The safety of Basturma, an armenian-type dried beef with respect to Salmonella

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Introduction

In 1982 an outbreak of human salmonellosis occurred in California as a result of consumption of Basturma, an armenian-type dried beef product. The outbreak raised the question of the safety of this and other ethnic specialty meat products produced by small plants and frequently distributed to many parts of the country (Johnston, 1983, Dairy and Food Sanitation, 3:415). Basturma, in particular, is very popular in Eastern Mediterranean countries where it is made from beef or camel meat (Abdallah, et al, 1978, Annals Agric. Sc. Moshtohor 9:125). It is made in the USA by curing the whole beef Semitendinosus muscle with injected brine (NaCl, $NaNO_2$) and dry salt at room temperature for 3 to 5 days. The product is then soaked in water for a couple of hours, dried for 3 to 4 days, next pasted with spices, dried for 3 to 5 additional days and then stored in the refrigerator until used. Literature addressing the safety and technology of Basturma with respect to its production in the USA is completely absent. In this study we determined the survival of Salmonella in meat brines and the product made under traditional methods, and then we developed thermal processing approaches which assured both the destruction of salmonellae and the preservation of product characteristics.

Materials and Methods

Preparation of Basturma. Fresh whole Semitendinosus muscle (eye of the round) was bought at delivery time from the local supermarket. After trimming the muscle (whole or cut longitudinally into two halves), it was then injected with 10% (w/w) brine made of 25% NaCl and 0.2% $NaNo_2$ in water. The muscles were placed in stainless steel pans and dry NaCl was added to their surface at levels of 4.7 to 10% (w/w). The meats were cured at 4°C for up to 6 days with frequent rotation to increase uniformity in brine penetration. After curing, the meats were soaked in water for 1 hour at room temperature and then drained and heated or simply hung for drying at room temperature (20-25°C). Heating was done in an air circulating laboratory oven. Oven and meat temperatures were recorded every 5 minutes using thermocouples and a Hewlett Packard 85 computer with a data aquisition control unit (No. 3Y97A). After drying for a predetermined time each muscle was pasted with a mixture of spices (21.1% of meat weight) in water (26.40% of meat weight). The spices included flour, foenugreek, pepper, cumin, garlic, paprika and food color. Next the meats were dried again for a desired time (usually 3-4 days) and then refrigerated. Analyses of meat for water, NaCl, brine and pH were done according to standard methods (A.O.A.C. 1975).

Salmonella inocula and counting. Serotypes S. typhimurium, S. infantis, and S. dublin were used as pooled inocula of 24 hour cultures in brain heart infusion (BHI) broth at predetermined levels. The salmonellae that were present in brines were counted by plating appropriate dilutions on XLD or BHI agars (Difco). Salmonellae present in meats were counted by homogenizing 70-90g of meat with 560-720 ml Selenite-Cystine broth (Difco) and then plating on XLD and BHI agars. For the detection of low levels of surviving salmonellae, the above homogenate was enriched for 18-24 hours at 37°C and then plated on XLD and BHI agars. Studies on Salmonella survival in meats during the various stages of meat processing were based on 0.01 ml of pooled cultures inoculated in multiple locations in the deepest part of each muscle along its longitudinal axis. At different intervals, segments of the muscles (70-90 g each) containing the individual inocula were cut and analyzed for salmonellae as described above. Surviving salmonellae are reported as cells/segment. From the initial inoculum and the surviving cells, the decimal reductions (DR) of the initial population exposed to a particular environment were calculated and reported.

