RUNNING HEAD: TASTING IN THE AIR

Tasting in the air: A review

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ABSTRACT

Many people complain about the taste and quality of airline food. Three of the key environmental factors that have been shown to play havoc with the passenger's ability to taste at altitude are the reduced cabin air pressure, the lack of humidity, and the loud background noise (of the plane's engines). In this review, after having outlined these and other problems that may adversely affect the tasting experience, I critically evaluate a number of the solutions that have been put forward over the years by the airlines, and others working in the field, in order to try and improve the situation. I also provide an explanation as to why it is that so many people drink tomato-based drinks while up in the skies, while rarely touching such drinks while down on the ground.

KEYWORDS: AIRLINE FOOD; CABIN PRESSURE; HUMIDITY; NOISE; UMAMI; GASTROPHYSICS; TOMATO JUICE.

Introduction

That plane food normally tastes disappointing is something that most travellers would readily seem to agree upon (e.g., Smith, 2013a; cf. McGuire, 2015).[1] While once upon a time, increased competition in the skies led the airlines to compete on the quality of their cuisine (e.g., Berry, 2013; Foss, 2014; Kovalchik, n.d.; Xie, 2016), nowadays, at least in Economy Class (where the majority of passengers end up), the standard of food, if any is offered, appears to be getting worse. In order to try and address the perceived problem, many of the airlines have brought in their own nationally, or better-still internationally, famous celebrity chefs to help advise on the food served to those sitting in the premium cabins (de Syon, 2008; Pemberton, 2015; Severson, 2007; see Spence, 2017, for a review). Generally-speaking, though, those airlines with the best-known chefs do not necessarily seem to find themselves any higher up on the annual rankings of airline food quality (e.g., Thornhill, 2015). Indeed, it never feels like one is getting the same experience that one would were one to be dining at one of the chef's flagship restaurants down on the ground (or, increasingly, in the airport terminal itself; see MacLeod, 2014; O'Ceallaigh, 2014), even if sitting in one of the premium cabins.[2]

So why *does* the food taste so bad in the air? And knowing about the latest findings from the emerging field of gastrophysics research (Spence, 2017) what, if anything, can be done to remedy the situation? These are particularly important questions given estimates that more than a billion passengers are serviced in the air each and every year (Jones, 2004, 2007). Most of the accounts that one reads about in the press concerning the parlous state of airline food tend to point the finger at the reduced cabin air pressure and the lack of humidity. While both of these factors undoubtedly play an important role in helping to explain what is going on, they are by no means the whole story. Indeed, the latest research now suggests that the sounds of the engines likely also plays an important role here too, suppressing our ability to both taste and smell (Spence, Michael, & Smith, 2014; Yan & Dando, 2015). Beyond that, the stress and anxiety of the passengers, the light (low-quality) cutlery and glassware (Moskvitch, 2015), the lack of descriptive dish naming, and the lack of social interaction while eating may also contribute to creating a poor impression of what is on offer, no matter how good the food being served actually is.

[1] Or as one journalist put it: *"The inexplicable blandness of airline food has been pondered at 30,000 feet by generations of travellers."* (Connor, 2010).

[2] Of course, the long-term service contracts that many of the airlines have signed-up to tend to stifle even the most creative chef's culinary innovation at altitude (see Jones, 2004, 2007; Spence, 2017).

In this review, I start by examining the effects that low cabin air pressure, the lack of humidity in the air, and the high levels of background noise have been shown to have on people's ability to taste and smell food and drink. I then move on to take a brief look at a number of other factors that are not typically mentioned, but which research on the ground suggests might impact a passenger's food and beverage experience while up in the air. I also highlight an important distinction between the short-term, marketing-led, innovations in food service provision in the air (that one often reads about in the press), and the longer-term fixes that will be needed if we are to improve the quality of the passenger's multisensory experience in the long-run.

