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The efficacy of novel rope flavours as environmental enrichment for stalled gilts

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Abstract

*The objective of this study was to evaluate the use of flavoured ropes as environmental enrichment for individually housed pigs (*Sus scrofa*). A 4 × 4 Latin square experimental design was utilised to evaluate the effects of four rope flavour treatments on 24 individually penned gilts: i) water; ii) salt water solution; iii) sugar water solution; and iv) apple juice. Cotton rope was soaked in the assigned treatment solution for 30 min on day 1 of each treatment. The rope was tied to an overhead bar at 1000h on day 1 and removed at 1900h on day 2. The following day, gilts received a different treatment using the same methodology. Gilts were video-recorded one day before treatments were given (baseline) and throughout the study. The video was analysed for enrichment interaction, eating behaviour, and posture using a 2-min scan sample interval between 0700 and 1900h. The addition of sugar flavour increased enrichment interaction compared to apple and salt flavours but did not differ compared to water treatment. Furthermore, gilts interacted with enrichment 61% more the first day the enrichment flavour treatment was provided compared to the second. Gilts given rope enrichment spent less time lying and more time sitting compared to when no enrichment was provided. The results of this study suggest that while the addition of flavours to cotton ropes caused minor changes in enrichment interaction and behaviour, provision of rope enrichment was beneficial for increasing activity in stalled gilts.*

Keywords: *animal welfare, behaviour, environmental enrichment, feed intake, flavour, pig*

Introduction

Biologically relevant environmental enrichment devices can improve pig (*Sus scrofa*) welfare by providing an outlet for exploratory (van de Weerd *et al* 2003) and play behaviours (Dudink *et al* 2006), decreasing aggression (Dudink *et al* 2006), and inducing positive cognitive bias (Douglas *et al* 2012). Pigs are highly oral-nasal focused and environmental enrichment devices that encourage foraging and chewing are likely valued by pigs (van de Weerd *et al* 2003). Pigs can quickly habituate to environmental enrichment devices (Apple & Craig 1992); therefore, the addition of novel qualities may be beneficial for maintaining interest (van de Weerd *et al* 2003).

In a survey sent to pig welfare scientists, 28% of respondents identified chewable, 14% identified novelty, and 11% identified olfactory/smell as important environmental enrichment properties (Bracke 2006). Cotton ropes can be beneficial for their chewable, changeable, and manipulable properties. However, cotton ropes rank low in smell and novelty qualities compared to other rootable environmental enrichment materials, such as straw, compost and earth (Bracke 2008). While these rootable materials are beneficial for many enriching qualities for the pig (Bracke 2008), they are often not practical for biosecure facility or laboratory settings as they can reduce swine hygiene and health (Scott *et al* 2006) and interfere with manure pits in systems with slatted floors (van de Weerd & Day 2009). Therefore, by adding a novel taste and smell to cotton ropes, the value of this environmental enrichment device to the pig may increase.

Recently, interest in pig flavour preference has grown with research evaluating weaned pig feed intake (Oostindjer *et al* 2010), the use of ropes for oral fluid collection (Kittawornrat *et al* 2010), and wild boar baits (Campbell & Long 2009). However, it is unclear if flavours can be an effective addition to environmental enrichment for maintaining pig interest. While regular rotation of environmental enrichment devices can be time consuming and expensive, the addition of novel flavours to environmental enrichment devices could potentially decrease labour associated with maintaining device novelty.

The objective of this study was to evaluate flavoured ropes as environmental enrichment for individually housed gilts. It was hypothesised that gilts would interact with flavour-enhanced ropes more than ropes soaked in water. Additionally, we hypothesised that gilts with access to flavoured ropes would be more active than when ropes were soaked in water or there was no rope access.

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Figure 1

Individually stalled gilts received a cotton rope soaked in the assigned flavour treatment tied to an overhead bar.

