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The Effects of Different Types of Feed Flavors on Feed Intake and Feeding Behaviors in Growing Pigs

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Abstract: The experiment was conducted to investigate the effect of different feed flavors on feed intake and intake behavior in growing pigs under auto feeding system. A total of 30 barrows (Landrace x Yorkshire) of 95 days old were selected and allocated to 1 of 5 treatments by BW for this 14 days experiment. There were 6 replicates in each treatment and 1 pig in each replicate. Diets containing: CON, the basal diet; BF, CON + 400 mg kg^{-1} banana flavor; MF, CON + 400 mg kg^{-1} sow milky flavor; SF, CON + 150 mg kg^{-1} sweetener and BMS, CON + 400 mg kg^{-1} banana flavor + 400 mg kg^{-1} milky flavor + 150 mg kg^{-1} sweetener. The ADFI in BF, MF, SF and BMS complex group was enhanced compared to the CON, respectively. The ADG and feed efficiency was respectively increased ($p<0.05$) related to the control treatment. The feed intake speeds and feed intake time of fruit, milky, sweetener and complex group were increased ($p<0.05$) than control. The results indicated that feed flavors affect feed intake behavior by elevating the feed intake speed and reducing the time of feed intake to enhance the feed intake of growing pigs and no difference was found between the three flavors.

Key words: Feed flavor, feeding behavior, growing pig, sweetener, basal diet

INTRODUCTION

Over the past few decades, the performance of pigs has been improved by the research of pig breeding experts. However, the increase in ADG, G/F and lean meat percentage led to a decrease in Feed Intake (FI) capacity (Ellis *et al*., 1983; Cameron, 1994). It is well known that more feed intake means more effective nutrients consumption and more production capacity. Especially for growing pigs, their body are <150 lb, once the feed intake is elevated, the proportion of maintenance requirement is decreased and feed efficiency would be enhanced (Lammers *et al*., 2007) or if feedstuffs with lower nutrient content or lower palatability were applied by increased feed intake then normal production levels could be maintained at a lower cost (Duran *et al*., 2000).

Feed intake and palatability are closely related (De Castro *et al*., 2000). In fact, palatability is evaluated by analyzing feed intake (Le Magnen, 1987; Ramirez, 1990). Palatability is predominantly influenced by the raw materials of feed and animal sensitivity. Pigs have a much more keen sense of smell and taste than humans (Chamorro *et al*., 1993, 1994; Mack *et al*., 1997; Kumar and Bate, 2004; Pichersky *et al*., 2006) so the palatability of a feedstuff will be improved when a preferred flavor is supplied. Reports have shown that olfaction and taste influence choice and FI since the 1970s (Baldwin, 1980). No appetite leads to a decrease in digestive juices which will decelerate or even block the digestion of feed. Therefore, one of the purposes by use of flavors is to enhance the digestion, absorption and utilization of feed by promoting appetite. Another purpose is to ameliorate palatability and promote feed intake of poor flavors raw materials which could lead to natural flavor loss of diet (Pauline and Hill, 1983; Nelson and Sanregret, 1997; Rogers *et al*., 1988). To satisfy the needs of livestock and to promote feed intake research and application of feed flavors came into being (McLaughlin *et al*., 1983; Tien *et al*., 1999; Duran *et al*., 2000; Bertram *et al*., 2002).

Earlier research on feed flavor concentrates the effects on the amount of water drinking (Kennedy and Baldwin, 1972; Maenz *et al*., 1993), feed intake (Campbell, 1976; Zivkovic *et al*., 1980; Langendijk *et al*., 2007; Sterk *et al*., 2008) and preference (Baldwin, 1980; McLaughlin *et al*., 1983; Parfet and Gonyou, 1991) of feed flavor. But not all of feed flavors can improve feed intake (McLaughlin *et al*., 1983; Kornegay *et al*., 1979) and

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different animals preferred different flavors (Damron and Day, 1988). The main objective of the present study was therefore to explore the reasons behind increased feed intake when sweetener and flavor were applied by investigating the effects of a compound sweetener and different kinds of flavors on feed attracting and behaviors with *ad libitum* intake.

