

Cereals and cereal product microbial spoilage and hazards



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1. 0Introduction

Cereals, belonging to the Gramineae or the grass family, are the basic carbohydrates sources for the human population (Adams & Moss, 2008; Swanson, 2011). Currently, the most important cereal crops supplying the nutrients for a large proportion of people in the world are rice (*Oryza sativa*), wheat (*Triticum* spp.), and maize (*Zea mays*), as stated by Adams and Moss (2008) and Harris *et al.* (2012). However, each species of cereals has its own range of optimal growing climatic conditions. As an example, the common wheat is grown extensively in both southern and northern hemisphere, whereas the durum wheat is grown in the Mediterranean region. In addition, the advancement in the biotechnology field also allowed these cereal plants to grow in regions outside of its origin, for example rice (Adams & Moss, 2008).

Cereal grains consist of three main edible anatomical parts, namely the embryo (germ), a pericarp (bran), and an endosperm. As suggested by Sidhu *et al.* (2007), the longitudinal crease that runs on the entire ventral side of the kernel can harbour microorganisms and dust. In terms of nutritional values, the germ proportion of the grains which constitutes 3% of the whole wheat kernel has significant levels of protein and vitamin E (tocopherols and tocotrienols) apart from being an excellent source of fibres and phytochemicals. During milling, most of the endosperm fraction finishes in white flour and the bran and germ end up as shorts (Sidhu *et al.* , 2007).

In addition, cereals are often used in the production of various functional foods, such as bread, breakfast cereals, pasta and noodles (Sidhu *et al.* , 2007). Because of their extensive use as human foods, the safety and microbiology of cereal grains and its products are highly concerned. The sources of the microbial contamination of cereals are mainly contributed by the environment in which the crops are grown, handled, and processed, which includes the air, soil, water, animals, shipping containers, and processing equipment (Ray, 2004; Bullerman & Bianchini, 2011).

Microbial food spoilage is defined as deprive of good or effective food qualities as a result of microbial activity. Microbial food spoilage can be identified and is visible in the form of surface slime or colonies, loss of texture, or presence of by-products of microbial metabolism such as gas, pigments, off-odours and flavours, or in combination of the above (Adams & Moss, 2008). However, this quality can be subjective as each individual judges its unacceptability differently.

In this study, the microbiology of cereal grains and cereal products (dried cereal products, bread, pasta and noodles) and its preservation are being studied.

2. 0Microbiology of Cereals and Cereal Products

As mentioned previously, the microbiological contamination of cereal grains begins at the growing phase of the grains. The intensity of the contamination can increase during the growth and after harvest (Harris *et al.* , 2012), resulting in the spoilage of the final products or worse, induces foodborne illnesses in the consumers if appropriate control measures are not taken.
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2. 1 Cereal Grains

The spoilage of cereal grains is commonly associated with moulds, and some of these moulds can be toxigenic. However, bacilli, some enteric bacteria, lactic acid bacteria, and micrococci can also contaminate the crops which may cause problems in the supply chain when products are made (Magan & Aldred, 2006; Harris *et al.*, 2012). According to Harris *et al.* (2012), the moulds affecting the crops can be categorized into two groups: the field fungi and the storage fungi.

The 'field fungi', consist primarily of the genera *Fusarium*, *Cladosporium*, *Alternaria*, and *Helminthosporium* (Magan & Aldred, 2006; Harris *et al.*, 2012), are moulds infecting the grains before harvest (Harris *et al.*, 2012). At this stage, a large number of such microorganisms are accumulated and these moulds grow on grains with a w of 0.90 or higher or 18 to 30% moisture (Bullerman & Bianchini, 2011). On the other hand, the 'storage fungi' are those that infect post-harvest grains, consist primarily of the genera *Rhizopus*, *Aspergillus*, *Penicillium*, *Mucor*, and *Wallemia* (Magan & Aldred, 2006) growing at low moisture contents (14 to 16%; Bullerman & Bianchini, 2011). Inadequately dried grains can support the growth of these fungi (Harris *et al.*, 2012).

Under favourable growth conditions, these moulds can produce mycotoxins, such as aflatoxins, nivelanol, fumonisins, and deoxynivalenol (DON; Swanson, 2011). Mycotoxins are difficult to be completely removed by processing treatments used for cereals. Therefore, it is very crucial to control

the prevalence of mycotoxin production to avoid food poisoning in the consumers.

The presence of certain bacteria and fungi can cause crop diseases in the plants, which can lead to spoilage of the harvested grains and thus reduced crop yields. Besides direct damage by the fungal growth, it can also result in the occurrence of chemical (by enzyme of fatty acid production) or physical (by spontaneous heating due to fungal activity or moisture and heat from insect contamination) damage in the grains (Magan & Aldred, 2006; Swanson, 2011).

2. 2 Dried Cereal Products

Breakfast cereals, snack foods, oatmeal, rice cakes, and infant cereals are examples of dried cereal products that are typically ready to eat (RTE) without the need of further cooking, though some are optional to be heated with added hot water or milk.

Dried cereal products have water activity <0.5 (Serna-Saldivar, 2012) which can inhibit the proliferation of most microorganisms except moulds, thus reducing the possibilities for the occurrence of microbiological hazards (Eskin & Robinson, 2000). In relation to that, foodborne illnesses associated with cereals are less common as long as proper storage practices are followed to ensure the exclusion of water, insects, birds, and rodents (Legan, 2000). In contrast, *Bacillus* spp. may grow if the water activity is favourable for growth (Jay *et al.*, 2005).

