



Original / *Pediatría*

Bacteriological quality and food safety in a Brazilian school food program

Samara Nagla Chaves Trindade, Julia Silva Pinheiro, Héllen Gonçalves de Almeida,
Keyla Carvalho Pereira and Paulo de Souza Costa Sobrinho

Department of Nutrition. Federal University of Jequitinhonha and Mucuri Valleys (UFVJM). Diamantina. Minas Gerais. Brazil.

Abstract

Introduction: Food safety is a critical issue in school food program.

Objective: This study was conducted to assess the bacteriological quality and food safety practices of a municipal school food program (MSFP) in Jequitinhonha Valley, Brazil.

Materials and methods: A checklist based on good manufacturing practices (GMP) for food service was used to evaluate food safety practices. Samples from foods, food contact surfaces, the hands of food handlers, the water supply and the air were collected to assess bacteriological quality in establishments that comprise the MSFP.

Results: Nine (81.8%) establishments were classified as poor quality and two (18.2%) as medium quality. Neither *Salmonella* nor *Listeria monocytogenes* were detected in food samples. Coliforms, *Escherichia coli* and *Staphylococcus aureus* were detected in 36 (52.9%), 1 (1.5%) and 22 (32.4%) of the food samples and in 24 (40.7%), 2 (3.3%) and 13 (22.0%) of the food contact surfaces, respectively. The counts of coliforms and *Staphylococcus aureus* ranged from 1 to 5.0 and 1 to 5.1 log CFU/g of food, respectively. The mean aerobic mesophilic bacteria count was 3.1 log CFU/100 cm² of surface area. Coliforms, *E. coli* and *S. aureus* were detected on the hands of 33 (73.3%), 1 (2.2%) and 36 (80%) food handlers, respectively. With regard to air quality, all the establishments had an average aerobic mesophilic count above 1.6 log CFU/cm²/week.

Conclusions: The results indicate the need to modify the GMP used in food service in MSFP in relation to food safety, particularly because children served in these establishments are often the most socially vulnerable.

(Nutr Hosp. 2014;29:80-87)

DOI:10.3305/nh.2014.29.1.7006

Key words: School. Day care. Good manufacturing practices. Food contamination. Foodborne diseases.

Correspondence: Paulo de Souza Costa Sobrinho.
Departamento de Nutrição.
Universidade Federal dos Vales do Jequitinhonha e Mucuri.
Rodovia MGT 367 - Km. 583, n.º 5000, Campus JK.
39100000 Diamantina, Minas Gerais, Brasil.
E-mail: psobrinho@ufvjm.edu.br

Recibido: 6-VII-2013.
1.ª Revisión: 1-X-2013.
Aceptado: 2-X-2013.

CALIDAD BACTERIOLÓGICA Y LA SEGURIDAD ALIMENTARIA EN UN PROGRAMA DE ALIMENTACIÓN ESCOLAR BRASILEÑO

Resumen

Introducción: La seguridad alimentaria es un tema crítico en el programa de alimentación escolar.

Objetivo: Este estudio se realizó para evaluar la calidad bacteriológica y prácticas de seguridad alimentaria de un programa de alimentación escolar municipal (MSFP) en Valle de Jequitinhonha, Brasil.

Materiales y métodos: Una lista de verificación basada en las buenas prácticas de fabricación (GMP) para el servicio de alimentos se utilizó para evaluar las prácticas de seguridad alimentaria. Las muestras de alimentos, superficies de contacto con los alimentos, las manos de los manipuladores de alimentos, se recogieron el suministro de agua y el aire para evaluar la calidad bacteriológica de los establecimientos que componen la MSFP.

Resultados: Nueve (81,8%) los establecimientos se clasificaron como de mala calidad y dos (18,2%) como de calidad media. Ni *Salmonella* ni *Listeria monocytogenes* se detectaron en muestras de alimentos. Coliformes, se detectó *Escherichia coli* y *Staphylococcus aureus* en 36 (52,9%), 1 (1,5%) y 22 (32,4%) de las muestras de alimentos y en 24 (40,7%), 2 (3,3%) y 13 (22,0%) de las superficies de contacto con alimentos, respectivamente. Los recuentos de coliformes y *Staphylococcus aureus* fue de 1 a 5,0 y 1 a 5,1 log ufc/g de alimento, respectivamente. El recuento de aerobios mesófilos media fue de 3,1 log UFC/100 cm² de superficie. Coliformes, se detectó *E. coli* y *S. aureus* en las manos de 33 (73,3%), 1 (2,2%) y 36 (80%) los manipuladores de alimentos, respectivamente. Con respecto a la calidad del aire, todos los establecimientos tenían un recuento de aerobios mesófilos por encima del promedio 1,6 log CFU/cm²/week.

Conclusiones: Los resultados indican la necesidad de modificar el GMP utilizado en el servicio de alimentos en MSFP en relación con la seguridad alimentaria, sobre todo porque los niños atendidos en estos establecimientos suelen ser los más vulnerables socialmente.