MATERIALS AND METHODS

Animals and experimental procedure: The protocol used for the current experiment was approved by the Animal Care and Use Committee of Dankook University and Sichuan Agricultural University. Thirty, 95 days old pigs (L×D) were selected and allocated by BW to 1 of 5 treatments. There were 6 replicates in each treatment and 1 piglet in each replicate. An ACEMO automatic feed intake system set in every pen was used to investigate the FI information. Considering the space and chance to access the diet, 6 pigs were grouped in one feeding station though each station can feed 12-15 pigs. Each pig was tagged with an electronic ear tag with a Radio Frequency Identification (RFID) to collect detailed FI characteristics. Once the tagged pigs entered into the feeding stations, the Feed Intake Recording Equipment (FIRE) would register the ear tag number immediately as well as the time entered or exited. The difference of the weights of the feed trough between before entering and after exiting is defined as the FI of that time.

Animals were then given free access to feed and water and 24 h of light all >14 days. The experiment was carried out at an experimental farm for the Institute of Animal Nutrition in Sichuan Agricultural University.

Dietary treatments: Pigs in different treatment were fed diets containing Pigs in different treatment were fed diets containing: CON, the basal diet; BF, the basal diet added with 400 mg kg^{-1} banana flavor; MF, 400 mg kg^{-1} sow milky flavor; SF, 150 mg kg^{-1} sweetener and BMS, 400 mg kg^{-1} banana flavor + 400 mg kg^{-1} milky flavor +150 mg kg^{-1} sweetener. In accordance with the standard of NRC (1998), the basal diet (Table 1) was formulated to exceed or meet the requirements for growing pigs. Pigs were housed in an environmentally controlled facility with slatted plastic flooring in 24 adjacent pens (1.8×1.8 m) and were allowed ad libitum access to feed and water.

Data collection and analyses: Electronic feeders can record detailed information about feed intake behavior in addition to ADFI from group-housed pigs (Von Felde *et al*., 1996) and automatic feed intake system used by this trial has the similar function. The FI characteristics of individual pigs was studied by calculating Average Daily Feed Intake (ADFI), average duration of feed intake per day, the frequency of feed intake named as average number of feed intake per day, average feed intake speed named as the amounts of feed intake per second (g sec^{-1}), feed intake duration per visit (sec n^{-1}) and the amounts of feed intake per visit (g n^{-1}). The FI characteristics were recorded from day 1 (start of the experiment) until day 14 (end of the experimental period), each pig was weighed at day 1, 8 and 15. Average Daily Gain (ADG) and feed utilization rate (G/F) was calculated according to weight gained and total FI, the pigs were given no access to feed for 12 h before weighing.

Table 1: Composition of the basal diets for growing pigs

Items	Ingredient (%)
Corn	71.60
Soybean meal	25.50
$CaCO_3$	0.70
$CaHPO_4$	0.90
NaCl	0.30
Lysine HCl	0.20
DL-Methionine	0.07
Choline chloride	0.10
Anti-mold	0.08
Antioxidant	0.02
Mineral premix[1]	0.53
Analysis composition	
DE (MJ kg^{-1})	13.88
Crude protein (%)	16.92
Ca (%)	0.64
Total P (%)	0.57
Lys (%)	0.94
Met + Cys (%)	0.64

[1]Per kilogram of complete basal diet content: Vitamin A, 12,000 IU; Vitamin D_3, 1200 IU; Vitamin E, 40 IU; Vitamin B_1, 1.0 mg Vitamin B_2, 3.5 mg Vitamin B_6, 1.5 mg; Vitamin B_{12}, 18.4 μg; Vitamin C, 80 mg nicotinic acid 17.5 mg; calcium pantothenate 15 mg, folic acid, 2 mg; Cu, 180 mg; Fe, 100 mg; Mn, 4 mg; Zn, 100 mg; Se, 0.3 mg; I, 0.5 mg

Diets and ingredients were frozen-dried and then ground finely to analyze DM and CP. Amino acids were analyzed by Sykam Amnio Acid Analyser (Laserchrom HPLC Laboratories Ltd. Inc., Rochester, UK). Before analysis, samples were hydrolyzed with 6 N HCl for 24 h at 110°C. Met and Cys were analyzed as Met sulfone and cysteic acid after cold performic acid oxidation overnight before hydrolysis. Tryptophan was determined after NaOH hydrolysis for 22 h at 110°C. Values for Apparent Ileal Digesitibility (AID) was calculated as described earlier.

