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# Safety and Quality of Beef Meat Sausages Produced in the Industrial Factory Using the HACCP System

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**ABSTRACT**

**Introduction:** Food safety and hygiene are important principles for food hygiene officials and the majority of large food industries around the world. The purpose of this experiment was to investigate the safety and quality of beef meat sausages produced in the local factories using the HACCP and non-HACCP systems.

**Methods:** One hundred and twenty samples of beef meat sausages from the non-HACCP and HACCP local meat product markets were examined for three months in terms of microbial (total viable count, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp., coliforms, and mold/yeast) and chemical (total volatile basic nitrogen and pH) properties based on the HACCP standard of meat products.

**Results:** The levels of microbial population and chemical properties of raw materials and beef meat sausages in the HACCP factory samples were significantly lower than those of non-HACCP factory samples ($P < 0.05$). Moreover, 100% of the examined spices in HACCP factory were found to have microbial populations below the critical limit of plants, while 100% of the examined spices in non-HACCP factory was contaminated.

**Conclusion:** The results of the present study indicated that the HACCP principle effectively controls the microbial hazards and chemical property of prepared beef meat sausages.

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## Introduction

Food safety and hygiene are important principles for food hygiene officials and the majority of large food industries around the world (1, 2). A weak food safety system leads to the spread and transmission of food-borne diseases with high morbidity and mortality rates (3, 4). Food products may suffer secondary microbial contamination during manufacturing, transportation, processing, and packaging (5). The World Health Organization (WHO) considers diseases caused by food contamination as one of the most important public health problems in the contemporary world (6). The consumed food may be completely in harmony with human physical needs and have all the conditions of adequate nutrition, but in terms of contamination and/or the presence of harmful microbial and chemical hazards, it seriously threatens human health (7, 8). The consequences of spoilage and contamination often occur due to the preparation and processing conditions of food products that can have adverse effects on human health either in the short term or in the case of continued consumption (9). According to the estimate made by the Center for Disease Control and Prevention in the United States of America, 75 million people suffer from food-borne diseases every year, more than 325,000 people are hospitalized, and 5,000 people die (5, 10). The annual cost of food-borne diseases, including direct medical costs and productivity loss in this country is approximately 5 to 6 billion dollars. Regarding *Salmonella* spp. infection, direct and indirect costs are estimated at approximately 1 billion dollars per year (6).

Management of food safety parameters, identification, evaluation, and control of risk factors in the food chains can lead to the prevention and reduction of microbial and chemical hazards, improve the quality and safety of food products, and ultimately provide safer food to consumers (2, 11). Various studies have shown that the microbial and chemical properties of different perishable foods can be improved by using food safety programs (7, 12-14). Moreover, the growing trend of the number of production units in the food industry and the

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changes in the technology and variety of products in the world have caused the owners of industries to make more efforts to establish quality systems (15-17). The Hazard Analysis Critical Control Points (HACCP) system was accepted by the Codex Commission in 1993 and was widely utilized in various food industries in countries, such as the United States of America and Japan (18, 19). In recent years, HACCP has been used as an effective control system at the global level (2). Therefore, the purpose of this experiment was to investigate the safety and quality of beef meat sausages produced in the local factories using the HACCP and non-HACCP systems.

## Materials and Methods

### *Sampling*

Cooked beef sausages were mainly prepared by defatted beef meat, ice water, wheat flour, starch, sodium polyphosphate, spices, ascorbic acid, sunflower oil, powdered milk, salt, guar gum, sodium nitrite, and wheat gluten (20). All the ingredients were mixed in the cutter machine and stuffed in polyamide casings. 120 samples of beef meat sausages from the non-HACCP and HACCP local meat product markets were examined for three months in terms of pathogenic and spoilage microbial agents based on the HACCP standard of meat products (12, 21). Sampling of beef meat sausages was conducted before and after sausage processing and packing. All obtained sausage samples were wrapped in aseptic bags, put in a piece of ice, and immediately transferred into the laboratory for microbiological and chemical analysis between 45 min and 1 h.