Atmospheric factors deleteriously affecting tasting at altitude

Lowered cabin air pressure: This will obviously affect olfaction (i.e., the sense of smell; Bert, 1978; Kuehn, Welsch, Zahnert, & Hummel, 2008; Stepanek, 2002), but, perhaps surprisingly, it has also been reported to influence people's taste thresholds as well. To put the problem into perspective, once a plane reaches cruising altitude, it has been suggested that the air pressure in the cabin will normally be equivalent to what one finds at c. 6,000-8,000ft above sea-level (Beck, 2014). Research conducted in a pressure-controlled chamber, where taste thresholds were assessed in the same six female participants at the equivalent of sea level, and then again at altitudes of 5,000 and 10,000 ft (with the order of conditions counter-balanced), documented significant changes at higher altitudes (see Maga & Lorenz, 1972). Specifically, the thresholds for detecting the presence of a tastant in solution increased from sea-level to 5,000 ft.[3] However, a more careful look at Maga and Lorenz's data reveals that this effect was driven solely by a dramatic change in the threshold for bitterness – that is, thresholds for sweetness, saltiness, and sourness were unaffected by the changes in air pressure. Their results showed that participants were able to detect the bitter solutions as a much lower molar concentration at sea-level than when tasting at a pressure equivalent to 5,000 ft or more.

Meanwhile, a study commissioned by Lufthansa from the Fraunhofer Institute in Germany showed that salt and sweet are most adversely affected by cabin conditions. In particular, Burdack-Freitag, Bullinger, Mayer, and Breuer (2011) conducted a series of carefully

[3] Taste thresholds in Maga and Lorenz's (1972) study did not change as the simulated altitude changed from 5,000 to 10,000 ft.

controlled psychophysical tests of taste and smell perception at normal and low atmospheric pressure in a simulated aircraft cabin (i.e., conducted in a 16m section of an airplane on the ground). The high-tech. set-up allows researchers to simulate not only air pressure and humidity, but also ambient noise and vibration typical of flight. The participants who took part in this study were given a series of solutions to taste. The results revealed that both taste and smell perception were suppressed under the low pressure conditions that are typical of flight. These results have been taken to support the claim that food loses 30% of its taste when sampled in the skies. Sweetness and saltiness seem to be especially badly affected (salt being rated as 20-30% less intense while sugar was rated as 15-20% less intense under simulated high altitude conditions). Sour, bitter, and spicy tastes, meanwhile, remained more or less unaffected (Michaels, 2010).[4]

Dry cabin air: The lack of humidity in the frequently-recycled air is also an important factor. It has been estimated that the air is recycled every 2-3 minutes (Beck, 2014), and that the humidity at 35,000 feet is something like 12%, much lower than one finds on the ground (equivalent to what one might find in the desert; Moskvitch, 2015; by comparison, humidity in the home tends to exceed 30%, see http://www.who.int/ith/mode_of_travel/chad/en/). Reduced levels of ambient humidity have been shown to impact the perception of aroma (e.g., Kuehn et al 2008; though see also Philpott, Goodenough, Passant, Robertson, & Murty, 2004), and hence flavour perception.

Noise: According to Ozcan and Nemlioglu (2006), the noise from the engines on commercial flights is somewhere in the range of 80-85 dB(A). The exact figure depends on where you sit relative to the plane's engines, and on the type of aircraft you find yourself flying in. A number of studies have demonstrated that loud background noise deleteriously affects taste perception (Woods, Poliakoff, Lloyd, Kuenzel, Hodson, Gonda, Batchelor, Dijksterhuis, & Thomas, 2011; Yan & Dando, 2015). However, it is worth noting that loud background noise has also been shown to impair olfactory perception (Seo, Gudziol, Hähner, & Hummel, 2011;

[4] The extra sugar that needs to be added to airline food to make up for this loss of taste may help to explain why it is that people consume more than 3,400 calories between their check-in at the airport and their arrival at their destination. This according to Dr. Charles Platkin, who does an annual calorie count of the food offered by the big airlines, the average number of calories per item in the air was 360 in 2012; Calorie estimate from a survey conducted by Jetcost.co.uk; See *The Sunday Times (Travel)*, **March 15th**, 3. However, passenger stress may also play a role here (Sproesser, Schupp, & Renner, 2014).