Results and Conclusions

To minimize the potential of Salmonella growth during the processing of Basturma some of our early recommendations to the manufacturer of the incriminated product included: 1) avoiding the purchase of beef from suppliers who transport and sell both beef and poultry meat together; 2) increase the amount of injected brine to obtain a level of 8% brine in meat or higher by the end of the curing; 3) cure at 4°C, soaking the meat in cool water after curing and; 5) acidifing the paste to pH 3.4 with food grade acetic acid. The last approach was found experimentally to cause 0.79 DR of salmonellae present on the surface of Basturma (9% brine) per day of drying. By comparison, the regular paste caused 0.34 DR and in the absence of paste the salmonellae died on the surface of Basturma at a rate of 0.27 DR/day of drying. Consequent monitoring of the finished product by U.S. Department of Agriculture personnel demonstrated the potential survival of Salmonella during the Basturma processing even after implementation of the recommended changes. These findings led to a reexamination of Salmonella survival in the product during the various stages of production. Additional efforts were made also to develop alternative processes which included a heating step to destroy the salmonellae present initially in the raw beef.

Effect of salt on Salmonella destruction in broth and curing brines. BHI broth (pH 6.0) with 3.8, 7.6 and 15.2% NaCl and meat juices with 25% NaCl were inoculated with the Salmonella pool and stored at 4°C. As shown in Figures 1 and 2, no significant decrease of Salmonella levels were observed during the first 8 days of storage. These findings are in agreement with reported data which indicated the survival of salmonellae for weeks in cured meats and brines with up to 25% salt. Morazza and Crespi, (1963, Att. Sco. Ital. Sci. Vet. 17:557) reported that two months storage at room temperature of naturally contaminated salami with 23% brine did not cause complete destruction of Salmonella. Ninety percent destruction of Salmonella in bacon with 9.1-10.7% brine took place in 4 weeks at 5°C and 98.5% destruction was observed at 25°C (Bardsley and Taylor, 1960, Br. Food Manuf. Res. Assoc. Res. Rep. p 99). Shipp (1958, Proc. 2nd Inter. Symp. Food Microbiol, p 227) found that S. enteritidis died faster in salt at 20°C than at 5°C. He reported that in meat extract broth with 25% NaCl S. enteritidis decreased by 4 DR after storage for 28 days, at 4°C and by 6 DR after storage for 4 days at 20°C. Overall S. enteritidis survived 20 hours at 37°C, 4-7 days at 20°C and 8-10 weeks at 5°C. Buttiaux and Moriamez (1958, Proc. 2nd Inter. Symp. Food Microbiol., p. 247) observed 1.24 DR of Salmonella in 23.5% brine with 7000ppm nitrate in 15 days at 6°C and 5.58 DR in 4 days at 15°C. In meat broth with the same brine concentration they observed 0.33 DR after 15 days at 6°C and 1.21 DR after 16 days at 15°C. In meat broth with 23.5 NaCl and 1100ppm nitrite the authors observed 0.65 DR after 15 days at 6°C and 1.59 DR after 15 days at 15°C. These and other authors have demonstrated the reduced lethal action of NaCl at low temperatures (Ingram and Kitchell 1967, J. Food Technol. 2:1). Overall the effect of NaCl on Salmonella growth and survival is affected by its concentration, Salmonella level and strain, nature of substrate, pH, Eh and temperature (Genigeorgis, et al 1977, Proc. 7th Inter. Symp. WAVFH p 269). In the present study curing of meat at room temperature could accelerate Salmonella destruction in certain spots, yet possible slow salt penetration could also allow growth of this and other pathogens before the brine reaches inhibitory levels.

Survival of Salmonella during traditional Basturma processing. Basturma was made as described in the methods without or with 10% glucose in the injected brine and 5% glucose in the dry salt. After one day curing at 4°C, the Salmonella pool was inoculated in multiple locations and the curing was extended for 5 more days. After curing, the meat was hung for 3 days at room temperature, then pasted and rehung for another 5 days. The presence of glucose in the meat did not cause any decrease in the regular pH (5.3-5.5) of Basturma. This was probably due to the repression of the lactic acid bacteria by the high brine concentration (>8%) in the meat during curing, and more than 15% after drying. The inoculated salmonellae decreased by about 1 DR (Figure 3) during the curing, 0.68-0.82 DR during the drying and 0.04-0.18 DR during the drying after pasting. Overall the commercial method of processing without use of heating could cause 1.68-2.1 DR to the inoculated salmonellae. This means that levels of contamination greater than 48-126 cells/g will result in survival in the finished product.

