

Review of Literature on Control of Microbial Food Spoilage of Bakery Products and Pickles by Soil Molds and Natural Plant Products

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ABSTRACT

Although it is extremely difficult to pinpoint the precise beginning of human awareness of the presence and role of microorganisms in foods. The era prior to the establishment of microbiology as a science may be designated the prescientific era. This era may be further divided into what has been called *the food-gathering period* and the *food-producing period*. The period covers the time from human origin over 1 million years up to 8,000 years ago. During this period, humans were presumably carnivorous, with plant foods coming into their diet later in this period. It is also during this period that foods were first cooked (Robinson *et al.*, 2000; Doyle *et al.*, 2001; Corry *et al.*, 2003; Ray *et al.*, 2003; Jay *et al.*, 2005; Hui, 2006; Pelter, 2006; Modi, 2007; Edwards, 2007; Montville and Matthews, 2008).

The food-producing period dates from about 8,000 to 10,000 years ago. It is presumed that the problems of spoilage and food poisoning were encountered early in this period. With the advent of prepared foods, the problems of disease transmission by foods and of faster spoilage caused by improper storage made their appearance. Spoilage of prepared foods apparently dates from around 6000 BC. The arts of cereal cookery, brewing, and food storage, were either started at about this time or stimulated by this new development (Stewart and Amerine, 1973; Adam and Moss, 2000; Ray, 2003; Jay *et al.*, 2005; Edwards, 2007; Montville and Matthews, 2008).

Key words: Bread, bacteria, mold, room and refrigerator temperature, pH and moisture content.

INTRODUCTION

The factors that affect the microbial growth in food and the associations between microorganisms that develop, can be divided into four categories: (i) physico-chemical properties of the food itself, such as the availability of nutrients, pH, water activity and antimicrobial structures, (ii) conditions of the storage environment, such as temperature, humidity and gaseous atmosphere, (iii) properties and interactions of the microorganisms present, and (iv) processing factors, such as slicing, washing, packing and pasteurization. These factors collectively determine the food's characteristic as a medium for microbial growth (Adams and Moss, 2000; Smith *et al.*, 2004). The main intrinsic factors governing the ability of microbes to bring about spoilage of food are water activity and pH. Water activity (a_w) is defined by the ratio of the aqueous vapour pressure of the food substrate to the vapour pressure of pure water at the same temperature. Most bacteria require a_w levels in excess of 0.95 for good growth. Most molds, on the other hand, can grow at a_w level as low as 0.80, while xerophilic molds can grow at a_w level as low as 0.65. When foods are stored at high humidity, uptake of moisture at the food surface will increase the localized a_w level to a point where growth of microbe will be more rapid than under optimal storage conditions (Adams and Moss, 2000; Frazier and Westhoff, 2003; Ray, 2003; Jay *et al.*, 2005; Aneja *et al.*, 2008). The pH of a food is also critical because a low pH favours the growth of yeasts and molds. In neutral or alkaline pH foods, such as meats, bacteria are more dominant in spoilage and putrefaction. Temperature and relative humidity of storage are the most important extrinsic parameters that affect the spoilage of foods. The success of storage temperature depends to a great extent upon the relative humidity of the storage environment and the presence or absence of gases such as CO_2 and O_3 (Frazier and Westhoff, 2003; Ray, 2003; Jay *et al.*, 2005).

A food borne infection involves the ingestion of the microbial pathogens followed by growth in the host, including tissue invasion and release of toxins. Microbial growth in food products can result in a

food intoxication in which symptoms are produced shortly after the food is consumed because growth of the disease causing microorganisms is not required. Toxins produced in the food can be associated with microbial cell or can be released from the cells. Chemical reactions that cause offensive and sensory changes in foods are mediated by bacteria and fungi that use food as a carbon and energy source. Some of the major bacterial genera which cause food borne infection and intoxication include *Staphylococcus*, *Bacillus*, *Escherichia*, *Shigella*, *Clostridium* and *Salmonella* (Jay, 2000; Ray, 2003; Jay *et al.*, 2005; Madigan and Martingo, 2006; de Souza, 2008). Fungi are major plant and insect pathogens and profused growth of fungi on animal hosts produce the disease collectively called mycoses, while dietary, respiratory, dermal, and other exposures to toxic fungal metabolites produce the diseases collectively called mycotoxicoses. Mycotoxins are fungal metabolites that are present in a large part of the world food supply and bear potential threat to food safety (Qazi and Fayyaz, 2006). *Aspergillus*, *Penicillium* and *Fusarium* are known to produce mycotoxins in foods that result to cause mycotoxicoses after ingestion (Frazier and Westhoff, 2001). Some mycotoxins are mutagenic and carcinogenic and some display specific organ toxicity. The major target organs for these toxins in human are liver, kidney, nervous system and endocrine system (Jay *et al.*, 2005; Madigan and Martingo, 2006).

