Application Effects of a Novel Aromatic-Sweet, Umami, and Sweet Compound Flavoring Agent in Piglet Diets (Postprint)

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Abstract

This study aimed to investigate the effects of novel saccharin-aroma, umami-aroma, and sweet-aroma compound flavoring agents on growth performance, serum gastrointestinal peptide indices, nutrient digestibility, and fecal microbial count in weaned piglets. A total of 128 healthy Large White weaned piglets at (28±2) days of age with similar body weight were selected and randomly allocated into 4 groups with 4 replicates per group and 8 piglets per replicate. The control group (Group A) was fed a basal diet, while the experimental groups were fed the basal diet supplemented with saccharin-aroma compound flavoring agent (0.8 g/kg plant aroma extract + 0.2 g/kg sodium saccharin, Group B), umami-aroma compound flavoring agent (0.8 g/kg plant aroma extract + 0.2 g/kg umami compound, Group C), or sweet-aroma compound flavoring agent (0.8 g/kg plant aroma extract + 0.2 g/kg plant sweet extract, Group D), respectively. The experimental period lasted 28 days. The results showed that, compared with the control group: 1) dietary supplementation with saccharin-aroma and umami-aroma compound flavoring agents significantly reduced the feed-to-gain ratio of weaned piglets during days 1–14 of the experiment ($P<0.05$); 2) dietary supplementation with saccharin-aroma and umami-aroma compound flavoring agents significantly improved the digestibility of organic matter in weaned piglets ($P<0.05$); 3) dietary supplementation with saccharin-aroma, umami-aroma, and sweet-aroma compound flavoring agents had no significant effects on serum gastrointestinal peptide indices or fecal microbial count in weaned piglets ($P>0.05$). It can be concluded that dietary supplementation with saccharin-aroma and umami-aroma compound flavoring agents can improve growth performance and nutrient digestibility in weaned piglets.

Full Text

Application Effects of Novel Aromatic and Saccharin, Aromatic and Umami, and Aromatic and Sweet Compound Flavoring Agents in Weaned Piglet Diets

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Abstract

This study investigated the effects of novel aromatic and saccharin, aromatic and umami, and aromatic and sweet compound flavoring agents on growth performance, serum gastrointestinal peptide indices, nutrient digestibility, and fecal microbial populations in weaned piglets. One hundred twenty-eight healthy Large White weaned piglets at (28±2) days of age with similar body weights were selected and randomly allocated into four groups, with four replicates per group and eight piglets per replicate. The control group (Group A) received a basal diet, while the experimental groups received the basal diet supplemented with aromatic and saccharin compound flavoring agent (0.8 g/kg plant aromatic extract + 0.2 g/kg saccharin sodium, Group B), aromatic and umami compound flavoring agent (0.8 g/kg plant aromatic extract + 0.2 g/kg umami compounds, Group C), or aromatic and sweet compound flavoring agent (0.8 g/kg plant aromatic extract + 0.2 g/kg plant sweet extract, Group D). The trial lasted for 28 days.

The results showed that compared with the control group: (1) dietary supplementation with aromatic and saccharin or aromatic and umami compound flavoring agents significantly decreased the feed-to-gain ratio of weaned piglets during days 1–14 ($P<0.05$); (2) dietary supplementation with aromatic and saccharin or aromatic and umami compound flavoring agents significantly improved organic matter digestibility ($P<0.05$); and (3) dietary supplementation with any of the three compound flavoring agents had no significant effects on serum gastrointestinal peptide indices or fecal microbial populations ($P>0.05$). These findings indicate that dietary supplementation with aromatic and saccharin or aromatic and umami compound flavoring agents can improve growth performance and nutrient digestibility in weaned piglets.

