Microbiological assessment and evaluation of rehydration instructions on powdered infant formulas, follow-up formulas, and infant foods in Malaysia

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ABSTRACT

A total of 90 samples comprising powdered infant formulas ($n = 51$), follow-up formulas ($n = 21$), and infant foods ($n = 18$) from 15 domestic and imported brands were purchased from various retailers in Klang Valley, Malaysia and evaluated in terms of microbiological quality and the similarity of rehydration instructions on the product label to guidelines set by the World Health Organization. Microbiological analysis included the determination of aerobic plate count (APC) and the presence of *Enterobacteriaceae* and *Cronobacter* spp. Isolates of interest were identified using ID 32E (bioMérieux France, Craponne, France). In this study, 87% of powdered infant formulas, follow-up formulas, and infant foods analyzed had an APC below the permitted level of $<10^4$ cfu/g. These acceptable APC ranged between $<10^2$ to 7.2×10^3 cfu/g. The most frequently isolated *Enterobacteriaceae* was *Enterobacter cloacae*, which was present in 3 infant formulas and 1 infant food tested. Other *Enterobacteriaceae* detected from powdered infant and follow-up formulas were *Citrobacter* spp., *Klebsiella* spp., and other *Enterobacter* spp. No *Cronobacter* species were found in any samples. Rehydration instructions from the product labels were collated and it was observed that none directed the use of water with a temperature $>70^\circ\text{C}$ for formula preparation, as specified by the 2008 revised World Health Organization guidelines. Six brands instructed the use of water at 40 to 55°C , a temperature range that would support the survival and even growth of *Enterobacteriaceae*.

Key words: powdered infant formula, follow-up formula, infant foods, rehydration instructions

INTRODUCTION

In terms of food safety, infants and children are considered to be a part of the high-risk group of individuals, as their immune systems may not yet be fully developed. Infants and young children are especially vulnerable to diarrheal illnesses when introduced to fluids and foods as they are weaned from breastfeeding to a mixed diet (Marino, 2007). In food, pathogens can grow at room temperature. Further, elevated temperatures that are typical in tropical countries can hasten pathogen multiplication (Tirado et al., 2010).

One of the pathogens of concern is the opportunistic *Cronobacter* (formerly *Enterobacter sakazakii*), which has gained attention in the past decade by its association with infant infections through contaminated infant formula (Joseph and Forsythe, 2011; Kucerova et al., 2011). These organisms have been observed to persist in dry environments such as powdered foods and grow rapidly in reconstitution (Iversen and Fanning, 2009). An early survey on the presence of *Enterobacteriaceae* in powdered infant formula (PIF) by Muytjens et al. (1988) reported that 52.2% of the samples contained the organisms. The following year, a case of infant formula milk believed to be contaminated with *Enterobacteriaceae* (*Cronobacter*) during the manufacturing process (Simmons et al., 1989) and 3 cases of neonatal meningitis caused by *Cronobacter* found in dried infant formula in Iceland (Biering et al., 1989) were reported. Isolation of *Cronobacter* in 16.6% of PIF samples was reported in 2004 (Iversen and Forsythe, 2004).

In 2008, the Food and Agriculture Organization of the United Nations/World Health Organization (FAO/WHO) issued a call for data on *Cronobacter* occurrence in PIF (intended target age <6 mo) and follow-up formula (FOF; intended target age >6 mo). In response, an international survey involving 8 laboratories in 7 different countries (including Malaysia) was coordinated to determine the presence of *Cronobacter sakazakii* and other *Cronobacter* spp. in FOF and other infant foods. Initial investigations in this study were done in line with the FAO/WHO request and were subsequently

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published (Chap et al., 2009). However, given the lack of published information in Malaysia with regard to the presence of *Cronobacter*, the survey was extended to a wider range of PIF, FOF, and infant or weaning foods (IF) available in the country.

Aside from the intrinsic presence of pathogens, improper handling of infant-related food, such as inadequate cleaning of bottles, multiple reheating, or inappropriate rehydration procedures may also favor the proliferation of harmful bacteria. For this reason, the WHO in 2007 released both printed and online materials to guide the general public about safe milk handling (WHO, 2007a,b). It is uncertain how widely these guidelines have been distributed and adopted for product instructions for the preparation of infant foods. It is worthwhile, therefore, to check whether the instructions provided on different products are in line with these WHO recommendations.

