Control Strategies of Microorganisms in the Production of Infant Formula

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Abstract: Food safety is a worldwide and public safety issue, and the control of food-borne diseases is an important part of food safety. Food-borne diseases caused by microorganisms, as well as microbial contamination of foods, are also a top priority for food safety. Hence, strengthening the management of microorganisms during producing is conducive to the quality and safety of infant formula. Based on author's learning and practical experience, this work first summarized the sources of microorganisms in infant formula, and then analyzed the safety events of microbial contamination of infant formula, finally put forward the control measures of microorganisms during production.

1. Introduction

Food-borne disease refers to the disease caused by toxic and harmful substances and other pathogenic factors that enter the human body through ingestion [1]. Infants and young children are a special group due to the imperfect development of digestive system and immature metabolic system. Also, they have special needs for nutrient intake. For the infant formula, as the main source of dietary nutrition except breast milk, if it is contaminated by microorganisms, it will have a great impact on the health of infants and young children [2]. Therefore, it is particularly important to control the pollution of infant formula and ensure the quality and safety of milk powder.

2. Sources of Microorganisms in Infant Formula

The contaminated microorganisms in infant formula are classified by source and may come from raw materials or the processing of milk powder. As shown in Table 1.

Raw milk is rich in nutrition and it can provide protein, fat and other nutrients needed to support life, especially a higher proportion of casein and whey protein. Rich nutrients are also a good medium for microorganisms. Raw milk is located in the upstream of infant formula industry chain. Grasping the quality control of raw milk from the source directly affects the quality and safety of infant formula. Microorganisms in raw milk not only affect the quality and safety of infant formula, but also affect the shelf life of products. Strengthening the control of raw milk microorganism is the main measure to prevent microbial pollution of infant formula [3]. The main pathogenic microorganisms in raw milk are hemolytic streptococcus, pathogenic coliform, salmonella, red dysentery, botulinum, which have great influence on human health and are easy to cause various diseases.

Formula milk powder is a kind of dehydrated product processed by concentrated spray drying. At present, it is impossible to produce formula milk powder without low microbial composition, which means that the milk powder is not completely aseptic [4-5]. Dairy and dairy products are contaminated by a wide range of sources: (1) The feeding environment of dairy cows, the environmental pollution related to the production of raw milk and the poor health management, such as feces, cushions, improper treatment, result in a large number of microorganisms in the cow house. As a result of the above reasons, the surface of the cow, the udder adhere to a variety of microorganisms. And if there is a large amount of bacteria in the air of the cow house, it may fall into the milk when milking. (2) The hygienic condition of the milking session does not meet the

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requirements, including environmental hygiene, milking utensils, health status and personal hygiene of milking workers. (3) During the transportation and storage of raw milk products, such as milk buckets, milk tank trucks, refrigeration equipment are not thoroughly cleaned and disinfected, resulting in the breeding of microorganisms. Abnormal processing equipment of dairy and dairy products may also lead to microbial contamination of dairy products.

Table 1 Sources of microorganisms in infant formula

Source	Pollution mode
Raw milk, auxiliary materials (whey powder, etc.)	Inherent flora in raw milk Microbial Control system of Raw and Auxiliary Materials
Processing	Direct invasion and pollution Surface proliferation (formation of biofilm or scaling) and growth
Packaging process	Packaging is the operation after spraying into powder, and secondary pollution may occur.

3. The Safety Event of Microbial Contamination of Infant Formula Milk Powder

There have been incidents of quality and safety of dairy products and infant formula around the world. Some famous events in the past decade are listed as follows:

In July 2000, 14000 people were poisoned by Staphylococcus flavus in the low-fat milk produced by Osaka factory of Japan Snow Printing Dairy Company;

In September 2002, a spokesman for the Hong Kong Food and Environmental Hygiene Department called on local people to stop eating special infant formula "Melobao" from Germany immediately. Since the milk powder sample was detected to contain a "Enterobacter sakazakii" that may cause inflammation of the intestines and meninges in newborns;

In 2005, a mass contamination of milk powder with salmonella was reported in France. In 2006, Laktalis Group acquired the Krone factory where pollution occurred [6]. In December 2017, another incident of problem milk powder broke out at the Krona factory, resulting in 37 infants and young children suffering from illness. The chief executive officer of the French dairy giant Laktalis Group acknowledged that the same type of salmonella Agoner was found in both the 2005 and 2017 problem milk powder incidents, which means that the problem of milk powder pollution sources may not have been removed.

