RUNNING HEAD: RECONSIDERING THE MICROWAVE

Reconsidering the microwave: A historical analysis of changing attitudes to modernist kitchen technology

DATE: DECEMBER, 2025

WORD COUNT: 8,875 WORDS

RESUBMITTED TO: *International Journal of Gastronomy & Food Science*

ABSTRACT

The microwave oven can perhaps be considered as the first modernist kitchen invention. However, despite early gastronomic excitement over the potential of the 1940's technology, there are few chefs or home cooks who celebrate using this kitchen device, despite the majority of kitchens nowadays being fitted with a microwave oven. Many of the safety concerns that were raised against the use of this technology since its widespread arrival in the home kitchen back in the 1970s have proven unfounded. At the same time, however, with the likely continued increase in energy prices (and other energy crises), the microwave oven should perhaps be re-evaluated, given that it constitutes a far more energy-efficient means of warming food than traditional ovens. Microwave cooking also represents a far more efficient means of preserving the nutrient, mineral, and anti-oxidant content in a range of fresh foods (e.g., vegetables). However, changing public perception will likely require a much better understanding of what, exactly, people object to concerning the technology: Is it safety fears, the functional inability to brown foods, the fact that it heats unevenly, or perhaps the sense that it is perceived as a lazy way to prepare (or reheat pre-prepared) food? Nudging people to embrace an energy-efficient form of heating food, and a nutrient-preserving way of cooking vegetables, will though likely require emotional as much as factual arguments.

KEYWORDS: MOLECULAR GASTRONOMY; SCIENTIFIC COOKING; MICROWAVE COOKING.

1. Introduction

The microwave oven might legitimately be considered the first modernist kitchen gadget (Spence & Piqueras-Fiszman, 2014). Nicolas Kurti, the Oxford-based Hungarian physicist, a key figure in the origins of the molecular cuisine, or gastronomy, movement famously highlighted its potential during his Royal Society 1969 Royal Society lecture, “The Physicist in the Kitchen”. There, the pioneering physicist and gourmet demonstrated the technology’s potential by using it to create a 'reverse Baked Alaska' (Kurti & Kurti, 1988).[1] According to Warren Belasco (2006, p. 237), even in the 1980s, the microwave was still considered somewhat revolutionary. However, nowadays many consumers appear to view the use of the microwave to prepare food somewhat negatively, perhaps even fearful of the technology. It is interesting to consider whether this is, in part, because the means of operation (microwaves) cannot be sensed, in the way that one can feel the heat of a traditional oven.

In this narrative historical review, we take a closer look at the emergence of this kitchen technology over the last half century or so. In contrast to other reviews of microwave applications, that tend to focus on the technical capabilities of the technology (e.g., Kakar, Sarwari, Rahime, Hassand, & Niazi, 2024; Pielak, Czarniecka-Skubina, & Kraujutienė, 2022), this review focuses primarily on the historical and psychological barriers to the widespread adoption of the microwave in the domestic environment and in commercial kitchens. We compare its uptake and acceptance both amongst consumers and in commercial kitchens, and look to its potential future uses, especially in the context of the food sustainability crisis, the rise in energy prices, and the introduction of novel and alternate foods (e.g., alternate proteins). Perhaps surprisingly, the microwave oven doesn’t obviously make an appearance in one of General Motor’s promotional films, *Design for Dreaming* (Union Films; https://www.youtube.com/watch?v=1gKl-mwMyck), nor in the musings of Isaac Azimov (e.g., Gittleson, 2014, ‘World’s Fair: Isaac Azimov’s predictions 50 years on’). In the 1956 short film, Kitchen of Tomorrow, sponsored by General Motors, a young woman is shown in a futuristic looking kitchen with a cake being baked ‘automagically’, with seemingly no effort on her part (Kitchen of Tomorrow, 1956; Spence & Velasco, 2025; see **Figure 1**). While various foods have become popular through their link with space food

[1] The reverse baked Alaska consisted of a frozen meringue shell filled with hot liquor. Kurti called it the "frozen Florida". Kurti’s interest in applying scientific knowledge to culinary problems laid the foundation for a new understanding of cooking as a site of innovation and inquiry. Among the early adopters of this approach was Raymond Blanc, a largely self-taught chef who collaborated with Kurti and played a formative, though often understated, role in shaping this emerging field (Cousins, O’Gorman, & Stierand, 2010; Stierand, 2015).

