

REVIEW ARTICLE OPEN ACCESS

Modulating Taste Perception in Newly Weaned Piglets: The Role of Palatability Additives in Enhancing Feed Intake and Performance

Luana Specht^{1,2}  | Gabriela Altenhofen¹ | Daiane Carvalho² | Michele Fangmeier²

¹Postgraduate Program in Biotechnology of the University of Vale do Taquari—UNIVATES, Lajeado, Rio Grande do Sul, Brazil | ²Research and Development Department, American Nutrients do Brasil Indústria e Comércio Ltda, Teutônia, Rio Grande do Sul, Brazil

Correspondence: Luana Specht (pesquisa@americannutrients.com.br)

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ABSTRACT

The continuous growth of global agribusiness stimulates the search for alternatives that can enhance the performance and quality of life of production animals. In swine production systems, multiple challenges arise during the post-weaning phase when piglets face substantial transitions, including diet changes, environmental shifts, and maternal separation. These stressors often lead to reduced feed intake and inadequate nutrient consumption, resulting in impaired growth and increased susceptibility to diseases, even mortality in extreme cases. To counter these challenges, the use of palatability enhancers has emerged as an essential strategy to stimulate feed consumption, ensuring sufficient nutrient intake and promoting the health and welfare of piglets. Considering the crucial role of taste perception and dietary preferences in pigs, this review explores the mechanisms behind taste perception, the impact of various palatability additives on feed intake, and highlights current advances in strategies designed to optimize the feeding of newly weaned piglets.

1 | Introduction

Swine production has advanced significantly in terms of nutrition; however, the growing demand for productivity and the need to reduce costs still impose important challenges in feed formulation. The introduction of new ingredients and nutritional strategies, although necessary, can compromise diet palatability, resulting in losses in fundamental zootechnical parameters such as weight gain, feed conversion, and carcass characteristics [1, 2]. In this context, the development of strategies that ensure diet acceptance, especially through the use of palatability enhancers, becomes essential to optimize piglet performance during critical phases such as weaning [3].

Swine production is one of the most relevant sectors of global agribusiness, with a direct impact on food security and the economy of producing countries. In Brazil, the activity stands

out for adopting production systems that seek to combine efficiency, competitiveness, and animal welfare, responding to the growing demand of both domestic and international markets [4]. This context reinforces the importance of investing in nutritional solutions that favor animal adaptation during critical phases, ensuring productive performance and sustainability throughout the production chain.

Palatability enhancers act by modulating the sensory characteristics of diets, directly influencing feed intake [5, 6]. This aspect is particularly relevant during the post-weaning period, when piglets undergo an abrupt transition from milk to solid feed, making them more vulnerable to nutritional, social, and environmental stressors [3]. Reduced feed intake at this stage may lead to growth delays, greater susceptibility to diseases, and significant economic losses, highlighting the need for additives that stimulate feed consumption.

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Although Brazilian swine production adopts welfare and biosecurity standards aligned with global best practices [7], palatability-related challenges are universal and affect different producing markets, such as China, the world's largest pork producer [8]. This scenario underscores the need for nutritional strategies that improve diet acceptance and animal performance, in line with increasingly demanding productive and commercial requirements.

In addition to zootechnical relevance, it is also necessary to consider the economic impact of using palatability additives. Although they represent an additional cost in feed formulation, their use may be justified when they promote higher intake, better nutrient utilization, and reduce losses associated with poor post-weaning performance. Therefore, the balance between cost and benefit must be part of nutritional planning, ensuring productive feasibility and economic return.

Understanding the mechanisms of taste perception and how specific additives modulate these sensory processes is essential for formulating efficient, highly acceptable diets for newly weaned piglets. Therefore, this review analyzes taste and olfactory mechanisms, discusses the impact of stressors associated with weaning, examines the types and efficacy of palatability enhancers, and proposes strategies to optimize feed acceptance

and animal welfare [9]. This study was conducted to review the use of palatability enhancers in weaned piglet diets, focusing on additives such as sweeteners and yeasts. Research was gathered from databases such as SciELO and PubMed, covering publications from 2001 to 2023. The aim was to analyze the impact of these enhancers on piglet nutrition, ensuring the relevance and currency of the information.