REVIEW OF LITERATURE

Bread is a principal food for all categories of people, including children and it is considered unsafe for people when bread with a high microbial load is consumed. The production of bread and other bakery products has evolved from a primitive, cottage industry into a large scale, modern manufacturing industry, generating billions of dollars in revenue and employing thousands of personnel. The ingredients of bread are supportive to growth of microorganisms and multiplication at different stages of bread production, slicing and wrapping (Smith *et al.* 2004; Khetarpaul *et al.* 2005). The main types of microbial spoilage of bread are ropiness and moldiness. Ropiness has been described as a discolouration of bread ranging from brown to black with an unpleasant odour (Ogundare and Adetuyi 2003) and is caused mainly by *Bacillus subtilis*, but other species of *Bacillus* are capable of causing rope and these include *B. licheniformis*, *B. megaterium*, *B. cereus* and *B. pumilus* (Thomson *et al.* 1998; Sorokulova *et al.* 2003). The molds most frequently involved in the spoilage of bread are the so called "bread mold", *Rhizopus nigricans*, with other mold species like *Penicillium expansum*, *R. stolonifer*, *A. niger*, *Mucor* sp., *Monilia (Neurospora) sitophila*, (Gassem, 1999; Frazier and Westhoff 2003, Ogundare and Adetuyi 2003; Guynot *et al.* 2004, 2005, Rehman *et al.* 2007). The fungal species mainly *A. niger*, *A. flavus*, *A. glaucous*, *A. carnosus*, *A. terreus*, *A. ochraceous*, *A. fumigatus*, *R. stolonifer*, *Trichoderma harrianae* and *T. roseum* have been isolated from the bread in India (Rai *et al.* 1990).

Worldwide, bakery products have been an important part of balanced diet for thousands of years. Indeed, cereal grains, mixed with water and cooked by fire, may have been our ancestors' "bread type" products. The production of bread and other bakery products has evolved from a primitive, cottage industry into large-scale, modern manufacturing industry, generating billions of dollars in revenue and employing thousands of personnel. A wide variety of bakery products can be found on supermarket shelves, such as breads, unsweetened rolls, buns, doughnuts, meat pies, pizza, crackers, cookies and other products (Smith *et al.*, 2004; Hui, 2006; Modi, 2007; Edwards, 2007; Montville and Matthews, 2008). According to Smith *et al.* (2004), several methods can be used to classify these products and the classification can be based on product type, that is unsweetened goods (bread, rolls, buns, crumpets and muffins), sweetened goods (pancakes, doughnuts, waffles and cookies) and filled goods (fruit and meat pies, sausage rolls, pastries, sandwiches, cream cakes, pizza and quiche) or their method of leavening, i.e., the biological, chemical or unleavened. From a technological viewpoint, bakery products have also



been classified on the basis of their pH, moisture content, and water activity (Seiler, 1988a; Doerry, 1990; Smith *et al.*, 2004).

Bakery industry in India is probably the largest among the processed food industries, production of which has been increasing steadily in the country. The annual production of bakery products which includes breads, biscuits, pastries, cakes and buns in India, is estimated to be in excess of 30 lakh tonnes. The two major bakery industries, viz., bread and biscuit account for about 82% of the total bakery products (Khetrapaul *et al.*, 2005). The most frequent problems, occurring in baking, are mold contamination and rope spoilage. Mold spoilage accounts between 1 and 5% of product losses depending on the season, type of product being produced and the method of processing (Guynot *et al.*, 2000, 2003). In addition to the economic losses, another concern is the possibility of the production of mycotoxins. The fungal spores are killed during baking and the airborne molds recontaminate the baked goods during the processing of bread such as cooling, slicing, wrapping and storage operations (Legan, 1993; Smith *et al.*, 2004). The most common spoilage molds isolated from bakery goods belong to the genera *Rhizopus*, *Mucor*, *Penicillium*, *Aspergillus*, *Monilia*, *Endomyces*, *Cladosporium* and *Fusarium* (Ponte and Tsen, 1987; Legan, 1993; Royle *et al.*, 2001; Fleet, 2007; Skovgaard, 2007; Juckett *et al.*, 2008).

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Bacillus subtilis and *B. licheniformis*, the two endospore forming bacteria are the major cause of rope spoilage in the baking industry. The most common source of contamination with these bacteria is flour and equipment that have been in contact with contaminated dough (Seiler, 1988b; Rehman *et al.*, 2007). The bread crumb becomes discoloured and sticky, due to protein and starch degradation during growth of the bacteria (Smith, 1992). There has been a documentation of cases of food poisoning involving, nausea, vomiting, diarrhea, headaches and chills due to the consumption of ropy bread (Vovsey, 1989; Kirschner and von Holy, 1989). Conditions favouring the appearance of rope are: a slow cooling period or storage above 25°C, pH above 5, high spore level and moist loaf (Smith *et al.*, 2004; Jay *et al.*, 2005; Rehman *et al.*, 2007).

Pickle is an edible product preserved and flavoured in a solution of common salt and vinegar. Spices and oil are also added to make pickles (Pederson, 1975; Joshi and Bhat, 2000; Khan *et al.*, 2005; Wood, 2006; Schafer, 2008). On the basis of ingredients used and the method of preparation, the pickle products are classified into four general classes: the fermented or brined pickles, fresh pack or quick process pickles, fruit pickles and relishes (Schafer, 2008). Pickles are prepared from fruits and vegetables like cauliflower, cabbage, onion, cucumber, mango, jack fruit, amla and lemon (Girdhar *et al.*, 1989; Ekici and Coskun, 2004; Wood, 2006; Schafer, 2008; Scott and Sullivan, 2008). Pickles are consumed along with staple food such as rice, breads, upma, etc. because they add to the palatability of a meal, aid in digestion and are good appetizers (Girdhar *et al.*, 1989; Ekici and Coskun, 2004; Guasch-Jané *et al.*, 2005; Flórez and Mayo, 2006). Mango pickle (Am ka achar) with or without oil is the most popular green mango product in India with a total annual market valued at Rs. 40,000 million (Joshi and Bhat, 2000).

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