Statistical analysis: All data were subjected to statistical analysis in a randomized complete block design using the GLM procedures (SAS Inst. Inc., Cary, NC) with the pen serving as the experimental unit. Duncan's multiple range test was used to compare the means of the treatments.

RESULTS AND DISCUSSION

Growth performance: All the parameters showed no significant change compared to the control except the ADG of the milk flavor and sweetener treatment in the 1st week and the whole trail period ($p<0.05$) (Table 2).

In the 1st week, compared with the control dietary, the ADFI in the fruit flavor, milk flavor, sweetener and complex flavors were elevated by 13.9, 17.7, 14.4 and 12.5%, respectively; the ADG were enhanced by 34.8, 49.1, 37.7, 28.9%, respectively and G/F were 16.0, 29.2, 20.1 and 14.8% higher than the control, respectively.

In the 2nd week, the ADFI in all of the groups except for the compound group were higher than the control especially for fruit group, milk group and sweetener group which increased by 11.3, 14.5 and 8.6%, respectively. Compared with the control, the ADG in the fruit group and the milk group rose 18.4 and 9.6% while 3.9 and 3.3% decreases were found in sweetener and compound group. As for G/F, the effect of the fruit group was the best which increased by 5.2%, the sweetener group was the worst decreasing 11.7% compared with the control.

From the whole period, ADFI, ADG and G/F were elevated at different levels. Compared to the control, the ADFI in the fruit group, milk group, sweetener group and compound group were respectively increased by 12.5, 15.9, 11.3, 3.4%; the ADG were respectively increased by 25.3, 26.3, 13.6 and 10.3% as while as 9.6, 11.3, 1.9 and 6.9% were enhanced in G/F of the fruit group, milk group sweetener group and compound group, respectively.

Intake behavior: The addition of flavors affected the average duration of feed intake per day ($p>0.05$). In the 1st week, the longest FI duration was the control while the durations were reduced by 1.87, 15.2, 4.3 and 11.9%, respectively in fruit group, milk group, sweetener group and compound group. This tendency lasted to the 2nd week since the durations were 9.2, 23.2, 25.3 and 16.1% shorter than the control. Therefore, the average durations of FI in fruit group, milk group sweetener group and compound group were 5.6, 19.2, 14.9 and 14.0% shorter than the control during the whole period (Table 3).

The frequency of FI per day in the milk flavor group was significantly higher than other treatments for a 58.6% increase while the sweetener group was the lowest since it was reduced by 50.1% compared with the control. It was same to the 2nd week since the frequencies of milk flavor group were increased by 61.3 and a 39.4% decrease in sweetener group was observed. So, during the whole period, the frequency of the milk flavor group was still the highest with a 59.9% increase while the sweetener group was the lowest with a 45.1% decrease compared with the control. There were no significant differences among the fruit flavor group, compound flavor group and control group ($p>0.05$) (Table 3).

As for the speed of FI, no significant changes were observed between the periods ($p>0.05$). Nevertheless, the speeds of flavors were faster than control. The speeds in fruit group, milk group, sweetener group and compound group were, respectively increased by 21.2, 5.5, 24.6 and 26.3% in the 1st week, 20.5, 6.5, 24.8 and 19.0% in the 2nd week and 21.2, 6.1, 30.0 and 22.8% for the whole period (Table 3).