(Spence, 2023), by and large microwave ovens are not typically found on airplanes, nor in space, due to possible interference with communication devices (Narayan, Kesavan, Jha, & Bommer, 2012; though see Ross, Sablani, & Tang, 2023).

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2. A short history of the microwave oven

The Raytheon Company filed a patent proposing that microwaves be used to cook food in 1946.[2] An oven that heated food using microwave energy was then placed in a Boston restaurant for testing. The first commercial microwave oven hit the market in 1947. These primitive units where gigantic and enormously expensive, standing 5 1/2 feet tall, weighing over 750 pounds, and costing about $5000 each (Gallawa, 2001; Osepchuk, 1984). In 1967, the first countertop, 100-volt domestic microwave oven was introduced to the US market, costing just $495. It was advertised as being smaller, safer and more reliable than previous models. By 1975, sales of microwave ovens exceeded those of gas ranges for the first time. The following year, a reported 17% of all homes in Japan used a microwave oven to cook food, as compared with just 4% of US households in the same year (Dickinson, 1976).

Before long, microwave ovens were to be found in the kitchens of over nine million homes, or about 14%, of the homes in the United States. In 1976, the microwave oven became a more commonly owned kitchen appliance than the dishwasher, reaching nearly 60%, or about 52 million U.S. households. According to Gallawa (2001), the cooking habits of North Americans were drastically changed by the time and energy-saving convenience of the microwave oven. Gallawa goes on to suggest that the microwave oven had developed from a luxury item into a practical necessity for a fast-paced world, or as the title of an article by Rubbright (1981) puts it: ‘The microwave oven enters the mass market’. Numerous cookbooks appeared during the 1970’s providing tips as to how to use this new kitchen technology (Anonymous, 1971, 1975; Shapter, 1987). In 1976, Pillsbury company of the United States introduced microwave popcorn for the first time, and then microwave foods such as potato chips, cakes, noodles, etc. appeared on the market in the mid to late 1990s

[2] However, that said, the idea of heating food with radio waves was by no means new. According to Ackerman (2024), Bell Labs, General Electric, and RCA had all been working on variations of the technology for some time. Indeed, at the 1933 World’s Fair in Chicago, Westinghouse demonstrated a 10-kilowatt transmitter that cooked steaks and potatoes between two metal plates. However, nothing came of these early innovative culinary technologies.

(Deng, Huang, Huang, Yang, Wu, Ci, He, Wu, Han, & Zhang, 2022). According to Ferdman (2022): “In the early 1980s, while microwave sales were booming, Orville Redenbacher brought the first microwavable popcorn to the market. And America liked it. Over the next dozen years, popcorn sales climbed more than 100%, according to data from the American Popcorn Board.” Sales have fallen by 40% in The States in the decade since sales peaked in 2004 (Ferdman, 2022). That said, according to the US Bureau of Labor Statistics, something like 90% of American households own a microwave.

However, at the same time as microwave ovens were becoming more popular in North American kitchens, concerns started to be raised concerning their safety (Ackerman, 2024). As microwaves became more common throughout the 1970s, concerns arose about the effects of microwave radiation on human health (Fenton, 1957; Rosen, 1972).[3] In 1974, the following appeared in an article in *The New York Times*: “After testing 15 microwave ovens…Consumers Union warned in March, 1973, that none could be considered “completely safe,” in part because there was no solid data on safe levels of radiation emission.” (Dullea, 1974). The situation had recovered by 1976, with another article in *The New York Times* now reporting that sales of microwaves were, once again, ‘sizzling’ (Dickinson, 1976). Moving the clock forward to the present day, according to Global Market Insights (2024): “The global microwave oven market was valued at USD 10.5 billion in 2024 and is anticipated to register a CAGR of over 4.6% between 2025 and 2034.”[4] Over-and-above being cheap to run, microwaves are also highly economical to purchase, with prices starting at around £40, with commercial models and high-end home appliances reaching up to around £700. Combined convection and microwave ovens, or combi-ovens, have also become more popular in the home kitchen (Gold, 2018; Yan, Sun, Tang, & Fan, 2024), as have steam ovens. According to Yan et al., the benefits of this combined solution include: “Microwave- hot air cooking enhances flavors, minimizes harmful compounds, and ensures even cooking in less time.” (see also Tinga & Eke, 2012).

