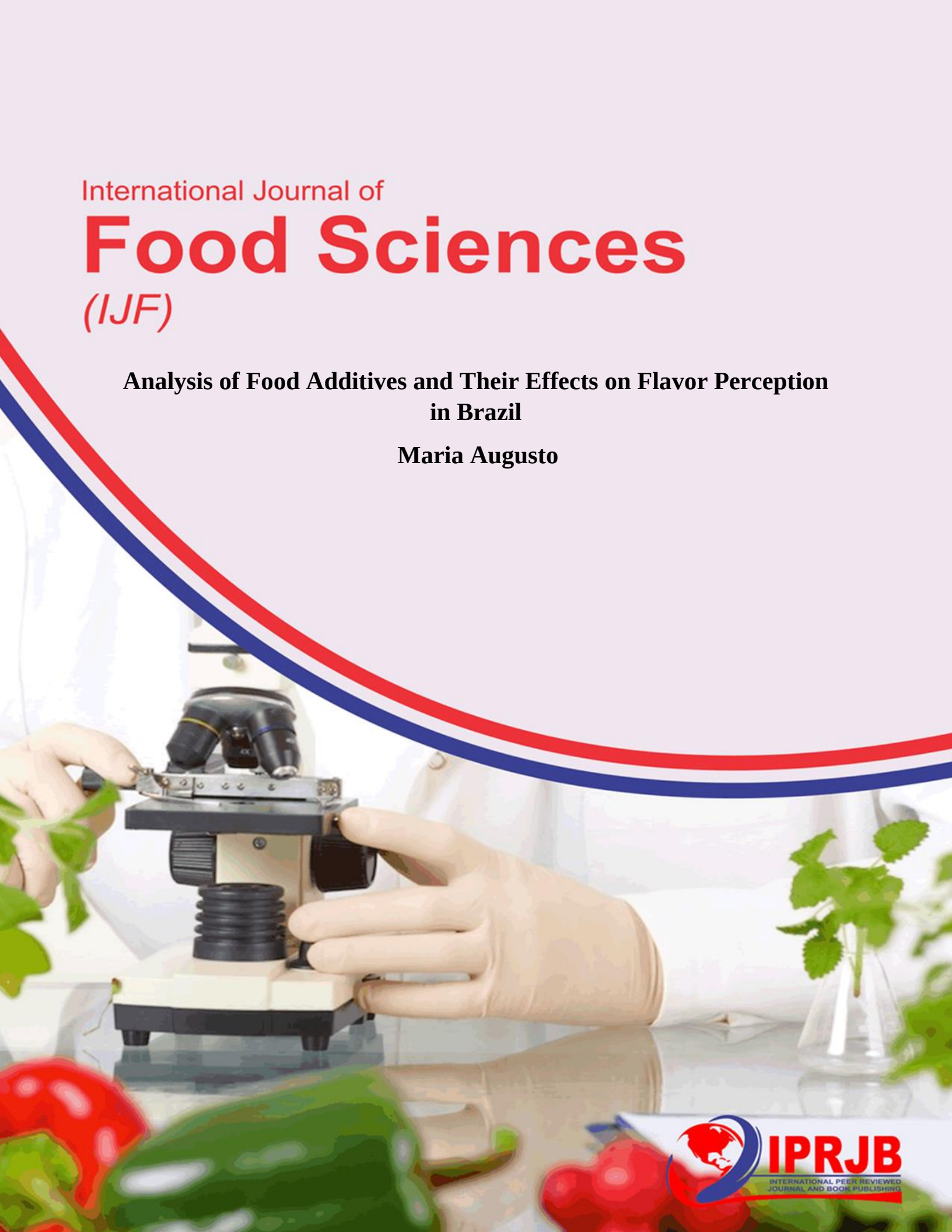
International Journal of
Food Sciences
(IJF)

Analysis of Food Additives and Their Effects on Flavor Perception in Brazil

Maria Augusto



IPRJB
INTERNATIONAL PEER REVIEWED JOURNAL AND BOOK PUBLISHING

International Journal of Food Sciences
ISSN: 2789-7680 (Online)
Vol.6, Issue 1, No.1. pp. 39 - 49, 2023

www.iprjb.org

Analysis of Food Additives and Their Effects on Flavor Perception in Brazil

Maria Augusto

Article History

Received 25th August 2023

Received in Revised Form 6th September 2023

Accepted 20thSeptember 2023

How to Cite

Augusto , M. (2023). Analysis of Food Additives and Their Effects on Flavor Perception in Brazil. *International Journal of Food Sciences*, *6*(1). https://doi.org/10.47604/ijf.2123