Keywords: compound flavoring agents; weaned piglets; growth performance; serum gastrointestinal peptide indices; nutrient digestibility; fecal microbes

Introduction

Adequate feed intake is critically important in pig production, as insufficient consumption negatively affects growth performance. Moreover, the growth status of piglets plays a significant role in subsequent fattening stages. Increasing feed intake in weaned piglets is therefore an essential measure to ensure optimal growth performance. Previous research on flavoring agents has demonstrated that combined supplementation of sweeteners and flavoring agents in growing pig diets can enhance feed intake, indicating a synergistic effect between these additives. However, whether similar synergistic effects exist between flavoring agents and umami substances remains unreported. Currently, few studies have investigated the application of two or more different types of compound flavoring agents in weaned piglet diets. Therefore, this study utilized weaned piglets as experimental subjects to evaluate the effects of aromatic and saccharin, aromatic and umami, and aromatic and sweet compound flavoring agents on growth performance, serum gastrointestinal peptide indices, nutrient digestibility, and fecal microbial populations, providing a scientific basis for their use in piglet diets.

Materials and Methods

1.1 Experimental Materials

The compound flavoring agents used in this study consisted of: aromatic and saccharin (plant aromatic extract + saccharin sodium), aromatic and umami (plant aromatic extract + umami compounds), and aromatic and sweet (plant aromatic extract + plant sweet extract). The plant aromatic extract (containing plant extracts, yeast hydrolysate, nucleotides, and amino acids; product code 78026Z), saccharin sodium, umami compounds (containing plant extracts, yeast hydrolysate, nucleotides, amino acids, and monosodium glutamate; product code 79021Z), and plant sweet extract (containing plant extracts, yeast hydrolysate, nucleotides, and amino acids; product code 79023Z) were all provided by Lucta (Guangzhou) Flavors Co., Ltd.

1.2 Experimental Design and Diets

One hundred twenty-eight Large White weaned piglets at (28±2) days of age with an initial body weight of (7.38±0.68) kg and good health status were selected and randomly divided into four groups according to sex and average body weight, with four replicates per group and eight piglets per replicate. The groups included a control group (Group A) and three experimental groups (Groups B, C, and D). The control group received a basal diet without added flavoring or sweetening agents, while the experimental groups received the basal diet supplemented with aromatic and saccharin, aromatic and umami, or aromatic and sweet compound flavoring agents, respectively. The experimental design is

presented in .

A corn-soybean meal basal diet was formulated according to the NRC (1998) nutrient requirements for swine. The composition and nutrient levels of the basal diet are shown in . The experimental period lasted 28 days.

1.3 Animal Management

The trial was conducted at the Aidemeng Swine Breeding Farm of Liaoning Debao Agriculture and Animal Husbandry Group. Experimental piglets were provided by Aidemong Swine Breeding Co., Ltd. All four groups were housed in the same building, with temperature maintained at (26±3)°C and adequate ventilation. Piglets were managed according to conventional procedures and normal immunization protocols. Throughout the trial, weaned piglets had ad libitum access to water and feed.

1.4 Measurements

1.4.1 Growth Performance Piglets were individually weighed on the morning before feeding on day 1, day 15, and the final day of the trial to calculate average daily gain (ADG). Feed intake was recorded daily on a replicate basis to determine average daily feed intake (ADFI). The feed-to-gain ratio (F/G) was calculated from ADFI and ADG. Fecal consistency was monitored daily to record diarrhea incidence and calculate diarrhea rate. Mortality and culling events were recorded, with immediate feed reconciliation and weighing of any removed animals.

Diarrhea rate (%) = [Number of diarrheic piglets / (Total number of piglets × Trial days)] × 100.

1.4.2 Serum Gastrointestinal Peptide Indices On the final day of the trial, one piglet was randomly selected from each replicate and 5 mL of fasting blood was collected from the anterior vena cava using vacuum tubes. After standing for at least 30 minutes, blood samples were centrifuged at 3,000 r/min for 15 minutes to separate serum, which was stored at -20°C for subsequent analysis. Measured indices included cholecystokinin (CCK), leptin (LP), glucagon-like peptide-1 (GLP-1), and ghrelin.

CCK concentration was determined by radioimmunoassay using a Sn-69513 immunoradiometric counter according to the kit instructions (kit purchased from the Department of Neurobiology, Second Military Medical University, Shanghai). LP, GLP-1, and ghrelin concentrations were determined by enzyme-linked immunosorbent assay using a Multiskan MK3 microplate reader according to kit instructions (kits purchased from Nanjing Baisenjia Biological Technology Co., Ltd.).

