Microbial update

infant feeds

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Produced as a service to the food industry by Thermo Fisher Scientific.

Infant feeds and baby food products form a diverse range of foods, manufactured with a wide range of ingredients and usually preserved either by:

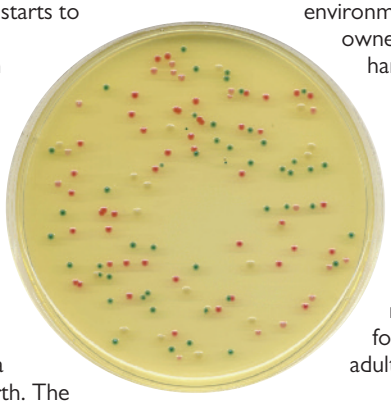
- A sterilising heat process and packed in hermetically sealed containers.
- Low water activity.

The key issue that draws this group of foods together is their intended consumer group, the very young.

The infant gut

The major issue we find in babies/infants is the nature of the microflora within the gut. In healthy adults, the gut contains a diverse range of microflora that have colonised the intestine and live within it, causing no ill effect. Indeed, this microflora potentially provide some degree of protection against possible harmful organisms by out competing them and preventing their ability to grow to harmful levels. The gut flora may also have some influence on the development and function of the immune system, although this is not a well understood area. In contrast, the microflora within the infant gut is much less well developed. Before birth, the foetal gut is essentially sterile. Food has not been taken in through the mouth and, therefore, there is no 'inoculum' to start to establish a gut flora. After birth, the baby begins to feed normally and starts to take in micro-organisms through the mouth. The infant gut flora begins to develop soon after birth, with some reports suggesting that Genera such as Enterobacter can be isolated from infant faeces only a few hours after birth. The initial colonisers rapidly consume any oxygen present in the gut, allowing growth of strict anaerobes such as Clostridia. Food consumed by the infant then plays a large influence on the gut flora development, with research reports indicating some key differences between the flora of breast fed and formula fed infants. The gut flora of formula fed infants has been reported to be made up of a range of groups including Enterobacteriaceae, Staphylococcus, Clostridium, Bifidobacterium, Enterococcus and Bacteroides spp. Breast fed infants by contrast, have a dominant flora made up of lactobacilli, bifidobacteria and streptococci. When solid food is introduced into the infant diet, it would appear that the flora of the gut changes once more and faecal microbiology of all infants becomes similar.

As the infant becomes older and eats a more diverse range of food products, the gut flora develops and becomes an environment better able to protect its owner, by inhibiting some potentially harmful organisms from developing.



Cronobacter sakazakii (blue-green), Proteus mirabilis and Serretia marcescens colonies on Thermo Scientific Brilliance Enterobacter sakazakii Agar (DFI Formulation).

Infant food

The nature of the infant gut is such that infants are much more susceptible to the potential harmful effects of micro-organisms ingested in foods, than older children and adults. Indeed, they are open to some forms of food poisoning that are never seen in adults and these are going to be considered in more detail in the rest of this article.

Infant/baby foods can generally be divided into those preserved by a heat process and storage in a hermetically sealed container, and those preserved by low water activity. These two formats will be considered separately as the hazards and risks can be very different.

Low water activity

The format of these foods ranges from powdered, rehydrateable infant foods, to hard biscuit type materials. As these foods do not all receive a sterilising heat process some are likely to contain a viable microbiological flora. The important issue is to ensure that this flora does not contain any organism able to cause a food safety risk to the infant.

Various organisations have given guidance on the microbiological criteria that should or could be applied to these foods. In 1986, the International Commission on Microbiological Specifications for Foods (ICMSF) gave examples of microbiological criteria for powdered infant foods requiring reconstitution.

These were based on a 3 Class sampling plan for Total Viable Count (TVC) and coliforms where: n = number of samples to test; c = number of results between the limits of 'm' and 'M' to retain acceptability;

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m = lower acceptance limit (any count below m is acceptable); M = upper limit, any count above M is unacceptable. The ICMSF proposed a two class sampling plan for salmonella.

Microbial group	n	c	m	M
TVC/g	5	1	10^4	10^5
Coliforms/g	5	1	10^1	10^2
Salmonella/25g	60	0	0	-

From ICMSF Book 2 1986

In a later book (ICMSF Book 8, 2011), the ICMSF reviewed their previous recommendations and considered other risks in these foods originating from Cronobacter sakazakii (formally known as Enterobacter sakazakii), and made both the coliform (noted in the more recent publication as the better defined group of Enterobacteriaceae), and TVC criteria more stringent.

Microbial group	n	c	m	M
TVC/g	5	2	$5x10^2$	$5x10^3$
Enterobacteriaceae/g	10	2	0	-
Salmonella/25g	60	0	0	-
Cronobacter sakazakii/25g	30	0	0	-

From ICMSF Book 8

The ICMSF Book 8 gives much fuller description of the testing of infant formulae and should be consulted by those intending to set up a full sampling and testing plan.

The Institute of Food Science and Technology (IFST) in their publication on Microbiological Criteria also give some guidance on testing needs for dried infant feeds requiring reconstitution. This publication divides the micro-organisms into 'pathogens' and 'indicators and spoilage organisms' (Table 1).

The European Commission issued the European Regulation on Microbiological Criteria for Foods in 2005 (EC2073/2005). This regulation considers infant feeds that require reconstitution and, as this is a European Regulation, manufacturers must follow its requirements.

Regulation 2073/2005 requires testing for Enterobacteriaceae, Bacillus cereus, salmonella and Cronobacter sakazakii in powdered infant feeds. Additionally, if the material is considered to be ready-to-eat (not intended to be given a process designed to reduce potentially harmful organisms to an acceptable level before consumption) then additionally it must be tested for Listeria monocytogenes. Those manufacturing or intending to manufacture or sell infant feeds in Europe, should read European Commission Regulation 2073/2005 in some detail, and ensure they comply with its requirements.