Materials and methods

All experimental procedures were approved by the Iowa State University Animal Care and Use Committee. The experiment was conducted over two weeks in December 2014.

Study animals and housing

Twenty-four crossbred female pigs (gilts; Genetiporc 6.0 × Genetiporc F25 [PIC Inc, Hendersonville, TN, USA]; mean [± SD] bodyweight on testing: 112 [± 13] kg) were individually housed in pens measuring 2.21 × 0.61 m (length × width) within sight and nose-to-nose contact of each other. Pens were located on slatted concrete flooring and contained a water nipple and a single-space feeder. Gilts had been acclimated to this housing for two months before the start of the study. All gilts previously had access to polypropylene ropes as environmental enrichment but had no previous experience with cotton ropes or flavour treatments. All gilts were provided *ad libitum* water and feed that met or exceeded National Research Council (NRC 2012) requirements. Pens were located within one climate-controlled room, set to thermoneutral requirements for this size of pig. An electronic recording device (HOBO Pro v2, temp/RH, U23-001, Onset Computer Corporation, Bourne, MA, USA) was located within the room to record ambient temperature (°C) and relative humidity (%). The mean (± SD) ambient temperature was 18.1 (± 0.4)°C and relative humidity was 69.9 (± 5.8)%.

Experimental design

A 4 × 4 Latin square experimental design was utilised, whereby four treatments were tested across eight days. Four flavour treatments were evaluated one time on each gilt: i) water; ii) salt (NaCl) water solution (10% w/w); iii) sugar (sucrose) water solution (10% w/w); and iv) apple juice (Mott's® Original Apple Juice, Mott's LLP, Plano, TX, USA). Cotton rope (1.2-m long) was soaked in the assigned treatment solution for 30 min on day 1 of each treatment. The rope was tied to an overhead bar at 1000h on day 1 and removed at 1900h on day 2 (see Figure 1). Gilts had no access to any environmental enrichment device after the rope was removed on day 2. The following day, gilts randomly received a different rope treatment using the previously described methodology. For consistency, the day that each treatment was applied will be referred to as day 1, regardless of treatment order.

Data collection

Average daily feed intake (ADFI) was measured by manually weighing all feed provided and weighing the feeders on day 1 (the day that each treatment was applied) and the final day of the study. Gilt behaviours were recorded on eight colour cameras (Panasonic, Model WV-CP-484, Matsushita Co LTD, Kadoma, Japan) that were positioned above the pens. The cameras were fed into a multiplexer using Noldus Portable Lab (Noldus Information Technology, Wageningen, The Netherlands) and time-lapse video was collected onto a computer using HandyAVI (version 4.3, Anderson's AZcendant Software, Tempe, AZ, USA) at 10 frames per second. The video was collected one day before the first treatment was given when gilts had no access to the rope environmental enrichment (baseline), and throughout the two-week study. Video observations were recorded via scan sampling (Dawkins 2007) using Observer software (The Observer XT version 10.5, Noldus Information Technology, Wageningen, The Netherlands) by two trained observers who had intra- and inter-observer reliabilities of ≥ 95%. Oral/nasal contact with the rope (defined as enrichment interaction), eating, standing, sitting and lying behaviours were collected (Table 1). To determine the scan sampling interval, the behaviours of four gilts were analysed over 12 h at 1, 2, 5, and 10-min intervals. The data for 1- and 2-min intervals were highly correlated ($r \geq 0.98$; Table 2). Therefore, all video recordings from this study were analysed using a 2-min scan sampling interval, from 0700–1900h daily. Since the environmental enrichment device was not in the pen on day 1 from 0700–1000h, these data were used to determine whether gilt behaviour returned to baseline before the subsequent treatment was introduced.