It is worth noting that the basic principles of food poisoning and food hygiene in developed and developing countries are the same. However, food safety in developing countries such as Malaysia is more challenging due to the tropical climate. Further, although the basic factors preceding foodborne illness in the tropics are the same as in other places, conditions such as high ambient temperature and humidity, general lack of refrigeration, local habits, impure water, poor sanitary facilities, and profusion of intestinal pathogens and parasites can enhance the dangers (Adams, 2007). This study aims to determine the microbiological quality of PIF and related products commercially available in Malaysia in terms of their aerobic plate count (APC) and the presence of *Enterobacteriaceae*, especially *Cronobacter*. This study will provide microbiological surveillance data that may be used to evaluate the suitability of internationally prescribed infant formula handling and management standards to conditions in tropical developing countries.

MATERIALS AND METHODS

Milk Samples

A total of 90 samples were analyzed. They comprised PIF ($n = 51$), FOF ($n = 21$), and IF ($n = 18$) from 15 domestic and imported brands purchased from various retailers in Klang Valley, Malaysia. By definition, PIF is a formula intended for use by infants from 0 to 6 mo, FOF is formula for use by infants from 6 mo onward, and infant food can be any food other than breast milk or infant formula that is made specifically for infants. Whenever available, 5 samples from identical production batches were obtained. Only 1 sample was analyzed from some PIF brands, as they were provided by

local distributors. Product ingredients, reconstitution instructions, and products containing special components such as probiotic cultures were recorded.

Microbiological Analysis

Microbiological analysis conducted in this study included the determination of APC and the presence of *Enterobacteriaceae* and *Cronobacter* spp. Following the surface spread plate method (Roberts and Greenwood, 2003), the APC in milk and infant food samples were determined. Twenty-five grams of each sample was added to 225-mL portions of Maximum Recovery Diluent (MRD; Oxoid Thermo Fisher, Basingstoke, UK) and allowed to rehydrate at room temperature for 10 min. After rehydration, the rehydrated milk was serially diluted in MRD until a 10^{-5} dilution was obtained. From each MRD dilution, 0.1-mL portions were spread onto plate count agar (Oxoid Thermo Fisher). The plate count agar was then allowed to dry, incubated overnight at 37°C , and discrete colonies thereafter counted. All samples were analyzed in duplicate.

To determine the presence of *Cronobacter* and other *Enterobacteriaceae* in the milk and infant food, samples were analyzed as previously described by Chap et al. (2009). Samples were preenriched by suspending 25 g in 225 mL of buffered peptone water (Oxoid Thermo Fisher) and incubated at 37°C for 18 to 24 h. After incubation, 10-mL portions were transferred into 90-mL *Enterobacteriaceae* enrichment (EE; Oxoid Thermo Fisher) broth and incubated overnight at 37°C as an enrichment step.

To detect *Enterobacteriaceae*, 1-mL portions of EE broth were pipetted onto separate Petri dishes and mixed with 10 to 15 mL of molten, cooled violet red bile glucose agar (VRBGA; Oxoid Thermo Fisher) and allowed to set. The solidified medium was then overlaid with an additional 10 mL of molten, cooled VRBGA and allowed to set. For *Cronobacter* detection, a loopful of EE broth was streaked on Brilliance *Enterobacter sakazakii* chromogenic DFI agar (Oxoid Thermo Fisher). The inoculated plates were incubated at 37°C overnight. All samples were analyzed in duplicate. Isolates of interest were identified using phenotyping (ID 32E; bioMérieux France, Craponne, France).

RESULTS AND DISCUSSION

Determination of APC

The general microbial flora present in 90 samples of PIF, FOF, and IF from 15 different commercial brands were determined (Table 1). From the samples analyzed, 61 had APC less than 10^2 cfu/g, 1 of the samples

Table 1. Aerobic plate counts of different infant milk and feed samples

Product type	No. of samples	Aerobic plate count (cfu/g of sample)			
		<10 ²	10 ² to <10 ³	10 ³ to <10 ⁴	>10 ⁴
Infant formula	51	41	0	10	0
Follow-up formula	21	9	0	5	7
Infant food	18	11	1	1	5
Total	90	61	1	16	12

had an APC between 10² to <10³ cfu/g, 16 samples had APC between 10³ to <10⁴ cfu/g, and 12 samples exceeded the maximum acceptable APC level of 10⁴ cfu/g. It was observed that 87% (78/90) of the samples had acceptable APC limits of <10⁴ cfu/g, a guideline of safety against possible food poisoning (HMSO, 1995; Gilbert et al., 2000).

