Growth of Bacteria in Soy-Extended Ground Beef Stored at Three Temperatures

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ABSTRACT

The objective of this study was to determine the influence of five separate levels of textured soy protein (TSP) on growth of psychrotrophs, mesophiles, coliforms, Staphylococcus aureus, and fecal streptococci in soy-extended ground beef stored at -16°, 0° and 6°C. Highly significant increases in psychrotroph and mesophile counts accompanied increased levels of soy at 0° and 6°C, but not at -16°C. Soy-extended beef samples containing 20 and 40% TSP spoiled one day faster at 6°C and four days sooner at 0°C than non-extended ground beef. No significant differences in coliform, fecal streptococci or S. aureus counts could be attributed to increasing levels of TSP in extended ground beef at -16°, 0° or 6°C. Protein content did not vary significantly with TSP concentration; however, fat decreased as soy level increased. Moisture and carbohydrate-ash content increased significantly as soy level increased, as did pH which reached a maximum of 6.5.

Soy proteins are used widely to extend ground beef and are being used increasingly in chicken and fish salads. Gunn et al. (6) were the first to report that a gastrointestinal illness was associated with soy-extended tuna salad. Comminuted meats such as ground poultry and pork are being used increasingly in meat emulsions with soy proteins. The market for such proteins is expanding rapidly; however, there is still concern as to how soy proteins may influence the microbial flora of foods in which they are used. Seideman et al. (11) found that combining soy and mechanically deboned beef increased initial psychrotroph counts. Bell and Shelef (2) demonstrated that psychrotroph counts were 1.2 logs higher in ground beef extended with 25% soy and refrigerated for 10 days. Draughon (5) reviewed numerous studies on the microbiology and shelf-life of meat and poultry extended with soy. She found that about one-half of the researchers had not studied psychrotrophs and only two researchers had studied streptococci or lactics in soy-extended meat. The effect of different storage temperatures on the shelf-life of extended ground beef has not been investigated.

The objective of this study was to determine the influence of various levels of textured soy protein (TSP) on selected bacterial groups occurring in raw refrigerated or frozen ground beef stored at three selected temperatures. This influence was assessed by five bacteriological assays: aerobic mesophile count, psychrotroph count, coliform count, fecal streptococci (KF) count and counts of coagulase-positive Staphylococcus aureus.

MATERIALS AND METHODS

Sample preparation

Samples were prepared by extending raw ground beef with 0, 5, 10, 20 and 40% (w/w) rehydrated TSP (Bontrae, Central Soya). The TSP, which contained approx 50% protein on a dry weight basis, was rehydrated at room temperature for 15 min using a 2:1 (w/w) ratio of sterilized water to soy. Proportionate amounts of beef and TSP were mixed individually for each percentage level, following accepted sanitary practices, and blended further by grinding through a 0.32-cm plate. Three bulk samples (500 g) of each of the various meat/soy blends were prepared and stored in sterile polyethylene bags. For each soy level, one bulk package was stored at 6°C, one at 0°C and one at -16°C. The entire experiment was replicated four times.

Bacteriological assays

Bacteriological assays were determined at varying times depending on the temperature of storage. For samples stored at -16°C, samples were taken at 0, 7, 15, 30, 60 and 90 days. Samples stored at 0°C were analyzed for microbiological counts on days 0, 2, 4, 6, 8 and 10. Samples stored at 6°C were analyzed daily to day 4. The selected temperatures of storage corresponded to frozen storage (-18°C), retail show case (6°C) and home refrigeration (6°C).

Aseptically weighed meat (11 g) was placed in a sterile blender jar with 99 ml of 0.1 M phosphate-buffered diluent, pH 7.2 (PB) and blended for 1 min. Serial dilutions were prepared in PB. Total aerobic mesophiles and psychrotrophs were determined on Standard methods agar at 35° ± 1°C for 48 h and 20° ± 1°C for 72 h (19), respectively. Coliforms were evaluated on Violet red bile agar incubated at 35°C for 24 h. KF streptococcal agar (9), incubated at 35°C for 48 h, was used to approximate the numbers of fecal streptococci. Staphylococcus aureus was determined by using Baird Parker agar (35°C for 48 h) and confirming typical colonies with the coagulate test. Only coagulase-positive typical colonies were counted.

