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Full Length Research Paper

Effect of fermentation and drying temperature on the characteristics of goat meat (Black Bengal variety) dry sausage

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A new variety of fermented goat meat sausage was prepared from Black-Bengal goat. Lactic acid bacteria (LAB) *Lactobacillus casei* (NCIM 2586), *Lactobacillus plantarum* (NCIM 2083) and *Pediococcus pentosaceus* (NCIM 2245) were used as starter culture. Effect of temperature during fermentation and drying steps of sausage preparation was studied with respect to change in pH, lactic acid production, proximate composition, sensory characteristics and microbial characteristics in sausage (LAB count and viable aerobic cell count). Decrease in meat pH to 4.7–5.1 and corresponding increase in lactic acid production within 24 h of fermentation indicated potential use of combined starter culture in commercial production of fermented sausage. Among samples fermented at 25, 30 and 35°C, the one at 35°C was mostly acceptable industrially due to its lowest production cycle. The decrease in pH due to formation of lactic acid was directly proportional to the increase in drying temperature from 10 to 15°C. Sample fermented at 30°C, followed by drying at 10°C was the most acceptable sample with respect to sensory characteristics. Lactic bacterial cell count of sausage samples increased from 6.4 to 6.92 – 9.26 log cfu/ml within the fermentation period, then dropped to 6.19 –7.23 log cfu/ml at the end of drying.

Key words: Goat meat (Black Bengal variety), sausage, fermentation, lactic acid bacteria.

INTRODUCTION

Today, the primary genera of bacteria used as meat starter cultures are *Pediococcus*, *Micrococcus*, and *Staphylococcus*, in pure form, or in a mixture of two or three. These cultures are available fresh, frozen, freeze-dried, or in a low-temperature stabilized liquid form. A commercial starter culture was developed (Deibel and Niven, 1957) and offered to the meat industry in 1957 (Harris et al., 1957; Niven et al., 1959). Properly selected, physiologically active starter culture will ensure the required pH decrease, safety of sausage as well as improve its uniformity in the sense of flavour, appearance and texture and shorten the production cycles (Everson et al., 1970). In the production of dry sausage, fermented by *Lactobacillus rhamnosus* strains GG, LC-705, E-97800 as well as *Pediococcus pentosaceus* E-90390 and *Lactobacillus plantarum* E-98098, Erkila et al. (2001) reported their suitability for use as probiotic starter cultures in fermenting dry sausage with respect to the viable lactic cell, acceptable biogenic amine level as well as flavour profile compared to the commercial starter culture. During low temperature fermentation of Turkish dry sausage (Ceylan and Fung, 2000) using *Lactobacillus sake* and *Pediococcus acidilactici* H it was observed that pathogenic organism *Yersinia enterocolitica* was eliminated within 3 days of

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fermentation as compared to control sausage sample without starter culture, not eliminating the same after 4 days of fermentation and 12 days of drying. Again use of spent meat has been reported in sausage industry (Reddyand Vijayalakshmi. 1998) to improve their organoleptic scores and microbial properties during storage. Fermented mutton sausage using *P.acidilactici* H and *L. plantarum* 27 exhibited acceptable sensory score after 60 days of storage at 4°C (Wu et al., 1991).

Goat meat, a rich source of nutrition, is consumed worldwide, especially in the tropics and developing countries in large quantities (Park 1988, 1990). Goat meat is one of the most popular meat consumed by Indian people. Among different varieties of goat, Black Bengal goats (*Capra hircus*) are highly prolific and reputed for quality meat and skin production throughout the world (Salim et al., 2002).

Again, it has been reported that black tea has dietary component such as polyphenol that has antioxidant efficacy and may be capable of scavenging reactive oxygen species implicated in biological damage (Matsingou et al., 2000). Tang et al. (2001) observed that the antioxidant potential of added tea catechins was two to four fold greater than that of α-tocopherol at the same concentration to raw minced red meat (beef and pork) muscle on susceptibility to lipid oxidation during 10 days of refrigeration at 4°C.

Liquid smoke has inhibitory action against pathogenic and food spoilage organisms like *Lactobacillus plantarum*, *Listeria innocua*, *Salmonella, Escherichia coli*, *Saccharomyces cerevisiae*, *Aspergillus niger*; and *Pseudomonas putida* (Milli et al., 2005). Liquid smoke also removes carcinogenic benzopyrine compound present in direct wood-smoke.