4. Control Measures of Microorganisms in Production

After analyzing the microorganisms in raw milk obtained by different milking methods, the results showed that the microbial indexes of raw milk obtained by manual milking were higher than those obtained by mechanical milking. The average number of milk sample colonies obtained by mechanical milking was 4.39×10^4 CFU/mL, the average number of aerobic spores was 28 CFU/mL, and the average value of coliform group was 3.20×10^3 CFU/mL. The average number of milk sample colonies obtained by manual milking was 1.35×10^6 CFU/mL, the average number of aerobic spores was 2.21×10^2 CFU/mL, and the average value of coliform group was 2.05×10^5 CFU/mL. Mechanical milking plays an important role in reducing microbial indexes in raw milk.

After different cleaning treatment of dairy cow nipples before milking, there was no significant difference in the total number of colonies between uncleaned and warm water cleaning at 45-65℃. The sterilization rate of nipples cleaned with 55-65℃ was 67.6%. In the case of more bacteria in nipples, cleaning nipples with 55-65℃ warm water has a certain sterilization effect, but there will be more bacterial residues [7]. There was significant difference in the total number of colonies between unwashed and 4% sodium hypochlorite aqueous solution cleaning, the sterilization rate was 99.43%. This shows that 4% sodium hypochlorite aqueous solution cleaning has a better

sterilization effect. The total number of colonies adhered to the nipples of non-cleaning cows was the highest, reaching 1.36×10^4 CFU/cm^2; After cleaning with 55-65 ℃ warm water and drying, the total number of colonies adhered to the nipples of dairy cows decreased significantly, which was 4.42×10^4CFU/cm^2; After cleaning with 4% sodium hypochlorite aqueous solution and drying, the total number of colonies adhered to the nipples of dairy cows was the lowest, only 3.4×10^3 CFU/cm^2. Therefore, the medicated bath treatment has a great influence on the microorganisms attached to the nipple surface of dairy cows.

Taking raw milk from large-scale mechanical milking dairy farms as research object, under cold storage (4℃) and room temperature (20℃), after stored for 0 hours, 6 hours, 12 hours, 18 hours, the total number of colonies (TPC), the total number of aerobic spores (TSC) and the number of thermophilic aerobic spores in the raw milk was detected. The results showed at 4℃ and 20℃, the increase of the total number of raw milk was accelerated, and the increase of aerobic spores and thermophilic aerobic spores was not sensitive to storage temperature. After 6 hours of milk storage at room temperature (20℃), the total number of bacteria in the raw milk reaches the limit standard of 5×10^5 CFU/mL specified in the *US Milk Quality Management Code Summary of FDA*; After 12 hours of storage, it has not met the 2×10^6 CFU/mL limit specified in GB19301-201. The total number of bacteria in raw milk within 18 hours of refrigerated (4℃) storage has not exceeded the FDA standard. Therefore, in order to ensure the quality of infant formula products and control the content of microorganisms, after milking raw milk, it should be cooled below 4℃immediately, which plays an important role in controlling the growth and reproduction of microorganisms.

After comparing the bactericidal effect of pre-pasteurization of raw milk with pasteurization only, the sterilization rate of pasteurized milk was 99.1%, and the sterilization rate of pre-pasteurized milk was 99.3%. The sterilization rate of the pre-pasteurisation is higher than that of the pasteurisation, but the difference between the two is not significant [8-9]. The study of pre-sterilization of pasteurized milk in preheating and homogenization stage showed that pre-sterilization could kill most of the moderate and low temperature bacteria, activate the spores of high temperature resistant bacteria, which was beneficial to the killing of spores by superpasteurized bacteria in the back and provided the necessary temperature for homogenization process. But given the influence of heating on milk protein and vitamins, the temperature and time of pre-sterilization should be strictly controlled. Under the condition that the microbial index of raw milk is relatively high, the microorganism and enzyme activities in raw milk can be reduced and the product quality can be improved through a pre-pasteurization. However, in order to reduce the cost and prevent the loss of heat-sensitive nutrients, pre-pasteurization is unnecessary when the microbial indexes of raw milk are qualified. Some countries have special laws to regulate pre-pasteurization process conditions to prevent excessive sterilization. Therefore, what conditions of raw milk need to be pre-pasteurized, need to be further discussed.

