ON-FARM EXPERIENCE WITH SWINE LIQUID FEEDING: RESEARCH UNIT AT ARKELL SWINE – UNIVERSITY OF GUELPH

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ABSTRACT

The swine liquid feeding system at the University of Guelph has now been operational for about 1½ years. Two unique features of this Big Dutchman liquid feeding system are that a new batch of liquid feed is prepared for each feeding and for individual troughs, and that liquid feed is moved to the feeders using high-pressure air. Since its installation, several adjustments have been made to the system, especially to accommodate the use of dry and high moisture corn, and the functionality of the system has been evaluated. In this short paper these adjustments are described and our practical experiences with the system are summarized. Growth performance and feed efficiency of growing-finishing pigs on the liquid feeding system are at least as good as those achieved on a conventional feeding system where pigs are fed pelleted feed. Growth rate of starter pigs on the liquid feeding system is somewhat lower as compared to conventional dry feeding of pelleted diets, largely because of feed intake restriction.

INTRODUCTION

During the spring of 2004 a liquid feeding system was installed at the Arkell swine research station of the University of Guelph. The system is used to support the research program on swine liquid feeding that was developed in close collaboration with the swine liquid feeding association and that is supported by a number of organizations (www.slfa.ca).

This system was chosen to more closely monitor feed delivery and feed usage in individual troughs. Two unique features of this Big Dutchman liquid feeding system are that a new batch of liquid feed is prepared for each feeding and for individual troughs, and that liquid feed is moved to the feeders using high-pressure air. These features are different from conventional liquid feeding systems that prepare batches of feed for several troughs at one time and that use water or feed to move the feed to the trough. The entire system can be controlled and monitored from a remote computer via a modem or the internet.

In this short paper, practical experiences with the system are outlined.

BRIEF DESCRIPTION OF THE SYSTEM

Figure 1 provides a general overview of the feed kitchen. The system can handle seven dry components and five liquid components. The dry feed components are stored in three large bins or four small 150 kg stainless steel bins. The small bins can be used for low inclusion premixes or complete feeds that are used in small quantities, such as phase I pig starter diets. Liquid components are stored in two 5000 kg tanks or three 2500 kg fermentation tanks.

Figure 1. Overview of feed kitchen of the liquid feeding system at the University of Guelph.

Fermentation tanks are placed on load cells to monitor weight and are equipped with probes to continuously monitor pH (acidity) and temperature of the contents. Each of the liquid components tanks has its own stainless steel stone trap and computer controlled pump. Each of the tanks is fitted with agitators, a washing system and 2 fogging units to enter two different cleaning agents (e.g. acid and base) in the tanks. When we use high moisture corn, it is ground in batches and then moved immediately into the liquid tank where it is stored mixed with water (in a 1 to 2 ratio; about 26% dry matter) and agitated hourly until use. Typically, a new batch of high moisture corn is prepared once a week.

Central to the liquid feeding system is the 80 kg mixing tank (Figure 2). The tank is placed on load cells and receives dry components from the seven short horizontal augers that are placed directly above the mixing tank. The short augers and small feed holding bins above the mixing tank enhance accuracy of dry component delivery to the mixing tank. Liquid components are entered via the top or bottom of the mixing tank. Each liquid component has its own line leading to the mixing tank with computer-controlled valves. Both cold and warm water can be used to prepare the liquid feed. Once the feed components are delivered and the liquid feed is mixed, the mixing tank is sealed and air pressure is then used to move the liquid feed to the troughs through a one-inch (25mm) feed line. A small amount of water is used to rinse out the feed line after each delivery of feed. Feed preparation and delivery is computer controlled and a new batch of feed can be prepared every 2 to 3 minutes. The mixing tank is equipped with a cleaning system, similar to that for the liquid component tanks.

Figure 2. Feed mixing tank of the liquid feeding system at the University of Guelph.

The 24 valves that control the liquid feed to each of 24 feed troughs are positioned in the hallway and outside of the pig rooms. There are two additional valves in the feed line; one valve at the end of the feed line is used to dispose of cleaning water and one valve at the beginning of the line is used for liquid feed sampling. Liquid feed is delivered to two identical rooms, with 12 pigpens each. Each pen can hold 16 starter pigs or 8 grower-finisher pigs. Heat lamps can be used to provide additional heat to young pigs.

