J Food Sci Technol (January–February 2010) 47(1):89–93

ORIGINAL ARTICLE

Effect of starter culture and turmeric on physico-chemical quality of carabeef *pastirma*

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Revised: 17 June 2008 / Accepted: 27 June 2009

Abstract Carabeef samples were sliced, pressed, cured and divided into 6 groups. Starter cultures (*Micrococcus varians* M483 (MV), *Staphylococcus carnosus* (SC), *Lactobacillus sakei* (LS), *M. varians* M483+ *Lb. sakei* and *Staph. carnosus* + *Lb. sakei)* were inoculated at the dose of 10^6–0^7cfu/g and stored at 10 ± 1°C for 7 days. Uninoculated samples were maintained as control. Samples were then divided into 2 treatment groups. Samples of treatment 1 (T_1) were smeared with a paste of turmeric followed by application of a thick layer of the paste of garlic, cumin, black pepper and red pepper whereas, samples of treatment 2 (T_2) were applied with a thick layer of spices as above without turmeric. With the gradual fall in pH there was a reduction in water-holding capacity (WHC) of samples. The WHC of samples treated with SC+LS of T_1 reduced to 6.3 ± 0.03 cm^2 and those inoculated with MV+LS of T_2 to 6.2 ± 0.03 cm^2. The extract release volume (ERV) increased in all samples during storage. The least ERV of 11.7 and 11.6 ml were recorded in samples inoculated with MV of T_1 and T_2, respectively. The tyrosine (TV) and thiobarbituric acid (TBA) number of turmeric treated samples were significantly lower than non turmeric treated samples. The samples inoculated with LS had the least TV of 30.9 mg tyrosine/100 g of meat and TBA number of 0.06 mg manoladehyde/kg of meat. Samples inoculated with MV and LS of both T_1 and T_2 were better in physico-chemical qualities.

Keywords Carabeef · *Pastirma* · *Micrococcus varians* · *Lactobacillus sakei* · *Staphylococcus carnosus* · Physico-chemical quality · Turmeric

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Introduction

Buffalo meat (carabeef) accounts for about 23.7% of the total of 6.32 million tonnes of meat produced in India (FAO 2007). In the Gulf countries, South-East Asian, European and American countries carabeef is relished because of its low cholesterol content and tender meat quality providing good export potential. Presently, carabeef is exported mostly in the form of deboned and deglanded meat that accounts for 97% of the total meat exports from India (APEDA 2008). The inherent problems in export of raw meat, such as freezer burn, surface discolouration, rancidity development, drip loss, microbial growth coupled with high cost of transportation have hindered in the expansion of Indian buffalo meat trade to lucrative European and American markets. To overcome these difficulties, processing and value addition of meat is viewed as a promising alternative. Processed meat products have the advantage of high microbial standard and minimum chance of disease transmission due to reduced water activity and pH. The low pH of processed meat product ensures inactivation of many pathogenic organisms and processing increases the palatability and tenderness of otherwise tough meat from aged animals.

Pastirma is a traditional processed meat product of Turkey. The name comes from '*bastirma*', meaning "being pressed". The beef is squeezed between stones to remove most of its water content. It is then covered with a paste called 'cemen', prepared from crushed fenugreek seeds, garlic and hot paprika and left for drying. It is prepared mostly from beef and carabeef and is valued for its superior keeping quality even at room temperature. The product is rated high for its exquisite flavour and taste.

It is nutrient dense and has superior biological value. As the production schedule includes marination of the product with incorporation of salt and salt-petre, there is scope of application of starter cultures in ensuring uniformity in quality and improvement in safety aspects of the product. Further, turmeric is an important condiment of India and is known for its preservative properties. However, no report on the effect of turmeric in the production of *pastirma*

could be found. In the present study, an attempt was made to elucidate the effect of starter cultures comprising of *M. varians, Staph. carnosus* and *Lb. sakei* and turmeric paste on quality attributes of carabeef *pastirma*.

Materials and methods

Raw materials, handling and curing: Carabeef from healthy animals slaughtered in the local market was collected in polyethylene bags and immediately brought to the laboratory. The lean meat was cleaned of visible fascia and cartilages and sliced into approximately 6 × 10 in size. Meat slices were then placed in between 2 stainless steel sheets and a weight of 100 kg was placed for overnight to remove free water from meat samples. After removal of free water, meat pieces were dry cured by using curing mixture consisting of salt (6–7%), sodium nitrite (0.20%) and sugar (3–3.5%) and were stored at 4 ± 1°C overnight.