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Data analysis

All data were evaluated for normality using the Shapiro-Wilk test and Q-Q plots using SAS (SAS version 9.4, SAS Institute Inc, Cary, NC, USA). Average daily feed intake was normally distributed and, therefore, was analysed using the Mixed Procedure of SAS and the model included the fixed effect of treatment. Behaviour data were not normally distributed; therefore, all behaviour data (including enrichment interaction, eating, standing, sitting and lying) were analysed using the Glimmix procedure of SAS with a beta distribution. To compare baseline behaviour with day 1 behaviour prior to receiving the rope treatment, behaviours (excluding enrichment interaction) were analysed with a model including the fixed effects of the previous day's treatment and a random effect of gilt. To evaluate the effects of both rope flavour treatments and day on behaviour, all behaviours (including enrichment interaction) were also analysed with models including the fixed effects of treatment, day, their interaction, and the random effect of gilt. The enrichment interaction model also included the fixed effect of treatment order. The significance level was fixed at $P \leq 0.05$.

Table 1 **Ethogram of behaviours recorded via 2-min scan sampling.**

Behaviour	Definition
Enrichment interaction	The pig was touching the rope environmental enrichment with its mouth or nose
Eating	The feeder lid was up with the pig's mouth and nose within the feeder
Standing	All four hooves were on the pen floor with limbs extended or the pig was walking with limbs in both extension and flexion
Sitting	The front limbs were extended and bearing weight and the rear limbs and body were in contact with the pen floor
Lying	The pig's body and limbs were in contact with the pen floor

Table 2 **Pearson correlations comparing 1- and 2-min scan sampling intervals for the behaviour results of four gilts.**

Behaviour	Correlation coefficient	*P*-value
Enrichment interaction	0.975	0.02
Eating	0.997	0.003
Standing	0.988	0.01
Sitting	0.999	0.0006
Lying	0.999	0.001

Results

Enrichment interaction

No rope flavour treatment by day interaction was observed ($P = 0.72$). However, rope flavour treatment ($P = 0.02$) and day ($P < 0.0001$) effects were observed. Gilts interacted with sugar more than apple and salt treatments ($P \leq 0.05$). Gilt interaction with the water enrichment treatment did not differ from salt, sugar, or apple enrichment treatments ($P \geq 0.10$; Figure 2[a]). Gilts interacted with the rope enrichment 61% more on day 1 than day 2 ($P < 0.0001$; Figure 2[b]).

Postures and feed intake

Gilt behaviour was evaluated on day 1 prior to introducing the rope enrichment (0700–1000h) to evaluate whether gilt behaviour returned to baseline before receiving a different rope flavour treatment. On day 1 prior to receiving the rope treatments, no rope flavour treatment effects were observed for eating ($F_{4,90} = 2.04$; $P = 0.10$), standing ($F_{4,92} = 2.04$; $P = 0.10$), sitting ($F_{4,79} = 1.72$; $P = 0.15$), or lying ($F_{4,92} = 0.15$; $P = 0.96$).

When gilts had access to rope enrichment, standing and sitting behaviours were affected by treatment ($P \leq 0.001$), but no day or treatment by day effects on standing and sitting behaviour were observed ($P \geq 0.14$). Gilts with water and apple rope enrichment were observed standing more than baseline, salt, or sugar treatments ($P \leq 0.03$). Gilts receiving water, salt, sugar, and apple rope enrichment sat more than baseline ($P < 0.0001$), and sugar treatment sat more than apple rope enrichment ($P \leq 0.02$). Lying behaviour was affected by treatment and day ($P = 0.03$); however, no treatment by day interaction was observed ($P = 0.83$). Gilts with the water, salt, sugar, and apple rope enrichment spent less time lying compared to baseline ($P < 0.0001$), and gilts with salt rope enrichment spent more time lying compared to water treatment ($P = 0.05$; Figure 3[a]). Gilts spent less time lying on day 1 compared to day 2 ($P = 0.03$; Figure 3[b]).