However, despite its increasing ubiquity in kitchens, both professional and domestic, the microwave oven remains a kitchen gadget that is seemingly often frowned on (sometimes causing embarrassment to the restaurateur when commercial kitchens are heard using one). In fact, there are numerous online sites dedicated to helping cooks in commercial kitchens to

[3] Several decades later, a similar concern was raised about the microwave signals from mobile phones leading to brain damage (https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/cell-phones-fact-sheet).

[4] CAGR = Compound Annual Growth Rate.

turn off the dinging sound that all too often gives away the use of a microwave (Spence, 2021). It is important to recognize that this negative emotional response differentiates the microwave from other food preparation technologies that have been introduced over the last 75 years or so. What is more, it is noticeable how this negative response to the distinctive sound of operation of the microwave oven contrasts strikingly with many other highly positively-valenced food preparation sounds, such as, for example, the 'pop' of a wine cork (Spence & Wang, 2017), or the various sounds of a premium coffee machine (Spence, 2017).

3. On the introduction of novel kitchen devices

Throughout the history of the development of modern cooking techniques (or), many novel appliances have been launched with the promise that they would revolutionize the way in which people prepare and cook food (at home, and in a commercial setting). That said, the response of both public and professional audiences to the introduction of new kitchen gadgets is often hard to predict *a priori*, as the following examples highlight (Spence & Piqueras-Fiszman, 2014).

3.1. Sous vide

In contrast to the microwave oven, *sous vide* has become a much lauded approach to food preparation in many professional kitchens (e.g., Baldwin, 2012). This French gastronomy term refers to the style of cooking in a vacuum, placing sealed meat or vegetables into a water bath at an exact (normally relatively low) temperature for much longer than one would normally cook food (up to 72 hours in some cases; Rayner 2004). This approach to cooking first made its appearance in Switzerland back in the 1960s as a way of preserving and sterilizing the food served in hospitals. The technique was further refined in 1967 (i.e., at roughly the same time as the microwave became affordable in home kitchens) by chef Pralus in his Roanne restaurant in France.

Sous vide appears to have found a central place in many modernist commercial restaurant kitchens that value the consistency of their offering. The technique of *sous-vide* cooking has been popularized and developed by chefs such as Heston Blumenthal and Thomas Keller. As

Heston Blumenthal put it back in 2006: *"We may use modern thickeners, sugar substitutes, enzymes, liquid nitrogen, sous vide, dehydration and other non-traditional means but these do not define our cooking. They are a few of the many tools that we are fortunate to have available as we strive to make delicious and stimulating dishes*" (Rayner 2006). This technique is likely to become increasingly popular across the commercial restaurant sector for the cost saving (relative to other cooking techniques) it offers, if not for the differentiated flavour experience, and enhanced flavour retention that this technique can provide. While sous vide has primarily found a place in professional (especially molecular) kitchens, it is worth noting that home versions also exist. For instance, the SousVide Supreme[5]. This machine started to appear on the shelves around 2009 for home cooks. For around $400 (plus another $100 or so for the vacuum packing device and a handy supply of bags), this machine allows the adventurous home chef to prepare perfectly consistent foods. However, the evidence suggests relatively limited uptake, linked to cost and expertise needed (Misu, Canja, Lupu, & Matei, 2024).

3.2. The air fryer

As a much more recent kitchen invention (at least one that has appeared in the home kitchen over recent years; Behir, 2021), one might consider the air fryer, which has become a very popular general cooking appliance in recent years (Çelik, 2024; Téllez-Morales, Rodríguez-Miranda, & Aguilar-Garay, 2024). It is widely considered both relatively healthy, and efficient, though once again, not appropriate for preparing all foods (de Oliveira, Viana, Keller, de Melo, Mulandeza, Barbosa, Júnior, & Saldanha, 2024).[6] The air fryer browns, and uses far less oil thus addressing an increasingly important safety concern, as well as being more energy efficient than conventional deep fat frying. There is also the additional health benefit of a reduced build-up of acrylamides, etc., at least when compared to deep fat frying (e.g., Navruz-Varlı & Mortaş, 2024; Verma, Singh, Chauhan, & Yadav, 2023), and the oil that is left over after cooking also provides a psychological satisfaction all of its own (see also Çelik, 2024). There has also been some commercial interest expressed in introducing a combined microwave air fryer to market (see Haque, 2019).

