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Full Length Research Paper

Effect of combination pre-treatment on physicochemical, sensory and microbial characteristics of fresh aerobically stored minced goat (Black Bengal) meat organs

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Minced goat meat organs (bicep fermoris muscle, heart, kidney and liver) of a particular variety of goat (Black Bengal) were stored aerobically in refrigerator at 4ºC for 15 days after some combination pretreatments: a) tea liquor and honey, b) acetic acid and glucose and c) spices and curing mixture; followed by subsequent refrigerated storage at 4°C. It was observed that pretreated samples exhibited significantly (P<0.05) better physicochemical (pH, water holding capacity, thiobarbutyric acid value and extract release volume), sensory (color and flavor) and microbial characteristics in comparison to the control goat meat samples without any pretreatment. Among all the pretreatments in this study, tea liquor and honey pretreatment as well as curing mixture pretreatment offered more effective results (P<0.05) for improving goat meat quality than pretreatment with acetic acid and glucose. However, acetic acid and glucose pretreatment controlled the fungal growth in meat samples most effectively. The curing mixture was most effective in controlling pH, water-holding capacity, extract release volume, flavor and aerobic bacterial count from the beginning to the end of experiment, whereas tea liquor and honey was the most effective pretreatment in controlling extract release volume (ERV), thiobarbutyric acid (TBARS) value, color and texture of samples. Among the organs, bicep femoris muscle exhibited best acceptable quality (P<0.05) throughout the storage time, whereas liver samples were most prone to spoilage (P<0.05).

Key words: Goat meat organs, pretreatment, acetic acid - glucose, tea liquor - honey, curing - mixture, physicochemical properties, microbial count.

INTRODUCTION

Goat meat is a rich source of nutrition and is consumed worldwide, especially in the tropics and developing countries, in large quantities (Park, 1988, 1990). Black Bengal goats (*Capra hircus*) are highly prolific and reputed for quality meat and skin production throughout the world (Salim et al., 2002). But a large percentage of foodborne illnesses have been linked to consumption of meat products (Bean et al., 1990). Blending different types of additives with raw meat during storage is common. Park et al. (1991) reported that the difference in composition might affect the storage characteristics of different goat organs; liver, kidney, heart and muscle bicep femoris. Lipid oxidation has been found to be responsible for the characteristic rancid off flavour developed in pre-cooked meat (Ladikos and Lougovois 1990; Salih et al., 1989; Wu and Sheldon, 1983). Tang et al. (2001) investigated the comparative effects of added tea catechins and α-tocopherol to raw minced red meat (beef and pork), poultry (chicken, duck and ostrich) and fish (whiting and mackerel) muscle on susceptibility to lipid oxidation during 10 days of refrigeration (4°C). They observed that the antioxidant potential of catechins was two to four fold greater than that of α-tocopherol at the same concentration and this potential was species dependent. It has been reported that black tea has dietary component, polyphenol, has antioxidant efficacy

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and may be capable of scavenging reactive oxygen species implicated in biological damage (Matsingou et al., 2000). In the United States, studies undertaken by researchers at the University of Illinois have revealed that honey's antioxidant qualities preserve meat without compromising taste (VATIS update Food Processing, May-June 2002). A just-published study says that honey – at least based on work done on human blood in the laboratory – slows the oxidation of low-density lipoproteins (LDL), a process that leads to atherosclerotic plaque deposition (Gheldof and Engeseth, 2002). Honey was more effective than traditional preservatives (butylated hydroxytoluene and tocopherol) in slowing oxidation in cooked, refrigerated ground turkey. While the meat browned during cooking more extensively than traditionally preserved products, taste was not negatively affected (McKibben and Engeseth, 2002). Researchers from University of Illinois in 1999 have also found a significant correlation of phenolic content and antioxidant capacity of honey. Researchers from University of Illinois in 1999 have also found a significant correlation of phenolic content and antioxidant capacity of honey. Moreover, honey has excellent antibacterial property (Al-Jabri et al. 2003).

Federick et al. (1994) observed that in a commercial pork slaughter facility, carcass washed with 2% acetic acid (25°C) as compared to control (non-treated) cheek meat, *salmonella* was decreased by 67% and a significant decrease in aerobic and coliforms occurred. Addition of glucose to meat at concentrations of 2% or more by weight did suppress odor and slime formation (Gill, 1986). Hot water washing can reduce initial contamination of meat, provided the surface reaches a temperature high enough for a sufficient period to pasteurize the surface. Raising the surface temperature to 60°C for 10 sec can give a 3-log reduction in microbial counts and although there is initial surface discoloration, acceptable color is regained after cooling (Babji and Murthy, 2000). Treatment of meat by spices and curing agent (nitrate, nitrite, sugar and salt) has been known since the mid-1920s (Tompkins et al., 1986). Reduction of nitrate to nitrite enables formation of cured meat color of sausage and enhances growth of desirable microorganisms such as *Lactobacilli* in meat.