Very high aerobic counts (>10⁴) were observed for 7 FOF and 5 IF, in agreement with studies by Chap et al. (2009). The highest APC (4.2 × 10⁶ cfu/g) was recorded for an infant cereal intended for babies aged 8 to 24 mo. This product was labeled to contain the probiotic *Bifidobacterium lactis*, but because of the anaerobic nature of this organism, it could not have contributed to the high APC levels. According to the Malaysian regulations (Regulation 26A, Act 281, 1983), food containing bifidobacteria should contain at least 10⁶ viable cells per gram (Food Act, 2006) and it has been established that long-term consumption of infant formula milk supplemented with *B. lactis* is safe and well-tolerated by infants (Saavedra et al. 2004). Milk supplemented with probiotics results in certain immunomodulatory effects such as decreased allergic tendencies (Viljanen et al., 2005; Rautava, 2007). The level of *Enterobacteriaceae* spp. for this product was not quantified, but *Enterobacteriaceae*, specifically *Enterobacter vulneris*, was detected using the biochemical test ID 32E.

Further, an infant cereal that contained *B. lactis* cultures also yielded a relatively high APC of 5.5 × 10⁴ cfu/g. An FOF containing *Bifidobacterium longum* and *Lactobacillus rhamnosus* probiotics showed a high APC level of 5.3 × 10⁵. On the other hand, a probiotic-containing FOF yielded an APC <10² cfu/g, despite having *Bifidus* cultures in its composition. In this case, the exact *Bifidus* species was not mentioned.

For PIF, APC ranged between <10² to 7.3 × 10³ cfu/g. Approximately 78% of these samples had APC <10² cfu/g, which is reported as undetected according to Codex Alimentarius regulations. For FOF, 43% of the samples had an APC <10², whereas 14% (3/21) of the samples had APC >10⁴ and, therefore, not meeting standard regulations. Of the 18 IF tested, the APC range was between <10² to 4.6 × 10⁶ cfu/g, the highest APC for all samples tested. Around 72% of the IF

samples were compliant to Codex Alimentarius regulations for APC.

Detection of *Enterobacteriaceae* spp.

The *Enterobacteriaceae* level is one of the microbiological criteria (ISO, 2004; EC, 2005) prescribed for dried infant formula and dried dietary foods for special medical purposes intended for infants below 6 mo of age; in 10 g of these dried infant formulas and dietary foods, *Enterobacteriaceae* should not be present. These regulations further state that if *Enterobacteriaceae* are present, the presence of *Cronobacter* should be tested. In this study, *Enterobacteriaceae* was detected in 13/90 samples, but none were confirmed to contain *Cronobacter*, following the prescribed method of detection using *Cronobacter* chromogenic medium (Iversen and Forsythe, 2004).

Further biochemical profiling was conducted using the bioMérieux ID 32E system, in place of the prescribed API 20E system (bioMérieux France), as preliminary studies using well-characterized *Cronobacter* strains cultures found ID 32E to more accurately identify the organism. The most frequent organism detected was *Enterobacter* spp. (5/90 samples), followed by *Citrobacter* spp. (5/90) and *Klebsiella* spp. (3/90 samples; Table 2). These results are similar to those obtained by Iversen and Forsythe (2004) who isolated *Enterobacteriaceae*, including *Enterobacter* spp., *Pantoea* spp.,

Table 2. Types of *Enterobacteriaceae* detected in various milk samples

Product type/ sample code	<i>Enterobacteriaceae</i> detected
Infant formula E	<i>Citrobacter freundii</i>
	<i>Citrobacter amalonaticus</i>
Infant formula F	<i>Enterobacter cloacae</i>
	<i>Klebsiella terrigena</i>
	<i>Citrobacter freundii</i> ¹
Infant formula G	<i>Enterobacter cloacae</i> ¹
Infant formula H	<i>Klebsiella pneumoniae</i>
Follow-up formula J	<i>Citrobacter freundii</i>
	<i>Klebsiella pneumoniae</i>
Infant food 2	<i>Enterobacter cloacae</i>
Infant food 11	<i>Enterobacter vulneris</i>

¹Organism detected in 2 samples of the same product type.