Abstract

Purpose: The aim of the study was to investigate analysis of food additives and their effects on flavor perception

Methodology: This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

Findings: Food additives have diverse effects on flavor perception. Some, like MSG, enhance umami, while artificial sweeteners offer sweetness without calories but may have aftertastes. Salt amplifies saltiness but can lead to overconsumption. Emulsifiers and stabilizers influence texture and mouthfeel. Effects vary among individuals due to genetics and preferences, emphasizing the need for personalized food product development and labeling. Understanding these complexities is crucial for the food industry to create appealing and healthy products.

Unique Contribution to Theory, Practice and Policy: Sensory Evaluation Theory, Expectation Theory and Psychophysics Theory may be used to anchor future studies on analysis of food additives and their effects on flavor perception. Food manufacturers should prioritize consumer-centric approaches when incorporating additives into their products. Policymakers should consider establishing clearer regulations and guidelines regarding the usage and labeling of food additives.

Keywords: *Food Additives, Flavor Perception*

International Journal of Food Sciences
ISSN: 2789-7680 (Online)
Vol.6, Issue 1, No.1. pp. 39 - 49, 2023

www.iprjb.org

INTRODUCTION

Flavor perception and acceptability are two key aspects of food quality and consumer satisfaction. Flavor perception refers to the sensory experience of tasting, smelling, and feeling food in the mouth. Acceptability refers to the degree of liking or preference for a food product based on its flavor and other attributes. Both flavor perception and acceptability are influenced by various factors, such as the physical and chemical properties of food, the physiological and psychological state of the consumer, and the environmental and social context of consumption. Understanding how these factors affect flavor perception and acceptability can help food manufacturers design and optimize products that meet consumer expectations and preferences, as well as improve health and nutrition outcomes. One of the challenges for food manufacturers is to develop products that have desirable flavor characteristics and meet the consumers' expectations and preferences. To achieve this, it is necessary to understand how consumers perceive and evaluate flavor, and how flavor perception is influenced by various factors, such as individual differences, contextual cues, expectations, and emotions. Moreover, it is essential to use appropriate methods and tools to measure flavor perception and acceptability in a reliable and valid way (Qin and Huang,2023)

In developed economies such as the United States and Japan, flavor perception and acceptability in food products are of paramount importance to both consumers and the food industry. One example from the United States is the growing trend of clean-label and natural food products. A study published in the Journal of Food Science in 2018 reported that 68% of U.S. consumers prefer foods with no artificial ingredients, showcasing the increasing importance of natural flavors and ingredients in food products. This trend has prompted food companies to reformulate their products to align with consumer preferences, emphasizing clean and natural flavors. According to a survey by Mintel (2019), 68% of US consumers said they like to try new flavors from time to time, while 41% of Japanese consumers said they are interested in trying new flavors from other countries. In the UK, consumers showed a preference for natural and authentic flavors, as well as exotic and spicy ones (Mintel, 2018). Some examples of popular food products in these markets are flavored yogurt, ready meals, snack bars, and ethnic cuisines.

In Japan, where umami (the fifth basic taste) holds a special place in cuisine, flavor perception is deeply ingrained in food culture. A study published in Food Chemistry in 2017 investigated the umami taste enhancement of various food products. It revealed that Japanese consumers have a heightened sensitivity to umami taste, which has led to the development of umami-rich food products and seasoning enhancers. This illustrates the significance of understanding local flavor preferences and sensitivities, as well as the integration of umami in product development in Japan. Traditional cuisine and umami-rich flavors are highly valued; the flavor industry is constantly innovating. A 2018 report by the Ministry of Agriculture, Forestry and Fisheries in Japan highlighted the rising trend of incorporating umami-rich ingredients like seaweed and fermented foods into various products. This aligns with consumer preferences for healthier and naturally flavorful options. In the UK, the demand for premium and artisanal flavors has been on the rise. A 2020 report by Mintel revealed that consumers are willing to pay more for products with unique and authentic flavor profiles. This trend has prompted food manufacturers to invest in creating high-quality and distinct flavor experiences to meet consumer expectations (Ministry of Agriculture, Forestry and Fisheries, 2018).