The objective of this work is to prepare dry goat meat sausage from Black Bengal goat using combined lactic starter culture viz. *Lactobacillus casei* (NCIM 2586), *Lactobacillus plantarum* (NCIM 2083) and *Pediococcus pentosaceus* (NCIM 2245) and to study on its physicochemical sensory and microbial characteristics during fermentation and other stages. New variety of sausage was prepared by pretreating the meat with tea liquor and the addition of liquid smoke solution in the sausage mix to produce a safe and value added meat product.

MATERIALS AND METHODS

Sausage preparation

Preparation of standardized smoke solution: Smoke solution was prepared from burning saw dust in a smoke-producer and standardized at 7% titratable acidity with 0.1 N NaOH solution and solidified in refrigerator at 4°C for use as ice flakes in sausage preparation.

Pretreatment of goat meat: Minced goat meat muscle (Bicep femoris) was purchased from local market. After washing in warm distilled water at 80°C for 1 min, meat was immersed in tea (TATA tea, India) liquor 5% (w/v) tea leaves in distilled water) for 1 h followed by decantation.

Maintenance of starter cultures: Lactic starter cultures of present study viz. *Lactobaciillus casei* (NCIM 2586), *Lactobaciillus plantarum* (NCIM 2083) and *Pediococcus pentosaceus* (NCIM 2245) were kept at –20°C in 1:1 mixture of 1% (w/v) skim milk powder suspension (Difco, USA) and 1% (v/v) glycerol (HI Media, India). The cultures were subcultured three times before use, each at 37°C for 24 h. Freshly grown cultures were centrifuged and washed with distilled water separately at 5000 x g for 15 min at 4°C and used for inoculation separately at 2% (w/v).

Mixing and stuffing: Sausage ingredients (as shown in Table 1) were ground in a food processor up to uniform batter preparation. Then the batter was stuffed in a cellulosic casing (each weighed 50 g) in a stuffing machine and were kept in a fermentation chamber for fermentation up to 24 h.

Fermentation: Stuffed meat batters in casing were fermented at 25°C, 30 and 35°C at 95±2% relative humidity inside the chamber for 24 h, so that pH lies between 4.5-5.2.

Ripening: Stuffed casings, after fermentation, were removed from fermentation chamber and were kept in a drying chamber at 10 and 15°C at relative humidity 70±2% inside the chamber for 15 days to obtain goat meat dry sausage.

Analysis of goat meat sausage

After removal at different intervals during fermentation and ripening, goat meat sausages were peeled and were immediately kept in refrigerator at 4±1°C before analysis within the same day of preparation. Every data was the mean of analysis of three replications.

pH: Measurement of pH was performed according to AOAC (1984). 1 g of meat sausage sample was blended with 9 ml of distilled water in a laboratory blender for 2 min, filtered and then pH of the filtrate was determined by digital pH-meter.

Titrable acidity: Titratable acidity was determined as % lactic acid by titrating with 0. 1 N NaOH, using phenolphthalein as an indicator (AOAC. 1990).

Sensory analysis: Sensory scores for meat colour and flavour were determined by a twelve-member trained flavour and colour descriptive attribute panel using Hedonic 5-point scale method (1 = extremely objectionable, 2= slightly objectionable, 3= Neither objectionable nor acceptable, 4 = slightly acceptable, 5 = extremely acceptable).

Microbial analysis: Microbial analysis of sausage samples were performed after aseptically blending 10 g of sample in 90 ml 0.1% peptone – water in a blender for 2 min at high speed. The resulting samples were subjected to 10-fold serial dilutions. Finally, 0.1 ml of appropriate dilutions was spread onto plate count agar

Table 1. Sausage formulations.

Sausage formulations ingredients	% (w/w or v/w)
Minced Goat meat	60
**Liquid smoke	10
Sodium ascorbate	0.05
Dextrose	1
Tetrasodium pyrophosphate	0.5
Table salt	2.5
Sodium nitrite	0.01
Vegetable oil	0.01
BHA	15
Monosodium glutamate	0.01
Potassium sorbate	0.05
Refined wheat flour	0.02
* Spice mix	3.5
Ice flakes	1.5
***Condiments	10
Starter culture	4.5
	10^6 cells per gm of milk

*Spice mix: Coriander (25%), cumin (25%), clove (25%), black pepper (25%).
**Liquid mix is 10% (v/w) of meat.
***Condiments: Onion (25% w/w), garlic (25% w/w), coriander leaves 25%(w/w) and pudina leaves 25% (w/w).

