5. DISCUSSION AND CONCLUSION

5.1 Discussion

Generally, the total aerobic mesophilic bacteria count, *Pseudomonas spp.*, fecal microorganisms (coliforms, *Enterobacteriaceae*) are important indicators of the hygienic quality in foods (Temelli, 2006).

In this study, a significant difference concerning hygiene indicators was observed between industrial samples and small enterprise samples. However, there was no statistically significant different between any of 3 brands of industrial samples. A similar situation existed regarding 3 different sources of small enterprises samples (street vendors, markets and restaurants). These results can express the uniformity in the structure of quality management systems within sub-groups. This deviation between industrial samples and small enterprise samples may be explained as a possible result of the effect of freezing on the growth of microorganisms because most bacteria are unable to propagate at freezing temperature. Furthermore, some microorganisms are slowly inactivated or destroyed at -4 ºC. Freezing of industrial pork dumplings at the end of the production line stops microbial multiplication whereas the germs of small enterprise samples propagate in the time between production and consumption because of improper cooling.

The recommended temperature for frozen foods is -18 ºC but the results of this study revealed the average core temperature of industrial samples was -5.49 [±1.82] ºC which is not suitable for deep frozen foods. This was possibly occurred due to the time elapse between sample collection and temperature determination since this could lead to increase temperature of the product. Moreover, the open-door freezing system at the supermarkets contributes the variability of the frozen temperature of the products. The last explanation is more plausible, because provisional measurements in the open-door- freezers showed temperatures between - 5 ºC and -10 ºC.

However, the microbial growth at and below freezing temperature depends on nutrient content, pH and the availability of liquid water (a_w). Freezing should not be regarded as a tool for destroying food-borne bacteria. The types of microorganisms that lose their viability in freezing state differs from strain to strain and are modified by the type of freezing employed, the nature and composition of the food, the time/temperature combination of freezing storage and other factors.

Another additional reason for the better hygienic status of the deep frozen pork dumplings may be that the industrial production implements advanced hygiene programs and safety assurance system; for example Good Hygienic Practices (GHP) and Hazard Analysis and Critical Control Point (HACCP). The plants which established these systems can minimize the microorganisms load due to general hygiene control points and the critical control points of the systems. At the processing line of one industrial plant which is reviewed in this study, there are 5 critical control points including raw material selection, foreign body elimination, heat process at 82 ºC, freezing process at -18 ºC within 1.5 hours, and metal detection (as mention in the introduction chapter).

Three of these CCPs help to minimize the microbiological contamination. In coming raw material, especially raw meat may raise the initial bacteria load. Certified suppliers and strict criteria for raw material with low microbial counts and an absence of pathogens could greatly contribute to the hygienic quality and safety of the final product. The thermal treatment is important for the safety of cooked meat product. To achieve an effective pasteurization the pork dumplings should be heated until they reach 82ºC. In small enterprises, however, proper heating is not guaranteed. Furthermore, it is essential to cool the product rapidly to -18 ºC within 1.5 hours and to store it at a low ambient temperature at -15 ºC to avoid the growth of any heat-resistant microorganism including spore-forming bacteria.

The high number of total aerobic count, coliforms and *Enterobacteriaceae* found in small enterprise samples may be an indication of insufficient hygiene and sanitary applications in the whole chain of production including farm, slaughter house,

production, transportation, storing and selling. Especially poor food hygiene at the point of sale contributes to the high counts of microorganisms, including factors such as varying temperatures during transportation, inadequate cooking and contaminated instruments (Metaxopoulos, 2003).

The coliforms which are presented in the samples may relate to the fecal coliforms including the genera *Aeromonas, Citrobacter, Escherichia, Enterobacter* and *Klebsiella*. Although most of the bacteria are not pathogenic, mainly *Escherichia* is a common indicator of feacal contamination, bad water quality and poor sanitary condition. In the case of the species *Escherichia coli* it must be mentioned that many pathogenic serovars exist. Some of the *Enterobacteriaceae* beside the coliforms which include many further genera like *Shigella, Salmonella, Erwinia, Hafnia, Edwardsiella, Morganella, Obesumbacterium* and *Yersinia* are part of the normal flora and incidentally cause diseases, while others such as the *Salmonellae, Shigellae* and *Yersiniae* are regularly pathogenic for humans.

It is widely known that the primary sources of contamination with coagulase-positive staphylococci are human beings. Especially the contact which may be caused by the personal hand in the plant even at the point of sale and the packaging of material is an important contamination and/or recontamination source particularly for *S.aureus* (Huss, 1997). In this study, the coagulase-positive staphylococci were only found in 2 parallel samples after storage at room temperature for 6-8 hours and in one sample after reheating. The high counts of 5.74 and 5.32 coagulase-staphylococci/g in the stored samples make these items really unsafe because a toxic doses of enterotoxin could be produced when 10^5 - 10^6 of *S. aureus* are presented in food. But still, all the samples analyzed directly after buying showed a satisfactory hygienic status concerning coagulase-positive staphylocooci.

All microbiological counts increased during the storage for 6-8 hours at room temperature. This storage period was suitable for the growth of microorganisms because the temperature lies on the optimum temperature range of mesophiles microorganism which includes virtually all human pathogens (the average core

temperature after storage for 6-8 hours was 20.76 [±2.06] ºC), and the time factor at 6-8 hours is enough for the multiplication of microorganisms. Alternatively, the numbers of microorganisms in parallel samples decreased if pork dumplings, which had been stored for 6-8 hours, were reheated to an average core temperature of 68.73 (±8.54) ºC. However; this reheating did not destroy all the microorganisms. Some of the heat resistant microorganism, spore-forming bacteria and thermophile microorganisms can tolerate this temperature range. Therefore, consumers should store the foods in the refrigerator before reheating. This preventive measure must be combined with home hygiene in the kitchen since the colonization of microorganisms can be further modified by manipulation of the intrinsic, extrinsic, and processing factors (Brown, 1982).

5.2 Conclusion

Statistically significant differences were observed between the industrial samples and small enterprise samples in terms of the results of microbiological quality indicators. Some of the small enterprise samples are not able to fulfill the requirements of the official microbiological standard of cooked-frozen or cooked-chilling food that have to reheat before consumption (FDA, Thailand). This indicates the poor food hygiene in the production line or during storage. Small enterprises should apply strict hygiene and sanitary conditions such as GHP and HACCP during processing, storage and transportation. Moreover, the study was the first investigation into the microbiological quality of pork dumplings. The detection of indicator organisms in the samples is only suitable to characterize the food hygiene and to describe a tendency in the safety of foods. Therefore, in future studies should include the analysis of pathogenic microorganisms such as *Salmonellae, Listeria monocytogenes,* and entheropathogenic *Escherichia coli*.