[5] https://www.sousvidesupreme.com/.

[6] E.g., https://www.linkedin.com/posts/versuni_versuni-turninghousesintohomes-philips-activity-7295073867184652289-A18K/

3.3 Steam ovens

Steam ovens are gaining popularity in high-end domestic kitchens. While traditional ovens cook using dry heat, steam ovens introduce moisture into the cooking process, either as pure steam or in combination with convection heat (combi-steam ovens). In some sense, steam ovens are an attractive middle ground between traditional oven cooking and microwave heating. Unlike microwaves, steam ovens are more likely to be associated with healthy cooking (as steaming is seen as a healthier cooking method) and a degree of culinary sophistication (perhaps due to the technology disseminating from professional kitchens, or perhaps due to their price point). Combi steam microwave ovens have also been developed.[7]

4. Limitations and benefits of microwave cooking

Surveys continue to highlight the fact that many consumers have a somewhat negative, possibly even embarrassed, and/or even slightly fearful response to microwave ovens (e.g., Guzik, Szymkowiak, Kulawik, Zając, & Migdał, 2022). There are potentially several reasons for such responses: Historic safety concerns (as mentioned earlier), functional limitations (e.g., the microwave oven's inability to brown foods and the fact that it tends to heat food unevenly), as well as psychological factors to consider. The latter relates to the sense that the use of the microwave oven suggests a lack of effort in terms of the preparation (perhaps due to its link with pre-prepared, or ready meals; though see Montero, Garrido, Gallardo, Tang, & Ross, 2021). Indeed, the latter concern was also, apparently, what famously hindered the early uptake of cake mixes (Shapiro, 2005; Spence, 2017).[8]

4.1. Safety concerns

[7] https://www.panasonic.com/uk/consumer/home-appliances-learn/home-appliances/the-health-benefits-of-steam-microwaves.html.

[8] The suggestion being that early 'just add water' cake mixes (such as the Betty Crocker cake mix) failed in the marketplace because the housewife of the day did not feel like they were cooking, and hence they were unable to show the love for those they were cooking for. Simply reintroducing the (technically) unnecessary step of adding an egg to the baking process, and encouraging artistic cake decorations, helped to solve this problem (Park, 2013). Though it should be noted that this account has not been accepted by all commentators (Purkiss, 2022).

The early safety concerns around warming food in the microwave have largely proved unfounded (Schiffmann, 2013). That said, there remain concerns around the heating of plastic containers and other forms of food packaging in the microwave in the contemporary discourse, with worries about the consumption of micro- and nano-plastics growing in the popular press (Baron, 2009; Díaz-Galiano, Gómez-Ramos, Beraza, Murcia-Morales, & Fernández-Alba, 2023; Hussain, Romanova, Okur, Zhang, Kuebler, Huang, Wang, Fernandez-Ballester, Lu, Schubert, & Li, 2023; though see Martins, Ramos, Pimentel, Freitas, Duarte, Azeredo, Silva, Cavalcanti, Esmerino, & Cruz, 2022; Quinn, 2022).[9]

However, beyond concerns about the possible negative health consequences of leaking microwave radiation, there are other health problems that are associated with uneven heating (and thus a failure to cook, especially meats, properly). The latter has been linked to outbreaks of food poisoning (e.g., salmonella), as when using the microwave to heat frozen chicken (Anonymous, 2008). According to Doug Powell, scientific director of the International Food Safety Network, based at Kansas State University: "Given how people use microwaves, it's great for reheating, but maybe not so good for cooking," The problem is that microwaves heat unevenly, and can leave cold spots in the food that harbour dangerous bacteria, such as *Escherichia coli* (E. coli), *Salmonella enterica*, or *Listeria monocytogenes*. Microwaving anything that includes raw meat, whether it's frozen or thawed, can cause problems. Meanwhile, according to another North American expert, Michael Davidson, a University of Tennessee food microbiologist: "I think most food-safety experts probably would have said it's not a good idea to microwave anything that's from a raw state," (quotes from Anonymous, 2008).