Effect of thermal processing on Salmonella destruction in Basturma. To minimize the potential of Salmonella survival in the finished product, a heating step after curing was evaluated in a number of experiments. To accelerate salt and heat penetration and improve product uniformity, each muscle was sliced into two halves (about 5 cm diameter). Curing was based on 10% injected brine, a 4.7-10% addition of dry salt, and storage at 4°C for 6 days. After curing the meats were soaked in water for 1 hour, drained and then cooked. Salmonellae were inoculated either before curing or heating. Meat segments containing the inocula were cut and analyzed, usually at hourly intervals. Cooked meats were dried, pasted with unacidified paste and dried again for a predetermined time. Selected experimental data are presented in tables 1 and 2. Heating in the laboratory oven was not uniform. Pieces of meat on the top rack showed faster heat penetration. This did not affect the experiments because heat penetration for each meat piece was monitored with thermocouples. Since direct plating on XLD agar gave lower Salmonella counts than plating on BHI agar, only the latter counts are reported in the tables. Due to variations in the initial meat temperature, brine concentration, inoculu size, and heat penetration rates, it is difficult to make practical comparisons of the various experiments. Nevertheless, some conclusions can be drawn. Curing of meat with 10% injected brine (w/w) and 5% or more dry salt and storage at 4°C for 6 days to accomplish 8% or more brine in the center of the meat, caused 0.96-1.10 DR to initially inoculated salmonellae. Heating the meat to a maximum internal temperature (I.T.) of 49.3°C within 6 hours caused >1.22-3.24 DR. Boosting the internal temperature to 53°C within 6 hours increased the DR to 2.93-3.20. Because of the interruption of the hours heating process to collect the inoculated meat segments every hour, the above Salmonella lethalities do not exactly parallel the full impact expected during an uninterrupted commercial heating process.

The effect of curing, uninterrupted heating and drying on Salmonella survival was evaluated in one experiment. Meat ws cured with 10% brine and 4.7% dry salt at 4°C for 6 days. This curing resulted in a meat brine of 8-9.8%. Using an oven temperature of 59°C, the internal meat temperature was raised to 51.8 within 6 hours after which the meat was dried for 3 days. None of the 2.8×10^3 and 2.8×10^4 salmonellae inoculated per meat segment survived the curing, cooking and drying steps indicating a reduction of greater than 4.45 DR. As a result of cooking, the meat lost more than 10% of its weight. The total weight loss during the drying period was 7.5-12.5% for the first day. 14-19% for the first 2 days and 17.8-24.5% for the first 3 days. The final brine in the meat ranged from 11.5-16.4 and the pH from 5.3-5.5. As expected, heat damaged salmonellae continue dying during the dehydration step. In one set of experiments (Table 1), drying for 4-6 days, after heating to I.T. 46.4-48.6 in 4-5 hours, resulted in 0.94-1.48 DR in addition to the DR obtained by heating. Drying after pasting gave an additional 0.43-0.57 DR which is by far greater than the 0.04-0.18 DR obtained for the same step of processing under the traditional method (using no heating).