However, there is no such information till now about the physicochemical, sensory and microbial characteristics of fresh aerobically stored minced goat meat organs of Black Bengal variety and effect of combination pre-treatment on the characteristics of meat during aerobic storage at 4°C. Thus, the aim of this work is to make a comparative study on the physicochemical, sensory and microbial properties of goat meat organs (bicep fermoris muscle, heart, kidney and liver) of Black Bengal goat pretreated with the combination treatment of a) tea liquor and honey b) acetic acid and glucose and c) spices and curing mixture; and subsequent refrigerated storage at 4°C. The purpose is to enhance the storage quality of the goat meat organs.

MATERIALS AND METHODS

Pretreatment and storage

Raw goat meat organs (bicep femoris muscle, heart, kidney and liver) from the same source of Black-Bengal goat variety (a lower-fat meat than mutton and age and weight of the breed being 10 months and 9.8 kg, respectively), were purchased from the local market, trimmed to 2 cm thickness and subjected to different pretreatments. Raw, untreated meat corresponding to the same organ were taken as control. The samples were packed in low density polyethylene (LDPE) packet and refrigerated at 4°C).

Pretreatment 1: Raw meat was washed with hot distilled water (80°C) for 30 s, then immersed in 2% acetic acid solution for 1 h, followed by addition of 2% (w/w) glucose and refrigerated at 4°C in LDPE packet.

Pretreatment 2: Raw meat was washed with hot distilled water (80°C) for 30 s, immersed into curing mixture (of composition given below) for 1 h and refrigerated at 4°C in LDPE packet. The curing mixture is composed of (% in distilled water) NaCl – 2% (w/v), citric acid – 0.2% (w/v), ascorbic acid – 0.05% (w/v), $NaNO_2$ – 0.1%, $NaNO_3$ – 0.1%, mixed spices – 1% (w/v) [Each 20% (w/v) of clove, coriander, black pepper, small elachi and cumin], sucrose – 0.7% (w/v).

Pretreatment 3: Raw meat was washed with hot distilled water (80°C) for 30 s, immersed in tea liquor (previously boiled in distilled water, 5% (w/v) and filtered) for 1 h, followed by mixing with honey 2% (w/v) and refrigeration in LDPE packet.

Analysis of stored samples

Samples were analyzed on 0, 5th, 10th and 15th day of storage. One packet of sample for physicochemical and sensory and another one for microbial analysis, were brought and taken out from the refrigerator and kept at room temperature for 30 min before analysis.

Physicochemical studies: Measurements of pH were performed according to AOAC (1984). 1 g of meat sample was blended with 9 ml of distilled water in a laboratory blender (Remi Sales, India) for 2 min, filtered and then pH of the filtrate was determined by digital pH-meter (Elico India Ltd). Water-holding capacity (WHC) of meat samples was determined by using press method (Mallikarjunan and Mittal, 1994) with some modifications. Two filter papers were weighed. 1 g of meat sample was placed between them. The sandwich was then placed in a WHC-measuring m/c (Reliance Enterprise, Kolkata, India) and 100 KPa absolute pressure was applied for 1 min. After withdrawing, the meat was discarded and wetted filter papers were weighed. WHC is then calculated as (Mass of filter papers with pressed juice – Mass of dry filter papers)/ Sample mass and expressed as g water/100 g of meat. Oxidative rancidity of the meat samples were determined by thiobarbutyric acid value (TBARS) value by the method of Tarladgis et al. (1960) with 10 g of meat sample using TBA reagent and expressed as mg malonaldehyde/kg of sample. The extract release volume (ERV) was determined following the method of Jay (1964). 25 g of meat samples were blended in a laboratory blender (Remi Sales, India) with 100 ml distilled water for 2 min and was filtered by Whatman filter paper no. 1. The volume of aqueous portion of the filtrate collected in a graduated cylinder in the first 15 min was taken as

Table 1. Effect of pretreatment on pH of refrigerated goat meat organs.

Treatment	Storage time (days)				Treatment mean ± SD(n = 12)
	0	5	10	15	
Bicep femoris muscle					
Control	5.48	5.86	6.03	6.84	6.05^{b}±0.57
1	5.22	5.38	5.65	5.91	5.54^{b}±0.30
2	5.28	5.30	5.49	5.89	5.49^{a}±0.28
3	5.37	5.43	5.73	5.96	5.62^{b}±0.28
Day mean ± SD	5.34^{a}±0.11	5.49^{a}±0.25	5.73^{a}±0.23	6.15^{a}±0.46	
Heart					
Control	5.88	5.94	5.97	6.72	6.13^{b}±0.407
1	5.56	5.76	5.92	6.13	5.84^{a}±0.24
2	5.45	5.50	5.76	6.07	5.70^{a}±0.29
3	5.83	5.78	5.93	6.07	5.90^{b}±0.13
Day mean ± SD	5.68^{a}±0.21	5.75^{a}±0.18	5.90^{b}±0.09	6.25^{b}±0.32	
Kidney					
Control	6.16	6.54	6.72	6.83	6.56^{d}±0.29
1	5.68	5.87	6.09	6.35	6.00^{c}±0.29
2	5.61	5.88	6.02	6.11	5.91^{a}±0.22
3	5.67	5.92	6.14	6.23	5.99^{b}±0.25
Day mean ± SD	5.78^{a}±0.26	6.05^{b}±0.33	6.24^{b}±0.32	6.38^{b}±0.32	
Liver					
Control	5.72	5.78	5.90	6.69	6.02^{c}+0.45
1	5.17	5.71	5.85	6.23	5.74^{b}+0.44
2	5.14	5.69	5.82	6.20	5.71^{a}+0.44
3	5.26	5.62	5.89	6.30	5.77^{b}+0.44
Day mean ± SD	5.32^{a}±0.27	5.7^{b}±0.07	5.87^{b}±0.04	6.36^{b} ±0.23	