Table 2. Variation of pH during fermentation and drying of sausage.

Stages	Treatment	Fermented at 25°C	Fermented at 30°C	Fermented at 35°C
Initial	-	6.3	6.3	6.3
	8	5.6	5.5	5.4
Fermentation (h)	16	5.2	5.0	4.9
	24	5.1	4.9	4.7
Drying at 10°C	5	4.8	4.9	4.6
(days)	10	4.9	4.7	4.7
	15	4.8	4.6	4.6
	5	4.6	4.6	4.4
Drying at 15°C	10	4.5	4.3	4.2
(days)	15	4.4	4.4	4.2

media for total aerobic bacterial count and MRS agar media for lactic bacterial count, and incubated at 30°C for 48 h until growth was evident. Colonies were counted.

RESULTS AND DISCUSSION

During fermentation of fermented goat meat dry sausage at various temperature; 25, 30 and 35°C as well as their drying at 10 and 15°C individually, following changes in characteristics of sausage samples were observed, sufficient enough to explain the variation of quality of sausage samples at various conditions.

pH and lactic acid

During 24 h (1 day) fermentation, the pH of samples decreased rapidly from initial pH of around 6.3 to final pH of 4.7-5.0 (Table 2), corresponding increase in lactic acid concentration (Table 4). These data suggested that by the fermentation with combination of *L. casei*, *L. plantarum* and *P. pentosaceus* as starter, pH decreased due to formation of lactic acid. During the fermentation, antibacterial compounds viz. bacteriocins were produced simultaneously, which suppressed the growth of other pathogens during fermentation. This phenomenon could also be supported by changes in pH and main microflora

Table 3. Variation of lactic acid concentration after fermentation and drying of sausage.

Samples	Stages	Lactic acid concentration (%)
Fermented at 25°C	Fermentation	0.5
	Drying at 10°C	1.1
	Drying at 15°C	1.5
Fermented at 30°C	Fermentation	0.7
	Drying at 10°C	1.3
	Drying at 15°C	1.5
Fermented at 35°C	Fermentation	1.3
	Drying at 10°C	1.1
	Drying at 15°C	1.6

Table 4. Proximate analysis of goat meat dry sausage at different stages of preparation.

Composition	Stages	Fermented at 25°C	Fermented at 30°C	Fermented at 35°C
Moisture (%)	Initial	61.2	61.2	61.2
	Fermentation	52.4	51.2	49.8
	Drying at 10°C	37.1	35.7	34.9
	Drying at 15°C	37.8	36.2	35.3
Fat (%)	Initial	14.3	14.3	14.3
	Fermentation	19.8	20.1	22.2
	Drying at 10°C	22.1	22.4	22.8
	Drying at 15°C	23.2	23.1	23.2
Protein (%)	Initial	21.1	21.1	21.1
	Fermentation	32.4	33.2	33.6
	Drying at 10°C	33.5	33.6	33.9
	Drying at 15^{o0}C	33.5	33.7	34.2

during fermentation (Tables 2 and 6). The buffering capacity for fermentation was contributed by the mutton (goat meat), nitrite and salt. Also, the starter cultures competed with natural meat microflora (Bacus, 1984). In spite of these factors, combined starter culture bacteria decreased to pH 4.7 – 5.1 within 24 h indicating their potential for use in commercial production of fermented sausage.

Again it has been observed that at the end of fermentation, desired pH of fermentation (4.9 - 5.0) was achieved after 24 h fermentation, at temperature 30 and 35°C, which is the desired mesophilic condition for lactic bacterial growth. With the progress of drying, the decrease in pH due to formation of lactic acid was directly proportional to the increase in drying temperature from 10 to 15°C. However, interesting notification was that samples fermented at 25 and 30°C achieved the same pH (4.4) after 15 day drying at 15°C, whereas samples fermented at 30 and 35°C, achieved same pH (4.6) at 10°C after completion of drying time.

Thus the sample fermented at 30°C was mostly acceptable in terms of change in pH in our study as we allowed 24 h fermentation. But production cycle of the sample incubated at 35°C was least, indicating its maximum industrial application.

Lactic acid concentration of sausage samples (Table 3) varied from 0 to 0.5-1.3 after fermentation and 1.1-1.6 after drying. Amount was directly proportional to the temperature. This increase may be due to reduction in moisture level.