1.4.3 Nutrient Digestibility On the final day of the trial, approximately 200 g of feces was collected from each replicate, mixed thoroughly, and treated with

10% hydrochloric acid solution to prevent ammonia volatilization before storage at -20°C. Contents of organic matter (OM), crude protein (CP), ether extract (EE), calcium (Ca), and phosphorus (P) in diets and feces were determined using conventional feed analysis methods.

Nutrient digestibility was calculated using the acid-insoluble ash (AIA) method as an endogenous indicator:

$$X = 100 - \left[\frac{b \times c}{a \times d}\right] \times 100$$

Where: X = nutrient digestibility (%); a = nutrient content in feed (%); b = nutrient content in feces (%); c = AIA content in feed (%); d = AIA content in feces (%).

1.4.4 Fecal Microbial Populations On the final day of the trial, fresh fecal samples were collected from one randomly selected piglet per replicate using sterile bags, sealed, labeled, and stored at 4°C for analysis. Populations of *Escherichia coli*, *Lactobacillus*, and *Bifidobacteria* were determined by plate counting. All culture media were purchased from Qingdao Hope Bio-Technology Co., Ltd.: MacConkey agar (HB6238-1) for *E. coli*, Lactobacillus selective agar (LBS medium, HB0385) for *Lactobacillus*, and Bifidobacteria agar (BBL medium, HB0395) for *Bifidobacteria*. *E. coli* was cultured aerobically at 37°C for 24 hours, while *Lactobacillus* and *Bifidobacteria* were cultured anaerobically at 37°C for 48 hours. Results were expressed as log colony-forming units per gram of feces [lg(CFU/g)].

1.5 Statistical Analysis

Experimental data were processed using Excel 2007 and analyzed by one-way ANOVA using SPSS 19.0 software. When significant differences were detected, Duncan' s multiple comparison test was applied. Significance was declared at $P<0.05$ and highly significant at $P<0.01$. Results are expressed as "mean ± standard deviation."

Results

2.1 Effects of Dietary Compound Flavoring Agents on Growth Performance of Weaned Piglets

As shown in , compared with the control group, Groups B, C, and D exhibited reduced feed-to-gain ratio (F/G) during days 1–14, days 15–28, and the overall experimental period (days 1–28). Specifically, all experimental groups showed significantly lower F/G during days 1–14 ($P<0.05$), with reductions of 14.38%, 13.43%, and 13.52%, respectively. However, no significant differences in F/G

were observed during days 15–28 or the overall period (P>0.05). No significant differences were detected among groups in ADFI, ADG, or diarrhea rate (P>0.05).

2.3 Effects of Dietary Compound Flavoring Agents on Nutrient Digestibility of Weaned Piglets

As shown in , organic matter (OM) digestibility was improved in all experimental groups compared with the control, with Groups B and C showing significant improvements (P<0.05) of 2.97% and 3.36%, respectively. No significant differences were observed among groups in digestibility of CP, EE, Ca, or P (P>0.05).

2.4 Effects of Dietary Compound Flavoring Agents on Fecal Microbial Populations of Weaned Piglets

As shown in , no significant differences were detected among groups in fecal populations of *E. coli*, *Lactobacillus*, or *Bifidobacteria* (P>0.05).

Discussion

3.1 Effects on Growth Performance

Aromatic and umami or aromatic and sweet compound flavoring agents first attract piglets through aroma, then stimulate appetite through sweet or umami taste. Yeast extract contains abundant umami substances that stimulate taste receptors in piglets and can reduce diarrhea incidence, thereby promoting growth. Wu (2007) reported that dietary supplementation with umami flavoring agents positively affected weight gain in finishing pigs, increasing ADG and decreasing F/G while improving economic benefits. Zhang et al. (2000) found that combined supplementation of sweeteners and flavoring agents increased ADFI and ADG in piglets. Lü (2011) reported that simultaneous addition of flavoring and sweetening agents improved growth performance in growing pigs, increasing ADFI by 3.4%, ADG by 10.3%, and feed utilization efficiency by 6.9%. In the present study, dietary supplementation with aromatic and saccharin or aromatic and umami compound flavoring agents reduced F/G, consistent with previous findings. These results demonstrate that aromatic and saccharin or aromatic and umami compound flavoring agents can improve growth performance in weaned piglets.