In the 1st week, the duration of FI per visit in sweetener group was significantly longer than the others ($p<0.05$). Shorter durations were observed in other groups especially in the milk flavor group, at a 47.5% reduction compared with the control. The duration in the 2nd week follow the same trend as the 1st week. Therefore, the

Table 2: The effect of different flavors on the growth performance in growing pigs

Treatments	Control	Fruit flavor	Milk flavor	Sweetener	Complex flavor
BW (kg)					
Initial	31.7±1.97	31.79±1.10	31.46±2.95	31.97±1.53	31.87±1.16
1 week	36.37±1.99	38.08±1.30	38.42±2.84	38.39±1.56	37.88±1.35
2 weeks	42.76±2.21	45.65±1.74	45.43±3.07	44.53±1.93	44.07±1.38
ADFI (g)					
1 week	1537.9±94.7	1752.0±103.3	1810.0±290.8	1760.6±99.5	1730.7±154.1
2 weeks	1836.5±118.8	2044.0±26.1	2102.3±390.6	1995.3±164.4	1817.5±114.4
1-2 weeks	1687.2±66.4	1898.0±45.2	1956.2±338.9	1877.9±130.2	1744.1±132.4
ADG (g)					
1 week	666±62^{a}	898.8±86.8^{ab}	994.3±92.7^{b}	917.9±72.4^{b}	859.5±76.5^{ab}
2 weeks	913±65.2^{ab}	1081±67.4^{b}	1001±41.2^{ab}	877.4±79.8^{a}	883.3±44.6^{ab}
1-2weeks	789.9±41.9^{a}	989.9±69.7^{b}	997.9±53.5^{b}	897.6±27.8^{ab}	871.4±45.7^{ab}
F/G					
1 week	2.39±0.23	2.06±0.26	1.85±0.28	1.99±0.2	2.03±0.24
2 weeks	2.03±0.10	1.93±0.11	2.06±0.29	2.30±0.13	2.07±0.13
1-2 weeks	2.16±0.13	1.97±0.16	1.94±0.28	2.12±0.13	2.02±0.07

$^{a, b}$In the same row, values with different small letter superscripts mean significant difference ($p<0.05$)

Table 3: The effect of different flavors on the feed intake behavior in growing pigs

Treatments	Control	Fruit flavor	Milk flavor	Sweetener	Complex flavor
Intake time per day (sec day^{-1})					
1 week	9080.0±1099.5	8910.0±1401.0	7694.8±1095.7	8686.1±1327.4	7998.4±840.1
2 weeks	9265.0±667.0	8409.8±763.5	7118.9±850.3	6920.8±635.1	7774.0±940.7
1-2 weeks	9172.50±793.1	8659.9±1044.1	7406.8±967.9	7803.5±844.9	7886.2±884.4
The frequency of feed intake (n day^{-1})					
1 week	6.88±1.23^{ab}	6.74±1.50^{ab}	10.91±2.35^{b}	3.38±0.67^{a}	7.95±1.57^{ab}
2 weeks	7.28±1.45^{ab}	6.43±1.32^{a}	11.74±1.72^{b}	4.40±0.96^{a}	7.55±1.71^{ab}
1-2 weeks	7.08±1.28^{ab}	6.58±1.38^{a}	11.32±2.00^{b}	3.89±0.80^{a}	7.75±1.63^{ab}
Feed intake speed (g sec^{-1})					
1 week	0.179±0.019	0.217±0.273	0.278±0.089	0.223±0.032	0.226±0.030
2 weeks	0.210±0.025	0.253±0.022	0.346±0.117	0.262±0.039	0.250±0.030
1-2 weeks	0.193±0.224	0.234±0.025	0.311±0.103	0.251±0.029	0.237±0.029
Feed intake duration per visit (sec n^{-1})					
1 week	1491.6±249.5^{a}	1462.9±315.1^{a}	783.2±152.2^{a}	2923.0±507.0^{b}	1223.4.5±233.8^{a}
2 weeks	1532.7±268.7^{ab}	1632.7±341.2^{ab}	662.8±143.3^{a}	1964.2±417.2^{b}	1416.3±375.8^{ab}
1-2 weeks	1492.4±244.5^{ab}	1637.8±327.4^{ab}	717.4±148.3^{a}	2345.4±369.7^{b}	1293.5±280.4^{a}
The amount of feed intake per visit (g n^{-1})					
1 week	285.1±80.0^{ABa}	377.7±106.8^{ABab}	196.6±51.7^{Aa}	599.5±90.0^{Bb}	253.5±37.2^{Aa}
2 weeks	345.3±104.2^{ab}	436.2±120.4^{ab}	195.3±44.3^{a}	528.7±73.6^{b}	343.5±105.0^{ab}
1-2 weeks	310.9±90.5^{ab}	405.7±113.1^{ab}	195.1±47.4^{a}	557.6±79.5^{b}	288.1±61.1^{a}

$^{a, b}$In the same row, values with different small letter superscripts mean significant difference ($p<0.05$) values with different capital letter superscripts mean significant difference ($p<0.01$)

duration of FI per time in sweetener group was the longest and the milk flavor was the shortest during the whole period (Table 3).

