

Microbiological Safety Concerns in the Milling and Baking Industry

Although it is generally agreed that flour and bakery products are microbiologically safe foods¹⁻⁴, the growing attention on food safety has resulted in increased demands for microbiological specifications on flour and bakery products, which has challenged many flour mills and bakeries. This technical bulletin summarizes the major microbiological indicators, the sources of contamination and the control measures used in both the milling and baking industry.

Microbiological Indicators

The most common microbiological indicators in flour and baked products are total aerobic count (often referred to as total plate count), coliform/enteric bacteria count, and yeasts and mould counts.

- Total aerobic count refers to a total count of microbe colonies growing on the media plate from the sample.
- Coliform or enteric bacteria count is a subset of the total aerobic microbe colony count and is often used as an indicator of direct or indirect fecal contamination.
- Yeasts and mould counts are not included in total aerobic counts although they are also often subject to maximum tolerances. Their main relation to food safety is the potential to produce mycotoxins which are toxic compounds produced by fungi that contaminate plants.

Microbial counts found in a flour mill will vary widely depending on a number of factors such as initial counts in the grain from crop conditions, milling practices, post-milling handling, moisture content of flour and storage conditions. Typical microbiological counts in flour are 1.5×10^4 for total aerobic count; 200 count for coliforms; 120 count for yeasts and 800 count for moulds⁵. Significant correlations have been observed between all microbial indicators and some quality criteria (e.g. test weight) and grading factors (e.g. wheat grade number, vitreous kernel content)⁶. A weak but significant correlation has also been reported between the total plate count and the moisture content of grain. Typical microbial counts for dough and baked products are given in Table 1.

Table 1. Microbial criteria for chilled and frozen dough and baked products (cfu/g)⁷

Micro-organism	Chilled and Frozen Dough	Baked Products
Total aerobic count	$10^2 - 10^6$	$10^1 - 10^3$
Coliforms	$10^1 - 10^2$	$0 - 10^2$
Yeasts	$10^5 - 10^6$	$10^1 - 10^3$
Moulds	$10^2 - 10^4$	$10^1 - 10^3$

Sources of Contamination

The baking process effectively eliminates the safety risk of microbial populations present in flour; however, to maintain acceptable levels in the flour during the milling process, other contributing factors prior to milling must be evaluated for their effectiveness in reducing counts.

Vegetative bacteria, including pathogens, moulds and viruses, are readily destroyed during baking, but post-baking contamination from air, equipment and handlers can occur⁷⁻⁹. A freshly baked product is essentially sterile^{2,4}, but certain spore-forming bacteria can survive the baking process and can grow to levels of concern if packing and storage conditions favour growth⁹.

Many ingredients other than flour pose a greater microbiological safety risk in the bakery. Ingredients containing meat, egg or dairy products such as fresh and synthetic creams, custards and icings (interface between icing and baked product) are the most likely sources of serious food safety hazards. Other ingredients added after baking, such as spices, nuts and fruit toppings or fillings, may also be a potential source of contamination.

Modified atmosphere packaging (MAP) appears to be another area of concern for the health risk of baked products, although little data presently exists regarding the safety of baked products packaged with this technology⁹. MAP is used to extend the shelf life of baked products stored at ambient or refrigeration temperatures³. This technology, however, may pose serious problems when used with high moisture products such as crumpets, as the higher water activity can lead to certain pathogenic anaerobic microbial growth at ambient temperatures.

According to the Canadian Food Inspection Agency (CFIA)¹⁰, baked products do not pose a health risk unless they have cream or meat fillings. Food safety issues associated with microbiological contamination of unfilled baked products have not been observed over the last two decades. Rope (spoilage due to *B. subtilis*) was occasionally encountered in the past and today mould is only rarely observed. Of almost 700 food recall notices posted by the CFIA over the last five years, about 50 involved baked products (crackers, cookies, cakes, breads) or dough. All except two were due to undeclared allergens (soy, peanut, nuts, egg, milk, gluten/wheat) – a health risk related to food labeling. The remaining two recalls were caused by chemical contamination (cakes) and packaging technology (MAP of flat bread products). No recalls of baked products contaminated by pathogenic (or non-pathogenic micro-organisms) was reported in this time period.