On the other hand, the contamination can be from the environment or the ingredients. If the raw grains are already contaminated with the production of mycotoxins from fungi, it is quite likely that the cereal products are to contain mycotoxins too. Thus, tests for mycotoxins are appropriate in cereal products (Swanson, 2011). On the other hand, United States Centers for Disease Control and Prevention (CDC) also reported two *Salmonella* Agona outbreaks in 1998 and 2008 associated with breakfast cereals, in which the investigations revealed that the cause of these outbreaks was related to the contamination of the processing line in the manufacturing plants.

In terms of microbial spoilage, it is less likely to occur in dried cereal products due to its low water activity unless the other ingredients added such as nuts and cocoa are contaminated (Swanson, 2011).

2.3 Breads

As stated by Swanson (2011), lactic acid bacteria may grow and contributes to the sourness in raw bread dough by producing lactic acid as end products. A notable point is that *Salmonellae* and *Bacillus cereus* may also be present in the raw dough. However, this will not be a major problem as these bacteria can be destroyed when the dough is cooked at high temperatures to attain its desired texture, colour, and structure. In addition, this process also dehydrates the surface of the breads which in turns inhibits the growth of microorganisms on the surface (Swanson, 2011).

Though baking can destroy the moulds in dough, recontamination can still occur. The water activity of bread which is higher than 0.96 (Serna-Saldivar, 2012) and with pH of about 5.5 to 6 gives a favourable conditions for the <https://assignbuster.com/cereals-and-cereal-product-microbial-spoilage-and-hazards/>

growth of moulds (Magan & Aldred, 2006). These moulds can be a great hazard to the consumers as they can produce mycotoxins. Legan (1993) reported that 90% of the spoilage occurs during cooling and wrapping operations. In other words, breads that are sliced and wrapped in individual packets are more prone to spoilage by moulds, especially when the breads are wrapped hot from the oven, contributing to the condensation of water droplets on the inside surface of the packaging (Cauvain & Young, 2007). On the other hand, sources such as air, equipment, raw ingredients and food handlers can also contaminate the breads with moulds (Smith & Simpson, 1995).

Mould species from the genera *Aspergillus*, *Penicillium*, and *Eurotium* are often the main concerns in bread products (Magan & Aldred, 2006). As stated by Swanson (2011), the visibility of moulds is greatly affected by the moisture level of the crust as well as the temperature of storage. At cooler temperatures, *Penicillium* spp. dominates while at ambient temperatures, *Aspergillus* and *Eurotium* spp., and very rarely *Rhizopus* and *Neurospora*, dominate (Magan & Aldred, 2006). *Rhizopus stolonifer* is also referred as the 'bread mould', characterized by its fluffy appearance of black sporangia and white cottony mycelium, while *Neurospora sitophila* is referred as the 'red bread mould' (Jay *et al.*, 2005; Cauvain & Young, 2007). On the other hand, sourdough breads with pH ranging from 4.5 to 5.1 are more likely to be affected by *Penicillium* spp., particularly the acid tolerant *P. roqueforti* and *P. commune* (Magan and Aldred, 2006).

Despite of the contamination and spoilage by moulds, Swanson (2011) also stated that *Bacillus subtilis*, *Bacillus mesentericus* and *Bacillus licheniformis*
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that are possibly present in flour can survive the baking process, which can lead to a type of spoilage known as ropiness (Smith & Simpson, 1995; Jay *et al.*, 2005). Ropiness is resulted from the growth and amylase production of *B. subtilis* and it can be identified by stickiness when breaking bread into two parts (Jay *et al.*, 2005; Magan & Aldred, 2006). Yeast, mainly the *Pichia burtonii*, known as 'chalk mould', can also cause surface spoilage of bread (Smith & Simpson, 1995).

2. 4 Pasta and Noodles

Pasta and noodles are categorized into two groups: fresh and dry pasta. Dry pasta is made by mixing finely grounded semolina flour and water into a paste and then form into the desired pasta shapes. This type of pasta has a long shelf life at ambient temperatures due to its low moisture content resulted from the drying process at low temperature that lasts for several days (Christensen, 2008). In contrast, fresh pasta has an extra ingredient – egg incorporated in the dough, giving a higher water activity as compared to dry pasta (Cunningham *et al.*, 2007; Sanguinetti *et al.*, 2011).

Since dry pasta has low water activity, its microbial hazards and spoilage are of less concerned, except if the flour used is contaminated with mycotoxins production by moulds. However, there are still cases reported where dry pasta was contaminated with *Salmonella* spp., *Clostridium perfringens*, *Staphylococcus aureus*, moulds, and yeasts (Smith & Simpson, 1995).

In contrast *Salmonella* spp. from the egg ingredients in fresh pasta are a major concern as they can survive the drying process and remain viable.

This can be a problem if proper cooking temperature is not achieved
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(Swanson, 2011). Smith and Simpson (1995) and Sanguinetti *et al.* (2011) also reported that contamination of the ingredients while raw or during processing may result in spoilage by *Bacillus cereus*, *Staphylococcus aureus*, *Streptococcus* spp., *Lactobacillus* spp., *Clostridium botulinum*, *Salmonella enteridis* and moulds. Similarly, Rodríguez-Lozano *et al.* (2010) also reported possible contamination of *Bacillus* spp. in pasta products.

According to Swanson (2011), the contamination of pasta products by *S. aureus* is mainly related to the presence of product residues from the manufacturing equipment that slows drying time. This issue is common as the equipment has narrow and complex shapes that give difficulty in cleaning. In addition, flour used to prevent the pasta from sticking to the equipment or together can be a potential hazard as spoilage bacteria can grow. Thus, control measures should be taken at this stage to prevent excessive build-up of dough and flour on the processing line.

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