Feed troughs (Figure 3) are placed on small concrete pads to correct for the slight slope in the partly slatted floors and can be exchanged to accommodate starter pigs or grower-finisher pigs. Each trough has a sensor to check whether feed is present in the trough prior to feeding. The dimensions of the troughs are provided in Figure 4. Trough width available per pig is 6.5” for starter pigs and 13” for growing-finishing pigs, so that all pigs can eat simultaneously. Special features of this design are the small lips at the top of the trough and the bars inside the trough that are spaced 13” apart for both starter and growing-finishing pigs. The cross-bars inside the trough prevent pigs from lying in the trough and limits (it does not prevent!) the pigs from moving the (stale) feed towards the ends of the trough.

Figure 3. Feed troughs used in the liquid feeding system at the University of Guelph. The height of the concrete pad underneath the feeder varies from 1" on one side to 4'' at the other side to correct for slopes in the floor.

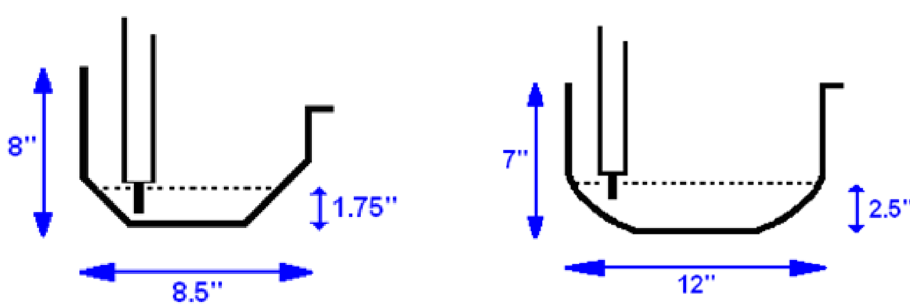
Figure 4. Schematic cross-section of the feed troughs used in the liquid feeding system at the University of Guelph. The dotted horizontal line represents the position of the cross-bars inside the feeders.

WEANER TROUGH

- TOTAL TROUGH LENGTH = 106.5"
- SENSOR HEIGHT = 0.25" to 0.5"
- DISTANCE BETWEEN CROSSBARS = 13"

GROWER/FINISHER TROUGH

- TOTAL TROUGH LENGTH = 106.5"
- SENSOR HEIGHT = 1"
- DISTANCE BETWEEN CROSSBARS = 13"



PRACTICAL EXPERIENCE WITH THE LIQUID FEEDING SYSTEM

General management

After the system was installed, some minor modifications have been made:

- The connection rings and couplers between the agitator gearbox and fiberglass storage tanks had to be reinforced to deal with resistance of agitating more dense liquid mixtures like high moisture corn.
- The diameters of the feed lines between the liquid feed ingredient tank and the stone trap has been reduced (from 3” to 1.5”), as well as the volume of the stone-trap. Given the relative slow speed of moving liquid components, these lines slibbed full with dry matter of the feed ingredients and became plugged, especially when high moisture corn was used.
- For most of the liquid feed ingredients the entrance into the mixing tank has been moved from the bottom to the top of the mixing tank. This has reduced variation in after-flow of liquid components and thus accuracy of feed preparation.
- A pressure reducer was inserted in the water lines, to ensure a constant flow of water into the mixing tank.
- The cold water lines have been insulated with plastic foam in order to reduce water condensation and dripping from the water lines.
- The air exhaust from the mixing tank was changed from a solid PVC pipe to a soft flexible tube. The solid pipe interfered with the load cells and thus accuracy of weighing of components into the mix tank.
- The stirring paddles inside the mixing tank were made heavier (reinforced). Especially when corn was used, some feed was building up in the mixing tank, resulting in the alarm “mixing tank not emptying”.
- The long, grey, solid PVC feed delivery line in the hallway was replaced with a transparent pipeline. This made it easier to identify blockage of the feed line.
- Some of the stators in the pumps at the liquid feed ingredients tank had to be replaced. Apparently (high) moisture corn wears the rubber inside the stators of these pumps down more quickly than other feed ingredients. In hindsight, these worn down stators were the main reason for blockages of lines between the liquid feed ingredient tanks and the mixing tank.