Part of the problem here is that it has been suggested that many consumers may wrongly assume that all frozen meals are precooked and thus only need to be warmed up. However, this is a misconception fostered in part by prepared meals that appear cooked, such as chicken that has been breaded or pre-browned. As noted by an Associated Press article: “Spotting raw ingredients isn't always easy because the only clue many companies offer is the two words "COOK THOROUGHLY" on the front of the package.” (Anonymous, 2008). What is more, surveys typically show that many consumers simply do not read the instructions on food packaging (Martins et al., 2022).

[9] The deleterious effects of exposure to microwaves has also been mentioned as a possible explanation of so-called ‘Havana syndrome’ (Corera, 2021).

4.2. Functional limitations

The fundamental limitation with using the microwave to cook food, especially meat, is that it doesn't brown. As Belasco (2006, p. 237) noted, excitement around the use of the technology settled down when it became clear to consumers that: "while this handy appliance could heat frozen foods, it was inferior to the conventional toaster oven when it came to baking, broiling, and browning." Consumers often also complain about the uneven heating of food in the microwave (Anonymous, 2008). That being said, it should be noted that advances in microwave technology, not to mention, the development of various forms of combination oven have helped to address many of these early concerns.

4.3. Benefits of microwave cooking

It has long been known that the microwave oven provides a significantly more efficient means of preparing/reheating many foods than conventional ovens (Hassoun, 1982; McConnell, 1974; Quinn, 2022; Snyder, 1978). A 2022 CNET breakdown found that using your microwave for an hour a day "would cost you about half the total energy of a natural gas oven and 60 per cent less than an electric oven" (Watsky, 2023; see also Clark, 2022). As such, it might be something we should get used to in future to do our bit to help save the planet. Indeed, in recent years, there have been reports in the British press suggesting that people may be falling back in love with the microwave because of the recent cost of living crisis (Butler, 2023). Even *British Vogue* ran an article a couple of years ago asking 'Is microwave cooking about to make a comeback?' (Syfret, 2023). That said, the article goes on to note that: "Almost one main meal a week is now cooked primarily with a microwave in the UK, according to the market research firm Kantar, which found usage rose 8% compared with last year." In other words, while its popularity may have increased in recent years, it remains a kitchen device that is still only used occasionally (at least in the UK).

The microwave heating of pre-prepared meals (requiring just a few of minutes in the microwave) is undoubtedly very convenient, albeit a behaviour that is associated with poorer nutritional health behaviours (Alkerwi, Crichton, & Hébert, 2015). Indeed, ready meals have been a common feature on the supermarket shelves in many countries for decades now

(Haden 2005). According to Statistica (n.d.), revenues in the Ready-to-Eat Meals market will amount to US$398.11bn in 2025, with the market expected to grow annually by an impressive 5.95% (CAGR 2025-2030), despite increased noise about the dangers of consuming ultraprocessed foods. The report goes on to suggest that the average volume per person in the Ready-to-Eat Meals market is expected to amount to 6.7kg in 2025.

While the time spent preparing a meal in the home has declined year-on-year in many developed countries (Weikle, 2024), there remains a sense in which whoever is preparing the food still wants to devote some minimal amount of effort to the process (Spence, 2017). Ease of use is an important consideration, especially given that fewer people are now learning to cook from scratch at home and increasingly rely on convenience foods and ready meals (not to mention the exponential rise in home delivery of meals; see Spence, Youssef, & Levitan, 2021).[10]

4.4. Nutrition

When compared to other cooking methods, such as frying, baking, or boiling, the research clearly shows that microwaving retains the highest amount of antioxidants and other phytochemicals, minerals, and vitamins in most vegetables, as compared to other common domestic cooking methods (Buratti, Cappa, Benedetti, & Giovanelli, 2020; Jiang, Yu, Jiang, Nakamura, & Qi, 2022; Thomas, Brenner, Eaton, & Craig, 1949; Zhao, Liu, Lai, Cao, Guan, Cheang, Liu, Zhao, Miao, Riviere, Capanoglu, & Xiao, 2019).[11] In particular, microwaving preserves more nutrients, especially heat-sensitive vitamins, such as Vitamin C (Lee, Choi, Jeong, Lee, & Sung, 2017; Lisciana, Aguzzi, Gabrielli, Camilli, Gambelli, Marletta, & Marconi, 2025; Lorenz, 1976). Microwave cooking typically involves shorter heating times and requires little or no water (thus reducing nutrient leaching). However, the challenge here is that unlike browning reactions (one of the Unique Selling Points, USPs, of conventional ovens in the context of cooking, e.g., animal protein), the end consumer cannot directly perceive antioxidants, and vitamins, and hence is required to take the nutritional benefits of microwave cooking (e.g., of fresh vegetables) on trust (Contreras, Benlloch-Tinoco, ... &

