±0.16	6.90±0.09	6.67±0.15	6.55±0.18	7.08±0.14**
Potato Flour	7.72±0.15	7.46±0.09	7.41±0.16	7.14±0.21	6.99±0.18	6.74±0.14	6.68±0.12	7.16±0.15**
Days mean±S.E.	7.65±0.12^{A}	7.44±0.13^{B}	7.39±0.16^{C}	7.12±0.19^{D}	6.94±0.14^{E}	6.70±0.15^{F}	6.61±0.15^{G}	

Overall means bearing different superscripts between rows (x,y) and between columns (A,B,C,D,E,F,G) differ significantly (P<0.01 or P<0.05). Interaction means bearing different superscripts (a,b,c,d,e,f,g,h,i,j) differ significantly (P<0.01 or P<0.05)

Table 3: Mean±S.E for Microbiological Characteristics of Pork sausage with 7 per cent Tapioca starch and 5 per cent potato flour during Refrigerated Storage at 4±1°C for 30 days (Counts expressed as log cfu/g)

	Storage Days							
Parameter	0	5	10	15	20	25	30	Mean±S.E
TVC (log cfu/g)								
Tapioca Starch	2.01±0.05	2.22±0.08	2.40±0.05	2.64±0.06	3.00±0.12	3.49±0.09	4.00±0.12	$2.82±0.08^{NS}$
Potato Flour	1.98±0.05	2.16±0.12	2.34±0.13	2.63±0.05	2.92±0.07	3.52±0.06	4.05±0.06	$2.80±0.08^{NS}$
Days mean±S.E.	$2.00±0.07^{A}$	$2.19±0.10^{B}$	$2.37±0.09^{C}$	$2.64±0.06^{D}$	$2.96±0.10^{E}$	$3.50±0.08^{F}$	$4.03±0.09^{G}$	
Psychrophilic Count								
Tapioca Starch	2.10±0.09	2.25±0.05	2.41±0.12	2.91±0.01	3.12±0.05	3.84±0.08	4.29±0.06	$2.99±0.07^{x}$
Potato Flour	2.07±0.03	2.16±0.05	2.38±0.06	2.85±0.12	3.05±0.04	3.75±0.08	4.23±0.05	$2.93±0.06^{y}$
Days mean±S.E.	$2.08±0.06^{A}$	$2.21±0.05^{B}$	$2.40±0.09^{C}$	$2.88±0.07^{D}$	$3.09±0.05^{E}$	$3.80±0.08^{F}$	$4.26±0.06^{G}$	
Staphylococcal Count								
Tapioca Starch	1.46±0.06	1.53±0.06	2.06±0.09	2.29±0.08	2.61±0.12	2.80±0.09	3.02±0.07	$2.25±0.08^{NS}$
Potato Flour	1.52±0.05	1.66±0.06	2.06±0.05	2.31±0.03	2.55±0.12	2.80±0.08	3.03±0.02	$2.28±0.06^{NS}$
Days mean±S.E.	$1.49±0.05^{A}$	$1.60±0.06^{B}$	$2.06±0.06^{C}$	$2.30±0.05^{D}$	$2.58±0.12^{E}$	$2.80±0.09^{F}$	$3.03±0.04^{G}$	
Lactic acid bacteria								
Tapioca Starch	1.84±0.04	1.93±0.08	2.09±0.08	2.35±0.03	2.66±0.05	2.71±0.09	2.91±0.07	$2.36±0.06^{x}$
Potato Flour	1.84±0.06	2.02±0.13	2.09±0.04	2.40±0.02	2.71±0.01	2.72±0.05	2.98±0.06	$2.39±0.05^{y}$
Days mean±S.E.	$1.84±0.05^{A}$	$1.97±0.11^{B}$	$2.09±0.06^{C}$	$2.37±0.03^{D}$	$2.68±0.03^{E}$	$2.71±0.07^{F}$	$2.95±0.07^{G}$	
Yeast and Mould Count								
Tapioca Starch	1.69±0.05	2.01±0.06	2.15±0.06	2.41±0.09	2.65±0.08	3.10±0.04	3.55±0.06	$2.49±0.06^{x}$
Potato Flour	1.63±0.07	1.92±0.04	2.16±0.03	2.36±0.05	2.63±0.05	2.96±0.04	3.47±0.06	$2.45±0.05^{y}$
Days mean±S.E.	$1.66±0.06^{A}$	$1.97±0.05^{B}$	$2.15±0.05^{C}$	$2.39±0.07^{D}$	$2.64±0.07^{E}$	$2.98±0.04^{F}$	$3.51±0.06^{G}$	

Overall means bearing different superscripts between rows (x,y) and between columns (A,B,C,D,E,F,G) differ significantly ((P<0.01 or P<0.05)

Microbial Characteristics: There was a linear and a highly significant (P<0.01) increase in all the microbial counts irrespective of the treatments with increase in storage days Upon storage there was no significant difference in TVC values between treatments. Psychrophilic counts showed an highly significant (P<0.01) increase during refrigerated storage and between treatments with higher values in tapioca starch incorporated sausages, Sausages with potato flour had higher values for Lactic acid bacteria, whereas staphylococcal counts and yeast and mould counts were higher in tapioca incorporated sausages. During the entire period of storage there was a sporadic occurrence of streptococcus, anaerobes and coliforms,

DISCUSSION

The changes in pH of sausages coincide with [19-21]. The obvious higher shear force value observed in sausages prepared using potato flour compared to tapioca starch may be due to the fact that starch in flour favors formation of strong heat induced structure through swelling of starch granules embedded in protein matrix [9]. Upon storage there was a reduction in shear values in both the treatments, which may be due to disintegration of protein matrix that embeds the gel structures of starches.

The progressive increase in TBARS number between treatment, between storage and interaction between storage period and treatment is in concurrence with [22,23] and is a reflection of the advance in oxidative changes in pork sausage during storage.

The observed linear and increased of Tyrosine value with the increase in storage days in both the treatments might be due to the fact that potato flour has a higher protein content and its breakdown must have boosted the value.

Clear reduction in scores of all sensory characteristics was observed with increase in storage days in both the treatments. A similar reduction in appearance, flavor, texture, juiciness and overall palatability on storage was also reported by [24, 25]. The reduction in juiciness, texture may be due to the fact that the moisture might have been utilized by the increase in microbial flora, thus causing disintegration of protein matrix, contributing to reduction of texture scores.

The linear and the obvious increase in all the microbial counts irrespective of the treatments with increase in storage days coincide with [26,27]. The difference in TVC values between treatments. was in accordance with [28]. The sporadic occurrence of streptococcus, anaerobes and coliforms, were in concurrence [26].

CONCLUSION

Sausages incorporated with TS were economical in terms of cost involved compared to that of PF incorporated sausages, but in spite of economical reasons the results of sensory and microbial analysis has revealed that PF incorporated sausages had higher score for texture, juiciness and overall palatability, whereas there was no significant difference in appearance and flavor scores between treatments. Since, lipid oxidation and microbial profile are the major components which determine the keeping quality and shelf life of the meat products, sausages with potato flour had values lower than that of tapioca starch incorporated sausages. Sausages prepared with both TS and PF were acceptable till 25 days at (4±1°C). Hence, it is concluded that sausages with 5 per cent potato flour is considered superior for preparing pork sausages with 70 per cent lean meat and 30 per cent low value meat (Head, Heart and Tongue) compared to that of sausages incorporated with tapioca starch in terms of sensory, microbial and storage stability.

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(Received: 30/05/2008; Accepted: 30/07/2008)