3.2 Effects on Serum Gastrointestinal Peptide Indices

CCK regulates appetite in animals; reduced serum CCK levels increase feed intake. Gou (2008) demonstrated that CCK active immunization improved growth performance in finishing pigs, increasing ADFI by 2.23% and ADG by 2.03%. Baranyiová and Hullinger (1999) reported that intravenous CCK injection in 1-day-old piglets significantly reduced feed intake. CCK promotes LP

secretion, and both hormones act synergistically as negative regulators of appetite and body weight. Lü (2011) found that dietary supplementation with aromatic and sweet compound flavoring agents reduced fasting serum LP concentration by 26.1% during week 1, with significantly lower LP levels than the control group after two weeks. In the current study, serum CCK and LP concentrations were slightly lower in the aromatic and saccharin and aromatic and umami groups compared with the control group, while the aromatic and sweet group showed slightly higher levels, mirroring trends in ADFI and ADG.

GLP-1 is synthesized and secreted by intestinal L-cells, which also express sweet taste receptors (T1R2/3) that are activated by nutrient stimuli, triggering signal transduction. GLP-1 secretion is positively correlated with food intake and can reduce food consumption and body weight in rats. Ghrelin is a brain-gut peptide hormone that promotes appetite and fat synthesis, regulates energy metabolism, and stimulates gastric acid secretion and gastrointestinal motility. Lü (2011) reported that aromatic and sweet compound flavoring agents and flavoring agents alone increased fasting ghrelin concentrations more than the control group during week 1, with fasting ghrelin levels consistent with ADFI changes. In this study, serum GLP-1 and ghrelin concentrations were lower in the aromatic and saccharin and aromatic and umami groups compared with the control group, though not significantly, possibly due to differences in flavoring agent composition requiring further investigation.

3.3 Effects on Nutrient Digestibility

Combining flavoring agents with sweeteners or umami substances creates a synergistic interaction between "aroma" and "taste" in feed, generating pleasant feeding experiences and conditioned reflexes that increase secretion of digestive juices and enzymes, ultimately improving growth performance and feed utilization. Mou (2008) reported that dietary flavoring agents significantly improved OM digestibility in piglets without affecting dry matter (DM), CP, EE, or ash digestibility. Liu (2007) found that dietary sweeteners significantly improved digestibility of gross energy, CP, and DM in piglets. The present study similarly demonstrated that aromatic and saccharin or aromatic and umami compound flavoring agents significantly improved OM digestibility.

3.4 Effects on Fecal Microbial Populations

Under normal conditions, intestinal microbial populations maintain a balanced distribution. However, during weaning stress, gastrointestinal pH increases, favoring proliferation of neutral/alkaline-adapted pathogenic *E. coli* while reducing acid-tolerant beneficial bacteria such as *Lactobacillus*, disrupting microecological balance and causing diarrhea and economic losses. In this study, dietary supplementation with aromatic and saccharin, aromatic and umami, or aromatic and sweet compound flavoring agents did not significantly affect intestinal microbial populations in weaned piglets.

Conclusions

1. Dietary supplementation with aromatic and saccharin or aromatic and umami compound flavoring agents improved growth performance in weaned piglets, while aromatic and sweet compound flavoring agents improved feed-to-gain ratio.
2. Dietary supplementation with aromatic and saccharin or aromatic and umami compound flavoring agents significantly improved organic matter digestibility, though none of the three compound flavoring agents significantly affected serum gastrointestinal peptide indices or fecal microbial populations.
3. Aromatic and saccharin compound flavoring agent (0.8 g/kg plant aromatic extract + 0.2 g/kg saccharin sodium) and aromatic and umami compound flavoring agent (0.8 g/kg plant aromatic extract + 0.2 g/kg umami compounds) are recommended for use in weaned piglet diets.

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Note: Figure translations are in progress. See original paper for figures.