1.1 | Sensory Mechanisms and Action of Palatability Enhancers in Weaned Piglets

1.1.1 | Basic Tastes

Pigs exhibit an advanced gustatory system, with approximately 19,904 taste buds—more than most mammals—which gives them heightened sensitivity to feed composition [10]. Taste perception in pigs is facilitated by gustatory cells housed within taste buds distributed across the tongue's surface. These cells detect chemical compounds present in feed and send sensory signals that influence feeding behavior (Figure 1).

The five basic tastes—sweet, salty, sour, bitter, and umami—play distinct roles in guiding dietary choices. Sweet taste indicates the presence of simple carbohydrates (e.g., glucose and sucrose), salty

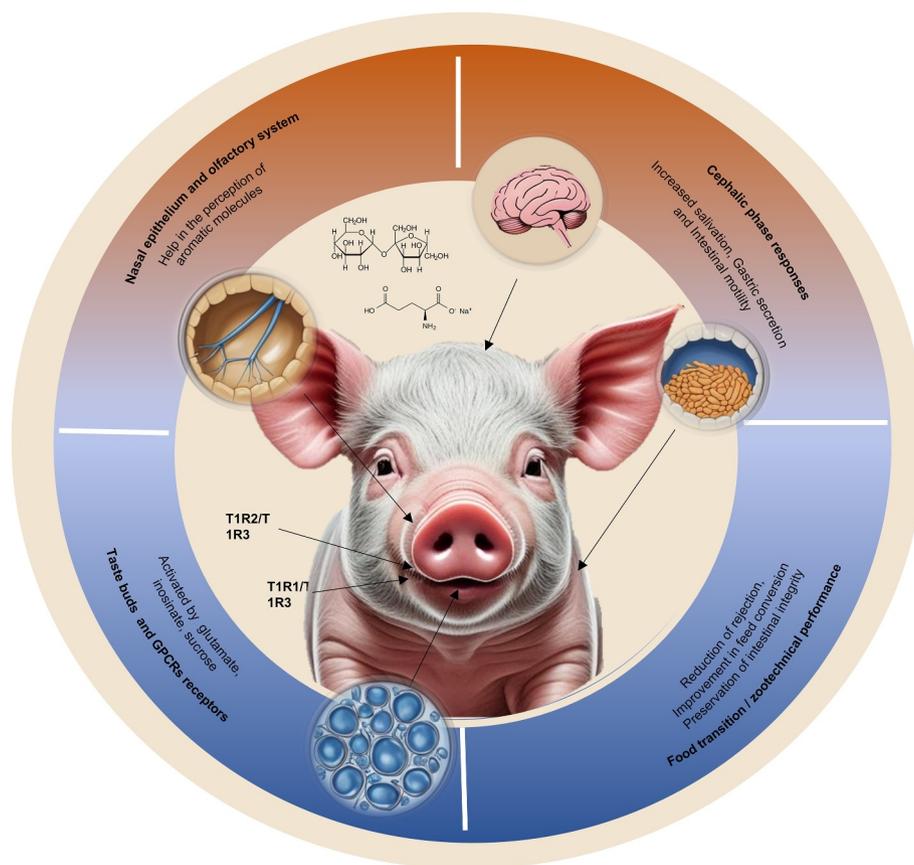


FIGURE 1 | Mechanism of action of palatability enhancers in newly weaned piglets. The diagram illustrates the main components involved in the action of palatability enhancers in piglets. Palatable compounds, such as glutamate and sucrose, activate taste receptors (T1R1/T1R3 and T1R2/T1R3) located in the taste buds. Simultaneously, aromatic compounds stimulate neurons in the nasal epithelium, triggering the olfactory response. The combined activation of gustatory and olfactory systems promotes cephalic phase responses, including increased salivation, gastric secretion, and intestinal motility. These effects lead to greater diet acceptance, reduced feed rejection, improved feed conversion ratio (FCR), and preservation of intestinal integrity.

taste helps detect essential electrolytes such as sodium, sour taste often relates to ripeness or spoilage, bitter taste signals potential toxins, and umami is associated with amino acids and proteins [11, 12]. Studies confirm that all areas of the tongue can perceive these tastes, debunking older theories of regional taste zones [13]. These evolutionary functions are particularly relevant in swine nutrition, as pigs tend to reject bitter feeds and show preference for sweet and umami flavors. Therefore, formulating diets that consider taste profiles is critical to maximizing feed intake and performance.