We have had substantial numbers of blockages in the main feed delivery line. We learned quickly that the system can not handle complete pelleted feeds; these problems were alleviated by crumbling the pelleted feed. To eliminate blockages of the feed delivery lines we are now maintaining the water to feed dry matter ratio above 2.6:1. In the future we may explore lowering this ratio and allow a longer soaking time in the mixing tank to reduce the incidence of blockages. Alternatively, the routine use of a more viscous ingredient, such as corn distillers solubles or corn steep water, may better maintain feed homogeneity and reduce blockages. The use of viscous ingredients may reduce the energy cost of moving feed through the system as well.

A series of tests was conducted to check accuracy of feed delivery to individual feed troughs and to establish typical feed intake curves and pig performance levels for this unit and the Arkell pure-bred Yorkshire pig herd. Based on 12 samplings, the actual dry matter content of individual batches of feed was 25.17 ± 1.06% - which was not different from the target value of 25.0% - while the amount of dry matter delivered was always within 5% of the targeted amount.

In terms of cleaning, the feed lines are flushed with about 10 to 30 liters cold water (varying with the number of meals per day) between feeding different diets, which is disposed of in the manure pits. Since we installed the transparent feed delivery pipeline, we have noted that some feed is left in the feed lines after each feeding, which is removed with the flush water. Initially, the mixing tank and the feed lines were cleaned with acids followed by base solutions once a week. Now we only do this between experiments. This change has not resulted in any apparent reductions in feed intake or growth performance of the pigs. We have not noticed any apparent build of mould, yeast or bacteria in the system, but we have not yet tried to quantify these organisms in different segments of the feed lines or in the feeders.

With the trough designs we have had little feed wastage, little fouling of the troughs, nor have pigs been stuck underneath the cross-bars inside the trough. Initially, we did not use the sensors much and adjusted the feeding curves when feed troughs were not emptied within 2 hours after feeding. At that time the feeding level was not changed by more than 10% between subsequent days. More recently, and now that we have established some reasonable feed intake curves, we have started to rely more on sensors to regulate feed delivery. During the first week after weaning and in some pens every 2nd meal may be skipped, meaning that feed can stay in the trough for about 4 hours and that these pigs may only receive three meals on some days. Rarely, however, do we have to remove stale feed from the troughs. When growing pigs are first introduced to the system, they may skip one out of four meals per day for about the first week. For both the starter pigs and grower pigs, the number of skipped meals is minimal after the week, and feed is generally eaten within one hour after feeding. This means that the pigs are not truly fed ad libitum.

Growth performance of growing-finishing pigs

In a growing-finishing pig performance study, conventional dry feeding was compared to liquid dry corn or high moisture corn based diets. There were 8 pens with 8 pigs per pen for each of the three treatments. Liquid fed pigs were fed equal meals four times daily, at 0600, 1000, 1400 and at 1800 h; at feeding all pigs were able to eat simultaneously and trough sensors were used to monitor liquid feed delivery. In the conventional dry feeding system, pigs were fed *ad libitum* from single space feeders. Good growth performance was achieved on all treatments (Table 1). In addition to conventional growth performance, we monitored animal behavior (using video cameras), feed digestibility, fecal excretion of lactic acid producing bacteria (LAB) and coliform bacteria, water usage and aspects of pork meat quality. In this study, we did not observe a growth performance advantage of liquid feeding of grower-finisher pigs. However, feed efficiency was about 5% better when pigs were fed high moisture corn through the liquid feeding system.

Table 1. Impact of feeding strategy on performance of growing-finishing pigs.

	Conventional feeding, dry pelleted feed	Liquid feeding, dry corn	Liquid feeding, high moisture corn
Initial Body weight, kg	23.5	23.7	23.4
Final Body weight, kg	104.7	105.8	104.2
Gain, kg/d	982	1011	1009
Feed:Gain (88% dry matter basis)	2.63	2.64	2.51
Carcass dressing (%)	82.2	80.4	82.5
Carcass lean yield (%)	61.2	60.9	61.0
24 pH loin	5.54	5.56	5.55

Treatment effects on pig behavior were observed, but only after pigs were adjusted to the feeding systems for about 5 weeks (Table 2). Pigs raised on liquid feeding systems spend more time lying and less time nosing other pigs than pigs on the conventional dry feeding system.