Seo, Hähner, Gudziol, Scheibe, & Hummel, 2012). Meanwhile, noisy ambient conditions can impair people's ability to discriminate the alcohol content in drinks served on the ground as well (Stafford, Agobiani, & Fernandes, 2013; Stafford, Fernandes, & Agobiani, 2012).

Yan and Dando (2015) conducted one of the most relevant studies on the impact of aircraft noise on taste thresholds. These North American researchers tested a group of participants (N=48) in the laboratory. The latter had to rate the intensity of a range of solutions containing one of the five basic tastes at one of a range of concentrations using a Labeled Magnitude Scale. The results revealed that perception of sweetness was suppressed when the participants were exposed to 85 dB of airplane noise, while the taste of umami was rated as more intense instead.[5] According to Prof. Dando: *"Interestingly, sweet taste intensity was rated progressively lower, whereas the perception of umami taste was augmented during the experimental sound condition, to a progressively greater degree with increasing concentration."* (quoted in Griffiths, 2015).

While we do not yet have a good account for why background noise should exert a differential effect on the various basic tastes, the point remains that such a pattern of results cannot simply be accounted for in terms of distraction (Connor, 2010), as that would be expected to affect all tastes equally.[6] Intriguingly, though, Yan and Dando's findings may help to explain one of the enduring mysteries about food and beverage consumption in the skies: Namely, why it is that so many people drink tomato juice or else order a Bloody Mary while up in the air (see Guilhem, 2014; Jackson, 2014; Spence et al., 2014).[7] Indeed, according to one German survey of 1,000 passengers conducted a few years ago, roughly one in four of us order a tomato-based drink from the flight attendants (Burdack-Freitag, Bullinger, Mayer, & Breuer, 2011). Intriguingly, 23% of passengers reported that they *never* drink tomato juice while on the ground.[8] Given that both tomato juice (and the Worcester

[5] Meanwhile, thresholds for bitter, salty, and sour were unaffected by the presence of realistic levels of airplane noise. Note here that Woods et al. (2011) reported that both sweetness and saltiness suppressed by loud white noise.

[6] See Ferber and Cabanac (1987), for one evolutionary suggestion regarding the impact of stressful loud noise on our responses to sweet and salty tastes.

[7] So, for example, Jackson (2014) notes that: *"A few years ago, the German airline Lufthansa realized they served about 53,000 gallons of tomato juice annually. That's just shy of the 59,000 gallons of beer they serve each year. Which is really significant, says Lufthansa catering executive Ernst Derenthal."*

[8] Of course, the mystery remains as to why certain tastes are affected and not others. Furthermore, one might also wonder why it is that sales of tomato juice and Bloody Mary haven't gone through the roof on the ground too, given how many restaurants and bars now clock-up a higher decibel count than that typically experienced on the plane (McLaughlin, 2010; Sietsema, 2008a, b; see Spence, 2014, for a review).

Sauce added to make a Bloody Mary) are umami-rich, it is almost as if passengers might be self-medicating at altitude by choosing to order a drink that should stand up well to the extreme atmospheric conditions found at altitude. Reports suggest that tomato juice tastes less earthy, more acidic, and the survey results would suggest more appealing, in the air.