Starter culture: Meat starter culture *M. varians* M483 (MV) was obtained from the culture collection of the department. The active culture (18–20 h old) grown in Mannitol salt broth (Chapman 1945) was then pelleted by centrifuging at 5000 rpm for 5 min in a refrigerated (–10°C) centrifuge (Model: 3K30, Sigma, Germany). The pellets were then resuspended in physiological saline solution to the desired concentration of cells. Number of cells/ml was determined by direct microscopic count method described by Harrigan and McCance (1976). Freeze-dried commercial meat starters comprising of *Lb. sakei* (LS) and *Staph. carnosus* (SC) were obtained from M/s Chr. Hansen, Denmark and applied at the same dose level as that of MV. Starter cultures were pumped in at multiple places in meat after curing and holding it for overnight at 10 ± 1°C at the dose level of 10^6–10^7cfu/g. The starter cultures were applied in 5 different combinations as MV, SC, LS, MV+LS, SC+LS and control samples were without any inoculation.

Meat slices were then put in polyethylene bags (0.001gauge) and stored at 10 ± 1°C for 7 days. Thereafter, the meat pieces were washed thoroughly in running tap water for 1 h to remove excess of salt, sodium nitrite and sugar. The samples were then air dried for 6 h in a locally fabricated clean air station maintained at 15 ± 1°C and with an air circulation rate of 0.05-0.1 m/sec.

Spices and turmeric application: After air drying, samples of each of 6 combinations were divided into 2 treatment groups. In treatment 1 (T_1), samples were applied with a thick paste of spices on all sides (garlic paste – equal to the weight of the meat, cumin powder 1%, black pepper 1%, red chilli powder 0.5% and turmeric powder 0.5% (w/w). In treatment 2 (T_2), samples were applied with paste of spices without turmeric. The samples of both T_1 and T_2 were stored at a temperature of 4 ± 1°C for 21 days. On completion of period of treatment, the samples were removed-off of the paste of spices and transferred to polyethylene bags (0.001 gauge) and stored at room temperature (22–27°C) up to 3 months.

Analysis: pH of fresh carabeef was determined by following the method of Pippen et al. (1965) by using a digital pH meter (Model 1000, Cyberscan, Merck, India) equipped with a combination probe electrode. Water holding capacity (WHC) was determined by following the filter paper press technique of Grau and Hamm (1953). The resultant impression area of the expressed water left behind on the filter paper was measured with the help of a digital polar planimeter (M/s Sokkia, Japan: Placom KP-90N). The average of 2 readings was taken and the WHC of meat sample was expressed in cm^2. Extract release volume (ERV) was determined by following the 'folded filter paper' method of Pearson (1967). Tyrosine Value (TV) was determined spectrophotometrically (M/s Varian, Cary 100 Bio UV-Vis, USA) by following the method of Pearson (1968). Thiobarbituric acid (TBA) number was determined spectrophotometrically by following the method described by Witte et al. (1970).

Statistical analysis: The data of 7 replicates of the experiment were analyzed statistically to ascertain the effect of starter culture and turmeric on physico-chemical properties of carabeef *pastirma* as per the methods described by Snedecor and Cochran (1994).

Results and discussion

The initial pH of the fresh carabeef lean was 6.2 ± 0.01 that decreased to 5.9 ± 0.01 after curing for 24 h. In all the samples treated with starter cultures as well as that of control samples, the pH declined steadily during storage (Table 1), registering the lowest pH of 5.6 ± 0.03 in samples treated with MV+LS. In control samples too, there was a gradual decline in pH up to 7 days of storage, the rate of pH fall being slower compared to samples treated with starter cultures. On 7th day, the control samples attained pH of 5.8 ± 0.06, which was significantly higher than the pH of treated samples. Starter cultures caused a significant difference in the rate of fall of pH of the carabeef *pastirma*. Irrespective of the starter cultures, samples treated with turmeric (T_1) had significantly lower pH than those without application of turmeric (T_2) (Table 2). The *pastirma* samples prepared with MV+LS and SC+LS showed fastest decline in pH registering a final pH of 4.6 ± 0.04. In control samples too, the pH of samples of T_1 was significantly lower (5.1 ± 0.03) than that of T_2 samples (5.6 ± 0.05) indicating a definite role of turmeric in causing a decline in pH of meat samples.