(Nutr Hosp. 2014;29:80-87)

DOI:10.3305/nh.2014.29.1.7006

Palabras clave: Escuela. Guardería. Buenas prácticas de fabricación. Contaminación de los alimentos. Enfermedades transmitidas por los alimentos.

Abbreviations

MSFP: Municipal School Food Program.
NSFP: National School Food Program.
NaCl: Sodium chloride.
CFU: Colony-Forming Unit.
AMB: Aerobic Mesophilic Bacteria.
GMP: Good Manufacturing Practices.
SSOP: Sanitization Standard Operating Procedure.
APHA: American Public Health Association.
FAPEMIG: Foundation for Research Support of Minas Gerais State.

Introduction

School food programs are popular government assistance programs that have an impact on education and children's health. In several countries, school food programs are becoming useful strategies to protect socially vulnerable individuals in light of the recent economic crisis.^{1,2} In Brazil, the National School Food Program (NSFP), established in 1955, guarantees meals to students registered in public and philanthropic day care facilities and elementary schools. In 2011, the NSFP's federal budget was 1.85 billion American dollars (U.S.\$1.00 = R\$1,67), benefitted 45.6 million students³ and served as an important component of the Zero Hunger program of Brazil.

Therefore, school food service facilities have become relevant in the issue of food safety because of foodborne illnesses. Approximately 45% of the outbreaks in schools are attributable to foodborne transmission,⁴ and foodborne illnesses have been reported in various parts of the world.⁵⁻⁷ In Brazil, more than 600 outbreaks occurred in day care facilities and schools in the past eleven years.⁸ Several risk factors related to the food service environment contribute to occurrences of foodborne illness: poor personal hygiene, inadequate sanitization of surfaces or equipment, cross-contamination of prepared food with contaminated ingredients and inadequate temperature control.^{9,10}

Objectives

The objective of this study was to evaluate the food safety practices and bacteriological contamination levels of utensils, food, water and air in food service areas of day care facilities and elementary schools in a city in Jequitinhonha Valley, Minas Gerais, Brazil. Jequitinhonha Valley is widely known because of its low social indicators.

Materials and methods

Sampling

The study was conducted in 11 (73.3%) of the 15 municipal public establishments, including 4 (66.7%)

schools and 7 (77.8%) day care facilities. The total number of children served by MSFP is 3,579. Of these children, 2,147 (60%) attend the 11 establishments we surveyed; 1,454 students were enrolled in the schools and 693 in the day care. The city employs 116 food service employees, with 39 based in schools and 77 based in day care facilities. The cost per meal of the municipal school food program in 2010 was U.S.\$0.36 in schools and U.S.\$0.84 in day care facilities. The schools operate part-time and serve snacks in the morning and afternoon, while the day care facilities operate full-time and serve snacks in the morning and afternoon, as well as lunch.

Collection and microbiological analysis of the samples

The samples obtained from the same establishments on different days were considered different samples. After they were collected, the samples were transported under refrigeration to the laboratory and analyzed within 4 hours after collection. The samples were obtained between May 2010 and December 2011. Decimal dilutions were carried out with sterile 0.9% NaCl solution in all samples.

Meals

The traditional meals prepared in these food service establishments include meats, rice, beans, cooked vegetables, cereals, pastas, salads, fruit and drinks at lunch. For snacks, they serve cookies, cake, cheese breads, porridge with cheese, bread, and drinks. The samples collected were taken from meals on the school menu, preferably lunch, the main meal (table I). The samples were collected immediately before or during the distribution of the food to the students. The samples included a single food or a mixture of foods (i.e., a meal). In some cases, two samples were obtained from the same establishment (a liquid food, such as chocolate milk or juice, and a solid food, such as a meal, biscuit, bread or cake).

For the enumeration of bacteria, twenty-five grams or ml of the sample were homogenized in 225 ml of sterile 0.9% NaCl solution for 1 min. Next, 10-fold dilutions were carried out and the following analyses were performed.

Enumeration of *Escherichia coli* and coliforms

Coliform and *Escherichia coli* counts were determined using Petrifilm™ *E. coli*/Coliform Count Plates (3M Microbiology, St. Paul, Minn., USA) that were incubated for 24 hours at 35°C (AOAC 991.14). The results were expressed as CFU per gram or ml of food.

Table I
The composition and frequencies of foods served in schools and day care facilities participating in a municipal school food program in the Jequitinhonha Valley region, Minas Gerais, Brazil

Food/Meal	Frequency (%) (n)
Rice	52.3 (34)
Bean	40.0 (26)
Beef	23.1 (15)
Carrot	18.5 (12)
Pumpkin	12.3 (8)
Cornmeal mush (angu), Sausage	9.2 (6)
Beets and juices	7.7 (5)
Chicken, chayote, Porridge with Cheese and Salted Cookie	6.1 (4)
Smoothie, okra, and Pasta	4.6 (3)
Cooked egg, Potato Sticks, String Beans, Chocolate Cake	3.1 (2)
Sardines, Potato, Egg Farofa, Biscuits, Brazilian cheese Bread, Bread with Cream Cheese, Apple	1.5 (1)

Enumeration of *Staphylococcus aureus*

Staphylococcus aureus counts were determined using Petrifilm™ Staph Express Count Plates (3M Microbiology, St. Paul, Minn., USA) that were incubated for 24 hours at 35°C (AOAC 2003.11). The results were expressed as CFU per gram or ml of sample.