Using gastrophysics findings to enhance the taste of airline food and drink

There are a number of suggestions/recommendations that flow naturally from each of these identified limitations for anyone wanting to enhance the passengers' experience of food and drink in the air:

Lowered pressure: One potential solution to dealing with the lowered air pressure in the cabin while at altitude might be to increase passenger's nasal air flow using something like a 'Breathe rite' strip, that were so popular amongst athletes a few years back. To date, though, this solution has not been tried in the air, at least not as far as I am aware. Unfortunately, however, the one study of this potentially important 'hack' tried on the ground by Raudenbush and Meyer (2001) failed to show any benefit. That is, these researchers failed to demonstrate any enhancement in people's experience of a range of regular foods when they were rated either with / without such a nasal strip in place. In fact, if anything, the participants' taste ratings actually went down somewhat when wearing a strip! This despite the fact that such 'appendages' have been shown to increase nasal air flow by as much as 25% (Griffin, Hunter, Ferguson, & Sillers, 1997; Hornung, Chin, Kurtz, Kent, & Mozell, 1997; Hornung, Smith, Kurtz, White, & Leopold, 2001). One possible reason as to why increasing nasal air flow doesn't work as one might expect is that there is some kind of perceptual constancy at play (cf. Walsh & Kulikowski, 1998).

The use of spice in food and foods that are noisy (think crispy, crunchy, and crackly) are a good idea, given that these are likely to stand up well at altitude (e.g., Moskvitch, 2015; Severson, 2017; Spence, 2017). Ice cream is another safe bet, at least according to Marion Nestle professor of nutrition, food studies and public health at New York University (Mouawad, 2012). Asian-flavoured dishes, which typically have an intense aroma, have also been reported to stand-up well under cabin conditions, while, fish and poultry will require much more seasoning with salt and herbs if they are to taste good to passengers in the air (see https://www.ibp.fraunhofer.de/en/Press/Research_in_focus/Archives/A_feast_for_research.ht

ml).

One other suggestion here is to drink 'New World' rather than old world wines at altitude (Smith, 2014). Many wines are often reported to taste bitter when sampled in the air (see also Tyrer, 2014). According to Liam Steevenson, wine buyer and advisor for Silverjet Airlines, amongst others: *"Wines that on the ground taste quite fruity, suddenly taste thin, tannic and acidic. Wines certainly thin out and become much leaner and more structured."* (Moskvitch, 2015). According to Smith, fruitier wines tend to fare better than noble wines with their structured tannins (see also Mouawad, 2012). He recommends Sauvignon Blanc for white and Malbec for red. One intriguing idea here is that those wines that are grown at altitude might stand up better to the lower cabin air pressure when at altitude (because they were made at a similar altitude to that found in the cabin). So, for example, the Zapata grapes in Nicolas Catana's Argentinian vineyard are grown at an elevation of 5,700 ft above sea-level – not so far off the 6-8,000 ft of the aircraft cabin at altitude (see Smith, 2014).

While the carbonation present in Champagne and other sparkling wines ought to help to maintain a desirable mouthfeel at altitude, it is worth noting that research by Taittinger in 2013 showed that the lowered air pressure plays havoc with the bubbles in their champagne. The latter exhibited a tendency to stick to the side of the glass rather than rising from the enucleation point in the glass (see http://susieandpeter.com/wp-content/uploads/2010/05/Bubbles-with-Altitude-PDF.pdf).

Cathay Pacific recently introduced a craft beer, called Betsy Beer, that had been especially created for altitude – the beer was had a carbonation that was around 10% higher than is typical for beers brewed on the ground (Gartenberg, 2017). The composition of the beer was also altered with an eye to reducing the bitterness, containing honey and "dragon eye" fruit which apparently tastes a bit like lychee. This innovative marketing solution was available to all First and Business Class passengers during the months of March and April 2017 (though only on certain routes).[9] Cathay were by no means the first to go down this route: For according to an article that appeared in *The New York Times* recently, Mikkel Borg Bjergso (from a company called Mikkeller in Belgium), has been brewing beer especially for Scandinavian airline SAS since 2014. Apparently, *"the airline has gone through about two million of his bottled and canned beers"* (quote from Freytas-Tamura, 2017).