Proximate analysis

Moisture fat and protein content raw goat meat were of 68.0, 12.1 and 21.0% respectively (Table 4). In this study, there was decrease in moisture content resulting in relative increase in fat and protein content of sausages, and it was found to be directly proportional to the fermentation temperature and inversely proportional to drying temperature. Drying sausages contain 30-40% moisture content (Jay, 1992). In our study, sausage samples, of initial moisture content of 61.2% reduced to 34.9-37.8%, conforming the previous data.

Table 5. Effect of fermentation and drying on sensory characteristics of sausage.

Attributes	Drying condition	Fermented at 25°C	Fermented at 30°C	Fermented at 35°C
Taste	Drying at 10°C	3.7	4.1	3.8
	Drying at 15°C	3.8	4.9	3.8
Flavour	Drying at 10°C	4.3	4.2	3.8
	Drying at 15°C	4.5	3.9	3.7
Texture	Drying at 10°C	4.3	4.7	4.1
	Drying at 15°C	4.5	4.3	3.8
Overall acceptability	Drying at 10°C	4.1	4.4	4.2
	Drying at 15°C	4.2	4.1	4.0

Table 6. Variation of microbial counts during fermentation and drying of sausages.

Microbial Counts	Stages	Fermented at 25°C	Fermented at 30°C	Fermented at 35°C
Aerobic plate count (log cfu/g)	Initial	6.23*	6.28	6.43
	Fermentation	7.26	7.89	8.26
	Drying at 10°C	8.13	8.20	9.22
	Drying at 15°C	8.41	8.85	9.37
Lactic acid bacterial count (log cfu/g)	Initial	6.35	6.40	6.45
	Fermentation	6.92	8.65	9.26
	Drying at 10°C	6.64	7.15	7.59
	Drying at 15°C	6.19	6.86	7.23

Sensory analysis

The acceptability on taste, flavour, texture and overall acceptability were satisfactory (Table 5). This is considered to be due to the hydrolysis of muscle proteins and lipid, which consequently released the taste and flavour components. The overall acceptability of goat meat dry sausages from any fermentation condition and corresponding drying condition was good. However, mostly acceptable taste flavour, texture and overall acceptability were from samples fermented at 30°C, followed by drying at 10°C; fermented at 25°C, followed by drying at 15°C; fermented at 30°C, drying at 10°C; and fermented at 30°C, followed by drying at 10°C, respectively. Hence sample fermented at 30°C, followed by drying at 10°C was mostly acceptable considering sensory characteristics.

Microbial characteristics

As indicated in Table 6, the LAB (lactic acid bacteria) counts of sample increased from around 6.4 to 6.92-9.26 log cfu/g, it increases with increase in fermentation temperature indicating optimum fermentation temperature to be 35°C; but at the end of drying, lactic bacterial cell counts dropped to 6.19-7.23 log cfu/g and the decrease in viable cell count was directly proportional to the increase in drying temperature. However, viable lactic bacterial cell, along with resultant acid and other antimicrobial products viz. bacteriocin might have been sufficient to destroy other pathogenic microorganisms, inhibiting the growth of main microflora, inhibiting growth of psychrophilic bacteria such as pseudomonas species and accelerate the hydrolysis of muscle proteins and lipids (Bacus, 1984).

Conclusion

During the preparation of goat meat sausage from Black-Bengal goat using starter culture of lactic acid bacteria (LAB) *L. casei* (NCIM 2586), *L. plantarum* (NCIM 2083) and *P. pentosaceus* (NCIM 2245) decrease in meat pH to 4.7–5.1 within 24 h of fermentation indicated potential use of the abovementioned starter cultures in commercial production of fermented sausage. 35°C was mostly acceptable fermentation temperature industrially due to its lowest production cycle i.e. to achieve the desirable pH of the sausage. Again decrease in pH was directly proportional to the increase in drying temperature from 10 to 15°C in this study. Sample fermented at 30°C, followed by drying at 10°C was the most acceptable sample with respect to sensory characteristics. Lactic bacterial cell count of sausage samples increased upto 9.26 log cfu/ml within the fermentation period, then dropped to 6.19–7.23 log cfu/ml at the end of drying. However, viable lactic

bacterial cell, together with resultant acid and other antimicrobial products such as bacteriocin, were sufficient to destroy other pathogenic microorganisms.

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