The micrococcal strain of *M. varians* M483 has been characterized to be mild producer of acids, the combined effect of which might be responsible for lowering of pH of *pastirma* inoculated with these cultures. Aksu and Kaya (2001) reported that *pastirma* samples prepared with *Staph. xylosus* + *Lb. sakei* had lower pH than *pastirma* manufactured with *Staph. carnosus*, *Staph. carnosus* + *Lb. pentosaceus*. Montel et al. (1992) reported that bacterial combination had a significant influence on pH fall in

Table 1 Effect of starter cultures on physico-chemical characteristics of carabeef *Pastirma* during storage at 10 ± 1°C

Storage period, days	Starter cultures					
	MV	SC	LS	MV+LS	SC+LS	Control
	pH					
1	5.9dC ± 0.01	5.8dC ± 0.01	5.7dB ± 0.00	5.7dA ± 0.00	5.7cA ± 0.00	5.9cD ± 0.01
3	5.8cC ± 0.01	5.8cC ± 0.02	5.7cB ± 0.02	5.7cA ± 0.03	5.7bA ± 0.01	5.9bD ± 0.00
5	5.8bC ± 0.02	5.7bBC ± 0.02	5.7bB ± 0.01	5.6bA ± 0.01	5.7bA ± 0.01	5.8bD ± 0.01
7	5.7aC ± 0.01	5.6aBC ± 0.02	5.6aB ± 0.01	5.6aA ± 0.03	5.6aA ± 0.00	5.8aD ± 0.06
	WHC					
1	3.5aAB ± 0.04	3.6aB ± 0.08	3.7aB ± 0.01	4.3aC ± 0.08	4.4aC ± 0.26	3.4aA ± 0.03
3	5.4bB ± 0.05	5.4bB ± 0.18	5.5bB ± 0.04	5.8bC ± 0.03	6.0bC ± 0.02	3.8bA ± 0.05
5	5.7cB ± 0.03	5.6cB ± 0.03	5.6cB ± 0.07	5.8cB ± 0.03	6.8cC ± 0.01	4.2cA ± 0.05
7	5.8dB ± 0.07	6.0dB ± 0.01	6.0dB ± 0.02	6.4dC ± 0.00	7.4dD ± 0.01	5.4dA ± 0.07
	ERV					
1	6.0aA ± 0.16	6.3aA ± 0.34	7.8aB ± 0.10	7.2aB ± 0.07	7.5aB ± 0.16	11.2aC ± 0.22
3	8.8bC ± 0.34	11.7bD ± 0.20	10.4bC ± 0.23	8.0bA ± 0.29	9.1bB ± 0.26	12.2bD ± 0.10
5	10.8cC ± 0.34	13.0cD ± 0.33	11.4cBC ± 0.34	10.2cA ± 0.19	10.7cBA ± 0.51	13.2cD ± 0.10
7	11.3dA ± 0.360	13.9dC ± 0.470	13.4dB ± 0.440	12.0dA ± 0.32	12.2dA ± 0.43	15.5dD ± 0.79
	TV					
1	26.8aC ± 0.07	26.4aB ± 0.05	26.1aA ± 0.01	26.7aC ± 0.05	26.4aB ± 0.01	27.0aD ± 0.01
3	28.0bE ± 0.01	27.6bC ± 0.00	27.2bA ± 0.01	27.7bD ± 0.06	27.4bB ± 0.02	28.5bF ± 0.00
5	28.7cC ± 0.00	28.6cB ± 0.00	28.4cA ± 0.00	28.6cB ± 0.00	28.5cB ± 0.00	29.4cD ± 0.00
7	29.9dC ± 0.00	29.3dA ± 0.00	29.3dA ± 0.01	29.8dBC ± 0.00	29.7dB ± 0.01	30.3dD ± 0.05
	TBA Nr					
	0.08 aA ± 0.001	0.06 aA ± 0.005	0.05aA ± 0.001	0.06aA ± 0.006	0.06aA ± 0.003	0.38aB ± 0.020
	0.19bB ± 0.007	0.19bB ± 0.002	0.13bA ± 0.004	0.17bA ± 0.006	0.14bA ± 0.005	0.83bC ± 0.052
	0.88cDE ± 0.026	0.84cCD ± 0.017	0.56cA ± 0.024	0.79cC ± 0.021	0.62cB ± 0.005	0.92cE ± 0.015
	1.46dCD ± 0.027	1.41dBC ± 0.013	1.34dA ± 0.026	1.39dAB ± 0.007	1.36dA ± 0.008	1.48dD ± 0.009

Mean ± SD in a column (a,b --) and in a raw (A,B ---) with different superscript differ significantly (P≤0.05) (n=7)
MV: *Micrococcus varians* M483; SC: *Staphylococcus carnosus*; LS: *Lactobacillus sakei*
WHC : Water holding capacity ; ERV : Extract release volume : TV: Tyrosine value; TBA: Thiobarbituric acid

fermented meat products and observed that sausages inoculated with *Lb. sakei* exhibited highest pH fall as compared to *Pediococcus acidilactici* and *P. pentosaceus*. Andersen (1995) however, reported that *Lb. sakei* used as the component of starter culture were low acid producers and pH developments were negligibly affected by addition of strain in meat mass.