[9] However, given that this beer was especially brewed to taste good when drunk up at 35,000 ft, one might wonder at the advisability of offering the very same beer on the ground in the airline's business lounges as well.

According to Kim (2013), British Airways has also been working with the English tea brand Twinings in order to try and develop a special blend of Kenya, Assam, and High Ceylon teas that would be guaranteed to taste good at altitude as well. One of the problems here being that water boils at around 89°C on-board an aircraft that has reached cruising altitude, not the ideal 100 degrees for making black tea (Foss, 2014; White, 2013).

Dry air: One thinks both of drenching the main, be it meat or pasta in sauce (Howe, 1985); Then there is the nasal douche idea that has been popularized by famous chef Heston Blumenthal (Liston, 2011) – the idea to spray water into the nose to help increase aroma uptake. Otherwise, it is hard to know what else can be done to address this particular issue.

Noise: In order to counteract the sound of the engines, noise-cancelling headphones ought to help (Spence et al., 2014). Beyond that, given how much impact the music playing in the background has been shown to have on the taste of food and drink, not to mention how much we enjoy the experience, one might think about trying to offer passengers audio, or audiovisual entertainment options that would match the style of their food (Spence, 2016). In fact, British Airways came out with just such a solution a couple of years ago. Though, once again, it would seem to have been more of a short-term marketing innovation rather than a concerted attempt to make the airline passengers' experience of the food taste better in the long-term.

Umami-rich menus: For example, British Airways, came out with their much-publicised Umami-inspired menu a few years back (see McCartney, 2013a, b). Other airlines, meanwhile, have started to introduce more umami-rich dishes onto their menus too, though without necessarily explicitly drawing the passengers' attention to the fact (Moskvitch, 2015). That said, this kind of approach is not without its own risks: For instance, reports surfaced recently of passengers on a Virgin Australia flight from Perth to Adelaide complaining about the smell (some even vomiting) when the passengers were served complementary parmesan sandwiches (Buaya, 2016). While it is certainly true to say that parmesan is a particularly rich source of umami in food, it is also true that isovaleric and butyric acid, which are a couple of the compounds that give this cheese its characteristic aroma, also happens to be found in vomit/sweaty socks as well (cf. De Araujo, Rolls, Velazco, Margot, & Cayeux, 2005; Herz &

Von Clef, 2001). The latter being what a number of the passengers said the plane smelled like!

Having covered the top three factors adversely influencing the passenger's experience of food and drink in the air it is worth briefly a number of other factors that may limit perceived quality on the food that is served in the air. There is, for example, an extensive body of research conducted down on the ground to show that adding a descriptive label to a dish can lead to an increase in the number of positive comments that people make about the food (e.g., Spence & Piqueras-Fiszman, 2014; Wansink, van Ittersum, & Painter, 2005).[10] Hence, the abrupt question *"Meat or pasta?"* that is all too often blurted-out by the burly flight attendant from the aisle probably isn't going to do anything to enhance the passengers perception of whatever it is that the latter end-up ordering (assuming, that is, that there is still a choice). Rather, choose a more descriptive label such as something like "*Golden, tender, free-range chicken breast served with an unctuous creamy Italian herb sauce"* or some such should do the trick. This will likely enhance the passenger's experience of their meal. However, before getting too carried away with overly descriptive dish naming, one just needs to make sure not to overdo it, and so avoid the possibility of the label giving rise to a negatively-valenced disconfirmation of expectation response (see Cardello, 2007; Deliza & MacFie, 1997; Piqueras-Fiszman & Spence, 2015).

Environment/atmosphere effects

Ever since the early work of Green and Butts (1945), researchers have been interested in studying how the atmosphere impacts on our experience of food and drink. Over the years, a number of studies have demonstrated how exactly the same food will often be rated very differently depending on the atmosphere/environment in which it is served (e.g., school canteen versus fancy restaurant, say; Edwards, Meiselman, Edwards, & Lesher, 2003; García-Segovia, Harrington, & Seo, 2015; King, Weber, Meiselman, & Lv, 2004).