The changes of amounts of FI per visit were similar to that of durations. Sweetener group was significantly higher than compound flavor and milk flavor group ($p<0.05$) as while as extreme higher than the control ($p<0.01$).

Daily feed intake behaviors: As shown in Fig. 1 that the amount of daily FI in each group was increasing with time and the addition of feed flavors elevated the amount of daily FI. The changes of the speed of daily FI are shown in Fig. 2. Compared to the control, the speed of milk flavor group was significantly increased. The speeds of all the treatments except control were elevated with time. The speed of FI in control group was decreased from days 2-5 and from days 9-13. Daily durations of FI changed in a saw tooth pattern as shown in Fig. 3. The duration of control was the highest and that of milk flavor was the lowest. Figure 4 and 5 demonstrate that no significant changes were observed with time in the frequency of daily FI and the amount of FI per visit. However, the frequency of sweetener group was lower than the control in the whole picture while opposite results was showed in milk flavor group.

Growth performance: To the best of the knowledge, various study have suggested that feed intake could be enhanced by the feed flavor but most of them investigated absolutely feed intake (Campbell, 1976; Zivkovic *et al*., 1980) or relative preference index (Parfet and Gonyou, 1991). However, Kornegay *et al*.

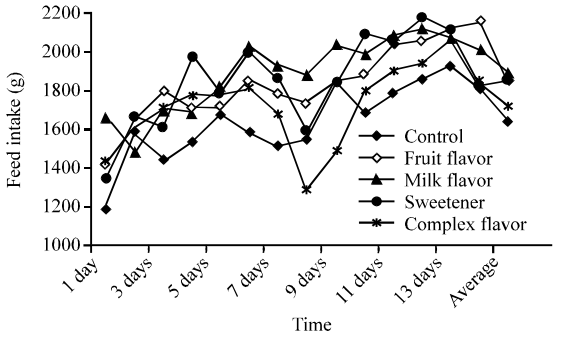

Fig. 1: The effect of different flavors on the daily feed intake in growing pigs

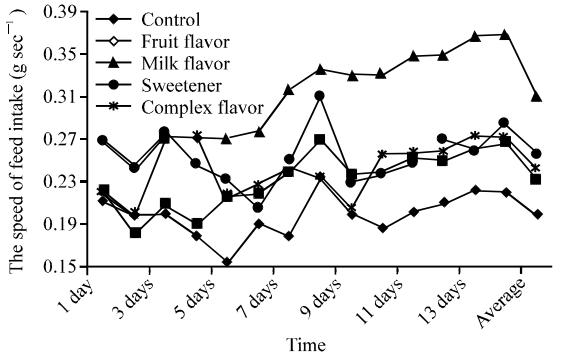

Fig. 2: The effect of different flavors on the daily feed intake speed in growing pigs

(1979) and Mou *et al*. (2007) found that there was no difference on the feed intake, feed to gain and body weight with flavor treatment. The reason for the inconsistent was likely to be the different flavor, dosage

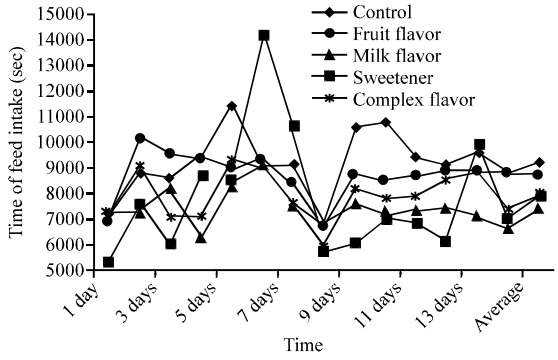

Fig. 3: The effect of different flavors on daily feed intake time in growing pigs