Table 2. Impact of feeding strategy on proportion of time (fraction of time ± standard error) that pigs were involved in different behaviors*.

Behavior	Feeding system		P value
	Liquid (n=16 pens)	Dry (n=8 pens)	
Lying	0.829 ± 0.007	0.799± 0.007	0.023
Nosing	0.011 ± 0.002	0.024± 0.003	0.002
Sitting	0.015 ± 0.002	0.022 ± 0.002	0.018
Active	0.040 ± 0.005	0.047 ± 0.007	0.507
Social	0.002 ± 0.001	0.003 ± 0.001	0.316
Fighting	0 ± 0.0002	0 ± 0.0002	0.671
Feeding	0.040 ± 0.003	0.046 ± 0.004	0.149
Drinking	0 ± 0.005	0.003 ± 0.006	<0.001

* Observations were obtained using video camera and about 5 weeks after pigs were assigned to the two different feeding systems.

Newly-weaned piglets

In a starter pig study, we compared (1) a conventional dry feeding program, (2) liquid feeding the conventional dry feeds, and (3) liquid feeding where all whey was removed from the dry feed and replaced with condensed liquid whey permeate on a dry matter basis. Pigs were introduced to the dietary treatments at weaning (17 to 21 days of age; average body weight 5.76 kg) and not fed any in-feed antibiotics in any of the treatments, with 8 pens of 16 pigs per treatment. Of the 8 pens of pigs that received condensed whey permeate, 4 pens received reducing levels of whey permeate (20/10/0 of dry matter during three phases with gradual transition) while 4 pens received a constant level of whey permeate (20% of dry matter). Liquid feeding was computer controlled and based on 6 equal feedings per day (0600, 0900, 1200, 1500, 1800, 2100 h); no feed was delivered when the previous meal was not consumed completely, monitored by sensors in each individual trough. Best performance was observed for dry feeding (Table 3), likely because of feed intake restriction in liquid fed pigs. Among the liquid fed groups, body weight gain was improved when whey permeate was included in the diet (377 vs. 331 g/d during the first 6 weeks post-weaning). Additional analyses are underway to assess pig behavior, nutrient digestibility, gut health, and gut development.

Table 3. Growth performance of newly weaned piglets.