Enumeration of Aerobic Mesophilic Bacteria (AMB)

The aerobic plate count (AMB) was determined following the pour plate technique¹¹ using plate count agar (Himedia, India). The results were expressed as CFU per gram or ml of sample.

Listeria monocytogenes detection

The detection of *Listeria monocytogenes* was performed using the ISO 11290-1 protocol. Negative plates were reincubated for an additional 24 hours. When appropriate, typical colonies were confirmed by API *Listeria* (bioMérieux S.A.). The results were expressed as the absence or the presence of *Listeria monocytogenes* in 25 grams or ml of food.

Salmonella spp. detection

The detection of *Salmonella* spp. was performed by pre-enriching 25 grams or ml of all the samples, which

were homogenized with 225 ml of buffered peptone water and incubated at 35° C for 24 hours. The samples were first enriched in Selenite Cystine Broth (at 35° C for 24 hours), followed by a second enrichment in M broth (at 35° C for 24 hours). After the second enrichment, the samples were analyzed using 3M™ Tecra™ *Salmonella* Visual Immunoassay (3M Microbiology, St. Paul, Minn., USA). The results were expressed as the absence or the presence of *Salmonella* spp. in 25 g or ml of food.

Food contact surfaces and hand of food handler

Two types of food contact surfaces were examined: a utensil used in food preparation (i.e., a cutting board) and another utensil used to serve meals (i.e., a serving plate). At the time of collection, the surfaces of the utensils were considered clean by the food handlers. The surface of the cutting board was swabbed using a sterile square area of 100 cm², and the bottom surface area of the serving plate was swabbed with an area of about 110 cm². For hands, samples were collected using a swab from the hands of a randomly selected food handler at each school during the preparation or distribution of meals. The swab was moistened in a sterile 0.9% NaCl solution, and microorganisms were removed mechanically. Next, the swabs were immersed in 10 ml tubes of sterile 0.9% NaCl solution and transported under refrigeration to the laboratory.

Counts of coliforms, *E. coli*, *Staphylococcus aureus* and AMB were determined from the tube containing the swab used to gather samples from workers' hands and the surfaces of utensils. Next, the enumerations were performed as described previously for food. The results were expressed as CFU/100 cm², CFU/110 cm² or CFU/hand.

Water quality

Samples of the water (250 ml) used to prepare the meals were collected in sterilized plastic bottles and analyzed for coliform, *Escherichia coli* and aerobic mesophilic bacteria, as described previously for food. The results were expressed as CFU/ml of water.

Ambient air

The sedimentation method was used to measure the quality of the local air near the preparation of meals by quantifying the number of aerobic mesophilic bacteria. Open Petri dishes (90 x 155 mm) containing approximately 20 ml of plate count agar (Himedia, India) were distributed in the processing area and exposed for 15 minutes. The Petri dishes were closed and incubated at 35° C for 48 hours.¹² The results were expressed as CFU/cm²/week.

Checklist evaluation

A checklist¹³ based on the Brazilian legislation on good manufacturing practices for food service¹⁴ and food processing/distribution¹⁵ was used to evaluate the adequacy of the GMP and sanitization standard operating procedures (SSOP). The checklist was divided into five parts: facility-design [evaluated by 23 questions (K = 10)], maintenance of utensils and equipment [10 questions (K = 15)], personal hygiene [7 questions (K = 25)], quality of raw and ready-to-eat food [4 questions (K = 20)] and production flow and quality control [14 questions (K = 30)]. The score for each section (P) was calculated using the following formula:

$$P = K \times TS / (T_1 - T_2)$$

TS represents the total points obtained; T_1 represents the total number of possible points; T_2 represents the total number of points “not applicable”; and K is the weight assigned to each subsection, with sum of the weights adding to 100. The score for each establishment was calculated by summing the scores for each of the five parts. The resulting score was classified according to the following scale: excellent: 91-100; good: 70-90; medium: 50-69; poor: 20-49; and very poor: 0-19.

Statistical analysis

All bacteriological counts were transformed into logarithms for statistical analysis. The level of statistical significance was set at 0.05 for all analyses. Univariate analysis was performed to determine measures of central tendency, dispersion, and the distribution characteristics. Student's t test was used to assess the differences in the mean counts between schools and day care facilities. All analyses were conducted using the version 18 of SPSS statistical package for Windows (SPSS Inc., Chicago, USA).

Results

Of the 11 establishments evaluated, nine (81.8%) were classified as poor quality with scores between 27.7 and 47.4, and two (18.2%) were classified as medium quality with scores 53.8 and 58.1. None of the facilities were received good quality scores, indicating the need to modify the food safety practices of school food services.