Published data indicated that NaCl affects both the heat resistance of microorganisms as well as their recovery after heat stress. The heat resistance is affected by: 1) the organisms being exposed to NaCl before heating; 2) the water activity (a_w) of the heating medium and the nature of humectant used to adjust the a_w and; 3) the presence of NaCl in the recovery medium. Growth or preincubation of various organisms, including Salmonella in the presence of increased NaCl concentrations, has resulted in increased heat resistance when the heating took place in media containing high NaCl concentrations (Sofos, 1983, J. Food Safety, 6:45). In the absence of experimental data we speculate that this might be the case in heated Basturma too. In general, a decreased a_w in the heating medium increases the heat resistance of microorganisms by protecting them from thermal injury and destruction. This is expecially true when weak electrolytes like sugars are used as humectants. The picture with respect to NaCl and Salmonella is not very clear and it may differ with NaCl level, strain and medium. (Sofos, 1983; Cotterill and Glauert, 1969, Poultry Sci. 48:1156; Baird-Parker, et al, 1970, J. Appl. Bact. 33:575). According to the latter authors, the resistance of heat resistant strains was generally decreased in the presence of NaCl, whereas that of the heat sensitive strains was increased. In our study (Table 2), we found indications, only in one instance, that higher brine levels caused faster destruction of salmonellae during the heating of Basturma; the presence of NaCl in the recovery medium seems to minimize the recovery of thermally injured salmonellae and other bacteria (Sofos, 1983). In the present study this was seen during the dehydration of Basturma when we observed more DR in heated than unheated meat (1.41-2.05 DR versus 0.72-1.0 DR, respectively).

Overall, the traditional Basturma process could not guarantee a finished product free of Salmonella. This process resulted in 1.68-2.10 DR of a Salmonella population present in the fresh beef or 1 Salmonella in 48-126 could survive the process and be found in the finished product. Introduction of a heating step followed by dehydration will increase the margin of safety. We had calculated that the overall process that includes a heating step to 49.3°C I.T. will allow survival of less than 1 in 4900 salmonellae (DR of at least 3.69). Heating to an I.T. of 53°C will allow survival of less than 1 Salmonella in 199,500 (DR of at least 5.30 for the whole process). Overall, the introduction of the cold curing step minimized spoilage levels. The introduction of the heating step in the process increased its margin of safety significantly. What is more significant is that the heating did not diminish the acceptability of the finished product. In the opinion of both producers and consumers it even improved it. The present study has demonstrated the potential of Salmonella survival in cured meat products whose process does not include a fermentation or a terminal heating step. It also demonstrated the potential hazard to consumers from such products. The level of surviving cells, the strain, and the health state of the individual consumer, will determine if food poisoning may occur.

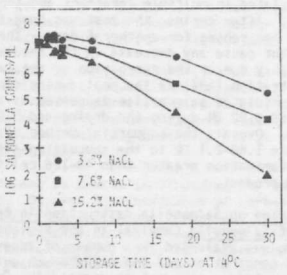

Figure 1. Reduction of salmonellae inoculated in brain heart infusion with three levels of sodium chloride during storage at 4 C (Reduktion der Salmonellenkeimzahl in Gehirn/Herz Infusions Kulturen mit drei verschiedenen Salzkonzentrationer bei 4°C)

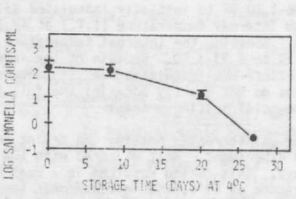

Figure 2. Reduction of salmonellae present in meat brines with 25% sodium chloride during storage at 4°C (Reduktion der Salmonellenkeimzahl in 25% Salz enthaltenden Fleischbeizen bei 4°C)

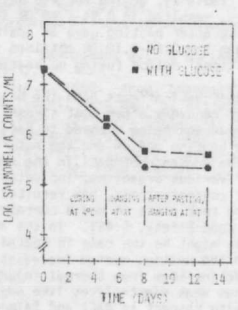

Figure 3. Fate of salmonellae in Basturma meat with or without glucose during three stages of processing (Salmonellen in Basturma-Fleisch mit oder ohne Glukose während drie verschiedene Verarbeitungsphasen)

Table 2. Survival of Salmonella during heating and drying of Basturma. (Die Überlebenstrate von Salmonellen in Basturmafleisch während seiner Erhitzungs- und Trocknungsphase).