Palatability enhancers modulate sensory perception by interacting with both gustatory and olfactory systems. Sweet and umami compounds activate G-protein-coupled receptors (GPCRs) such as T1R1/T1R3 (umami) and T1R2/T1R3 (sweet), which trigger intracellular signaling cascades that stimulate feed-seeking behavior. Simultaneously, aromatic compounds activate olfactory neurons in the nasal epithelium, contributing to the full flavor experience and enhancing diet attractiveness [8, 14]. This dual sensory stimulation promotes positive associative learning, which is especially important in newly weaned piglets transitioning to solid diets. Specific amino acids and nucleotides—such as glutamate, inosinate, and guanylate—are known to elicit strong umami responses and can mask bitterness, improving the acceptance of nutritionally dense, protein-rich feeds [15].

Additionally, palatability enhancers may stimulate cephalic phase responses, including increased salivation, gastric enzyme secretion, and intestinal motility—physiological changes that improve nutrient digestion and utilization. By reducing feed rejection and accelerating adaptation to solid diets, these additives help preserve intestinal integrity, enhance feed conversion ratios (FCR), and support piglet health and performance during the post-weaning period [8].

2 | The Fifth Basic Taste: Umami

Among the sensory elements that influence feed palatability in piglets, umami plays a particularly important role due to its association with protein-rich diets and its strong appeal to swine taste receptors. Umami, recognized as the fifth basic taste, was first identified by Professor Kikunae Ikeda in 1908. Through the isolation of glutamate from a traditional Japanese seaweed broth, Ikeda demonstrated that this compound was responsible for the savory taste known as umami [16]. Umami substances, such as monosodium glutamate (MSG), inosine-5'-monophosphate (IMP), and guanosine-5'-monophosphate (GMP), interact with specific taste receptors in the oral cavity, enhancing the perception of protein-rich foods [11, 12]. In addition to glutamate, other molecules such as peptides and nucleotides contribute to umami taste perception.

These compounds can intensify savory and salty flavors, increase appetite, promote satiety, and synergistically enhance both salty and sweet tastes while masking bitterness. Importantly, the synergistic effect between L-glutamate and nucleotides such as IMP can amplify umami intensity by up to seven times compared to glutamate alone [12]. These functional characteristics make umami-enhancing additives a valuable tool

in formulating palatable and nutritionally efficient diets for newly weaned piglets.

2.1 | Weaning Stress and the Role of Palatability Enhancers

Weaning represents one of the most critical and stressful phases in the life of piglets [17]. This transition involves an abrupt change from maternal milk to solid feed, compounded by environmental and social disruptions. These stressors often result in reduced feed intake, impaired growth, and increased susceptibility to diseases [18, 19]. Among the primary challenges are dietary neophobia, separation anxiety, immune suppression, and intestinal dysbiosis. These factors significantly affect zootechnical performance, as newly weaned piglets frequently reject unfamiliar or bitter-tasting feeds, especially those containing amino acids, plant-based anti-nutritional factors, or antibiotics [20, 21].

Studies indicate that nearly 45% of piglets experience fasting for more than 15 h post-weaning, and in some cases up to 97 h without feed intake. This prolonged fasting period results in weight loss, villus atrophy, reduced nutrient absorption, and heightened vulnerability to pathogens [22, 23]. To counter these effects, the use of palatability enhancers emerges as a highly effective strategy. These additives modulate sensory perception, mask undesirable flavors, and stimulate early and consistent feed intake. By increasing feed attractiveness, they help mitigate the impact of early weaning stress, support gut integrity, and enhance growth performance and welfare [24, 25].

2.2 | Categories of Palatability Additives Commonly Used

Palatability additives used in piglet nutrition can be grouped into three functional categories: sweeteners, flavor/aroma enhancers, and taste modulators. Each category plays a distinct role in stimulating sensory receptors and improving feed acceptance [26].