SD = Standard deviation; $^{a-d}$ means with different superscripts in a column are different (P<0.05).

ERV of the sample.

Sensory analysis: Sensory scores for meat color and odor were determined by a twelve-member trained (odor and color descriptive attribute) panel using Hedonic 9-point scale method (1 = Extremely objectionable, 3 = fairly objectionable, 5 = Neither objectionable nor acceptable, 7 = fairly acceptable, 9 = extremely acceptable). Meat texture was evaluated by using a shear-force test on an Instron Universal testing machine (Model no. 4301, Instron Corp., Caton, MA). The meat sample was cut at crosshead speed 20 mm/min. The peak load of shear was expressed as Newtons (i.e. Peak load in relation to total sample area sheared).

Microbial analysis: For microbial analysis, 10 g of meat sample was blended aseptically with 90 ml of 0.1% (w/v) peptone water in a laboratory blender (AOAC, 1990). To determine aerobic plate count, 1 ml of the blended sample was serially diluted up to 10^{8} dilution and transferred to duplicate petriplates. Plate count agar (DIFCO, USA) was added and inocubated at 37°C for 48 h. Colony forming units were counted in a colony counter (Bentex, India) and were expressed in log (cfu/g of sample. To determine yeast and mold count, 1 ml of the blended sample was serially diluted up to 10^{8} dilution and transferred to duplicate petriplate. Potato-dextrose agar (DIFCO, USA) was added and incubated at 30°C for 72 h. Colony forming units were counted and were expressed in log cfu/g of sample.

Statistical analysis

All data were the means of replications for three individual tests. Data were analyzed using analysis of variance (ANOVA) followed by Tunkey's critical difference test and the significance (p<0.05) between the means were tested using critical difference test (Snedecor and Cochran, 1968).

RESULTS AND DISCUSSION

Physicochemical characteristics

Initial pH of the pre-treated samples had lower values (Table 1) than the control without any pre-treatment. This was due to the acidic nature of the pre-treatment media 1, 2 and 3. With the progress of storage time, pH of meat samples were seen to increase between the range of 5.14 - 6.84, and the increase in control sample was greater than in the treated samples in case of all organs. However, effect of treatment 2 was the best in controlling increase of pH among all pre-treatments. In case of bicep femoris muscle, only pretreatment 2 showed significantly (P<0.05) lower pH value compared to the control, whereas in case of heart samples, pH of pretreatments 1 and 2 were significantly lower than control.

Water holding capacity (WHC), as expressed by pressed juice (g of water/100 g of meat), decreased with storage time in all samples from 33.98 - 5.24% (Table 2). However, WHC of different organs changed differently with the progress of storage time, e.g., WHC of heart, kidney and liver samples were found to decrease significantly (P<0.05) from 5th day of storage and that of

Table 2. Effect of pretreatment on water-holding capacity (g of water / 100g of meat) of refrigerated goat meat organs.

Treatment	Storage time (days)				Treatment mean ± SD (n = 12)
	0	5	10	15	
Bicep femoris muscle					
Control	18.06	14.70	13.62	3.24	$12.41^{a} \pm 6.40$
1	35.70	20.86	15.96	7.29	$19.95^{c} \pm 11.90$
2	20.79	14.73	13.89	11.31	$15.18^{b} \pm 4.01$
3	24.12	20.19	14.07	13.02	$17.85^{b} \pm 5.24$
Day mean ±SD	$24.67^{b} \pm 7.76$	$17.62^{b} \pm 3.37$	$14.39^{b} \pm 1.07$	$8.72^{a} \pm 4.45$	
Heart					
Control	26.88	16.98	11.22	3.63	$14.68^{a} \pm 9.80$
1	26.55	24.84	16.29	7.89	$18.89^{b} \pm 8.60$
2	28.92	19.23	17.55	8.04	$18.44^{b} \pm 8.55$
3	28.68	18.57	17.85	8.79	$18.47^{b} \pm 8.13$
Day mean ± SD	$27.76^{c} \pm 1.22$	$19.91^{b} \pm 3.42$	$15.73^{b} \pm 3.08$	$7.09^{a} \pm 2.34$	
Kidney					
Control	20.46	20.25	16.02	3.60	$15.08^{a} \pm 7.92$
1	38.66	21.78	23.58	21.78	$26.45^{c} \pm 8.18$
2	33.98	31.61	23.58	21.78	$27.74^{c} \pm 5.96$
3	31.68	22.62	17.25	12.87	$21.11^{b} \pm 8.10$
Day mean ± SD	$31.20^{d} \pm 7.72$	$24.07^{c} \pm 5.12$	$20.11^{b} \pm 4.04$	$15.01^{a} \pm 8.69$	
Liver					
Control	22.95	14.64	12.96	3.60	$13.54^{a} \pm 7.94$
1	31.26	25.89	15.24	13.26	$21.41^{b} \pm 8.59$
2	23.25	22.44	19.14	13.92	$19.69^{b} \pm 4.24$
3	29.94	28.65	15.87	13.53	$22.00^{b} \pm 8.50$
Day mean ± SD	$26.85^{c} \pm 4.37$	$22.91^{b} \pm 6.07$	$15.80^{b} \pm 2.55$	$11.01^{a} \pm 4.99$	