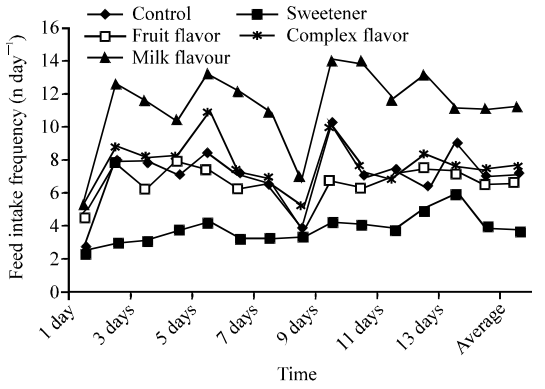

Fig. 4: The effect of different flavors on the daily feed intake frequency in growing pigs

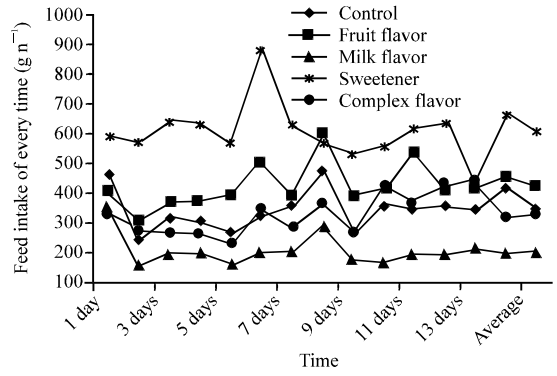

Fig. 5: The effect of different flavors on the daily feed intake of per time in growing pigs

supplemented or provided methods. It has been earlier reported that pigs exhibit preferences to milk, cheese, chocolate, maple sugar, mint, sweet apple, orange, lemon and strawberry flavor however not all of the flavors demonstrated the same effect on FI since it varied with feed formulas as while as flavor ingredients (McLaughlin *et al*., 1983). The results indicated that the ADFI were significantly increased, >10%, in the treatments with fruit flavor, milk flavor, sweet flavor and compound flavor especially in the 1st week. It was evidenced that all the flavors used in the experiments exhibited positive effects on the FI of pigs.

It is a surprise that the ADFI of the compound flavor was lower than the control in the 2nd week which indicated that no synergy effect existed between the flavors. Besides, no synergy effect of different feed flavours was showed during the whole trial period. Nonetheless, this result contradicts the findings previously reported (Hof, 2000; Liu *et al*., 2008). The synergy effect doesn't exist when flavor and sweetener are added which is mainly because the ingredients among the flavors difference (Zhang *et al*., 2000). One possible reason for the result maybe partly because researchers added two kinds of flavor and one kind of sweetener while the previously reports only added one kind of each which means that the amounts of flavor were doubled in the experiment. Overexposure will exhibit a negative effect on taste as reported by McCaugthey who found that overexposure to appetitive stimuli affected both sensory-specific satiety and non-specific satiety. Sensory-specific satiety occurred when the palatability of one food decreased after consuming large amounts of it and the palatability of other foods increased; the neural responses and firing responses also were reduced. Excessive overexposure would change the physiological state of the perceiver and even cause aversive behaviours.

The results demonstrated that the increase of treatment in the 1st week was higher than that in the 2nd week compared to the control. This is possibly because in the Ist week, the flavors stimulated the olfaction and taste to generate satiety which then modulated the digestive juices and gastrointestinal peristalsis to enhance the appetite. In the 2nd week, no significant priority was observed since the nerve excitement was much lower than before when the pigs adapted to the flavor. This agrees with the results of McLaughlin *et al*. (1983) and Sterk *et al*. (2008). However, there is no special report about effective action time of feed flavor in pigs.