Control Measures

Control measures to minimize the presence of moulds and mycotoxins should be implemented at the grain handling, transportation, storage and milling stages. Once at the bakery, control measures will include proper flour storage, good manufacturing practices (GMP), process control (e.g. proper cooling prior to packaging) and the use of antimicrobials (e.g. propionates).

Post-baking contamination can be controlled with proper GMP (e.g. sanitation, employee training). Newer technologies such as MAP can be employed to increase shelf life stability. Industrial bakeries are well equipped to minimize risks, while there may be greater potential for hazards in smaller bakeries. Similarly, higher risks will occur in tropical countries as opposed to temperate ones due to climate conditions.

We are unaware of any report comparing overall microbial load in wheat and its relationship to quality parameters. This limits our ability to provide solid technical evidence to wheat buyers of acceptable limits of bacteria, yeasts and moulds, until additional data can be compiled. Such data will help to (i) establish confidence in what defines normal microbial loads in wheat shipments, (ii) verify authenticity/reliability of microbial counts reported by the wheat buyers, (iii) identify factors contributing to high counts as reported and validated by the wheat buyers, and (iv) evaluate the relative contribution of wheat to the health hazard risk associated with baked products.

References

1. Richard-Molard, D. 1994. The microbiology of cereals and flours. Chapter 2 (pp. 143-154) in: Primary Cereal Processing; A Comprehensive Sourcebook. B. Godon and C. Willm (Eds.), VCH Publ. Inc., New York, NY.
2. Fung, D.Y.C. 1995. Microbiological considerations in freezing and refrigeration of bakery foods. Chapter 6 (pp. 119-133) in: Frozen and Refrigerated Doughs and Batters. K. Kulp, K. Lorenz and J. Brummer (Eds.), American Association of Cereal Chemists, St. Paul, MN.
3. Kotsianis, I.S., V. Giannou and C. Tzia. 2002. Production and packaging of bakery products using MAP technology. Trends Food Sci. Technol. 13:319-324.
4. Gelinas, P. 2003. Flour know-how? Bakers Journal 63(7): 14-15, 66.

5. Sperber, W.H. 2003. Microbiology of milled cereal grains: Issues in customer specifications. Technical Bulletin of the IAOM. 3(6): 7929-7931.
6. Manthey, F.A., C.E. Wolf-Hall, S. Yalla, C. Vijayakumar and D. Carlson 2004. Microbial loads, mycotoxins and quality of durum wheat from the 2001 harvest of the Northern Plains Region, USA. J Food Protection 67(4): 772-780.
7. Dale, H. 2003. Microbial threats in the bakery. International Food Hygiene 14(1): 9-10.
8. Smith, J.P., D.P. Daifas, W. El-Khoury and J. Koukoutsis. 2002. Foodborne illnesses associated with bakery products. Technical Bulletin of the American Institute of Baking. 24(4) 1-11.
9. Smith, J.P., D. Phillips Daifas, W. El-Khoury and J.W. Austin. 2003. Microbial safety of bakery products. Chapter 1 (pp. 3-33) in: The Microbial Safety of Minimally Processed Foods, J.S. Novak, G.M. Sapers and V.K. Juneja (Eds.), CRC Press, Boca Raton, FL.
10. Canadian Food Inspection Agency web site. Food Recalls. Last accessed 30 January 2004 at: <http://www.inspection.gc.ca/english/corpaffr/recarapp/recaltoce.shtml>

For more information please contact:

Dr. Mingwei Wang
Technical Specialist, Baking Technology

Gordon R. Carson
Director, Cereal Technology

November 27, 2005