[10] The question of whether such loss of knowledge should be condoned or else represent a cause for concern is beyond the scope of this article.

[11] That said, it is perhaps a little misleading to suggest that ‘Do microwaves make food more nutritious’ as appeared in the title of one early article (Decareau, 1977).

Martínez-Navarrete, 2017). In their review of the literature, Deng et al. (2022) also stress the benefits of microwave cooking.

5. Microwave use in the professional kitchen

While microwaves have been a common appliance in most professional kitchens for several decades now, often used for used reheating and defrosting, rarely will you find a chef who wishes their guests hear the microwave's distinctive 'bing' ring through their dining room. Furthermore, it's unlikely the microwave will be positioned in the open kitchen if there is one. Instead, it is far more likely to be found 'hidden away' in the back kitchen. Kurti was perhaps the first to demonstrate the microwave oven's unique potential to deliver a novel culinary creation, namely the reverse Baked Alaska (Kurti & Kurti, 1981). That said, the microwave oven has various uses in the context of molecular gastronomy (think microwave sponge), for example (Youssef, 2013).[12] And what, one might ask here, are other foods is the microwave oven uniquely, or especially good, at helping the professional chef to prepare? After all, it is used in ALL professional kitchens - warming, defrosting, making herb crisps etc. (Myhrvold & Young, 2011; Spence & Youssef, 2018; Youssef, 2013).

5.1. Practical uses in the modernist kitchen

With the rise in popularity towards taking a more scientific approach to cooking, the microwave oven has been put to use for creating various unique preparations in the context of molecular and modernist cuisine. One of the most popular uses of the microwave oven being the creation of 'microwave sponges' (Youssef, 2013). Produced by whipping an aerated batter —often with the aid of a siphon (NO_2-charged canister)—into a paper or plastic cup and then microwaving it for 30–40 seconds. The resulting sponge is light in texture and nearly impossible to replicate using traditional baking methods (and with minimal cooking time required). This technique, popularised by chefs such as Ferran Adrià at El Bulli and further disseminated through the Modernist Cuisine books (Myhrvold & Young, 2011), has become a staple among avant-garde kitchens.

[12] https://infamouscookery.wordpress.com/2013/06/24/modernist-sponge-cake-on-the-cheap/.

Microwaves also offer a remarkably fast and uniform way of drying ingredients such as citrus zest or fruit purées Even thin herb leaves can be rapidly dehydrated into crisps or powders, preserving colour and volatile aromatics more effectively than alternative slower, higher-temperature dehydration methods (Bala, Dey, Patra, & Singha, 2024). According to Harold McGee (1984/2004), microwave the leaves is also a good, if rather unconventional way of drying them. Another popular technique involves controlled puffing or expansion of starchy foods—such as prawn crackers, puffed quinoa, or rice paper—by rapidly vaporising residual moisture within the preparation, thus leading to sudden expansion. This technique can be used to create crunchy garnishes. Elsewhere, the use of the microwave to dry various herbs and spices has also been investigated by researchers, though other methods tend to be preferable (Chan, Lim, Wong, Lim, Tan, Lianto, & Yong, 2009).

It has long been recognized that microwave blanching helps to preserve the vitamin content (Proctor & Goldblith, 1948). More recently, for instance, Xiao, Pan, Deng, El-Mashad, Yang, Mujumdar, Gao, and Zhang (2017) demonstrated that microwave blanching of green beans resulted in higher retention rates of vitamin C as compared with hot water-blanched samples. However, it is important to note that the impact of different microwave treatments on food texture are by no means always desirable (Kutlu, Pandiselvam, Saka, Kamiloglu, Sahni, & Kothakota, 2022). One of the other challenges concerns the alteration of taste/flavour that microwave cooking may impart and which often differs significantly from traditional cooking devices (Guo, Sun, Cheng, & Han, 2017).