### *Microbial Analysis*

For microbial analysis, an amount of 25 g beef meat sausages were homogenized at high speed for 3 min in a sterile bag mixer through the stomacher (BagMixer, Interscience, France) with 225 ml of 0.1% sterile buffered peptone water (Merck, Germany). The culture medium was sterilized by autoclaving for 15 min at 121 ± 2 °C. The homogenates prepared by the stomacher were serially diluted with sterile 0.1% buffered peptone water, and 0.1 ml was cultured on the plate count agar (incubated at 37 ± 1 °C for 48 h), eosin methylene blue agar (incubated at 37 ± 1 °C for 24 h), Baird Parker agar (incubated at 37 ± 1 °C for 48 h), *Salmonella-Shigella* agar (incubated at 37 ± 1 °C for 24 h), violet red bile agar (incubated at 37 ± 1 °C for 24 h), and sabouraud dextrose agar (incubated at 25 ± 1 °C for 7 days) to enumerate total viable count (TVC), *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp., coliforms, and mold/yeast in meat products, respectively (5). All corresponding culture media were obtained from Merck, Germany.

### *Chemical Analysis*

The beef meat sausages (10 g) were homogenized in the stomacher for 10 min with 90 ml of distilled water to make a thick slurry, and then the pH was determined using a digital pH meter (Farazbin, Iran) (22). To determine the total volatile basic nitrogen (TVB-N) content of the samples, 20 g of the sample was mixed with 200 ml distilled water, stirred for 12 min at 3400 rpm, filtered, and alkalinized by incorporating 5 ml MgO solution (10 g/l). The volatile base components were extracted through steam distillation using a Kjeldahl distillation unit for 10 min and obtained with 10 ml boric acid (20 g/l), and a few drops of 0.1% methyl red and bromocresol green indicators. Following that, the sample was titrated with 0.1 mol/l HCl. The TVB-N content was expressed as mg N/100 g (14).

*Statistical analysis*

All analysis was conducted three times. Statistical analysis of the results was done using Tukey's multiple comparison test through the SPSS program (version 21 for Windows, Chicago, IL, USA). The findings were exhibited as mean ± standard deviation. $P < 0.05$ was described as a statistically significant difference.

## Results and Discussion

The Codex Alimentarius defines food hygiene as "all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain". Prerequisite hygiene programs, including good hygiene practices (GHP) and HACCP are compulsory (2). Based on the results presented in Table 1, the levels of microbial population of raw materials in the HACCP factory samples were significantly lower than those of non-HACCP factory samples ($P < 0.05$). The higher microbial population of non-HACCP factory samples suggests the poor hygienic quality of the raw materials, inadequate handling, and storage practices (16, 23). Isolated coliforms in raw materials could be related to the existence of fecal contamination during the slaughtering process (24). All samples were negative for *Salmonella* spp. in the non-HACCP

and HACCP markets. Reduction of the potential existence of *E. coli* and coliforms in raw materials is crucial, since *E. coli* and coliforms can lead to serious public diseases (1). As previously reported, three important factors that affect the hygiene quality of raw materials are the situations under which animals are reared, slaughtered, and processed along with the intrinsic and extrinsic parameters of microbial growth in raw beef meat samples and spices (25). The results of TVC, *E. coli*, *S. aureus*, *Salmonella* spp., coliforms, mold/yeast, pH, and TVB-N of beef meat sausages prepared in the non-HACCP and HACCP markets are presented in Table 2. The levels of microbial and chemical properties of beef meat sausages prepared in the HACCP factory were significantly lower than those of prepared in the non-HACCP factory ($P < 0.05$). Based on our findings, the TVC, *E. coli*, *S. aureus*, *Salmonella* spp., coliforms, mold/yeast, pH, and TVB-N of beef meat sausages prepared in both non-HACCP and HACCP markets were in the acceptable ranges of national standards (26). Poumeyrol, et al., (2010) reported that the hazard analysis effectively controlled by good hygiene practices for numerous bacterial hazards, particularly *Listeria monocytogenes*, *Salmonella* spp., and *S. aureus* (12). Hwang, et al., (2011) also found that the levels of aerobic plate count, total volatile basic nitrogen, and total coliforms in fish samples obtained from the HACCP factory were significantly lower than those of fish samples obtained from the two non-HACCP factories (14). Metaxopoulos, et al., (2003) indicated that the utilization of the HACCP system might be considered appropriate but more impacts are necessary for the control of the microbial and chemical safety of the incoming compounds and processing (27). Manios, et al., (2015) (28) reported that the high microbial population in meat products could be a consequence of raw materials with a high initial microbial counts, poor hygiene conditions during processing and packaging, along with high temperatures in the processing lines.