None of the establishments were able to present a good manufacturing practices manual or the SSOP. There were no records of sanitization of the water reservoir. The establishments did not have any instruments to control or register the temperature during food preparation.

The scores for the adequacy of facility design ranged from 17.4 to 58.1%. The most common nonconformities (100%) observed were the absence of window screens to prevent the entry of insects and birds, free access by visitors and non-food handlers and the absence of disposable paper towels and liquid soap, both in kitchens and in lavatories. In a day care facility, the bathroom has direct communication with the area of food preparation.

Among personal hygiene practices, the main nonconformities were the use of adornment and nail polish, the absence of uniforms and the lack of periodic exams. The personal hygiene scores ranged from 21.4 to 64.3%.

The frequencies for the foods that composed the meals collected are listed in table I. The most prevalent foods were rice (52.3%), beans (40.0%), beef (23.1%) and carrots (18.5%). Table II shows the distribution of microorganisms in the samples of meals served in schools and day care facilities. Of the 68 meal samples analyzed in this study, of which 36 (52.9%) were collected in schools and 32 (47.0%) in day care facilities, none tested positive for *Salmonella* spp. or *Listeria monocytogenes*.

Coliform bacteria were detected in 36 (52.9%) samples. Counts were above 3 log CFU/g in 13.2% of the samples. *E. coli* was detected in only one sample (starch porridge with cheese), with a count of 4.08 log CFU/g. Typically, for this type of dish, the cheese is at the end of the food preparation and therefore is not exposed to intense heat.

In this study, *S. aureus* was detected in 22 (32.4%) of the samples analyzed. The counts were above 3 log CFU/g in 5 (7.3%) samples: fruit juice and milk (1), porridge with cheese (1), biscuits (2), and chocolate cake (1). These samples are not thermally treated, or they have been heated long before consumption. The counts of AMB ranged from 1.0 to 7.2 log CFU/g, and the counts were above 5 log CFU/g in 7 (10.3%) of the samples: juice (2), porridge with cheese (3), bread with cheese (1), and one sample containing rice, beans, sausage, corn mush and chayote.

The surfaces of cooking utensils (cutting board and serving plate) were examined for coliform bacteria, *E. coli*, *S. aureus* and AMB. Coliforms were detected in 10 (37.0%) of the samples from cutting boards and 14 (43.8%) of the samples from serving plates. However, *E. coli* were detected in only 2 samples from cutting boards in two different day care facilities (counts of 1 and 3.2 log CFU/100 cm²), and none were detected in the samples from serving plates. There were no significant differences ($P > 0.05$) in the bacteria counts between day care facilities and schools (considering both cutting boards and serving plates). Additionally, there was no significant difference ($P > 0.05$) in the mean count of the microorganisms between the utensils, according to the results of Student's t test.

Sneed et al.¹⁶ proposed a standard for food contact surfaces that there be less than 1.3 log CFU/cm² (3.3 log

Table II
The distribution of microbial populations in a municipal school food program in the Jequitinhonha Valley region, Minas Gerais, Brazil

Sample	Bacteria	Establishment				
		School		Day care		All
		Mean (SD)*	Range	Mean (SD)	Range	Mean (SD)
Meal** (n = 68)	Coliforms	1.26 (1.55)	0-5.03	1.40 (1.44)	0-4.98	1.32 (1.49)
	<i>E. coli</i>	0.11 (0.68)	0-4.08	0.00 (0.00)	0-0.00	0.06 (0.49)
	<i>S. aureus</i>	1.22 (1.58)	0-5.08	0.26 (0.68)	0-2.73	0.77 (1.32)
	AMB	3.47 (1.37)	1.60-7.26	3.12 (1.06)	1.00-5.11	3.30 (1.24)
Utensil: serving plate (n = 32)	Coliforms	1.16 (1.54)	0-3.85	1.37 (1.65)	0-4.15	1.27 (1.58)
	<i>E. coli</i>	0.00 (0.00)	0-0.00	0.00 (0.00)	0-0.00	0.00 (0.00)
	<i>S. aureus</i>	0.21 (0.55)	0-1.78	0.31 (0.70)	0-1.95	0.26 (0.62)
	AMB	3.28 (1.61)	0-5.80	3.01 (1.63)	0-5.46	3.14 (1.60)
Utensil: cutting board (n = 27)	Coliforms	0.98 (1.37)	0-4.21	0.73 (1.24)	0-4.02	0.83 (1.27)
	<i>E. coli</i>	0.00 (0.00)	0-0.00	0.26 (0.82)	0-3.20	0.16 (0.64)
	<i>S. aureus</i>	0.30 (0.52)	0-1.30	0.92 (1.73)	0-5.35	0.67 (1.39)
	AMB	2.51 (1.94)	0-6.82	3.48 (1.55)	1.48-6.31	3.08 (1.75)
Hands (n = 45)	Coliforms	1.60 (1.33)	0-3.92	1.56 (1.14)	0-3.54	1.58 (1.23)
	<i>E. coli</i>	0.08 (0.40)	0-1.90	0.00 (0.00)	0-0.00	0.04 (0.28)
	<i>S. aureus</i>	1.66 (1.03)	0-3.45	1.60 (1.00)	0-3.51	1.63 (1.00)
	AMB	4.00 (0.83)	3.00-5.62	3.91 (0.76)	3.02-5.53	3.96 (0.79)
Water (n = 32)	Coliforms	0.00 (0.00)	0-0.00	0.03 (0.11)	0-0.50	0.01 (0.08)
	<i>E. coli</i>	0.00 (0.00)	0-0.00	0.00 (0.00)	0-0.00	0.00 (0.00)
	AMB	0.69 (0.86)	0-2.48	0.56 (0.84)	0-2.60	0.62 (0.84)
Air (n = 25)	AMB	2.45 (0.41)	1.48-2.95	2.23 (0.57)	1.30-3.16	2.34 (0.50)