Sweeteners play a central role, particularly in the first weeks after weaning, since piglets develop a marked preference for sweet flavors due to prior exposure to lactose in maternal milk. This gustatory memory makes sweetness an effective tool to stimulate early solid feed intake, a critical step for physiological adaptation and gastrointestinal development [27]. Commonly used sweeteners include neotame, a high-intensity synthetic additive 7,000 to 13,000 times sweeter than sucrose; stevia, a natural alternative that may also provide antioxidant properties [28, 29], and sodium saccharin, a widely used additive, often combined with other compounds to reduce undesirable metallic notes [30]. Studies confirm their efficacy: stevia supplementation increased average daily gain without a proportional increase in feed intake [31], whereas neotame and sucralose improved both growth and intake [27, 32]. The findings of these studies are summarized in Table 1, which presents the effects of different palatability enhancers on the performance of weaned piglets.

This table compiles experimental results on different palatability enhancers in piglet diets. Positive effects were observed for both

TABLE 1 | Effects of different palatability enhancers on the performance of weaned piglets.

Palatability additive	Test period (days)	Recommended Concentration (mg/kg)	Control ADG (g/day)	ADG with additive (g/day)	Control ADFI (g/day)	ADFI with additive (g/day)	Reference
Stevia	23–65	0.125	480	510	840	850	Budiño et al. [31]
Neotame	1–35	20–30	304	335	515	567	Zhu et al. [27]
Sucralose	0–28	150	336	384	551	624	Zhang et al. [32]
Sodium saccharin	0–14	350	—	—	320	630	De Paula et al. [33]
Hydrolyzed yeast	1–25	10,000	347	389	485	530	Keimer et al. [34]

Abbreviations: ADFI = average daily feed intake; ADG = average daily gain.

synthetic and natural additives, with improvements in growth rate (ADG) and, in some cases, increased feed intake (ADFI). It is worth noting that hydrolyzed yeast also provides functional compounds (nucleotides and peptides), contributing to gut health and nutrient absorption, in addition to enhancing feed palatability.

Beyond sweetness, aromas play a decisive role in feed acceptance. Volatile compounds activate olfactory receptors and trigger positive behavioral responses associated with feed memory, such as salivation, feed exploration, and anticipatory consumption [14]. This stimulation is particularly relevant for piglets in the nursery phase, which are exposed to social and environmental stressors and may refuse feed. Studies indicate that familiar notes, such as vanilla, cheese, fruit, and milk, increase diet attractiveness and help sustain regular intake [35, 36]. Thus, aromas not only facilitate initial adaptation but also support consistent intake throughout the post-weaning period.

Another important category involves non-sweet palatability enhancers, such as sodium saccharin and hydrolyzed yeast. Supplementation with sodium saccharin at 350 mg/kg nearly doubled average daily feed intake within 14 days [33]. Similarly, hydrolyzed yeast at 10,000 mg/kg from day 1–25 improved both average daily gain and feed intake [34]. Beyond palatability, hydrolyzed yeast provides nucleotides and bioactive peptides that enhance intestinal integrity, digestibility, and nutrient absorption, thereby playing a multifunctional role [37, 38]. This combination of nutritional and sensory benefits makes these additives particularly relevant in nursery programs.

The traditional composition of piglet diets, based mainly on corn and soybean meal, can compromise palatability due to anti-nutritional factors and bitter-tasting amino acids [39]. Since piglets cannot synthesize most essential amino acids, their inclusion in diets is unavoidable, even though their sensory effect is often unfavorable. Feed rejection caused by these compounds can reduce intake, impair growth curves, and compromise intestinal health. Table 2 summarizes the gustatory responses of piglets to different amino acids used in swine nutrition, indicating which are accepted, neutral, or rejected [20].

In this context, taste modulators play a strategic role. They mask undesirable flavors from amino acids, antibiotics, or plant-derived compounds, rebalancing the sensory profile of diets and encouraging feed intake [40]. Key examples include yeast extracts rich in glutamate and peptides, which enhance umami taste and reduce bitterness; animal protein hydrolysates, which intensify the sensation of “kokumi” or mouthfulness; and neohesperidin, which provides sweetness while neutralizing bitter notes, especially when used in combination with other sweeteners [41]. These modulators expand formulation possibilities, allowing the inclusion of nutritionally relevant but sensorially limiting ingredients.