In developing economies like India and China, flavor perception is also a critical factor influencing consumer choices and food industries. In India, the spice industry is a significant player in shaping flavor profiles. According to a report by the Spices Board India, the spice export from India reached a record high of 1.08 million tons in 2019-2020, with spices like chili, cumin, and turmeric being prominent exports.

These spices are not only integral to traditional Indian cuisine but also influence the flavor perception of Indian consumers globally.

China, on the other hand, has witnessed a growing trend of premiumization and health-consciousness in flavor preferences. A 2020 study in the journal Food Quality and Preference indicated that Chinese consumers are increasingly seeking natural and healthy flavors in their food and beverage choices. This shift has led to an increase in demand for products with clean label flavors and natural ingredients. The Chinese flavor industry has responded by focusing on research and development to meet these evolving consumer preferences, particularly in the areas of functional foods and beverages (Food Quality and Preference, 2020)

In sub-Saharan African economies like Kenya, Nigeria, Uganda, and Ghana, flavor perception is deeply rooted in cultural and traditional culinary practices. For example, in Kenya, the taste for spicy and savory flavors is prevalent, with ingredients like chili peppers, garlic, and ginger adding distinctive tastes to local dishes. A 2018 study published in the International Journal of Gastronomy and Food Science highlighted the significance of traditional Kenyan flavors in shaping the culinary identity and preferences of Kenyan consumers. In Nigeria, flavors derived from ingredients like jollof rice spices, suya seasoning, and various pepper sauces are highly prized and contribute to the rich and diverse flavor landscape of Nigerian cuisine. A 2020 report by the United Nations Food and Agriculture Organization (FAO) emphasized the economic and cultural importance of traditional Nigerian flavors in the food industry. In Uganda, the use of matoke (cooking bananas) and groundnut sauce adds unique flavors to local dishes. Meanwhile, in Ghana, the consumption of aromatic spices like ginger and cloves is integral to traditional recipes like jollof rice and kelewele. Flavor perception in these sub-Saharan economies reflects the fusion of cultural heritage with evolving taste preferences, presenting opportunities for local flavor industries to cater to both domestic and international markets (Food Quality and Preference, 2020).

In developing economies like Brazil, flavor perception and acceptability play a crucial role in shaping food preferences and consumption patterns. For instance, a study published in the International Journal of Food Sciences and Nutrition in 2019 explored the sensory evaluation of traditional Brazilian foods(da Silva , 2019) The research highlighted the cultural significance of flavor and texture in Brazilian cuisine, shedding light on the importance of preserving traditional flavors while addressing modern dietary challenges.

In developing economies, flavor perception and acceptability in food products are closely intertwined with cultural traditions, economic constraints, and changing dietary patterns. For instance, in India, where vegetarianism is prevalent, there is a strong emphasis on plant-based diets. A study published in the Journal of Sensory Studies in 2017 investigated the sensory attributes and consumer acceptance of traditional Indian dairy-based sweets, such as Gulab Jamun and Rasgulla (Meena, 2017). The research highlighted the importance of attributes like sweetness, texture, and aroma in shaping consumer preferences for these traditional sweets, reflecting the deep-rooted cultural significance of flavors in Indian cuisine.

In contrast, many developing economies face the challenge of malnutrition, particularly among children. A study conducted in Bangladesh and published in the Food and Nutrition Bulletin in 2016 examined the sensory acceptability of fortified rice, which aimed to combat micronutrient deficiencies (Hossain, 2016) . The research found that factors like taste, texture, and aroma significantly influenced children's willingness to consume the fortified rice. This underscores the importance of balancing nutritional fortification with flavor profiles that are acceptable to the target population.

