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Bacterial Transfer Associated with Blowing Out Candles on a Birthday Cake

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Abstract

This study examined the potential spread of bacteria when blowing out candles on a birthday cake. Preliminary tests of blowing on nutrient agar indicated that bioaerosols in human breath expelled from the mouth may be a source of bacteria transferred to cake surfaces. To test aerosol transfer to cake, icing was spread evenly over foil then birthday candles were placed through the foil into a Styrofoam™ base. After consuming pizza, test subjects were asked to extinguish the candles by blowing. Icing samples were sterilely recovered then surface plated, to determine the level of bacterial contamination. Blowing out the candles over the icing surface resulted in 1400% more bacteria compared to icing not blown on. Due to the transfer of oral bacteria to icing by blowing out birthday candles, the transfer of bacteria and other microorganisms from the respiratory tract of a person blowing out candles to food consumed by others is likely.

Keywords: birthday candles, aerosolized bacteria, blowing, bacterial transfer

1. Introduction

1.1 Blowing Out Birthday Candles

The tradition of blowing out birthday candles has different theories as to its origin. Some theorize the practice began in Ancient Greece related to bringing cakes with lit candles to the temple of the goddess of the hunt, Artemis. Other ancient cultures believed the smoke from candles carried their wishes and prayers to the gods. A written account reported of birthday candles matching the age of Count Ludwig Von Zinzendorf being presented at the Count's birthday celebration in Germany in 1700's (Frey, 1753). This tradition has become commonplace in many parts of the world.

1.2 Spread of Bacteria

Bacteria are an unavoidable part of life, present in and on almost everything humans contact. Whether benign or pathogenic, it is important to understand how bacteria are transferred and become familiar with measures for avoiding contamination. Illnesses related to pathogenic bacteria, which can spread rapidly throughout the population, are a major public health concern in today's society. Bioaerosols and poor air hygiene can have adverse effects on human health (Douwes, Thorne, Pearce & Heederik., 2003; Xu et al., 2011). Respiratory droplets expelled by coughing and sneezing are sources of normal human flora, as well as pathogenic bacteria (Obeng, 2008; 1970; Houk, 1980) and viruses (Loosli, Hertweck, & Hockwald, 1970). The respiratory tract can be colonized with pathogenic organisms that can then be aerosolized in the breath of an infected individual (Couch, Knight, Gerone, Cate, Douglas, 1969; Knight, 1973). The spread of respiratory diseases including SARS (Yu et al., 2004) and H1N1 avian influenza (Baker et al., 2010) have been attributed to oral airborne transmission. In fact, influenza virus particles were detected in the exhaled breath of infected individuals through coughing, breathing and talking (Fabian et al., 2008; Stelzer-Braid et al., 2009; Huynh, Oliver, Stelzer, Rawlinson & Tovey, 2008; Lindsley et al., 2010). When respiratory droplets are released, they may spread infection directly from person-to-person or by contamination of surfaces then touched by others (Obeng, 2008). The bacteria may have originated from either respiratory droplets expelled directly onto surfaces or indirectly as droplets coating hands that are transferred by hands to surfaces. In fact, exhaled breath contained 693 to 6,293 CFU of bacteria/m^3 (Xu et al., 2012) and Qian, Hospodsky, Yamamoto, Nazaroff & Peccia, (2012) reported that human occupants are

significant contributors to indoor air bacteria and that humans emit bacteria at a rate of about 37 million gene copies per person per hour. Thus when a person forcibly exhales, as with blowing out birthday candles, bacteria or viral particles are aerosolized from the respiratory tract of that individual.

1.3 Research Objective

The purpose of this research was to evaluate the level of bacterial transfer transferred to the top of a cake when blowing out the candles on a birthday cake. Scientific data from our investigation may help raise awareness of possible health risks associated with birthday celebrations and encourage others to take steps toward preventing the spread of bacteria.

2. Methods

2.1 Blowing Out Candles

A sheet of foil (Bakers & Chefs, Bentonville, AR) cut in the shape of a circle with a diameter of 149 mm placed on a Styrofoam™ disc (Styrofoam Brand Foam, Floracraft, Ludington, MI), of the same size then 18g of icing (Betty Crocker Rich & Creamy Vanilla Frosting, General Mills, Minneapolis, MN) was spread in a thin layer on the foil. Seventeen candles (Best Occasions, Bentonville, AR) (3.2 mm in diameter, 50.8 mm high, and set in plastic holders 19.0 mm high) were evenly spaced into the Styrofoam, passing through the icing and foil layers. Each test subject was asked to smell and consume a piece of hot pizza to simulate a meal-dessert sequence. After lighting the candles, test subjects were instructed to blow until all of the candles were extinguished on the mock cake (Figure 1). For each testing session a control sample was collected where the procedure was followed for the test sample except candles were not blown out.

2.2 Enumeration of Bacteria

After lit candles were blown out (blow) or not blown out (no-blow) the candles and holders were removed from the Styrofoam™ base, without touching the icing. Using sterile forceps, the foil was folded in half with the layer of icing inside. Then, the foil was placed in a stomacher bag (Classic 400, Seward, UK) and unfolded inside the bag.