5.2 Chefs' attitudes towards microwaves

In recent years, several prominent celebrity haute cuisine chefs have publicly endorsed the microwave for its versatility and time-saving capabilities in the kitchen. While some chefs, like Britain's Gordon Ramsay, are known for their strong aversion to the appliance (e.g., Hart, 2021),[13] others, including David Chang (Garrad-Cole, 2022), Marco Pierre White (Spencer-Elliott, 2024), and Jamie Oliver[14] have been vocal in highlighting the technology's benefits for specific cooking tasks. Momofuku founder David Chang, who rebranded as "a

[13] Albeit recognizing the merits of using a microwave to get the cooking process started or to reheat leftovers. But that is the only positive. Ramsey said: "Ugh, I mean, microwaves are for lazy cooks," and went on to explain that it is only with a pan and stove that you can achieve "the texture and the searing and the contrast," (quoted in Hart, 2021).

[14] https://www.youtube.com/watch?v=XD5au3oAUE4.

microwave guy" a few years ago. His 2021 book *Cooking At Home: Or, How I Learned To Stop Worrying About Recipes (And Love My Microwave)* perhaps says it all. Marco Pierre White, for example, was quoted as calling them 'Sensational things' (Spencer-Elliott, 2024).[15] Microwave ovens are particularly useful for steaming vegetables, cooking seafood, and even for achieving unique textures in certain dishes (Zilberman, 2022). In fact, according to Marco Pierre White, the microwave is the optimal device to cook kippers! Speaking of how he used the microwave to prepare veal kidney at his restaurants, White said: "When we used to cook veal kidney in the fat, we'd start them in the microwave because they'd cook from the inside out. "The best way of cooking marrowbone is in the microwave, the best. If you want to warm up a fish terrine, in the microwave, it's the best," (Spencer-Elliott, 2024). Of course, these celebrity chefs often say whatever their industry sponsors would have them say (cf. Rodrigues, Brochado, Sousa, Borges, & Barbosa, 2023).

Looking back, perhaps the problem was that the microwave oven was released to the public at a time when science in the kitchen was not necessarily all that fashionable. Subsequently, of course, with the rise of molecular cooking (and science in the kitchen), a couple of decades later, as promoted by the likes of Heston Blumenthal, it might have gained much wider acceptance. That said, it is worth noting how not many of the other kitchen gadgets that emerged during the height of popularity of molecular, and then modernist, cooking, such as, for example, the Anti-griddle, the Rotary Evaporator, or the PacoJet, have actually made it into widespread use in home kitchens

Perhaps the microwave is associated with laziness, with food lacking in nutrition and is thus socially looked down upon. But what if it symbolised, efficiency (in cooking, time, energy saving), and innovation. What if a Michelin star chef were to write a microwave cookbook – not so far-fetched as these do exist (just not by a noteworthy author).[16]

It is important to note that many of the traditional concerns and limitations (such as uneven heating) concerning microwave cooking have largely been eliminated by recent innovations (Kakar et al., 2024). Fakhouri and Ramaswamy (1993) studied temperature uniformity following microwave heating with commercially refrigerated and frozen foods (e.g., frozen lasagna; see also Liu, Shen, Liu, Gong, Liu, Zheng, Zhang, & Yang, 2023; Liu, Tian, Liu,

[15] It would certainly be interesting to see what kind of celebrity works best in terms of promoting such a technology-based solution.

[16] It is perhaps also worth noting how oftentimes, one needs a celebrity chef to back a particular kitchen utensil, gadget, or even ingredient in order for consumer sales to really take off (e.g., see Park, Motoki, Velasco, & Spence, 2022).

Shen, Zhu, Liu, Zheng, Deng, & Zhao, 2024; Zhu, He, Hong, Yang, Wu, Yang, & Huang, 2018).

6. Industrial applications of microwave cooking

In the context of industrial food production, microwave pasteurization is commonly used (Chandrasekaran, Ramanathan, and Basak (2013), especially in the context of ready-to-eat meals that are available to consumers in the marketplace (Tang, Hong, Inanoglu, & Liu, 2018). What is more, commercial developments such as overs that combine microwave heating with infrared heating, steaming, and other functions should also be recognized, though their use so far is primarily restricted to commercial food preparation (e.g., drying sweet potato, Kgonothi, Mehlomakulu, & Emmambux, 2024). Microwave drying is also involved in the industrial preparation of baked biscuits (Ahmad, Morgan, & Okos, 2001).