If manufacturing or selling powdered infant feeds in other parts of the world, manufacturers should check local/national legislation in those countries, and ensure they comply with any requirements of that legislation.

The major microbiological hazards in low water activity infant food are salmonella and Cronobacter sakazakii. Both survive well in low water activity conditions and can become considerable problems in powder production and mixing factories.

They cannot grow in dry conditions, which is the reason why wet cleaning of dry production/mixing areas must be considered in some depth before being implemented. Introducing water into such dry areas can create conditions in which these organisms can grow, increasing the risk of product contamination. Effective dry cleaning techniques should always be the preferred option for the routine cleaning of dry production areas.

Salmonella infection in the very young can produce symptoms similar to those seen in adults; however, these can have very serious outcomes due to the relatively undeveloped immune system in infants.

Additionally, diarrhoea and vomiting will rapidly induce dehydration in the very young with potentially very severe consequences.

Cronobacter sakazakii is an organism that is usually only considered a risk in the very young, in older children and adults it only

Pathogens	Good Manufacturing Practice Level	Maximum level
Salmonella	Not detected (ND) in 250g	ND in 250g
Verocytotoxin producing E. coli (beef containing products)	ND in 250g	ND in 250g
Clostridium perfringens	<10/g	102/g
Bacillus cereus	<10/g	102/g
Staphylococcus aureus	ND in 1g	102/g
Indicators		
TVC	<103/g	104/g
Enterobacteriaceae	<10/g	102/g
E. coli	ND in 1g	10/g

From IFST "Development and use of microbiological criteria in foods. 1999.

Table 1. Pathogens' and indicators and spoilage organisms.

rarely causes any food related problems, and is usually never part of any food testing regime. In the very young the organism can produce serious life threatening illness including blood infections, meningitis, and brain cysts or abscesses.

The most seriously affected tend to be low birth weight infants. It is because of these serious symptoms and their possible outcomes, that guidelines and standards have such strict microbiological criteria for these food products.

Powdered infant formula

There has been much consideration of the role of rehydration in increasing the safety of powdered infant formula. Understanding that these powdered materials are not sterile, the use of a well designed rehydration procedure utilising very hot water, could reduce microbiological risks to infants by inactivating contaminating vegetative micro-organisms.

There are two problems to consider with this approach. The first is the scalding risk to infants if products rehydrated with very hot water, are consumed without proper cooling.

The second is the risk of microbial growth if rehydrated products are allowed to cool to 'drinking temperature' and then held for long periods, thus allowing growth of any surviving micro-organisms.

The current advice in the UK and published by the UK Department of Health is to rehydrate infant formula with water at a temperature of 70°C or higher.

Heat processed infant feeds

As well as powdered infant formula, the one other major type of infant/baby food are those provided in jars or pouches that are fully hydrated and are stable for long periods when stored under ambient temperature conditions.

The safety of these products is assured via the use of a heat process, usually applied to the filled container and designed to kill contaminating micro-organisms. These products are therefore usually considered to be commercially sterile.

The heat processes used in the production of these products have to be designed to kill bacterial spores.

The vegetative cells of most bacteria will be killed at relatively low temperatures (for example the application of 70°C for two minutes will inactivate large populations of vegetative bacteria), bacterial spores are different and require a much higher heat process to assure their destruction.

The pathogenic organism that needs to be controlled in any long shelf life, ambient stable, high water activity product is Clostridium botulinum.

This is a spore forming organism that if allowed to grow in foods, can produce potent neurotoxins capable of causing paralysis and death of those consuming such products. Its control in this type of food is of the greatest importance.

C. botulinum tends to be controlled in one of two ways in most high water activity ambient stable foods; firstly the use of an in pack heat process in excess of 121°C for three minutes, this tends to be known as a 'bot cook' and will inactivate a large number of C. botulinum spores; secondly in products with a pH of less than 4.5, a pasteurisation process of less than 121°C for three minutes.

The latter relies on the fact that C. botulinum spores cannot germinate, grow and produce toxin at a pH of 4.5 and lower, therefore the pasteurisation inactivates vegetative cells and the pH prevents the growth of and therefore toxin production by C. botulinum.

In infant feeds, however, we have to consider one additional risk. In healthy older children and adults, the consumption of foods containing low levels of C. botulinum spores (those that have not been able to grow, and produced no toxin) is not considered to be a major risk. In the very young however, it is possible that the consumption of C. botulinum spores could result in spore germination, growth and toxin formation within the gut.

This can result in the very serious condition known as infant botulism. Infant botulism is relatively rare with only 10 cases being recognised within the UK between 2007 and 2013.

However, the resulting illness is very severe and any infant food that could contain viable C. botulinum spores, even if these spores cannot grow and produce toxin within the food, should be carefully risk assessed for their safety for infants.

In some types of food the risk from infant botulism is considered so great that they are not recommended for children below 12 months of age (for example honey, where high levels of C. botulinum spores can be found).

Conclusions

Due to the relatively undeveloped nature of the infant gut microflora and immune system, great care must be taken when producing any foods designed for this group. Organisms which provide little risk to older children and adults can cause severe illness in the very young.

However, as long as the microbiological risks are well understood by producers, and appropriate measures are taken to reduce these to an acceptable level, then infant feeds form a very safe food with an excellent safety record.

It is strongly recommended that anyone wishing to produce any foods designed to feed infants or babies, obtains expert advice from appropriate organisations on methods of production, hygiene and current legislation, beforehand.

This is a very sensitive and susceptible group of the population and great care should be taken in producing foods designed for them. ■

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