SD = Standard deviation; $^{a-d}$ means with different superscripts in a column are different ($P<0.05$).

Table 3. Effect of pretreatment on thiobarbutyric acid value (mg malonaldehyde /kg meat) of refrigerated goat meat.

Treatment	Storage time (days)				Treatment mean ± SD (n = 12)
	0	5	10	15	
Bicep femoris muscle					
Control	0.26	0.89	3.55	6.30	$2.75^{b} \pm 2.50$
1	0.12	0.60	0.89	0.93	$0.64^{b} \pm 0.34$
2	0.08	0.26	0.44	0.64	$0.36^{a} \pm 0.22$
3	0.03	0.20	0.28	0.64	$0.29^{a} \pm 0.24$
Day mean ± SD	$0.12^{a} \pm 0.10$	$0.49^{a} \pm 0.29$	$1.29^{b} \pm 1.38$	$2.13^{b} \pm 2.52$	
Heart					
Control	0.46	2.87	6.8	8.87	$4.75^{c} \pm 3.43$
1	0.35	0.48	0.83	0.92	$0.65^{b} \pm 0.24$
2	0.01	0.03	0.74	0.87	$0.41^{a} \pm 0.41$
3	0.02	0.23	0.41	0.54	$0.30^{a} \pm 0.21$
Day mean ± SD	$0.21^{a} \pm 0.21$	$0.90^{a} \pm 1.20$	$2.20^{b} \pm 2.78$	$2.80^{b} \pm 6.45$	
Kidney					
Control	0.42	0.72	3.59	6.47	$2.8^{b} \pm 2.56$
1	0.17	0.43	0.72	1.02	$0.59^{b} \pm 0.35$
2	0.19	0.41	0.66	0.89	$0.54^{a} \pm 0.28$
3	0.14	0.22	0.69	0.89	$0.49^{a} \pm 0.33$
Day mean ± SD	$0.23^{a} \pm 0.12$	$0.45^{a} \pm 0.19$	$1.42^{b} \pm 1.31$	$2.32^{b} \pm 2.50$	
Liver					
Control	0.64	2.52	5.14	8.52	$4.21^{b} \pm 3.09$
1	0.40	0.66	0.92	0.97	$0.74^{a} \pm 0.24$
2	0.23	0.71	0.83	0.90	$0.67^{a} \pm 0.28$
3	0.11	0.43	0.86	1.00	$0.60^{a} \pm 0.37$
Day mean ± SD	$0.35^{a} \pm 0.21$	$1.08^{b} \pm 0.88$	$1.94^{b} \pm 1.94$	$2.85^{c} \pm 3.42$	

SD = Standard deviation; $^{a-d}$ means with different superscripts in a column are different ($P<0.05$).

Table 4. Effect of pretreatment on extract release volume (ERV) (ml) of refrigerated goat meat.

Treatment	Storage time (days)				Treatment mean ± SD (n = 12)
	0	5	10	15	
Bicep femoris muscle					
Control	44.9	33.0	21.5	15.3	28.68^{a}±11.2
1	48.4	36.0	25.0	26.0	33.85^{a}±9.17
2	42.6	48.5	38.5	29.0	39.65^{a}±7.72
3	43.0	35.0	29.0	31.0	34.50^{b}±5.15
Day mean ± SD	44.73^{b}±2.40	38.13^{b}±6.36	28.50^{a}±6.64	25.33^{a}±6.32	
Heart					
Control	42.1	34.0	22.5	18.0	29.15^{a}±9.48
1	45.8	42.0	25.5	19.0	33.08^{b}±11.48
2	41.0	38.0	33.5	26.0	34.63^{b}±5.93
3	41.5	32.0	28.0	25.0	31.63^{ab}±6.50
Day mean ± SD	42.60^{b}±1.95	36.50^{b}±4.01	27.38^{a}±4.22	22^{a}±3.69	
Kidney					
Control	53.6	21.0	12.5	7.5	28.64^{a}±18.75
1	49.0	34.0	31.5	20.0	33.63^{c}±10.79
2	45.0	32.0	32.0	25.0	33.50^{b}±7.55
3	46.0	31.5	30.0	26.0	33.38^{b}±7.91
Day mean ± SD	48.40^{b}±3.49	29.63^{b}±5.29	26.50^{a}±8.48	19.63^{a}±7.69	
Liver					
Control	51.5	24.0	10.5	8.0	23.50^{a}±18.75
1	50.3	31.0	22.5	13.0	29.20^{ab}±10.79
2	43.2	31.0	27.0	15.5	30.54^{bc}±7.55
3	42.3	33.0	27.5	24.8	31.90^{c}±7.91
Day mean ± SD	46.83^{a}±4.29	29.75^{a}±3.53	21.88^{b}±7.15	15.33^{b}±6.37	