WHC: The initial WHC of fresh carabeef was 3.1 ± 0.01 cm^2 which was marginally reduced to 3.2 ± 0.02 cm^2 by the end of curing process. The WHC of all *pastirma* samples inoculated with different starter cultures except those with *M. varians* M483 of 1 day was significantly lower than WHC of control samples (Table 1). The WHC of samples inoculated with LS either alone or in combination with MV or SC was lowest. On 1st day, the lowest WHC (4.4 ± 0.26 cm^2) was recorded for samples inoculated with SC+ LS. On 7th day, the samples inoculated with SC+LS had lowest WHC (7.4 ± 0.01 cm^2). Turmeric did not influence WHC of samples (Table 2). The samples inoculated with SC+LS had the lowest WHC in *pastirma* samples of both T_1 and T_2.

The extent of post-mortem pH fall affected WHC and higher the pH, less is the diminution in WHC of meat. Boschkova et al. (1983) in their study on the influence of starter cultures upon hydrophilic properties of non-comminuted raw-dried pork products also observed that WHC decreased with the drop in pH of meat. Smith and Palumbo (1983) while enlisting the beneficial effect of using starter culture for the production of fermented sausages noted that the pH fall brought about by the production of lactic acid by the homofermentative LAB caused denaturation of meat protein resulting in decreased WHC of sausage mix.

ERV: The ERV of fresh carabeef was 6.2 ± 0.01 ml, which decreased to 5.0 ± 0.01 ml after curing. ERV of all samples of *pastirma* increased during storage (Table 1). The samples prepared with the inoculation of *M. varians* M483 produced the minimum ERV of 11.3 ± 0.36 ml while that

Table 2 Effect of turmeric on physico-chemical properties of ready-to-eat carabeef *pastirma* stored for 3 months at room temperature (22–27°C)

		Starter cultures					
	Treatments	MV	SC	LS	MV+LS	SC+LS	Control
pH	T_1	4.8aC ± 0.01	4.8aC ± 0.03	4.7aB ± 0.02	4.6aA ± 0.04	4.6aA ± 0.04	5.1aD ± 0.03
	T_2	4.8bC ± 0.01	4.8bC ± 0.02	4.7bB ± 0.10	4.7bA ± 0.02	4.7bA ± 0.13	5.6bD ± 0.05
WHC	T_1	6.5BC ± 0.02	6.5B ± 0.02	6.6C ± 0.04	6.9D ± 0.01	8.3E ± 0.04	6.3A ± 0.03
	T_2	6.2A ± 0.02	6.6B ± 0.04	6.2A ± 0.03	6.8A ± 0.02	8.9D ± 0.02	6.2A ± 0.03
ERV	T_1	11.8bA ± 0.10	15.8bC ± 0.23	16.0bC ± 0.23	14.2bB ± 0.33	15.3bC ± 0.15	18.7aD ± 0.14
	T_2	11.6aA ± 0.12	14.4aC ± 0.25	15.7aD ± 0.44	13.8aB ± 0.33	15.0aC ± 0.26	18.8aE ± 0.32
TV	T_1	31.5aD ± 0.01	31.2aC ± 0.01	30.9aA ± 0.01	31.1aAB ± 0.01	31.0aB ± 0.01	32.1aE ± 0.01
	T_2	32.0bB ± 0.01	32.0 bB ± 0.01	31.8bA ± 0.01	31.9bB ± 0.01	31.8 bA ± 0.06	33.0bC ± 0.01
TBA number	T_1	0.12bE ± 0.00	0.11bD ± 0.00	0.06aA ± 0.00	0.09aC ± 0.00	0.08aB ± 0.00	0.14aF ± 0.00
	T_2	0.11aD ± 0.00	0.11aD ± 0.00	0.07 bA ± 0.00	0.09bC ± 0.00	0.09bB ± 0.00	0.14bE ± 0.00