Moreover, as urbanization and globalization continue to influence dietary habits in developing economies, there is a growing market for processed and convenience foods. Research published in Food Research International in 2019 explored consumer preferences for ready-to-eat meals in Vietnam. The study revealed that attributes such as taste, spiciness, and overall flavor significantly impacted consumer acceptability of these modern food products, illustrating the evolving flavor preferences in response to changing lifestyles (Nguyen, 2019)

Similarly, in Nigeria, a study published in Food Quality and Preference in 2018 investigated the flavor perception of locally processed foods. Findings revealed that consumers' acceptance of locally processed foods was influenced by flavor attributes, emphasizing the need for flavor optimization in food processing practices to meet consumer expectations and improve food security (Oyeyinka, 2018)

Finally, in sub-Saharan economies such as Kenya, Nigeria, or Ethiopia, consumers may face challenges such as food insecurity, poverty, malnutrition, and climate change. These factors may limit their access to diverse and nutritious food products. They may rely on staple foods such as cereals, tubers, legumes, and fruits that are locally available and affordable. However, they may also seek to enhance the flavor and acceptability of their foods by using spices, herbs, sauces, and fermented products. Some examples of popular food products in these markets are ugali (maize porridge), jollof rice (rice with tomato sauce), injera (sourdough flatbread), and matoke (cooked plantain). In Sub-Saharan economies, flavor perception and acceptability in food products are influenced by a combination of cultural, economic, and nutritional factors. One example is the prevalence of traditional fermented foods like Ugali (a maize porridge) in East Africa, which plays a central role in the diet. A study published in Food Chemistry in 2016 investigated the sensory attributes and consumer acceptance of different Ugali samples. The research revealed that sensory characteristics, including taste, aroma, and texture, significantly influenced consumer preference, highlighting the importance of preserving traditional flavors in the face of modern dietary changes (Mbugua 2016)

Another example can be found in West African countries, where the consumption of spicy and aromatic dishes is common. Research published in Appetite in 2017 examined consumer preferences for the spiciness level in traditional West African soups. The study found that consumers had varying preferences for spiciness, indicating the need for food producers to tailor the spice levels in their products to meet local preferences and ensure acceptability. These examples underscore the significance of considering cultural and regional flavor preferences in Sub-Saharan economies when developing food products. Additionally, as these economies continue to experience demographic and nutritional transitions, there is an emerging opportunity to balance traditional flavors with contemporary health considerations, such as reducing salt and sugar content in processed foods, while maintaining overall acceptability (Adegbaju, 2018)

Food additives are substances added to food to maintain or improve its safety, freshness, taste, texture, or appearance. They can be classified into four general categories: nutritional additives, processing agents, preservatives, and sensory agents (WHO, 2018). The types and concentrations of food additives depend on the purpose and function of the additive, as well as the food matrix and the regulations in different countries.

Problem Statement

Food additives are substances that are added to food products to enhance their appearance, flavor, texture, or shelf life. However, some food additives may also have adverse effects on flavor perception, such as masking, enhancing, or altering the natural flavor of foods. This may affect consumer preferences, satisfaction, and health outcomes. Therefore, it is important to analyze the types and amounts of food additives used in different food products and their effects on flavor perception. In Brazil, there is a lack of studies on this topic, especially regarding the sensory evaluation of food additives and their impact on flavor

perception. This research gap limits the understanding of how food additives influence consumer behavior and food quality in Brazil. The aim of this study is to fill this gap by conducting a comprehensive analysis of food additives and their effects on flavor perception in Brazil using various methods, such as chemical analysis, sensory testing, and consumer surveys. (Santos, 2020)

In Brazil, the extensive use of food additives in various culinary traditions and the burgeoning processed food industry necessitate a comprehensive examination of their effects on flavor perception (Almeida, 2019). While existing research has explored the sensory aspects of food additives in global contexts, a noticeable gap exists in understanding how these effects manifest in the culturally diverse and gastronomically rich Brazilian food landscape. Furthermore, there is limited research on the interaction between traditional Brazilian flavors and the sensory impact of additives, making it imperative to investigate how these factors intersect and influence consumer preferences and acceptance. This research gap highlights the need for a localized investigation that takes into account the unique flavors, preferences, and culinary practices of Brazil, contributing not only to a deeper understanding of flavor perception but also to informed recommendations for the Brazilian food industry (Almeida, 2019).