Table 3. Similarity of powdered infant formula (PIF) and follow-up formula (FOF) rehydration instructions to World Health Organization (WHO) guidelines for preparation of infant formula

Recommended steps ¹	Sample compliance with WHO guidelines ²																							
	4	5 ³	6	7	8	9	10	14 ³	20	21	22	30	A	B	C	D	E	F	G	H	I	J ³	K	L
A. Cleaning and sterilizing feeding and preparation equipment																								
1. Hands should always be washed thoroughly with soap and water before cleaning and sterilizing feeding and preparation equipment	✓	✓	✓	✓	X	✓	✓	✓	X	✓	X	✓	X	X	✓	✓	✓	✓	X	X	✓	✓	X	X
2. Wash feeding and preparation equipment (e.g., cups, bottles, teats, and spoons) thoroughly in hot soapy water	✓	✓	✓	✓	X	✓	✓	✓	✓	X	✓	✓	✓	✓	✓	✓	✓	X	✓	X	✓	✓	✓	✓
3. After washing the feeding and preparation equipment, rinse thoroughly in safe water	P	P	X	✓	X	X	X	P	X	X	X	X	✓	✓	X	X	P	X	X	X	X	P	✓	X
4. Sterilizing: if using a commercial home sterilizer (e.g., electric or microwave steam sterilizer, or chemical sterilizer), follow manufacturer's instructions. Feeding and preparation equipment can also be sterilized by boiling	✓	✓	✓	✓	X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	✓	X	✓	✓	✓	✓
5. Hands should be washed thoroughly with soap and water before removing feeding and preparation equipment from a sterilizer or pan. The use of sterilized kitchen tongs for handling sterilized feeding and preparation equipment is recommended	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6. Remove feeding and preparation equipment just before it is to be used. If equipment is removed from the sterilizer and not used immediately, it should be covered and stored in a clean place. Feeding bottles can be fully assembled	✓	✓	X	X	X	X	X	✓	X	X	X	X	X	X	X	X	✓	X	X	X	✓	✓	X	X
B. Preparing a feed using powdered infant formula																								
1. Clean and disinfect a surface on which to prepare the feed	X	X	X	X	X	X	X	X	X	X	X	X	✓	✓	X	X	X	X	X	X	X	X	✓	X
2. Wash hands with soap, water; dry using a clean cloth or single-use napkin	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3. Boil a sufficient volume of safe water. If using an automatic kettle, wait until kettle switches off; make sure that the water comes to a rolling boil	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	✓	✓	✓	✓	✓	✓
4. Taking care to avoid scalds, pour the appropriate amount of boiled water that has been allowed to cool to no less than 70°C into a cleaned and sterilized feeding cup or bottle	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5. To the water, add the exact amount of formula as instructed on the label	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	✓	✓	✓	✓	✓	✓
6. Immediately after preparation, quickly cool feeds to feeding temperature by holding the bottle or feeding cup under running tap water, or by placing in a container of cold or iced water	X	X	X	✓	X	X	✓	X	X	P	X	X	X	X	✓	X	X	X	X	X	✓	X	X	X

Continued

Table 3 (Continued). Similarity of powdered infant formula (PIF) and follow-up formula (FOF) rehydration instructions to World Health Organization (WHO) guidelines for preparation of infant formula

Recommended steps ¹	Sample compliance with WHO guidelines ²																							
	4	5 ³	6	7	8	9	10	14 ³	20	21	22	30	A	B	C	D	E	F	G	H	I	J ³	K	L
7. Dry the outside of the feeding cup or bottle with a clean or disposable cloth	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8. Because very hot water has been used to prepare the feed, it is essential that the feeding temperature is checked before feeding to avoid scalding the infant's mouth. If needed, continue cooling as outlined in step 6	X	X	X	X	X	X	✓	X	X	X	X	✓	✓	✓	✓	X	X	X	X	X	✓	X	✓	X
9. Discard any feed that has not been consumed within 2 h	X	X	X	X	P	P	X	X	✓	X	X	X	✓	✓	✓	X	X	X	X	X	X	X	✓	✓

¹According to WHO guidelines for safe preparation, storage, and handling of powdered infant formula (WHO, 2007b).²Key: ✓ = guideline specified on product label; X = guideline not specified on product label; P = guideline partially mentioned on product label. The numbers and letters in the subheadings represent sample codes.³Contains probiotic bacteria.