SD = Standard deviation; $^{a-c}$ means with different superscripts in a column are different (P<0.05).

bicep femoris decreased significantly (P<0.05) from 15th day of storage. In case of control, the value was significantly (P<0.05) lower than all the pretreated samples. Among the organs, water-holding capacity of bicep femoris was the lowest throughout the experiment. This might be due to shrinkage of myosin filaments, regulating hardening of meat samples as shown by texture score in Table 7. Pretreatment 2 was most effective in checking the decrease of WHC of meat.

Effect of pre-treatment 3 was best in controlling the TBARS value (a measure of oxidative rancidity) (Table 3). Oxidative rancidity of meat samples is well defined by the TBARS value. However, all the samples subjected to both pretreatments 2 and 3 showed significantly lower TBARS values than the control. TBARS values of bicep femoris and kidney samples with pretreatment 1 did not significantly (P<0.05) differ from control. With the progress of storage time, TBARS value generally increases and value > 1 signified objectionable rancid flavour. Pre-treated samples were found to be acceptable up to 15 days in comparison to the control samples (5 days), the control liver and heart samples being exceptionally unacceptable after 5 days of storage. Treatment 3, i.e., pre-treatment with tea liquor in combination with honey was the most effective in the control of rancidity. This may be due to the presence of polyphenol oxidase in tea liquor acting as antioxidant and effectively preventing the oxidative rancidity of meat. Also honey, another ingredient present in pretreatment 3 mixtures has antioxidant property, which can minimize the oxidative rancidity in meat, thereby preserving meat colour and flavour.

Samples having values of extract release volume (ERV) above 25 ml were only considered to be acceptable. ERV (a physical parameter of microbial spoilage) of the meat organ samples were observed to decrease significantly from 10th day of storage, except the insignificant decrease of ERV of bicep femoris samples throughout the storage period (Table 4). Among the organs, liver contained the lowest ERV at the end of storage. In case of bicep femoris samples, only pretreatment 3 offered significantly (P<0.05) higher ERV values than control. In contrast, heart samples did not how significant (P<0.05) difference of ERV compared to control. In case of kidney samples, effect of all the pretreatments significantly (P<0.05) differed from control, whereas in liver samples, only pretreatment 1 had no significant (P<0.05) effect compared to the control. Thus, pretreatment 2 and 3 were more effective than pretreatment 1 in controlling microbial spoilage. Both tea liquor and honey, present in pretreatment 3, have antibacterial activity. Honey has antibacterial properties and has even established usage in wound dressing (Cooper et al., 1998; Willix et al., 1992). It is also an antibacterial to *Staqphylococcus aurius*, *Escherichia Coli* and *Pseudomonas* type bacteria, which can grow under

Table 5. Effect of pretreatment on colour of refrigerated goat meat.

Treatment	Storage time (days)				Treatment mean ± SD (n = 12)
	0	5	10	15	
Bicep femoris muscle					
Control	7.50	5.83	4.33	3.17	$5.21^{a}\pm1.70$
1	4.83	5.83	5.25	4.17	$5.02^{a}\pm0.63$
2	6.83	6.77	5.50	5.33	$6.11^{b}\pm0.73$
3	7.00	6.33	5.17	6.00	$6.13^{b}\pm0.69$
Day mean ± SD	$6.54^{b}\pm1.06$	$6.19^{b}\pm0.41$	$5.06^{b}\pm0.46$	$4.67^{a}\pm1.13$	
Heart					
Control	7.33	5.33	4.16	3.00	$4.96^{a}\pm1.67$
1	5.67	5.67	5.50	3.83	$5.17^{b}\pm0.81$
2	6.87	6.00	5.67	5.00	$5.89^{b}\pm0.71$
3	7.00	6.50	6.17	5.33	$6.25^{b}\pm0.64$
Day mean ± SD	$6.72^{c}\pm0.66$	$5.88^{b}\pm0.45$	$5.38^{a}\pm0.78$	$4.29^{a}\pm0.97$	
Kidney					
Control	7.00	5.50	4.33	3.00	$4.96^{a}\pm1.54$
1	5.50	5.67	5.17	3.83	$5.04^{b}\pm0.76$
2	6.17	6.00	5.67	5.00	$5.71^{b}\pm0.47$
3	7.17	6.67	6.00	5.33	$6.29^{c}\pm0.73$
Day mean ± SD	$6.46^{c}\pm0.70$	$5.96^{b}\pm0.47$	$5.29^{a}\pm0.66$	$4.29^{a}\pm1.63$	
Liver					
Control	7.17	6.50	4.50	3.33	$5.38^{a}\pm1.61$
1	5.33	5.00	4.17	3.17	$4.42^{a}\pm0.87$
2	6.83	5.50	5.50	4.33	$5.54^{b}\pm0.93$
3	6.67	6.50	5.17	4.83	$5.79^{b}\pm0.84$
Day mean ± SD	$6.5^{c}\pm0.73$	$5.88^{b}\pm0.68$	$4.84^{a}\pm0.55$	$3.92^{a}\pm0.72$	