Recently, Holthuysen, Vrijhof, de Wijk, and Kremer (2016) served a couple of versions of two top-selling airline meals (a chicken curry rice dish and a pasta Bolognese dish) to people (N=464) in one of three different conditions – a sensory lab, a simulated airplane cabin

[10] See also Bell, Meiselman, Pierson, and Reeve (1994) for evidence concerning the effect of giving meals a more Italian name, combined with making the inside of a dining room more Italian in terms of its decorations.

environment on the ground, and to passengers while in flight (from Amsterdam to Tenerife). Surprisingly given the literature on atmospheric effects, there was actually little difference between people's ratings (of overall liking and Just-about-Right ratings) in the three environments. If anything, the food was rated as tasting better in either the simulated or real airline situations than in the lab. Furthermore, a distinction in liking between the two versions of the same dish was only observed in the simulated and real aircraft environments. Furthermore, Just-about-Right ratings of taste Intensity, Fruity, Spicy, Sweet, Bitter, Sour, Salt, Tomato, and Mushroom attributes for the meals did not differ between the simulated and real flight conditions either.

When interpreting these results, though, it is important to note the differing demographic of the individuals tested in each of these three locations / conditions complicates the interpretation of these results somewhat.[11] While much of the previous research can be criticized for its reliance of simple taste stimuli (unlike real foods), Holthuysen et al.'s (2016) might raise questions about the sensitivity of the Just-about-Right measure. What is more, it is hard to know whether the fact that the passengers on the plane were unexpectedly offered a free meal on the plane might not have improved their mood somewhat, and so perhaps have biased their judgments toward giving the food a higher rating than otherwise would have been the case had they had to pay for it.

The free vs. paid-for distinction is also likely relevant here, especially given that the mark-up on the food served in the plane is higher than pretty much anywhere else – with a 2600% mark-up being noted with some budget airlines here in the UK (Smith, 2013b). And while paying more can make things taste better (Plassman, O'Doherty, Shiv, & Rangel, 2008; Plassman & Weber, 2015), such extortionate pricing is more likely to lead to a rebound effect instead.

Other factors that might deleteriously impact passengers experience of the food and drink on a plane include the atmosphere (think dull lighting; Kim, 2013), the light cutlery/glassware (e.g., Michael, Velasco, & Spence, 2015; Spence & Piqueras-Fiszman, 2011, 2014), and the confined space.[12] Note also that there is typically little sense of sharing in the skies. Research conducted down here on the ground has shown that sharing the experience of eating enhances

[11] And, as the authors of the study note themselves, the sample sizes used in some of the conditions were rather small in this between-participants study.

[12] Or as my colleague Peter Barham put it when speaking to *The New York Times* recently*: "Imagine your favorite meal — it tastes great. But if it's served in a plastic container and you're squashed elbow to elbow between two people, it doesn't taste so good."* (quote from Freytas-Tamura, 2017).

people's enjoyment of that which is being consumed, but also amplifies their dislike of things they don't (Boothby, Clark, & Bargh, 2014). This is why Eos airline's revolutionary cabin design, one that allows as many as four passengers to swivel their seats and so sit together at the same table to share the meal might be a good idea, at least in terms of enhancing the perceived quality of the food (see Severson, 2007). A number of the airlines have started to think more seriously about their cutlery and crockery used for premium passengers, and even the lighting to show off the airline food to best effect (see O'Flaherty, 2015; Spence & Piqueras-Fiszman, 2014).