In the 1st week and the whole trial period, the increase of ADG of feed flavor may be the result of elevated FI and G/F. After analyzing the FI, ADG and G/F in the 2nd week, researchers found that the amounts of FI of fruit flavor, milk flavor and sweetener group were elevated but only the fruit flavor group's G/F was significantly improved. This indicated that the increase of ADG in the fruit flavor group may be the result of elevated

FI and G/F while the increase of ADG in the milk flavor group was the result of enhanced FI. Contradictory to the fruit flavor and milk flavor, the ADG of sweetener was decreased for the low G/F and the compound flavor decrease was attributed to insufficient FI.

Intake behaviors: As feed flavor affecting FI characteristics, the ADFI of all the treatments were superior to the control throughout the whole period of the results. The speed of FI is defined as the FI per second during the feeding period (Forbes, 2007). According to this definition, the FI per second in the groups with feed flavors were increased compared to the control in the results. It was clearly demonstrated that the addition of flavor could accelerate the speed of FI compared to a control.

The factors affecting FI speed include the intake process, palatability, appetite and others. Auffray and Marcilloux (1983) observed that the speed of FI was affected by the intake process. Moreover, the speed of consumption in a diet with bad palatability was slower than that of regular diet as reported by Brasser *et al.* (2005). Yeomans and Gray (1996) also verified the relationship between speed of FI and palatability by adding Naltrexone into a diet for humans. The results also implied that the accelerated speed of FI was the consequence of ameliorated palatability and enhanced appetite.

Based on the results of the experiment, evidence supports that sweetener can be used to reduce the frequency of FI and increase FI per visit and speed of FI; these results indicated that the main function of sweetener is to ameliorate palatability. Milk flavor increased FI by enhancing the frequency and speed of FI; it indicates that milk flavor works as an attractant in feed. As for fruit flavor, no significant changes were observed about the frequencies of FI compared to the control. However, the speed, duration and FI per visit were increased which led to more FI than the control. This indicates that fruit flavor would ameliorate the palatability of feedstuffs. The compound flavor affected FI by increased FI frequency and speed were observed but the action effect is minute in all flavors. Nevertheless, there are no coordination among fruit flavor, milk flavor and sweetener.

Feed intake behaviors: During the animal production, animal maybe encounter many stresses such as heat, weaning, transport, changing diet, immunity and so on. Stresses would lead to decreased FI and even blocked growing in animals. The results clearly demonstrated that the weighing on day 1 and 8 affected the FI, frequencies and durations of that day as while as affected the following 4 days FI speed and the amount of FI per visit (Fig. 2 and 5). Obviously, weighing is a stress for pigs which has negative effects on the behaviors of FI. It has been reported that stresses are closely related to olfaction; the impact of stresses can be alleviated by providing flavors which are similar to those preferred by animals (Rattaz *et al.*, 2005). The similar relationship between taste and stress also was reported by Pijlman *et al.* (2003) who found that mice under stress preferred benzosulfimide solutions to water. It is presumed that more stresses will be avoided when pigs choose favorite flavors which comfort their psychological and physiological upset. The results also supported this theory as the impact of weighing in groups added with flavor was less than control. Moreover, the speed of FI was increased gradually while the control decreased in days 2-4 after weighing.

It was also a stress for pigs that their basic diet was changed to an experimental diet on the 1st day since the two diets had some differences. Therefore the speed of FI was decreased in days 2-5, however after adding favorite flavors, the speed increased gradually. It also indicated that favorite flavors would alleviate the impact of changing diet stress. In fact, changing of diet is one of the novelty phobias but intake will be enhanced when a familiar flavor is added (Du Toit *et al.*, 1991; Launchbaugh *et al.*, 1997). The similar result was reported by Tien *et al.* (1999) who found that sheep was more easily to accept rice bran with addition grass flavors than rice bran alone. However, the relationship between ingredients and palatability of feed is not clear and the interaction between flavor and raw materials is still unknown.

CONCLUSION

Fruit flavor, milk flavor and sweetener all increased FI by affecting FI speed and FI duration but different flavors mean different reasons for FI improvement. Although, fruit flavor, milk flavor and sweetener resaearch as attractants in feed, the effect of it can be influenced by the FI habit and stresses. The behaviors of FI can be significantly changed by adding flavors but whether hormones are involved in this process needs further research.

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