*SD = Standard Deviation.

**log (CFU/g or ml).

CFU/100 cm² for AMB and less than 10 CFU/cm² (3 log CFU/100 cm²) for *Enterobacteriaceae*. In our study, coliform and AMB counts above the standard were detected more frequently on serving plates (25% and 46.9% of the samples, respectively) than on cutting boards (7.4% and 40.7% of the samples, respectively). The same was not observed for *S. aureus*; with counts above the standard appeared only on the cutting boards (7.4%).

Five samples (15.6%) from serving plates and 8 samples (29.6%) from cutting boards were positive for *S. aureus*. The mean count on utensils was 0.46 log CFU/100 cm², with only two samples (3.4%) having counts higher than 3 log CFU/100 cm² (cutting boards at a day care and another at a school). The mean AMB count was 3.1 log CFU/100 cm², and 24 (40.7%) of the samples surpassed the value of 3.3 log CFU/100 cm².

Using the standard proposed by Sneed et al.¹⁶ for food contact surfaces, 5 (45,5%) of the establishments (3 day care facilities and 2 schools) in the present study had mean AMB levels above the acceptable limits on serving plates. The mean coliform count was above

acceptable limits in only 1 (9%) establishment (a day care facility), and in no establishment did we detect *S. aureus* above the limit. On cutting boards, 5 (45,5%) of the establishments (4 day care facilities and 1 schools) had mean AMB levels above acceptable limits. None of the establishments had a mean coliform count above the acceptable limit, and only 1 (9%) establishment (day care) had a mean *S. aureus* count above the limit.

A total of 45 samples from the hands of food handlers in the establishments investigated were analyzed. Coliforms, *E. coli* and *S. aureus* were detected in 33 (73.3%), 1 (2.2%) and 36 (80%) samples, respectively. The *E. coli* count was 1.9 log CFU/hand. Coliform counts greater than 2 and 3 log CFU/hand were detected in 10 (22.2%) and 6 (13.3%) samples, respectively. Higher loads of *S. aureus* (> 3 log) were detected in 4 (8.9%) samples. The AMB counts were above 5 log CFU/hand in 5 (11.1%) samples. No significant differences (P > 0.05) were noted between the hand samples of food handlers in day care facilities versus schools for coliform, *S. aureus* and AMB counts.

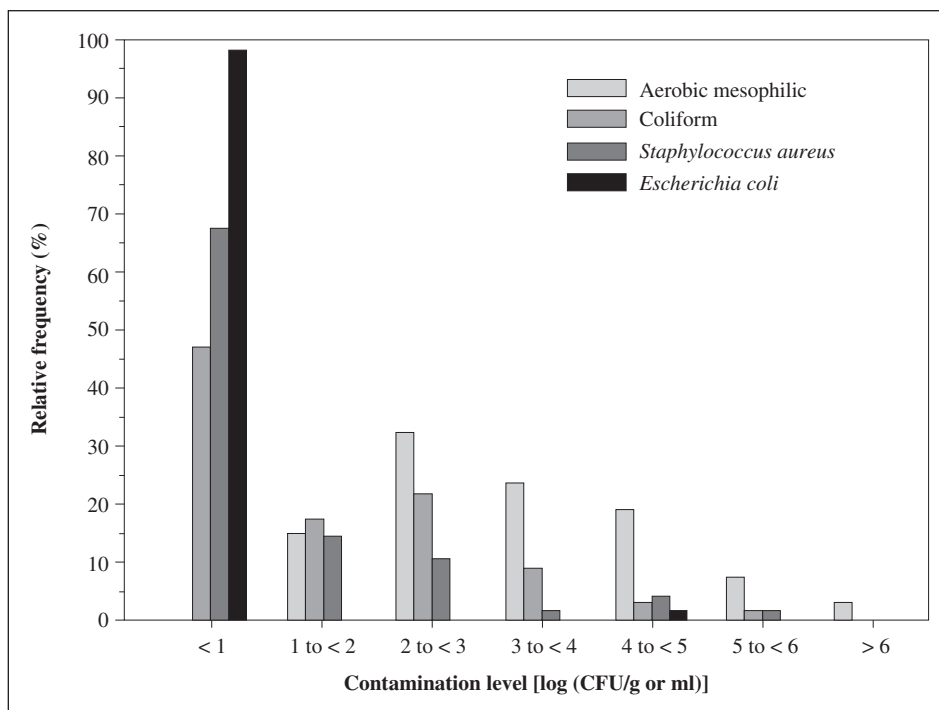


Fig. 1.—The distribution of microbial populations in meals served in a municipal school food program in the Jequitinhonha Valley region, Minas Gerais, Brazil.