The sterilization conditions of traditional milk powder production are 92-95℃/12-15s, under this condition, although the total number of colonies can also meet the requirements, the loss of vitamin C is obviously higher. The amount of vitamin C in the ingredient is 105mg/100g, and the loss rate of vitamin C is 39.2% under this condition. At 113-116℃/3-8s, the loss rate of vitamin C was 26.7%, and the total number of colonies was lower. Therefore, combined with the requirements of the total number of colonies and avoiding the loss of vitamins, if you want to increase the sterilization intensity, you should first increase the temperature rather than extend the time when adjusting the bactericidal parameters.

Microbial detection results of infant formula milk powder during continuous production cycle shows from the third day (72h), the count of colony and total aerobic spores began to increase rapidly [10]. The scaling of pipeline or heating surface results in the decrease of thermal conductivity, so with the same sterilization temperature and time, a longer cleaning cycle interval will make the sterilization intensity can not meet the requirements. It causes a rise in microbial indicators. During the CIP cleaning process of the factory, the CIP cleaning and replacing acid-alkali solution shall formulate the recycling process (e.g., testing conductivity) according to

their own production conditions, regularly supplement the concentration and regularly discharge and replacement.

5. Summary

In recent years, according to the results of sample examination of infant formula published by the State Administration of Food and Drug Administration, there are many reasons why milk powder is not up to standard. Compared with other reasons, the content of microorganism is not up to standard, which has a particularly great impact on the health of infants and young children. If infants and young children are fed with contaminated milk powder, their health may be irreversibly affected. Some of the pathogenic bacteria in milk powder contaminated by microorganisms have a great impact on the health of infants and young children, especially highly susceptible infants, including premature babies, infants with low birth weight (< 2500g), immunodeficient infants, etc. It can even lead to death. It is particularly important to control the microbial pollution of milk powder in the whole production process in order to ensure the quality of infant formula, revitalize the brand of domestic milk powder and enhance the confidence of the people in the infant formula industry.

References

[1] Food, F. (2004). Enterobacter sakazakii and other microorganisms in powdered infant formula. World Health Organization.

[2] Sonbol, H., Joseph, S., Mcauley, C. M., Craven, H. M., & Forsythe, S. J. (2013). Multilocus sequence typing of cronobacter spp. from powdered infant formula and milk powder production factories. International Dairy Journal, 30(1), 1-7.

[3] Fu, S., Gao, J., Liu, Y., & Chen, H. (2011). Isolation of cronobacter spp. isolates from infant formulas and their survival in the production process of infant formula. Czech Journal of Food Sciences, 29(4), 391-399.

[4] Obladen, & Michael. (2014). Historic records on the commercial production of infant formula. Neonatology, 106(3), 173-180.

[5] Mojska, H., Zukowska, K., & Stos, K. (2010). Trans fatty acids in infant formulae and follow-up formulae in poland. Żywienie Człowieka I Metabolizm.

[6] Liu, C., Zheng, W., Zhang, H., Hou, Y., & Liu, Y. (2009). Sensitive and rapid detection of enterobacter sakazakii in infant formula by loop-mediated isothermal amplification method. Journal of Food Safety, 29(1), 12.

[7] Day, J. B., Sharma, D., Siddique, N., Hao, Y. Y. D., & Al-Khaldi, S. F. (2011). Survival of salmonella typhi and shigella dysenteriae in dehydrated infant formula. Journal of Food Science, 76(6), M324-8.

[8] Dong, X., Wu, Q., Wu, K., & Zhang, J. (2013). Real-time pcr targetingompagene for detection ofcronobacterspp. in powdered infant formula. Food Science and Biotechnology, 22(2), 309-313.

[9] Darío Pérez‐Conesa, Ginés López, Ros, G., Pedro Abellán, & Hartemink, R. (2006). Fecal microbiota changes with the consumption of follow‐up formulas containing bifidobacterium spp. and/or galactooligosaccharides by rats and a follow‐up infant formula containing bifidobacterium spp. by human infants. Journal of Food Science, 71(1), 7.

[10] Mete, E., Catal, F., Tayman, C., Uras, N., & F. Özkaragöz. (2009). Comparison of human milk, cow's milk and infant formulas for their antifungal effects against environmental fungi. Turkish Journal of Medical Sciences, 39(1), 67-72.