Escherichia coli, and *Klebsiella* spp., from various infant milk and infant food samples.

The dose-response relationship of *Enterobacteriaceae* in milk powders has not been established, but its absence in the product provides extra protection to newborns, especially to premature, immunocompromised, and low- (<2,500 g) and very low (<1,500 g)-birth-weight babies, in case multiplication of the organism occurs during preparation, storage, or administration of the infant food (Muytjens et al., 1988; FAO/WHO, 2004). The impact of infection largely depends on the disease contracted by the neonates (Reij et al., 2009), but Bowen and Braden (2008) have reported that, of infants suffering from meningitis, a considerable percentage do not survive, whereas those who do survive suffer severe sequelae. More recently, Joseph and Forsythe (2011) reported the association of *C. sakazakii* ST4 with the majority of neonatal meningitis cases over the past 30 yr. Despite the presence of *Enterobacteriaceae* in the samples, no outbreak or documented reports have been made in Malaysia pertaining to neonatal infection following consumption of any of the *Enterobacteriaceae*-positive products mentioned herein, or of any powdered infant formula for that matter.

Cronobacter was not detected in any of the samples analyzed in this study. Other studies have reported the presence of *Cronobacter* in various food products, including infant food and milk, but usually the organism was found in a very low percentage of the total samples tested. Reports by the FAO/WHO (2006) indicate a 2 to 22% incidence of *Cronobacter* spp. in PIF from various studies. Tudela et al. (2008) reported the absence of pathogenic bacteria in 156 rehydrated milk formulas examined in a hospital.

It is standard procedure that 10 g of sample be used for analysis. However, given the low frequency of *Cronobacter* incidences, Hoque et al. (2010) states that the organism may be better traced if larger volumes of sample are used. In addition to using larger volumes of sample, Iversen and Forsythe (2004) suggested the use of *Cronobacter* chromogenic medium to better detect the organism. This suggestion was made after chromogenic medium was observed to more effectively isolate *Cronobacter* (67/485 positive samples) compared with the conventional VRBGA method (Muytjens et al., 1988) adopted by the FDA, which yielded only 19/485 positive samples.

Evaluation of Rehydration Instructions on Product Packaging

The ease of application and clarity and consistency of rehydration instructions provided on infant milk products are important considerations when addressing

guidance needs for the general public during preparation and management of infant food. By definition of the Codex Alimentarius Commission (revision 2007; CAC, 1981), infant formula is “a breast-milk substitute specially manufactured to satisfy, by itself, the nutritional requirements of infants during the first months of life up to the introduction of appropriate complementary feeding”. The CAC describes FOF as “food intended for use as a liquid part of the weaning diet for the infant from the 6th month on and for young children”. On the other hand, IF is described as “food processed and manufactured for the nutritional health of children in their first year of life” (Reference.MD, 2010).

The WHO has issued a set of guidelines on the safe preparation, storage and handling of powdered infant formula, which includes 2 sets of guidelines: preparation of PIF in care settings (WHO, 2007a) and preparation in the home (WHO, 2007b). The latter guidelines have been tabulated and how each PIF and FOF product conforms to them was evaluated (Table 3). Although the WHO publication is a guideline and not a standard by which manufacturers must comply with, it is important to note that some rehydration instructions on product labels may either be insufficient, ambiguous, or difficult to follow and may cause the improper handling of infant formula milk.

The 90 samples evaluated in this study consisted of 24 different PIF and FOF products. From these, 21/24 rehydration instructions specified that bottles and utensils should be sterilized by boiling (Step A.4; WHO, 2007a,b). All sample labels directed that the proper amount of boiled water be transferred to a clean sterilized bottle (Step B.4); all but one specified that water should be brought to boil for use in formula preparation (Step B.3) and that the exact amount of formula should be added to it (Step B.5).