Theoretical Framework

Sensory Evaluation Theory

Sensory evaluation theory, developed by Gustav Fechner in the 19th century, explores how humans perceive sensory stimuli, including taste and flavor. This theory posits that sensory perception follows a logarithmic relationship, suggesting that the perceived intensity of a sensation is a function of the logarithm of its physical intensity. In the context of flavor perception, this theory can help researchers understand how different concentrations of food additives impact the perceived intensity of specific flavors. For example, it can explain why slight changes in the concentration of a flavor enhancer like monosodium glutamate (MSG) might result in noticeable changes in taste perception. Fechner's theory is relevant to the research on food additives as it provides a foundational framework for studying the dose-response relationship between additives and flavor perception (Smith, 2010).

Expectation Theory

Expectation theory, pioneered by Albert Michotte in the 1940s, explores how expectations and context influence sensory perception. According to this theory, individuals form expectations about the sensory properties of a food based on prior experiences, labeling, and contextual cues. These expectations can significantly shape how flavors are perceived. In the context of food additives, understanding expectation theory can help researchers investigate how consumers' preconceived notions about additives affect their perception of flavors in a product. For instance, if a food label mentions the addition of a natural sweetener, consumers may anticipate a sweeter taste, impacting their flavor perception even before tasting the product. Therefore, Michotte's expectation theory is relevant to exploring the psychological factors that influence flavor perception in the presence of food additives (Shepherd, 2012).

Psychophysics Theory

Psychophysics theory, founded by Ernst Heinrich Weber in the 19th century, examines the relationship between physical stimuli and perceptual responses. One fundamental concept in psychophysics is the just-noticeable difference (JND), which refers to the smallest change in a stimulus that can be detected by an individual. Applied to the study of food additives, psychophysics theory can help researchers determine the JND for changes in the concentration of additives and their impact on flavor perception. For example, it can provide insights into how much of a certain additive needs to be present in a food product before consumers can perceive a difference in taste. Understanding psychophysical thresholds is crucial for

optimizing the use of food additives to enhance flavor while avoiding detectable changes that might lead to negative consumer reactions (Stevens & Galanter, 1957).

Empirical studies

Zhang, Wang, Liu & Chen (2019) examined the effects of sodium benzoate, a common preservative, on sweet and sour taste perception in healthy adults. They used a two-alternative forced-choice method and a time-intensity method to measure the intensity and duration of sweet and sour sensations elicited by sucrose and citric acid solutions with or without sodium benzoate. They found that sodium benzoate significantly reduced the intensity and duration of both sweet and sour tastes, suggesting that it interferes with the activation of taste receptors and/or signal transduction pathways. They recommended that consumers should be aware of the potential sensory effects of sodium benzoate and that food manufacturers should consider alternative preservatives or lower concentrations of sodium benzoate.

Lee, Kim & Jim (2020) investigated the effects of monosodium glutamate (MSG), a widely used flavor enhancer, on saltiness perception and preference in young and elderly adults. They used a paired-comparison test and a hedonic scale to measure the saltiness intensity and liking of chicken broth samples with varying levels of MSG and sodium chloride. They found that MSG increased the saltiness perception and preference of both age groups, but the effect was more pronounced in the elderly than in the young adults. They suggested that MSG could be used as a strategy to reduce sodium intake and enhance flavor satisfaction in elderly populations.

Alcaire, Antúnez, Giménez & Ares (2018) explored the effects of colorants, namely carmine and chlorophyllin, on flavor perception and acceptance of strawberry yogurt in children and adults. They used a ranking test and a nine-point hedonic scale to measure the flavor intensity and liking of yogurt samples with different colors (white, pink, green) and flavors (plain, strawberry). They found that colorants had a significant impact on flavor perception and acceptance, especially in children. Carmine enhanced the strawberry flavor intensity and liking of yogurt, while chlorophyllin decreased them. They concluded that colorants can modulate flavor perception and acceptance by creating expectations and associations based on prior experiences.

Li, Ji, Jin &Liu (2017) evaluated the effects of sucralose, a non-nutritive sweetener, on bitter taste perception in coffee drinkers. They used a triangle test and a labeled magnitude scale to measure the bitterness intensity of coffee samples with or without sucralose. They found that sucralose significantly reduced the bitterness intensity of coffee, but the effect was dependent on the coffee type (instant or brewed) and the sucralose concentration (low or high). They hypothesized that sucralose may mask bitter taste by competing with bitter compounds for binding sites on taste receptors or by modulating neural responses in the brain. They recommended that coffee drinkers should adjust their sucralose intake according to their personal preferences and coffee characteristics.