Mean ± SD in a column (a,b --) and in a raw (A,B ---) with different superscript differ significantly ($p \leq 0.05$) (n=7). ($p \leq 0.05$) WHC, ERV, TV, TBA, MV, SC, LS: As in Table 1

of control samples released maximum of 15.5 ± 0.79 ml at the end of 7 days. The ERV determined at the end of 1st day showed that the *pastirma* samples prepared with the application of MV released minimum of 6.0 ± 0.16 ml of ERV while on 3rd and 5th day, the samples treated with MV+LS released the least ERV of 8.0 ± 0.29 and 10.2 ± 0.19 ml, respectively. Least ERV of 11.8 ± 0.10 and 11.6 ± 0.12 ml was by *pastirma* samples prepared with the application of MV and maximum ERV was recorded for the control samples in both T_1 and T_2. Strange et al. (1977) while evaluating 7 rapid analytical tests to monitor alterations in meat quality during storage opined **t**hat the ERV could not predict or monitor meat quality as expected.

TV: The TV of the fresh carabeef was 20.8 ± 0.01 mg tyrosine/100 g of meat and after curing for overnight, the TV was 24.5 ± 0.01 mg tyrosine/100 g of the sample. The TV of *pastirma* samples prepared with application of *Lb. sakei* was lowest (Table 1). Control samples showed highest TV. TV showed an increasing trend in treated as well as in control samples during storage. Samples treated with MV either alone or in combination with *Lb. sakei* had higher TV than samples treated with other starter cultures indicating that the strains possessed mild proteolytic activity. Turmeric had a significant effect in controlling the rate of protein degradation of *pastirma* (Table 2). The lowest TV of T_1 (30.9 ± 0.01 mg tyrosine/100 g of meat) was in samples treated with LS, while in T_2, the TV for the similar sample was 31.8 ± 0.01 mg tyrosine/100 g of meat. The highest TV was in the control samples in both treatments indicating that the starter cultures employed could effectively arrest the growth and multiplication of spoilage organisms. TV is used as a tool to monitor meat spoilage – higher the TV, more advanced will be the spoilage of the meat (Pearson 1968). *Lb. sakei* does not possess higher proteolytic activity (Andersen 1995). The micrococcal strain *M.varians* M483 possesses mild proteolytic activity and could cause milder but controlled proteolysis of meat with the liberation of free amino acids.

TBA number: The TBA number of fresh carabeef was 0.01 ± 0.002 mg malonaldehyde/kg of meat. After curing overnight, the TBA number remained almost same at 0.01 ± 0.012 mg malonaldehyde/kg of meat. Irrespective of starter cultures employed, there was a gradual increase in TBA number during storage (Table 1). Samples treated with LS showed minimum TBA. Turmeric showed a significant effect in controlling oxidative rancidity of fat of *pastirma*. The lowest TBA of T_1 was in samples treated with LS at 0.06 ± 0.00 mg malonaldehyde/ kg of meat, while in T_2, it was 0.07 ± 0.00 mg malonaldehyde/ kg of meat for similar samples. The highest TBA was in control samples in both treatment groups indicating that the starter cultures employed could effectively arrest oxidative rancidity of fat of carabeef *pastirma. Pastirma* samples inoculated with MV and SC had significantly higher accumulation of TBA as compared to samples inoculated with LS alone or in combination with MV and SC. Goma et al. (1978) reported that TBA of *pastirma* increased during salting and storage, the increase being less for samples stored at 4°C than those stored at room temperature. Salama and Khalafalla (1987) opined that there was a noticeable increase in TBA values after 48 h, followed by a marked drop, but values remained within safe limits in *basterma* processed with different levels of $NaNO_2$ and sorbic acid. Aksu and Kaya (2001, 2002b) reported that TBA values of *pastirma* produced with starters were lower than those of control group; however, they recorded TBA numbers much higher than those found in the present experiment. Aksu and Kaya (2002a) studied the effect of different commercial starter cultures on fatty acid composition of the *pastirma* and observed that *Staphylococcus carnosus, Staphylococcus carnosus + Lactobocillus pentosus, Staphylococcus xylosus + Lactobacillus sakei* had significant ($p < 0.01$) effect on fatty acid composition

of *pastirma*. TBA values of *pastirma* samples produced with starters were lower than those of the control group. Aksu and Kaya (2002b) reported that pastirma produced by using potassium nitrate and commercial starter culture (*Staphylococcus carnosus* + *Lactobacillus pentosus*) had a significant effect on counts of total aerobic mesophilic bacteria, *Micrococcus/Staphylococcus* and lactic acid bacteria.

Acknowledgement Authors acknowledge the support provided by Assam Agricultural University in carrying out the study. M/s Chr. Hansen, Denmark, deserves special thanks for providing the starter cultures as a gift.

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