2.3 | Legislation on the Use of Additives in Animal Nutrition

Feed additives used in animal nutrition are regulated worldwide to ensure food safety, animal health, and environmental protection. In Brazil, the use of such additives is governed by Normative Instruction No. 110, issued on November 24, 2020, which defines the list of approved ingredients, additives, and carriers for use in animal feed [42, 43]. In the United States, the regulation of additives used in animal feed is governed by the Federal Regulations Code, with the Food and Drug Administration (FDA) acting as the main responsible authority. All additives must be approved by the FDA before being incorporated into animal feed. The FDA carries out this task in collaboration with state and local partners through various mechanisms, such as cooperative agreements, contracts, grants, and partnerships aimed at implementing uniform policies for the regulation of products intended for animal feed [44].

The European Union enforces strict regulations through Directive 70/524/EEC and subsequent updates, allowing only substances that have undergone scientific risk assessment. Certain additives, such as saccharin, are restricted or banned in some EU countries, highlighting the need for caution when formulating feed products for international markets [45]. In China, the world's largest producer and consumer of pork [46], the use of approved palatability enhancers and feed additives is permitted, provided they comply with national regulations. The

TABLE 2 | Taste responses related to amino acids used in swine nutrition.

Amino acid	Sensory response in piglets	Practical implication in diet formulation
Histidine	Indifference/reduced preference	May limit intake when included at high levels
Isoleucine	Indifference/reduced preference	Neutral effect, but excess can reduce palatability
Leucine	Indifference/reduced preference	Excess associated with bitter aftertaste
Proline	Indifference/reduced preference	Generally tolerated but not preferred
Tyrosine	Indifference/reduced preference	May affect feed attractiveness if over-supplied
Valine	Indifference/reduced preference	Balanced inclusion needed to avoid intake reduction
Arginine	Clear rejection	Strong negative effect on feed intake
Phenylalanine	Indifference/reduced preference	Potential bitterness at higher concentrations
Tryptophan	Indifference/reduced preference	Tolerated in balanced amounts

Note: The table summarizes the sensory responses of piglets to essential amino acids in feed. Responses range from indifference (neutral or reduced preference) to clear rejection (strong aversion). Understanding these responses is important when formulating diets based on corn and soybean meal, which naturally contain bitter-tasting amino acids. Adapted from Glaser et al. [20].

Ministry of Agriculture and Rural Affairs of China (MARA) is responsible for their administration and regulation [47] and sale of feed or feed additives without quality standards, quality certification, production number, or production registration is prohibited, ensuring the safety and quality of products intended for animal nutrition [47, 48].

2.4 | Final Considerations

The weaning period represents a critical phase in the life of piglets, marked by abrupt dietary, environmental, and social changes that compromise feed intake and increase susceptibility to health disorders. Palatability enhancers emerge as a key nutritional strategy to mitigate the adverse effects of weaning stress. By stimulating sensory receptors and enhancing the taste and aroma of feed, these additives promote higher feed intake, better nutrient absorption, and improved growth performance.

Recent studies demonstrate that the use of sweeteners, umami substances, flavoring agents, and masking compounds can significantly reduce the fasting period post-weaning and enhance zootechnical indicators such as average daily gain (ADG) and feed conversion ratio (FCR). Despite the promising results, there is a clear need for further research exploring optimal formulations, synergistic combinations of additives, and their long-term effects on animal welfare and productivity.

Moreover, with the growing importance of international markets, compliance with diverse regulatory frameworks (Brazil, USA, Europe, and China) becomes essential for the safe and effective use of palatability additives in global pig production. In conclusion, palatability enhancement should be integrated into comprehensive nutritional strategies aiming not only to improve performance but also to ensure animal welfare, health, and sustainable production.

Author Contributions

Luana Specht: conceptualization, literature review, methodology, writing – original draft, graphical abstract preparation. **Gabriela Altenhofen:** literature review, writing – review and editing. **Daiane**

Carvalho: supervision, validation, critical revision of the manuscript. **Michele Fangmeier:** visualization, reference formatting.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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