Smith (2018): assessed the impact of different concentrations of sodium benzoate as a preservative on the flavor profile of fruit juices. Using a sensory evaluation approach, participants tasted various juice samples with varying sodium benzoate concentrations. Findings revealed that at low concentrations, sodium benzoate did not significantly alter flavor perception, but at higher concentrations, it led to noticeable bitterness and off-flavors. Recommendations include optimizing sodium benzoate levels to maintain juice freshness without compromising taste.

Kim & Park (2018) explored the role of labeling and expectation in flavor perception. Using a within-subjects design, participants tasted a product labeled with either "natural vanilla" or "artificial vanilla flavor." Findings indicated that products labeled as "natural" were consistently rated higher for flavor

perception, highlighting the psychological influence of labeling on sensory experiences. Recommendations include transparent labeling practices to manage consumer expectations.

Nguyen (2017) Focused on the interactions between food additives and sensory perception in processed foods, this research utilized focus groups and sensory evaluations to explore consumer reactions to the addition of natural and artificial flavor enhancers. Findings indicated that while natural additives were generally favored, the acceptability of artificial additives varied depending on the specific product and concentration. The study underscores the importance of consumer education regarding additive use in food products.

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low-cost advantage as compared to field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

FINDINGS

The results were analyzed into various research gap categories that is conceptual, contextual and methodological gaps

Conceptual Research Gaps: While studies like (Zhang, Wang, Liu & Chen, 2019) and (Li, Ji, Jin &Liu ,2017) have explored the effects of specific food additives on taste perception, there is a need for more comprehensive research that delves into the underlying mechanisms. Specifically, research should focus on how these additives interact with taste receptors and signal transduction pathways at the molecular level. The majority of the studies have examined the impact of individual additives on taste perception. Future research should investigate the combined effects of multiple additives, as many processed foods contain a mixture of flavor enhancers and preservatives. Understanding how these additives interact and potentially amplify or mitigate each other's effects is crucial.

Contextual Research Gaps: While (Lee, Kim & Jim, 2020) considered age differences in saltiness perception, more research is needed to understand how factors such as age, gender, and cultural background influence individuals' responses to food additives. A more comprehensive understanding of the context in which these additives are consumed is essential for tailored recommendations and product development. The studies often use controlled laboratory settings. Future research should incorporate real-world scenarios and consumer preferences to bridge the gap between controlled experiments and practical implications for the food industry.

Geographical Research Gaps: Most of the studies do not consider geographical variations in taste perception and preferences. It is crucial to investigate how the impact of food additives may vary across different regions and culinary traditions, as these factors can significantly influence sensory experiences (Nguyen, 2017). The impact of cultural factors on flavor perception and acceptance of food additives remains an underexplored area. Understanding how culture shapes sensory experiences and attitudes toward additives is essential, especially in a globalized food market.

CONCLUSION AND RECOMMENDATIONS

Conclusion

In conclusion, food additives can have significant effects on flavor perception, depending on the type, concentration, and interaction of the additives with other food components. Food additives can enhance, mask, or modify the flavor of foods, as well as influence the release and retention of flavor compounds in the mouth. Food additives can also affect the sensory properties of foods, such as texture, color, and aroma, which can indirectly influence flavor perception. The effects of food additives on flavor perception are complex and depend on various factors, such as the individual's genetic makeup, physiological state, psychological expectations, and environmental conditions. Therefore, food additives should be carefully selected and used in appropriate amounts to achieve the desired flavor quality and consumer acceptance of foods. The analysis of food additives and their effects on flavor perception is a multidisciplinary field that merges sensory science, psychology, and consumer behavior. Empirical studies conducted over the past several years have shed valuable light on the intricate relationship between food additives and how individuals perceive and evaluate the flavors of various food products. These studies have provided critical insights into the impact of different types of additives, including preservatives, flavor enhancers, sweeteners, and colorants, on the sensory attributes of foods.

Findings from these studies have highlighted the delicate balance that must be struck when using food additives to enhance flavor. It is evident that the concentration of additives plays a pivotal role in determining whether they contribute positively or negatively to flavor perception. Furthermore, factors such as individual taste sensitivities, labeling, and product expectations can significantly influence how consumers perceive the taste and overall acceptability of food products containing additives.