All the establishments in our study receive their drinking water from the public treatment system. Coliforms were detected in 1 (3.1%) sample collected from a day care facility, with a count of 0.48 log CFU/ml. *E. coli* was not detected in the samples analyzed.

The air quality in the food preparation area was evaluated by counting AMB. A maximum of 1.48 log CFU/cm²/week is the level recommended by the American Public Health Association (APHA) for ambient air in the food industry¹². The average counts are presented in table II. Only one sample (4.0%) had a count below the reference value. All establishments had an average AMB count above 1.6 log CFU/cm²/week. There was no significant difference between the AMB counts in day care facilities and in schools ($P > 0.05$).

Discussion

Food safety is a critical issue in school food program. Adopting good manufacturing practices in school and day care facilities requires attention, particularly because the children served in these establishments are often socially vulnerable. The results obtained using the checklist for school food service standards indicate that facilities have poor quality food safety practices: inadequate facilities, missing documentation, deficient equipment and utensils, inadequate pest control, and poor hygiene practices by food handlers that persist despite frequent training.

In general, the buildings and the facilities were not built to serve as food service facilities. They were adapted without correcting the inadequacies of the

physical facilities and the environment, operating in buildings similar to family homes. In addition, no preventive measures were taken for pest control. One way to minimize the need to adapt buildings and facilities would be to adopt manufacturing practices in other critical areas, such as the hygiene of food handlers, hygiene and preparation practices and documentation. However, there were no day care facilities or schools with manuals of good practices or sanitization standard operating procedures written and implemented.

Some non-compliance by the food handlers can be attributed to the lack of products and equipment in the workplace. For example, no establishments we investigated had products for disinfecting hands after the food handlers washed their hands with soap. Another practice observed was that facilities allowed free access to food preparation area by non-food handlers (e.g., preschool teachers and child care workers).

These results are in agreement with studies of schools in other regions of Brazil^{10,13,17} and of other food service locations.¹⁸ However, different results were observed in schools in the city of Curitiba, where 20% had excellent or very good conditions, 52.5% had regular conditions and 7.5% had poor or very poor conditions.

Given the results described above, it appears that there are significant differences in the implementation of good manufacturing practices between the school/day care food service facilities located in different regions of Brazil. These disparities reflect the different levels of social development in these regions, even though the national school meals program is meant to be consistently implemented throughout the entire country.

On the basis of the results obtained, it was concluded that the microbiological analysis of the meal samples indicated the absence of the pathogens *Listeria monocytogenes* and *Salmonella* spp. and a low percentage of positive *E. coli* samples (1.5%). However, a third of the samples (32.5%) were contaminated by *S. aureus*. The majority of the samples that tested positive for *S. aureus* contained food that was not heat-treated or was exposed to mild heat. The current Brazilian legislation sets the maximum level of *S. aureus* at 3 log CFU/g or ml for ready-to-eat food in restaurants or other food service facilities. In this study, 5 (7.35%) samples from 4 different establishments had unsatisfactory levels detected.

This contamination has human origins, and it is introduced by poor handling practices. Food handlers can cause microbial contamination of food products with *S. aureus* by sneezing, talking, laughing, allowing hair to fall into the food or using soiled coats.¹⁹

With regard to AMB, counts above 5 log CFU/g have been considered a potential risk for the presence of pathogens.²⁰ In this study, the average count was found to be 3.3 log CFU/g or ml. However, counts of AMB above the limit of 5 log were detected in 10.3% of the samples collected in 7 (63.6%) different establishments, all related to improper hygiene and/or a problematic distribution process.

Our results demonstrated that utensils can harbor a high microbial load if they are not properly cleaned or if they are excessively worn. Two types of food contact surfaces, a utensil used in food preparation and another used to serve meals, showed similar contamination and microorganism counts, indicating a deficiency in hygienic practices. Significant differences in the microbial counts on the surfaces of utensils were observed between the establishments, as mean counts above the acceptable limit were detected in 6 of 11 establishments. Transferring microbes from human hands has been reported as a potential cross-contamination route.²¹ In fact, scientific studies report that hand-contact surfaces are more likely to be contaminated than food-contact surfaces.²² This result was corroborated by the high counts of AMB found on both vessels.

The design and construction of child care centers, especially the separation of the toilet from the food handling and eating areas, are important in the control and transmission of infectious diarrhea.²³

This study revealed that the mean coliform, AMB and *S. aureus* counts on the cutting boards and serving plates were lower than the mean counts detected on the hands of food handlers, indicating poor standards of cleanliness and a lack of general hand-washing hygiene. Unlike the results from the surfaces of the utensils, coliforms and *S. aureus* were detected on the hands of handlers in all establishments. Approximately 73% of food handlers had an AMB count above 3.3 log CFU/hand.