SD = Standard deviation; $^{a-c}$means with different superscripts in a column are different (P<0.05).

refrigeration (Al et al., 2003).

Sensory characteristics

Treatment of goat meat organs with pretreatmets 2 and 3 resulted in significantly (P<0.05) higher colour score than the control samples. Pretreatment 1 showed insignificantly (P<0.05) lower colour score than the control (Table 5). Initially colour score of raw meat was highest and was comparable only with the samples from pretreatment 3. With the increase of storage time, red colour intensity of samples decreased and at the end of the storage period from 10-15 days, a slimy greenish type appearance was observed in control liver sample. This may be due to some pseudomonas type bacterial growth (Guillou and Guispin-Michel, 1996) or may be due to some fungal growth. Pretreatments 2 and 3 scored higher than that of pretreatment 1 from the initiation of storage as red color disappears in the latter due to acetic acid treatment. In case of bicep femoris samples, colour score decreased significantly (P<0.05) beyond 10 days of storage, but for all other organs, it was after 5 days of storage. Among pretreatments, pretreatment 3 offered highest colour score in all organs due to the presence of antioxidants like tea liquor and honey.

With the progress of storage time, flavour of all organs was found to decrease significantly (P<0.05). However, flavour score of pretreated samples of all organs was observed to be significantly (P<0.05) higher than the control. Although at the initiation of storage, the meaty odor of control sample was comparable with the samples from pretreatments 2 and 3, with the progress of storage time, the control samples became objectionable with respect to odor; this may be due to the growth of spoilage bacteria in meat (Table 6). The samples treated with pretreatment 1 had lower flavour score than control at the beginning of storage, for having acidic flavor. However with the progress of storage time, it showed higher score than the control; this might be due to the presence of acetic acid and glucose that controlled the growth of undesirable microorganism to a greater extent than the control one.

Texture score of meat samples increased with storage time. However, texture score of pretreated samples was lower than control (Table 7). In case of bicep femoris muscle, there was no significant effect (P<0.05) of pretreatments on textural changes compared to control, with increasing storage days. This may be due to the contraction of myofibriler muscle in goat meat. Heart and liver samples treated with pretreatment 3 exhibited significantly (P<0.05) lower compression value than

Table 6. Effect of pretreatment on flavour of refrigerated goat meat.

Treatment	Storage time (days)				Treatment mean ± SD (n = 12)
	0	5	10	15	
Bicep femoris muscle					
Control	7.75	5.50	4.00	2.50	$4.94^{a}\pm2.03$
1	6.75	5.75	5.75	5.50	$5.94^{b}\pm0.50$
2	7.75	6.25	5.75	5.75	$6.38^{b}\pm0.86$
3	7.25	5.75	5.50	5.50	$6.00^{c}\pm0.76$
Day mean ± SD	$7.38^{d}\pm0.44$	$5.81^{c}\pm0.30$	$5.25^{b}\pm0.76$	$4.81^{a}\pm1.40$	
Heart					
Control	7.75	5.50	3.75	2.50	$4.88^{a}\pm2.06$
1	6.50	6.00	5.25	5.75	$5.88^{b}\pm0.47$
2	7.50	6.50	5.75	5.75	$6.38^{c}\pm0.75$
3	7.00	6.50	5.25	5.17	$5.98^{bc}\pm0.83$
Day mean ± SD	$7.19^{b}\pm0.50$	$6.13^{c}\pm0.44$	$5.00^{b}\pm0.78$	$4.79^{a}\pm1.41$	
Kidney					
Control	7.50	5.25	3.75	2.50	$4.75^{a}\pm1.95$
1	6.75	5.75	5.25	4.75	$5.63^{b}\pm0.77$
2	7.25	5.75	5.75	5.25	$6.00^{c}\pm0.79$
3	7.17	5.50	5.50	5.25	$5.86^{c}\pm0.80$
Day mean ± SD	$7.17^{c}\pm0.29$	$5.56^{b}\pm0.22$	$5.06^{a}\pm0.81$	$4.44^{a}\pm1.19$	
Liver					
Control	7.50	3.75	2.50	2.25	$4.00^{a}\pm2.19$
1	6.25	5.75	5.25	4.67	$5.48^{b}\pm0.62$
2	7.50	6.75	5.75	5.50	$6.38^{c}\pm0.84$
3	7.25	6.25	5.25	5.25	$6.00^{c}\pm0.87$
Day mean ± SD	$7.13^{b}\pm0.54$	$5.63^{a}\pm1.19$	$4.69^{a}\pm1.34$	$4.42^{a}\pm1.34$	

SD = Standard deviation; $^{a-d}$ means with different superscripts in a column are different ($P<0.05$).