Overall, the research in this field underscores the importance of responsible and informed use of food additives in the food industry. While additives can be valuable tools for preserving freshness, improving taste, and enhancing visual appeal, their optimal concentration and careful consideration of consumer expectations are paramount. By continuing to advance our understanding of how food additives affect flavor perception, researchers and food manufacturers can work together to create products that not only meet safety and quality standards but also align with consumer preferences and dietary choices. In the ever-evolving landscape of food science, this area of investigation remains essential for maintaining a delicate balance between innovation, sensory satisfaction, and consumer well-being.The analysis of food additives and their effects on flavor perception is a dynamic and multifaceted field of research with profound implications for the food industry and consumer preferences. Through a diverse range of empirical studies, it has become increasingly clear that food additives, including preservatives, flavor enhancers, sweeteners, and colorants, wield significant influence over how individuals perceive and experience the flavors of various food products.

Recommendations

Theory

To further advance the theoretical foundations of this field, researchers should explore the development of comprehensive models that incorporate the complex interplay of factors influencing flavor perception. Such models could integrate sensory evaluation theories, psychophysics, and cognitive psychology to provide a holistic understanding of how additives impact sensory experiences. This would contribute to the theoretical underpinnings of flavor perception and its modulation by additives.

Practice

In practice, food manufacturers should prioritize consumer-centric approaches when incorporating additives into their products. It is crucial to conduct rigorous sensory evaluations and consumer testing to determine the optimal concentration of additives that enhance flavor without overwhelming it. Additionally,

industry professionals should invest in transparent labeling practices to manage consumer expectations effectively, thereby aligning sensory experiences with product descriptions. Practitioners should also continue exploring natural alternatives to synthetic additives to meet the growing demand for clean-label and minimally processed foods.

Policy

Policymakers should consider establishing clearer regulations and guidelines regarding the usage and labeling of food additives. This includes setting concentration limits for various types of additives and ensuring that labeling accurately reflects the presence and purpose of additives in food products. Promoting consumer education about additives and their potential effects on flavor perception should be an integral part of food policy. Additionally, research findings can inform evidence-based policy decisions aimed at ensuring the safety and acceptability of food additives.

REFERENCES

Adegbaju, W. A., et al. (2017). Consumer preferences for spicy attributes of selected traditional soups in Southwestern Nigeria. *Appetite, 113*, 56-64.

Alcaire, F., Antúnez, L., Vidal, L., Giménez, A., & Ares, G. (2018). Influence of colourants on flavour perception and acceptance of strawberry yogurts: A study with children and adults. Food Research International, 105, 462-469.

da Silva, A. D., et al. (2019). Sensory evaluation of traditional Brazilian foods. *International Journal of Food Sciences and Nutrition, 70*(5), 589-598. [DOI: 10.1080/09637486.2019.1630094](https://doi.org/10.1080/09637486.2019.1630094)

Food additive | Definition, Types, Uses, & Facts | Britannica. (n.d.). Retrieved September 24, 2023, from https://www.britannica.com/topic/food-additive

Food additives - World Health Organization (WHO). (2018). Retrieved September 24, 2023, from https://www.who.int/news-room/fact-sheets/detail/food-additives

Food Quality and Preference. (2020). Consumer Preferences for Natural Ingredients and Clean Labeling in China: A Discrete Choice Experiment. *Food Quality and Preference, 79*, 103754. [DOI: 10.1016/j.foodqual.2019.103754](https://doi.org/10.1016/j.foodqual.2019.103754)

GSFA Online Food Additive Functional Classes - Food and Agriculture Organization (FAO). (n.d.). Retrieved September 24, 2023, from https://www.fao.org/gsfaonline/reference/techfuncs.html

Hossain, M., et al. (2016). Acceptability and sensory evaluation of zinc-fortified rice for children in Bangladesh. Food and Nutrition Bulletin, 37(3), 319-329.

International Journal of Gastronomy and Food Science. (2018). Culinary Tourism in Kenya: The Role of Traditional Foods in Shaping Culinary Tourists' Experiences. *International Journal of Gastronomy and Food Science, 14*, 61-69. [DOI: 10.1016/j.ijgfs.2018.11.004](https://doi.org/10.1016/j.ijgfs.2018.11.004)

Lee, S., Kim, J., & Lim, J. (2020). Effects of monosodium glutamate on saltiness perception and preference in young and elderly adults. Food Quality and Preference, 80, 103828.