Food handlers who do not practice proper personal hygiene, including hand washing at the appropriate times and using appropriate hand-washing methods, can contaminate foods with organisms from the gastrointestinal

tract.²⁴ Insufficient and inadequate hand washing by employees in retail food service establishments is a well-known contributing factor to foodborne illnesses and is particularly critical when employees are preparing and serving food to vulnerable individuals, such as young children.²⁵ Several factors may contribute to the contamination on the hands of food handlers (e.g., all schools and day care facilities lacked an effective sanitizer for hand hygiene). Furthermore, the workers in schools and day care facilities typically have multiple responsibilities that include food preparation, service, and cleaning.²⁴ The retention of bacteria on food contact surfaces increases the risk of cross-contamination of food with these microorganisms.

Assisted-living facility food service operations generally met the proposed standards for each microbiological test performed. The high aerobic plate count on utensil surfaces and the hands of food handlers may indicate cross-contamination, verifying observational studies that indicate noncompliance with hand-washing and potential cross-contamination, particularly in the dishwashing area.^{16,25} Almost one-fourth of the cutting boards also had detectable counts of *S. aureus*, which indicates either inadequate sanitation or recontamination. Furthermore, high standards are needed when providing meals to children and other vulnerable populations.

In general, the public water system provides clean water, and outbreaks that are attributable to drinking water are rare. The results of this study reflect this reality, showing the high quality of the water used in schools and day care facilities. However, AMB were detected in 16 (50%) of the samples analyzed, with counts above 2 log CFU/ml in 3 (9.3%) samples.

According to the standard recommended by the APHA, the air quality in areas where food is handled and prepared in schools and day care facilities is poor. These results suggest that the risk of airborne microorganisms seems to be high in the school food service facilities evaluated in this study. The air quality in food processing plants may not directly affect the microbiological safety or the quality of some perishable foods. However, foods that are susceptible to deterioration are particularly sensitive to contamination by airborne organisms.

High levels of contamination may be caused by the lack of a physical barrier, and no establishments studied had screens on their windows or protective doors. These missing barriers are associated with increased contamination of the air. Adopting good food safety practices is necessary to reduce the risk of cross-contamination in food preparation environments. Risk management of airborne microorganisms is necessary to ensure food safety of school food services. The high contamination of the air of the local food preparation is a reflection of the inadequacies noted in the physical structure of schools and day care facilities as catering for children. There is a need to create recommendations for microbiological control of food service environments.

Developing a set of standard sanitary operating procedures, similar to those used by the food industry and the

food service industry, should be developed to assist day care center staff (directors, cooks, and teachers) in effectively cleaning and sanitizing surfaces to reduce potential hazards.

Conclusions

Based on the results of this study, it is concluded that the production of meals in the establishments analyzed does not comply with most of the requirements of good manufacturing practices and therefore put at risk the health of assisted children. The results present should help risk managers to adopt better control strategies to prevent foodborne disease in the school environment and promote and ensure food safety.

There are limitations in the study. We could not establish a correlation between the bacteriological quality of the food served and epidemiological surveillance data evidencing the occurrence of foodborne disease in schools and day cares evaluated. The results cannot be generalized to all schools and day care centers in the municipality, the study did not include private establishments and not all public facilities. Another limitation was the lack of funds to include other pathogens such as parasites, viruses and other bacteria.

Acknowledgement

The authors are grateful to the *Fundação de Amparo a Pesquisa do Estado de Minas Gerais* (FAPEMIG) for providing funding for this research (Process APQ-02091-09), to nutritionists Hemerson Petherson de Lima and Ana Flávia Abreu for the technical assistance and to Eliznara F. Correia for her invaluable assistance throughout this research.

References

1. Alderman H, Bundy D. School Feeding Programs and Development: Are We Framing the Question Correctly? *World Bank Res Obs* 2011.
2. Bundy D, Burbano C, Grosh M, Gelli A, Jukes M, Drake L. Rethinking School Feeding: Social Safety Nets, Child Development, and the Education Sector. Washington, DC: World Bank, 2009.
3. Anonymous. Fundo Nacional de Desenvolvimento da Educação. Alimentação Escolar. Available at: <http://www.fnede.gov.br/index.php/programas-alimentacao-escolar>. Accessed May 2011.
4. Lee MB, Greig JD. A Review of Gastrointestinal Outbreaks in Schools: Effective Infection Control Interventions. *J Sch Health* 2010; 80: 588-98.
5. Daniels NA, Mackinnon L, Rowe SM, Bean NH, Griffin PM, Mead PS. Foodborne disease outbreaks in United States schools. *Pediatr Infect Dis J* 2002; 21: 623-8.
6. Niehaus AJ, Apalata T, Coovadia YM, Smith AM, Moodley P. An Outbreak of Foodborne Salmonellosis in Rural KwaZulu-Natal, South Africa. *Foodborne Pathog Dis*. 2011; 8: 693-7.
7. Michelin ADF, do Carmo LS, Carlos IZ. Food-borne staphylococcal intoxication outbreak in Birigüi municipality, São Paulo State. *Rev Inst Adolfo Lutz* 2006; 65: 46-9.
8. Anonymous. Dados Epidemiológicos - DTA período de 2000 a 2011*. Unidade Técnica de Doenças de Veiculação Hídrica e

Alimentar. Coordenação Geral de Doenças Transmissíveis. Secretaria de Vigilância em Saúde. 2011. Available at: http://portal.saude.gov.br/portal/arquivos/pdf/dados_epidemiologicos_dta_15911.pdf.