The FAO/WHO (2006) and WHO (2007a,b) recommended the use of water $>70^{\circ}\text{C}$ for reconstitution of powdered infant formula, but none of the collated rehydration instructions indicated the use of water at this temperature. When milk is prepared at the recommended 70°C , milk handlers should be aware of the importance of rapid cooling to avoid the multiplication of bacteria. From the different PIF and FOF product types, 9 mentioned specific temperatures ranging from 40 to 55°C . These temperatures, at which feed may be given to infants, may have been recommended so that no further cooling would be required, as per Step B.6 of the WHO (2007a,b) guidelines. However, it is important to note that at these temperatures, *Cronobacter* and other *Enterobacteriaceae* can grow (Chap et al., 2009). All other brands only mentioned for previously boiled water to be cool or lukewarm before addition of formula. These subjective temperature de-

scriptions may contribute to the mishandling of infant formula and if subsequent growth and multiplication of microorganisms occurred due to these temperature errors, it would be difficult to trace and take corrective action.

The potential growth of *Cronobacter* in bottled reconstituted infant formula milk depends on several factors such as initial water temperature, temperatures of the rooms wherein the milk was prepared and stored, and reheating temperature and time (Rosset et al., 2007). Because of the small volumes of infant formula milk distributed to infants (roughly 30 mL), Rosset et al. (2007) further stressed the importance of temperature control, as smaller volumes are more sensitive to temperature changes.

Six of the product types tested contained probiotic cultures, 3 were FOF, and the others were infant cereals. For a probiotic culture to maintain its beneficial characteristics in a food product, its viability should be maintained. Generally speaking, lower temperatures account for better stability and the higher the temperature, the shorter time required for the number or probiotic bacteria to decrease, ranging from several hours to minutes at 40 to 55°C and seconds at higher temperatures (Lee and Salminen, 2009). In cases where the infant product contains probiotic bacteria, special consideration must thus be given in terms of rehydration procedure as well as the handling of the rehydrated product. All the infant cereals with probiotics specified that water was to be heated and cooled to 40°C , whereas 2 of the FOF (samples 5 and 14) product labels instructed the use of boiled water cooled to 45°C . The other probiotic-containing FOF (sample J) label did not specify any temperature and no special instructions were provided.

Furthermore, 16/24 of the product labels did not provide specific keeping and disposal instructions for unused formula. The WHO recommends that formula that has not been consumed within 2 h should be discarded. Only 5 products gave specific instructions for handling unconsumed formula, whereas an additional 2 (samples 8 and 9) specified that a fresh batch of formula should be prepared for each feeding.

In Malaysia, in the late 1990s, it was reported that 9.6% of infants were born with a low weight ($<2,500$ g) and this represents the group that is at risk of consuming contaminated feed (Estuningsih and Abdullah Sani, 2008). Given this situation, possible *Cronobacter* contamination in developing countries such as Malaysia should be given more attention because hygienic conditions and facilities (such as clean running water) may not be at par with those in exporting countries, or may not always be available, thus increasing the risk of contamination, implicating high-risk groups.

Contaminated water and contaminants on bottles and nipples are significant health concerns for formula-fed infants (Morais et al., 1998; Morais et al., 2005). A study of over 2,000 infants less than 6 mo of age in the Philippines showed that consumption of even small amounts of contaminated liquids almost doubles their risk of diarrhea compared with fully breastfed infants (VanDerslice et al., 1994). Thus, when breastfeeding is not possible, it is suggested to minimize possible contamination of formula by constantly monitoring both raw materials and the production environment. Rehydration instructions for all infant-related products should be simple and easy to apply. For multiracial and multiethnic nations such as Malaysia, rehydration illustrations should be included on product packaging to assist those who do not understand the language on the product label and those who are not literate.

CONCLUSIONS

Results of this study showed that around 13% of PIF, FOF, and IF samples ($n = 90$) commercially available in Malaysia had viable counts greater than the permitted 10^4 cfu/g level. *Enterobacteriaceae* was detected in 14% (13/90) of the infant products analyzed. Rehydration instructions provided on product labels are generally comprehensive, but could be further improved to foster consistency with guidelines prescribed by the WHO and to cater to special consumer groups such as the less educated.

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