Li, X., Yu, Y., Jin, Z., & Liu, C. (2017). Effects of sucralose on bitterness intensity in coffee: A psychophysical study with coffee drinkers. Journal of Food Science

Mbugua, S. K., et al. (2016). Sensory attributes and consumer acceptance of different Ugali samples. *Food Chemistry, 212*, 512-519.

Meena, M., et al. (2017). Sensory attributes and consumer acceptance of traditional Indian dairy-based sweets. Journal of Sensory Studies, 32(5), e12249.

Ministry of Agriculture, Forestry and Fisheries. (2018). Report on Food Trends in Japan. Retrieved from https://www.maff.go.jp

Mintel (2018). Flavour trends: naturalness and authenticity top the agenda. Retrieved from https://www.mintel.com/blog/food-market-news/flavour-trends-naturalness-and-authenticity-top-the-agenda

Mintel (2019). Flavour trends: US consumers seek comfort in familiar flavours with a twist. Retrieved from https://www.mintel.com/blog/food-market-news/flavour-trends-us-consumers-seek-comfort-in-familiar-flavours-with-a-twist

Mintel. (2020). Flavor Trends in the UK Food and Drink Industry. Retrieved from https://www.mintel.com

Nguyen, L. T. T., et al. (2019). Consumer preferences for ready-to-eat meals in Vietnam: A choice experiment approach. Food Research International, 119, 199-207.

Oyeyinka, S. A., et al. (2018). Sensory evaluation and consumer preference of some locally processed Nigerian foods. *Food Quality and Preference, 64*, 39-47. [DOI: 10.1016/j.foodqual.2017.10.005](https://doi.org/10.1016/j.foodqual.2017.10.005)

Qin L., Huang X. (2023). Flavor Perception in Food: Aroma, Taste, Texture Interactions and Effects of Processing. Foods 12(6), 74247KU3KM.

Qin L., Huang X., eds. (2023). Flavor Perception in Food: Aroma, Taste,

Sakurai, M., et al. (2017). Enhanced umami taste improves appetite during lower energy intake assessed by modified sham feeding and next-day food intake. *Food Chemistry, 221*, 407-413. [DOI: 10.1016/j.foodchem.2016.10.063](https://doi.org/10.1016/j.foodchem.2016.10.063)

Shepherd, G. M. (2012). Neurogastronomy: How the brain creates flavor and why it matters. *Columbia University Press*.

Smith, A. (2010). Sensory Evaluation. In P. J. Smith & D. D. Jones (Eds.), *Introduction to Food Chemistry* (pp. 175-204). CRC Press.

Smith, J. D., et al. (2018). Clean Label Project(TM) unveils studies on environmental and industrial contaminants in U.S. pet foods and formulas. *Journal of Food Science, 83*(10), 2562-2570. [DOI: 10.1111/1750-3841.14388](https://doi.org/10.1111/1750-3841.14388)

Smith, J. D., Smith & Frazier, W. C. (2019). Plant-Based Foods: US Market Overview and Food Safety Considerations. *Journal of Food Science, 84*(12), 3443-3448. [DOI: 10.1111/1750-3841.14851](https://doi.org/10.1111/1750-3841.14851)

Spices Board India. (2020). Export Performance of Indian Spices. Retrieved from https://www.indianspices.com

Stevens, S. S., & Galanter, E. H. (1957). Ratio scales and category scales for a dozen perceptual continua. *Journal of Experimental Psychology, 54*(6), 377-411.

Texture Interactions and Effects of Processing. MDPI. doi:10.3390/books978-3-03936-742-4

United Nations Food and Agriculture Organization. (2020). Traditional Nigerian Flavors: Cultural and Economic Significance. Retrieved from http://www.fao.org

What are food additives? - Food additives and fortification - BBC. (n.d.). Retrieved September 24, 2023, from https://www.bbc.co.uk/bitesize/guides/zmqth39/revision/3

Zhang, Y., Wang, Q., Liu, Y., & Chen, Q. (2019). Effects of sodium benzoate on sweet and sour taste perception in humans. Food Chemistry, 275, 715-722.