9. Todd ECD, Greig JD, Bartleson CA, Michaels BS. Outbreaks Where Food Workers Have Been Implicated in the Spread of Foodborne Disease. Part 3. Factors Contributing to Outbreaks and Description of Outbreak Categories. *J Food Prot* 2007; 70: 2199-217.
10. Lockis VR, Cruz AG, Walter EHM, Faria JAF, Granato D, Sant'Ana AS. Prerequisite Programs at Schools: Diagnosis and Economic Evaluation. *Foodborne Pathog Dis* 2010; 8: 213-20.
11. Morton RD. Aerobic Plate Count. In: Downes FP and Ito K, (eds.). Compendium of Methods for the Microbiological Examination of Foods. 4 ed. Washington, DC: American Public Health Association, 2001, pp. 63-7.
12. Evancho GM, Sveum WH, Moberg LJ, Frank JF. Microbiological monitoring of the food processing environment. In: Downes FP and Ito K, (eds.). Compendium of Methods for the Microbiological Examination of Foods. 4 ed. Washington, DC: American Public Health Association, 2001, pp. 25-35.
13. Santana NG, Almeida RCC, Ferreira JS, Almeida PF. Microbiological quality and safety of meals served to children and adoption of good manufacturing practices in public school catering in Brazil. *Food Control* 2009; 20: 255-61.
14. Brasil. Agência Nacional de Vigilância Sanitária (ANVISA). Resolução RDC nº 216, September 2004. Regulamento Técnico de Boas Práticas para Serviços de Alimentação. 2004.
15. Brasil. Agência Nacional de Vigilância Sanitária (ANVISA). Resolução RDC nº 275, 23 October 2003. Regulamento Técnico de Procedimentos Operacionais Padronizados aplicados aos estabelecimentos produtores/industrializadores de alimentos e a lista de verificação das boas práticas de fabricação em estabelecimentos produtores/industrializadores de alimentos. 2003.
16. Sneed J, Strohbahn C, Gilmore SA, Mendonca A. Microbiological evaluation of foodservice contact surfaces in Iowa assisted-living facilities. *J Am Diet Assoc* 2004; 104: 1722-4.
17. Cardoso RdCV, Góes JÁW, Almeida RCDC et al. Programa nacional de alimentação escolar: há segurança na produção de alimentos em escolas de Salvador (Bahia)? *Rev Nutr* 2010; 23: 801-11.
18. Veiros MB, Proença RPC, Santos MCT, Kent-Smith L, Rocha A. Food safety practices in a Portuguese canteen. *Food Control* 2009; 20: 936-41.
19. Todd ECD, Michaels BS, Greig JD, Smith D, Bartleson CA. Outbreaks Where Food Workers Have Been Implicated in the Spread of Foodborne Disease. Part 8. Gloves as Barriers To Prevent Contamination of Food by Workers. *J Food Prot* 2010; 73: 1762-73.
20. Ayçiçek H, Sarimehmeto lu B, Çakiro lu S. Assessment of the microbiological quality of meals sampled at the meal serving units of a military hospital in Ankara, Turkey. *Food Control* 2004; 15: 379-84.
21. Pérez-Rodríguez F, Valero A, Carrasco E, García RM, Zurera G. Understanding and modelling bacterial transfer to foods: a review. *Trends Food Sci Technol* 2008; 19: 131-44.
22. DeVita MD, Wadhwa RK, Theis ML, Ingham SC. Assessing the potential of *Streptococcus pyogenes* and *Staphylococcus aureus* transfer to foods and customers via a survey of hands, hand-contact surfaces and food-contact surfaces at foodservice facilities. *J Foodservice* 2007; 18: 76-9.
23. Thompson SC. Infectious diarrhoea in children: Controlling transmission in the child care setting. *J Paediatr Child Health* 1994; 30: 210-9.
24. Strohbahn C, Sneed J, Paez P, Meyer J. Hand Washing Frequencies and Procedures Used in Retail Food Services. *J Food Prot* 2008; 71: 1641-50.
25. FDA. Food and Drug Administration. Trend Analysis Report on the Occurrence of Foodborne Illness Risk Factors in Selected Institutional Foodservice, Restaurant, and Retail Food Store Facility Types (1998-2008). 2011. Available at: <http://www.fda.gov/Food/GuidanceRegulation/RetailFoodProtection/FoodborneIllnessRiskFactorReduction/ucm223293.htm>. Accessed September 2011.