Another area of research in microwave cooking technology that has recently started to attract the interest of scientists concerns the development of digital twins to improve the quality and safety of foods, such as, for example, Cambodian pâté (Nget, Mith, Boué, Curet, & Boillereaux, 2023). Note that the digital twin approach to modelling and predicting other forms of cooking (i.e., not just the microwave) has also become more popular in recent years (Cabeza-Gil, Ríos-Ruiz, Martínez, Calvo, & Grasa, 2023).

7. Conclusions

Surveys suggest that the microwave oven is undoubtedly one of the most frequently used appliances on a daily basis at home and in the office (Williams, Yang, Beraki, Desroches, Young, Ni, Willem, Greenblatt, Dunham, & Donovan Consultant, 2012), in almost every household, while at the same time it is also a device whose use is somehow looked down upon. There is a certain snobbery around the use of microwave foods, despite the fact that most major supermarkets stock a wide number of ‘microwavable meals’ in their chilled and frozen aisles. Microwaves are arguable one of the most widely used appliances in the kitchen when it comes to reheating foods (especially in the workplace), due to the speed and efficiency (allowing people to reheat the product in its container, or packaging vs. the oven or

hob which will typically require more cooking tools – pots, trays, foil etc).[17] At the same time, however, they are widely perceived as a lazy way to prepare food (Hart, 2021).

Despite the scientific analysis of the potential and benefits of microwave cooking (Baldwin, 1983; Orsat, Raghavan, & Krishnaswamy, 2017; Regier, Knoerzer, & Schubert, 2017), this modernist cooking technology never caught on in the public imagination kitchen (be it home or commercial) in quite the way that many of the commentators imagined that it would when the technology was first introduced into home kitchens in the 1970s. A combination of largely unfounded safety fears, together with functional limitations (i.e., a limited ability to cook, rather than just to heat up foods) has seemingly inhibited the widespread use of this scientifically-advanced form of heating food. At the same time, however, it is one of the most frequently used of kitchen appliances.[18]

Despite many consumers having a negative response to the microwave oven, it may be time to re-evaluate the technology given its much higher efficiency (in terms of the energy needed to heat food; Butler, 2023), its convenience (in terms of the speed of preparation), and a growing body of scientifically robust evidence showing that microwave cooking helps to preserve the nutrients and anti-oxidants in various fresh vegetables, such as broccoli (albeit with steaming been shown to be the most beneficial preparation approach; Deng et al., 2022; Yuan, Sun, Yuan, & Wang, 2009). However, it remains an open question how best to educate, or nudge, the public (cf. Osepchuk, 1984). Furthermore, looking to the future, and the likely increased consumption of a range of novel foods, then it is also important to consider whether microwave heating may be a more appropriate alternative, as suggested, for example, recently (Deng et al., 2022).[19] Ultimately, as we look forward to an increasingly uncertain food future, it may therefore be time to reevaluate how we think about the microwave, and the ways in which it might one day be used to help prepare foods in the future. Only time will tell whether the recent press reports suggesting that Gen-Zs are ditching the kettle and instead microwaving cups of tea hints at what may lay ahead (Pollard, 2025).

[17] It has been suggested the phenomenal popularity of fish and chips amongst working class Brits in the early decades of the 20th Century may have had a very similar explanation (given that they were eaten by hand in the newspaper wrapping that they came from the fish shop in.

[18] See https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%203.1.pdf?utm_source=chatgpt.com.

[19] Even if the food futurologists don't find the resurgence of the microwave to be a very exciting option: See, for example: 'Takeaway of the future! Experts predicts that by 2040 you'll be able to BREATHE on your phone to show how healthy your diet is and order foods that are good for you' (Pearson-Jones, 2023).

The global microwave oven market size was estimated at USD 16.22 billion in 2024 and is projected to hit around USD 24.02 billion by 2034 (see 'Microwave Oven Market Size and Forecast 2025 to 2034', 2025).

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Figure 1.