Heating time (hrs)	Experiment 5 — Sliced muscle cured with 10% dry salt; brine in center 15%; oven temp. 57.5°C — A: Meat temp. (°C)	A: Salmonella[a] counts	B: Meat temp. (°C)	B: Salmonella counts	Experiment 6 — Sliced muscle cured with 10% dry salt; brine in center 13%; oven temp. 57°C — Meat temp. (°C)	Salmonella counts	Experiment 7 — Sliced muscle cured with 6.0% (A) and 7.5% (B) dry salt; brine 11.5% (A) and 14.2% (B); oven temp. 57.5°C (A) — Meat temp. (°C)	A: Salmonella counts	Meat temp. (°C)	B: Salmonella counts
0	20.2	8.6×10^3	20	8.6×10^2	18.4	1.4×10^3	16.6	1.6×10^3	16.6	1.6×10^3
2	42.7	+	47.3	+			44.4	+	44.4	+
3	46.2	+	50.8	+			47.9	+	47.9	+
4	48.6	+	52	+	47.6	+*	50.4	+	50.4	+
5	49.9	+	53	+	52.4	(*3.15DR)	51.7	+	51.7	+
6	47.6	+	53.5	* (2.93DR)	51.6		52.4	+	52.4	(3.2DR)
7							54.4	(3.2DR)	54.4	
After heating 4 hrs and hanging 6 days		+								
After heating 5 hrs and hanging 6 days		+								
After heating 6 hrs and hanging 7 days		- (3.93 DR)								

*Based on enrichment and plating

a = Zero time Salmonella counts represent the level inoculated per meat segments

DR = Decimal reductions of initial Salmonella inoculum

Table 1. Survival of Salmonella during heating and drying of Basturma. (Die Überlebenstrate von Salmonellen in Basturmafleisch während seiner Erhitzungs- und Trocknungsphase).

Heating time (hrs)	Experiment 5 — Sliced muscle cured with 10% dry salt; brine in center 15.16%; oven temperature 57.5°C — Meat temp. (°C)	Salmonella surviving counts	DR*	Experiment 4 — Sliced muscle cured with 10% dry salt; brine in center 13.6%; oven temperature 52.5°C for 4 hours then 57.5°C — Meat temp. (°C)	Salmonella surviving counts	DR	Experiment 7 — Sliced muscle cured with 5% (A) and 7.5% (B) dry salt; brine in center 8.6% (A) and 14.2% (B); oven temperature 57.5°C (A) and (B) — temp. (°C)	Salmonella surviving counts	DR	temp. (°C)	Salmonella surviving counts	DR
0	20	8.6×10^6	0.00	19.6	3.0×10^7	0.00	16.4	1.6x10	0.00	15.8	1.6×10^7	0.00
2	44.4	1.8×10^5	0.68	41.9	3.4×10^6	0.95	40.5	3.7x10	0.64	41.5	1.8×10^6	0.95
3	44.9	8.8×10^5	0.69	42	4.8×10^6	0.80	43	3.4x10	0.67	44.3	2.1×10^6	0.88
4	47.6	2.0×10^5	1.63	43.5	3.8×10^5	0.90	45.8	1.1x10	1.16	47.0	1.2×10^5	1.18
5	48.6	1.2×10^5	1.36	46.4	2.9×10^5	1.01	47.7	2.4x10	0.82	48.5	4.8×10^5	1.52
6							48.5	9.6x10	1.22	49.3	2.4×10^5	1.82
	After heating 5 hrs, hanging 6 days	4.0×10^3	3.34	After heating 4 hrs, hanging 4 days	4.0×10^5	1.87						
				After heating 4 hrs, hanging 4 days, after pasting 6 days	4.0×10^4	2.44						
				After heating 5 hrs hanging 4 days	3.2×10^5	1.97						
				After heating 5 hrs. hanging 4 days, after pasting 6 days	1.2×10^5	2.40						

* DR = Decimal reduction of initial Salmonella inoculum