Figure 1. Styrofoam™ base and candle apparatus with icing used to test bacterial transfer when blowing out candles

Fifty ml of 0.1% sterile peptone solution were poured into the stomacher bag over the iced surface of the foil. The stomacher bag was placed in a stomacher (Stomacher 400, Seward, UK) at 230 rpm for 1 min. Duplicate samples of 1 ml and 0.1 ml volumes were aseptically removed from the stomacher bag (Classic 400, Seward, UK), serially diluted and surface plated on plate count agar (Difco Plate Count Agar, Sparks, MD) in petri dishes. Samples were spread evenly on the agar and incubated at 37 ℃ for 48 hours. Colony forming units (CFU) were counted on plates containing 25-250 colonies and converted to CFU per sample and $\log_{10}$ of CFU per sample.

2.3 Research Design and Statistical Analysis

The experiment was replicated 3 times on separate days by 11 subjects yielding 33 observations per treatment (blow or no blow). The effect of blowing vs. not blowing candles out on bacterial counts in the frosting was determined using the proc univariate command of SAS (2010) to obtain mean, median, range and standard deviation. The student's t-test was also performed and proc glm and pdiff commands were used to determine if significant differences existed between the blowing and non-blowing treatments.

3. Results and Discussion

Blowing out candles over icing resulted in 15 times more and statistically higher number of bacteria recovered from icing compared to icing that did not have candles blown out (Table 1). Also, the variation (range) in bacteria recovered from icing was 100 times greater for icing exposed to the blow compared to the no blow treatment. Furthermore, the median and maximum transfer of bacteria increased 300 and 12,000 %, respectively, due to blowing out candles. Studies on airborne droplet size from the oral cavity are found as early as 1899 (Flugge, 1899) and by several others before the mid 20th century (Hutchison, 1901; Winslow, 1910; Strausz, 1922; Lange & Nowoselsky, 1925; Hamburger, 1944; Duguid, 1946). These early studies came to varying conclusions but found droplets were released into the atmosphere surrounding humans that are breathing, coughing and sneezing. One study reported that 90% of bacteria-carrying droplets remaining airborne for 30 minutes in still air and that some smaller droplets remained for up to 30 hours (Duquid, 1946). More recently, Wan et al. (2014) established that up to over 2,000 moisture particles were released per breath, all less than 5 um in diameter. The particle size is an important factor since bioaerosols will carry both bacteria and viruses in small particle droplets generated by breathing, blowing and coughing. The average size of expelled particles generated by couching and speaking was found to be much larger (13.5 um for coughing and 16.0 um diameter for speaking) by measurement at the mouth opening thus minimizing the effect of evaporation on droplet (particle) size (Chao et al., 2008) which may be a factor in other studies using droplet condensation methodology. Chao et al. (2008) also found that there were between 1000 to 2000 in number and 2 to 5 ml in volume of droplets per cough and even 0.2 ml of moisture droplets during speaking. Therefore the size of droplets in expelled air are large enough to carry bacteria as well as viruses. Normal respiratory aerosols can include *Staphylococcus* spp., *Streptococcus* spp., *Corynebacterium* spp., *Haemophilus* spp., and *Neisseria* spp. (Madigan, Martinko, Dunlap, & Clark, 2009). Madigan et al. (2009) also found certain pathogenic species, such as *Streptococcus pneumonia* and *Staphylococcus aureus*, may cause illness when spread through surface contamination via oral aerosols. Considering contagious diseases such as influenza, some researchers have concluded that airborne transmission is a likely pathway (Weder & Stilianakis, 2008; Wein & Atkinson, 2009). Fabian et al. (2008) and Stelzer-Braid et al. (2009) detected viral influenza in the exhaled breath of infected patients. To this point, Fabian et al. (2008) reported that 60% of patients with influenza A had detectable levels of the virus in exhaled breath with 87% of exhaled particles less than 1 um in diameter. In another study, Lindsley et al. (2010) reported that 81% of influenza patients had influenza RNA in their breath and that 65% of the influenza were found in aerosol particles 4 um in diameter or smaller.

Verifying that bacterial cells as well as viruses are carried on human bioaerosols, Fennelly et al (2004) reported that 25% of tuberculosis patients exhaled from 3-633 CFU per cough of *Mycobacterium tuberlosis* in expelled air particles.

Birthday celebrations routinely include the ceremonial blowing out of candles on top of a cake. Some food safety concern exists in light of previous research on bioaerosols generated by breathing, coughing and speaking supported by the results of the present study finding that bacterial levels averaged 15 times higher in icing due to blowing out candles.

Table 1. Mean, median, range and standard deviation of the bacterial counts for cake icing exposed to blowing out candles and not blowing out candles

	No blow[1]	Blow[2]	Increase from No-blow to blow	
	CFU/sample[3] (log CFU/sample)[4]		CFU/sample[5]	(%)[6]
Mean	183[b] (2.2)[b]	2889[a] (3.5[a])	2706	1479
Median	150 (2.2)	600 (2.8)	450	300
Maximum	300 (2.5)	37,450 (4.6)	37150	12383
Standard deviation	112 (2.1)	6620 (3.8)	6508	5811

[1]*No-blow = cake icing not exposed to blowing out candles*

[2]*Blow = cake icing exposed to blowing out candles*

[3]*CFU/sample = colony forming units per cake icing sample. N = 33.*

[4]*Log CFUsample = log_{10} of colony forming units per cake icing sample*

[5]CFU/sample Increase = CFU/sample from samples blow on - CFU/sample from samples not blown on

$$^{6}\%\text{Increase} = \frac{(\text{CFU/sample from samples blow on} - \text{CFU/sample from samples not blown on})}{\text{CFU/sample from samples not blown on)}} \text{ X } 100$$

[a ,b] means with different superscripts are significantly different ($p \leq 0.0001$).

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