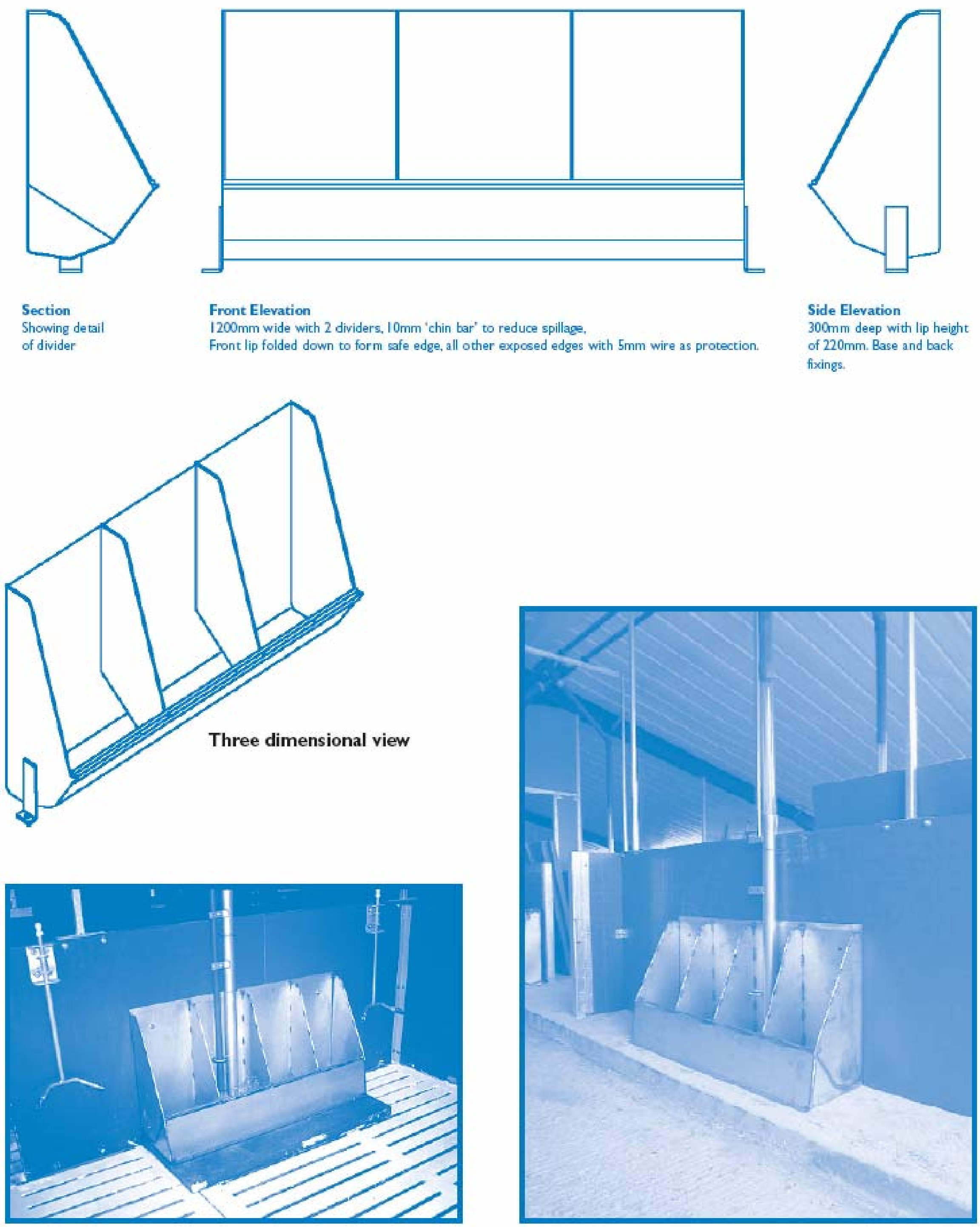
	Conventional feeding dry	Liquid feeding 'dry feed'	Liquid feeding 'condensed whey permeate'	
			Step-down	Constant at 20%
Initial Body weight, kg	5.76	5.76	5.87	5.67
Daily gain, g/d				
Day 0-7	99	87	95	
Day 28-42	616	541	509	616
Day 0-42	399	334	331	377
Feed:gain				
Day 0-42	1.41	1.50	1.53	1.42

CONCLUSIONS AND ADDITIONAL CONSIDERATIONS

During the spring of 2004 a liquid feeding system was installed at the Arkell swine research station of the University of Guelph. The system is used to support the research program on swine liquid feeding that was developed in close collaboration with the swine liquid feeding association and that is supported by a number of organizations. Several adjustments have been made to the system, especially to accommodate the use of dry and high moisture corn. The system was deemed accurate in delivering the intended amounts of feed to individual feed troughs. Growth performance and feed efficiency of growing-finishing pigs on the liquid feeding system are at least as good as those achieved on a conventional feeding system where pigs are fed pelleted feed. Growth rate of starter pigs on the liquid feeding system is somewhat lower as compared to conventional dry feeding of pelleted diets, largely because of feed intake restriction.

The system at the University of Guelph is using long troughs, based on meal feeding and does not allow steeping of mixed feed before feed delivery. This is in contrast to ad libitum feeding systems that use short troughs, such as at the Stotfold pig development unit in the UK. In that system, 20 kg batches of feed are delivered whenever the feed level in the trough is lowered below the sensor. Moreover, liquid feed is prepared in large batches and is allowed to steep in the mixing tank. From midnight to about 2:00 am, no feed is delivered to ensure that the troughs are emptied at least once per day. The design and dimensions of these troughs are given in Figure 4. This system supports growth performance of growing-finishing pigs that is slightly better as compared to a conventional dry feeding system. In these studies, pigs are fed barley and wheat, rather than corn based diets, which may have contributed to the advantage to liquid feeding as well. The Stotfold system has not been used for starter pigs.

Figure 5. Schematic of feeders used in the liquid feeding system for growing-finishing pigs at the Stotfold pig development unit in the UK (www.stotfoldpigs.co.uk/ Courtesy Dr. P. Gill).



Liquid feeding troughs in the fully slatted (left) and straw based (right) buildings with delivery pipes and sensors fitted.