**Table 1.** Microbial population (log CFU/g) of raw materials from non-HACCP and HACCP markets.

| | TVC | *E. coli* | *S. aureus* | *Salmonella* spp. | coliforms | mold/yeast |
|---|---|---|---|---|---|---|
| **Non-HACCP market** | | | | | | |
| **Additives** | 5.30 ± 0.13[a] | 2.21 ± 0.02 | 3.81 ± 0.03[a] | < 1 | 3.89 ± 0.04[a] | 3.89 ± 0.03[b] |
| **Spices** | 5.49 ± 0.24[a] | < 1 | < 1 | < 1 | < 1 | 5.12 ± 0.02[a] |
| **Batters** | 5.83 ± 0.02[a] | < 1 | 4.20 ± 0.02[a] | < 1 | 3.87 ± 0.02[a] | 2.18 ± 0.15[a] |
| **HACCP market** | | | | | | |
| **Additives** | 4.11 ± 0.02[b] | < 1 | 2.12 ± 0.23[b] | < 1 | 2.45 ± 0.08[b] | < 1 |
| **Spices** | 3.27 ± 0.28[b] | < 1 | < 1 | < 1 | < 1 | 2.15 ± 0.02[c] |
| **Batters** | 4.18 ± 0.12[b] | < 1 | 2.81 ± 0.14[b] | < 1 | 2.40 ± 0.03[b] | 2.01 ± 0.08[c] |

[a-b] Means with different lowercase letters in the same column are significantly different between raw materials of non-HACCP and HACCP markets ($P < 0.05$). Data are shown as mean ± standard deviation.

**Table 2.** Microbial and chemical properties of beef sausages prepared in the non-HACCP and HACCP markets.

| | non-HACCP market | HACCP market |
|---|---|---|
| **TVC (log CFU/g)** | 3.96 ± 0.04[a] | 2.17 ± 0.25[b] |
| ***E. coli* (log CFU/g)** | < 1 | < 1 |
| ***S. aureus* (log CFU/g)** | < 1 | < 1 |
| ***Salmonella* spp. (log CFU/g)** | < 1 | < 1 |
| **Coliforms (log CFU/g)** | < 1 | < 1 |
| **Mold/yeast (log CFU/g)** | < 1 | < 1 |
| **TVB-N (mg N/100 g)** | 14.56 ± 0.07[a] | 7.34 ± 0.02[b] |
| **pH** | 6.29 ± 0.07[a] | 6.20 ± 0.14[a] |

[a-b] Means with different lowercase letters in the same raw are significantly different between beef sausages of non-HACCP and HACCP markets ($P < 0.05$). Data are shown as mean ± standard deviation.

Previous studies reported that one of the possible sources of food product contamination is spices, which consist of very high levels of microorganisms, particularly spore-forming *Bacillus* spp. and more frequently, *Clostridium* spp., that both of them enhanced TVC of sausage samples produced in non-HACCP factory (2, 29). As a small amount of spices was utilized in beef meat sausages, the incorporated spices in the current experiment did not overall contribute greatly to spoilage microorganisms of the product, however, it is possible consisted of heat-resistant pathogenic bacteria (2, 30). Moreover, raw beef meat samples should be handled properly to prevent any potential microbial contamination of final meat products along with

the areas in which they are processed (31). The microbial population of raw materials is likely related to the handling of samples during defrosting, deboning, and transporting to the next processing stages, cross-contamination during processing, and lack of high hygiene conditions of working staff and equipment (32). Another potential way for higher microbial contamination of beef meat sausages in non-HACCP factories could be the degree of contamination of the personnel and the surfaces in the processing plants constitutes, which is considered an important risk factor and should be controlled (21, 32). Our findings showed that 100% of the examined spices in the HACCP factory were found to have microbial populations below the critical limit of plants. Moreover, 100% of the examined spices in the non-HACCP factory were contaminated, which could be owing to the fact that they were not appropriately prepared and sterilized.

## Conclusion

The results of the present study indicated that the HACCP principle effectively controls the microbial hazards and chemical property of prepared beef meat sausages. Moreover, the main enhancement must be regarding the standardization of the raw materials used, processing of the meat products, and training of the working staff. The present study has been conducted on a small scale without consideration of all the processing steps of beef-cooked sausages. Therefore, further experiments should be conducted for microbial analysis of meat cut at all operational steps, including the slaughterhouse, processing line, and retail outlets. More research is also required on the HACCP principle of a wider range of beef meat products.

## Competing Interest

The author declares no conflict of interest.

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