Table 7. Effect of pretreatment on texture of refrigerated goat meat.

Treatment	Storage time (days)				Treatment mean ± SD (n = 12)
	0	5	10	15	
Bicep femoris muscle					
Control	2.65	4.73	4.90	11.76	$6.01^{a}\pm3.59$
1	0.81	3.50	4.62	4.88	$3.45^{a}\pm1.68$
2	2.65	2.70	4.73	5.03	$3.78^{a}\pm1.16$
3	3.30	4.19	5.06	6.18	$4.68^{a}\pm1.11$
Day mean ± SD	$2.35^{a}\pm0.97$	$3.78^{a}\pm0.80$	$4.83^{b}\pm0.18$	$6.96^{b}\pm2.94$	
Heart					
Control	1.35	5.30	7.28	7.65	$5.40^{b}\pm2.61$
1	0.32	1.06	1.77	3.08	$1.56^{a}\pm1.06$
2	1.55	2.34	3.11	3.40	$2.60^{a}\pm0.75$
3	1.95	2.64	5.74	5.97	$4.08^{a}\pm1.88$
Day mean ± SD	$1.29^{a}\pm0.63$	$2.84^{a}\pm1.61$	$4.48^{b}\pm2.26$	$5.03^{b}\pm1.97$	
Kidney					
Control	2.49	2.59	2.91	7.20	$3.80^{b}\pm2.05$
1	1.32	2.95	3.65	5.03	$3.24^{a}\pm1.40$
2	1.77	2.13	2.50	5.64	$3.01^{a}\pm1.61$
3	1.38	2.66	5.50	5.87	$3.85^{b}\pm1.98$
Day mean ± SD	$1.74^{a}\pm0.49$	$2.58^{a}\pm0.31$	$3.64^{a}\pm1.20$	$5.94^{a}\pm0.83$	
Liver					
Control	0.57	0.48	1.36	3.37	$1.45^{a}\pm1.22$
1	0.32	0.90	2.34	3.83	$1.85^{b}\pm1.42$
2	1.03	1.72	2.66	3.66	$2.27^{b}\pm1.03$
3	1.20	1.70	2.81	3.52	$2.31^{b}\pm0.95$
Day mean ± SD	$0.78^{a}\pm0.37$	$1.20^{b}\pm0.56$	$2.29^{c}\pm0.59$	$3.60^{d}\pm0.19$	

SD = Standard deviation; $^{a-d}$ means with different superscripts in a column are different ($P<0.05$).

Table 8. Effect of pretreatment on total viable count (cfu/g) of refrigerated goat meat.

Treatment	Storage time (days)				Treatment mean ± SD (n = 12)
	0	5	10	15	
Bicep femoris muscle					
Control	4.69	6.12	7.24	8.14	6.55^{c}±1.35
1	3.50	3.67	4.81	5.74	4.43^{a}±0.95
2	3.35	3.52	4.76	5.67	4.33^{a}±0.99
3	3.54	3.74	4.92	5.59	4.45^{b}±0.88
Day mean ± SD	3.77^{a}±0.56	4.26^{a}±1.12	5.43^{a}±1.09	6.29^{b}±1.12	
Heart					
Control	4.78	6.38	7.28	7.90	6.59^{c}±1.23
1	3.16	3.21	4.06	5.65	4.02^{a}±0.94
2	3.22	3.30	4.17	5.43	4.03^{a}±0.93
3	3.59	4.16	5.29	6.01	4.76^{b}±0.99
Day mean ± SD	3.69^{a}±0.68	4.26^{a}±1.33	5.20^{b}±1.35	6.25^{c}±1.10	
Kidney					
Control	4.70	6.25	6.88	7.36	6.30^{d}±1.05
1	3.23	3.78	4.11	4.59	3.93^{a}±0.52
2	3.85	4.36	4.64	5.03	4.47^{b}±0.55
3	3.97	4.72	4.93	5.56	4.80^{c}±0.59
Day mean ± SD	3.94^{a}±0.59	4.78^{a}±0.96	5.14^{b}±1.09	5.64^{c}±1.10	
Liver					
Control	4.75	6.00	7.73	8.26	6.69^{c}±1.46
1	3.26	3.48	4.79	5.30	4.21^{a}±0.90
2	4.10	4.52	4.91	5.30	4.82^{b}±0.47
3	4.18	4.65	5.12	5.75	4.93^{b}±0.61
Day mean ± SD	4.07^{a}±0.56	4.66^{b}±0.94	5.64^{b}±1.27	6.15^{c}±1.29	

SD = Standard deviation; $^{a-d}$ means with different superscripts in a column are different (P<0.05).

control. With kidney with pretreatment 3 showed reverse effect of contraction of meat that has been reflected through higher score, which would need further investigation.