Proximate analysis

Percent protein, fat and moisture were determined on duplicate samples according to Official Methods of Analysis (1). Carbohydrate and ash were calculated by difference.

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RESULTS AND DISCUSSION

A dry sample of the TSP used to extend the ground beef in this study had a log count of <2 bacteria/g when examined for mesophiles, psychrotrophs, coliforms, streptococci and S. aureus. Therefore, the soy was not an important contributor to the total microflora of the meat-soy blends.

Coliform, S. aureus and fecal streptococci counts of soy-extended ground beef were not significantly higher than counts from non-extended ground beef at any of the selected temperatures. However, all bacterial counts increased significantly \((P<0.01)\) during storage at 0°C and 6°C, but not at -16°C.

Non-extended ground beef had significantly \((P<0.05)\) lower psychrotroph counts than 20 and 40% soy-extended ground beef at 6, 8 and 10 days of storage at 0°C (Fig. 1). The higher bacterial counts in soy-extended ground beef appeared to be the result of increased growth rates between 2 and 4 days storage at 0°C. Ground beef extended with 5 and 10% TSP also had higher psychrotroph counts than non-extended ground beef after 8 and 10 days of storage but at a lower level of significance \((P<0.10)\). At 6°C, non-extended ground beef also had significantly lower counts than ground beef extended with 20 and 40% TSP at 3 and 4 days storage (Fig. 2). All samples were considered spoiled by subjective olfactory evaluation after 4 days at 6°C. Only the 20 and 40% soy-extended ground beef samples were spoiled by day 3 of storage at 6°C.

Mesophile counts were significantly higher \((P<0.05)\) in ground beef extended with 20 and 40% TSP than in non-extended ground beef at both 6°C (day 3 and 4) and 0°C (day 6, 8, and 10) (Fig. 3 and 4). The increased growth rate of total mesophiles in the 20 and 40% soy-extended ground beef was very apparent at 6, 8 and 10 days of storage at 0°C (Fig. 3). Mesophiles increased rapidly in all five treatments at 6°C (Fig. 4).

Mesophilic counts were approx one log lower per g than psychrotroph counts for all meat and soy-extended meat samples. A trend for mesophiles similar to psychrotrophs was observed which showed increasing levels of bacteria with increasing soy levels.
BACTERIAL GROWTH IN SOY-EXTENDED BEEF

Proximate analysis of the meat extended with TSP showed that protein content did not vary significantly (Table 1). The amount of fat decreased significantly with increasing soy. Water increased (P<0.05) as soy level increased and unanalyzed material (ash and carbohydrate) increased significantly (P<0.05) as soy level increased.

The psychrotrophs require a high aw to grow well (0.97). Therefore, the higher level of moisture in the 20 and 40% TSP-extended samples (Table 1) may play a very important role in bacterial growth. Some researchers have suggested that an increase in carbohydrates (provided by TSP) may provide additional nutrients for bacterial growth (8). However, psychrotrophic bacteria, such as pseudomonads which constitute a large percentage of the microflora of ground beef and soy-extended ground beef (7), do not ferment sugars. A few will utilize glucose oxidatively, but it is highly unlikely that they can utilize stachyose, sucrose or...
raffinose which are contributed by TSP (3,4). Keeton and Melton (8) noticed a sour odor associated with spoiled soy-extended ground beef and Bell and Shelef (2) reported that lactic bacteria were one log count higher in soy-extended as compared to non-extended ground beef. Lactobacilli can use a number of disaccharides and oligosaccharides and may be responsible for the sour odor which other researchers have noticed in spoiled soy-extended meat. Future studies concerning shelf-life and microbial flora of soy-extended ground beef should include lactics in their experimental design.

Something as simple as pH may be the major factor enhancing bacterial growth. This problem would be fairly easy to correct merely by adjusting the pH of the soy protein extenders so that the soy-extended meat would remain at pH 5.7 or lower. Studies are needed to evaluate the effect of pH, carbohydrate and a_w on growth of bacteria in soy-extended meat.

REFERENCES

Fruin and Guthertz, con't. from p. 698

REFERENCES