Of course, on top of all of the above factors, many passengers find themselves stressed and/or anxious while in flight (e.g., de Syon, 2008; Kim, 2013; see also Butler, Nicholas, Lackland, & Friedberg, 2000). Once again, research on these factors conducted on the ground has also been shown to influence taste/smell thresholds deleteriously as well (see also Ferber & Cabanac, 1987). Then, for long-haul Eastbound flights (e.g., normally overnight flight) this will likely mean a disruption of the circadian rhythms may come into play as well. For instance, the spontaneous flow of saliva in the oral cavity typically obeys a 24-hr cycle. It is normally much lower during the hours of darkness (Shannon & Suddick, 1973). This might also impact taste perception as well (see Spence, 2011, for a review). Note here also that stress has been shown to interfere with salivary function as well (Bates & Adams, 1968).

Personalizing the experience in the skies

What mystifies me at the moment is why more use of personalization isn't made use of in the skies. Many of the airlines now already provide their cabin staff with information about their frequent flyers. And while that information is currently used to welcome the regular passenger by name – *"Oh Prof. Spence, so nice to see you again…"* on take-off no hint of personalization seemingly enters into the provision of the food and beverage offering in flight. Now, if done in the wrong way, this can undoubtedly feel a little overbearing, but when managed skilfully, it has been shown to enhance the offering (see Spence, 2017). No wonder that many top restaurants are increasingly investing in the personalization of the multisensory food and beverage experience that they provide.

One intervention from the airlines that starts to move in this direction comes from the 'Taste by Appointment' service offered to premium passengers in the Grey Goose Loft Bar at Virgin's Clubhouse lounge at Heathrow's Terminal 3. Depending on the passenger's taste

preferences (there are a pair of cocktail recommendations around each of the five basic tastes), different cocktails are recommended and may then be served once in the air as well (Lawrence, 2013). This kind of approach can help to give the passenger a feeling of personalization, one that extends beyond the welcome into the food and beverage encounter as well. (Singapore Airlines has also been looking into customizing its cocktails too.)

There are also obviously marketing opportunities – specially formulating drinks for the atmospheric conditions at altitude (Gartenberg, 2017). This was an approach taken recently by Cathay Pacific with their Betsy beer through to British Airways introducing their umami-inspired menu. Then there was the Sound Bite menu also introduced by British Airways in the long-haul flights back in November, 2014 (Skift, 2014; Victor, 2014). The idea here was that passengers could tune in to the appropriate channel in the head-rest to listen to a selection of tracks that had been specially chosen to complement the foods being served. Mark Tazzioli, a chef working for British Airways had the following to say: *"Your ability to taste is reduced by 30 per cent in the air, so we do everything we can to counteract this. The sonic seasoning research is fascinating, and our pairings should really help bring out the flavors."* (quoted in Skift, 2014).

Conclusions

Prior to the arrival of large-scale commercial space flight, one of the most challenging environments in which to make food taste good currently is while flying at altitude. The emerging science of gastrophysics is increasingly starting to help some of the more progressive airlines to nudge their food offering toward a better place. This is an important, if little-studied topic, given that a billion meals are served on airplanes every year. While currently such gastrophysics insights have tended to be seized on by the marketing departments for their short-term potential (e.g., Gartenberg, 2014; Skift, 2014; Victor, 2014), the hope is to be that a more considered (not to mention sustained) approach to enhancing the in-flight meal experience will emerge in the coming years. Of course, it is also possible that an alternative future stands before us, one in which many more passengers will start to make use of one of the all-new Smartphone apps, like *Alaska, Food on the Fly*, *B4 You Board*, or *DeliSky* that allow passengers to get a meal delivered no matter where they are those in the

terminal, even at the departure gate (Diebelius, 2015).[13] Such a change would see responsibility for providing great-tasting food in the air shifting from the airlines to the food producers on the ground. The latter will presumably benefit more than most from a better understanding of the factors limiting taste perception in the skies.

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[13] Though best to make sure not to order something too odorous for fear of irritating your fellow passengers (Kessler, 2012).

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