Microbial characteristics

From the beginning of storage, all the pretreated samples showed significantly (P<0.05) lower TVC (total viable count) (Table 8), and yeast and mold count (Table 9) than control. This may be due to the pretreatments, which initially lowered the surface growth of samples. Considering 6 log cfu/g to be the marginal TVC for spoilage, control sample became unacceptable beyond 5 days of storage, whereas the treated samples extended the acceptable quality of goat meat up to the end of the storage period of 15 days. Treatment 2 was found to be most effective in controlling the growth of aerobic bacteria (except with bicep femoris where pre-treatment 3 was most effective), whereas treatment 1 was most effective in controlling fungal growth (except with liver samples pretreatment where 2 was most effective). Thus different organs were affected differently with the pretreatments. Liver samples in all cases were noted to contain maximum count of TVC, and yeast and mold. Thus, the above mentioned three treatments were acceptable in the of control microbial spoilage and to improve the quality of goat meat during 15 days storage at 4^{0}C. However, treatment 2 and 3 were more effective than 1 in controlling all the properties, with the exception of fungal growth of meat samples. Liver samples were most prone to spoilage.

CONCLUSION

In this study, minced goat meat organs were stored aerobically in a refrigerator at 4°C for 15 days after some combination pretreatments. It was observed that pretreated samples exhibited better physicochemical (pH, water holding capacity, TBARS value and extract release volume), sensory (colour and flavour) and microbial characteristics (P<0.05) in comparison to the control goat meat samples without any pretreatment. Among the pretreatments, tea liquor and honey pretreatment, and curing mixture offered more effective results for improving goat meat quality than pretreatment with acetic acid and glucose. However, acetic acid and glucose pretreatment controlled the fungal growth in meat samples most effectively. Curing mixture was most effective in controlling pH, water-holding capacity, extract release volume, flavour and aerobic bacterial count from the beginning to the end of duration of storage studied,

Table 9. Effect of pretreatment on yeast and mold growth (cfu/g) in refrigerated goat meat.

Treatment	Storage time (days)				Treatment mean ± SD (n = 12)
	0	5	10	15	
Bicep femoris muscle					
Control	3.23	4.61	6.31	6.57	5.18^{c}±1.42
1	2.71	3.28	4.36	4.58	3.73^{a}±0.80
2	2.93	3.44	4.65	4.92	3.99^{a}±0.87
3	2.85	3.53	4.78	5.11	4.07^{b}±0.96
Day mean ± SD	2.93^{a}±0.21	3.72^{a}±0.55	5.03^{b}±0.79	5.30^{c}±0.80	
Heart					
Control	3.29	4.76	6.46	6.78	5.32^{d}±1.47
1	2.95	3.29	3.48	4.77	3.62^{a}±1.39
2	3.08	3.37	4.65	5.08	4.05^{c}±0.88
3	2.99	3.83	4.00	4.94	3.94^{b}±0.73
Day mean ± SD	3.08^{a}±0.14	3.81^{a}±0.61	4.65^{a}±1.18	5.39^{a}±1.08	
Kidney					
Control	3.17	4.72	6.28	6.49	5.17^{d}±1.40
1	2.76	3.04	3.30	4.32	3.36^{a}±0.62
2	2.91	3.28	3.70	5.08	3.74^{c}±0.86
3	2.86	3.42	3.85	4.75	3.72^{b}±0.72
Day mean ± SD	2.93^{a}±0.16	3.62^{a}±0.68	4.28^{b}±1.22	5.16^{b}±0.85	
Liver					
Control	3.26	4.28	6.20	6.69	5.11^{a}±1.46
1	3.25	3.91	4.18	5.43	4.19^{a}±0.68
2	3.43	4.19	4.66	4.85	4.28^{a}±0.58
3	3.28	3.95	4.46	5.03	4.18^{a}±0.83
Day mean ± SD	3.31^{a}±0.10	4.08^{a}±0.18	4.88^{a}±0.82	5.50^{a}±0.75	

SD = Standard deviation; $^{a-d}$ means with different superscripts in a column are different (P<0.05).

whereas tea liquor – honey was the most effective pretreatment in controlling ERV, TBARS value, colour and texture of samples.

From this experiment it was concluded that pretreatment with curing mixture was most effective in controlling physicochemical, sensory and microbial characteristics of meat samples among all the pretreatments. Introduction of herbal-based tea liquor and honey pretreatment might be compared with the chemical-based pretreatment (acetic acid – glucose and curing mixture pretreatment) to improve meat quality and extension of shelf-life of minced goat meat, the former being more beneficial with added antioxidant activity, forming a value-added food product.

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