Gilts with water and sugar treatments were observed eating more than baseline ($P \leq 0.03$). However, when comparing all rope enrichment treatments, eating behaviour was not affected by treatment ($P = 0.09$; Figure 3[a]). Eating behaviour was affected by day and a treatment by day interaction was observed ($P \leq 0.05$). Gilts were observed eating less on day 1 compared to day 2 ($P = 0.05$; Figure 3[b]). On day 1, water and sugar treatments were observed eating less compared to day 2 ($P \leq 0.04$); however, baseline, salt, and apple treatments did not differ between day 1 and 2 ($P \geq 0.08$). No rope enrichment treatment differences were observed in ADFI (Baseline = 3.3 kg per day, water = 3.4 kg per day, salt = 3.4 kg per day, sugar = 3.5 kg per day, apple = 3.5 kg per day, SEM = 0.17; $F_{4,92} = 0.38$; $P = 0.82$).

Discussion

Abnormal behaviours, such as stereotypies, can be a problem in pigs housed in unstimulating environments which are commonly used for pigs in conventional production and research facilities. Thus, environmental enrichment can improve pig welfare by providing an outlet for exploratory behaviour (Fraser 1975). In the current study, sweet flavours were added to rope environmental enrich-

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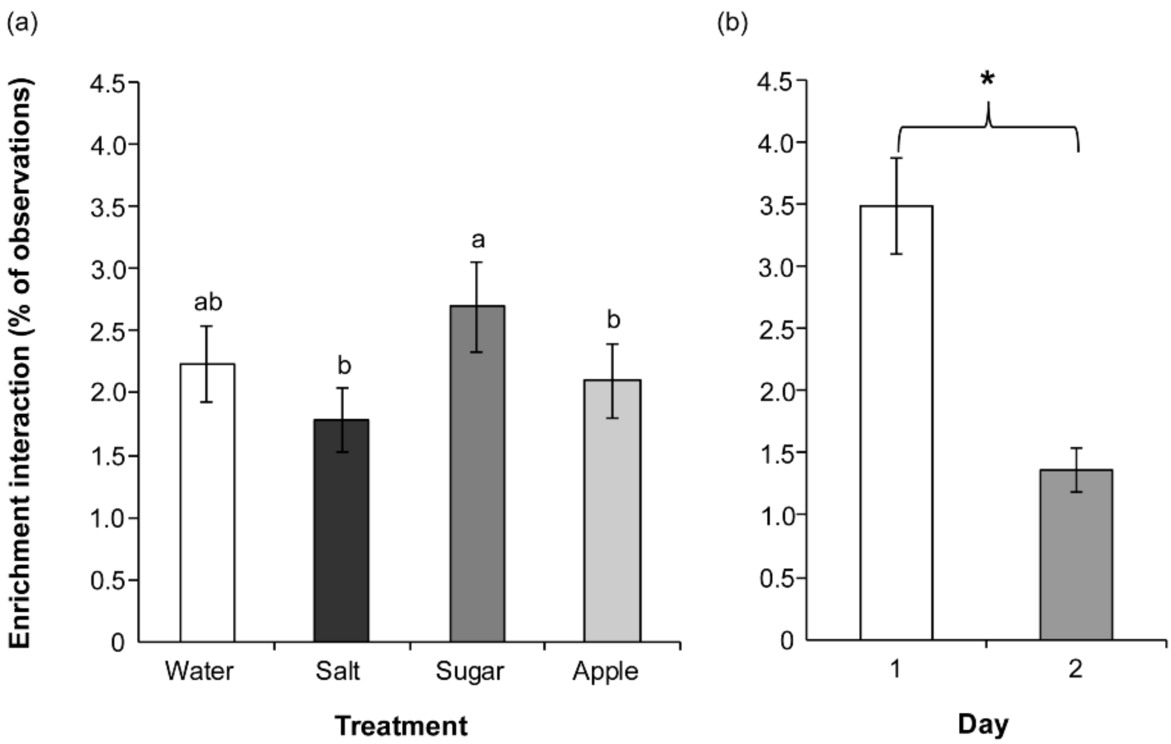
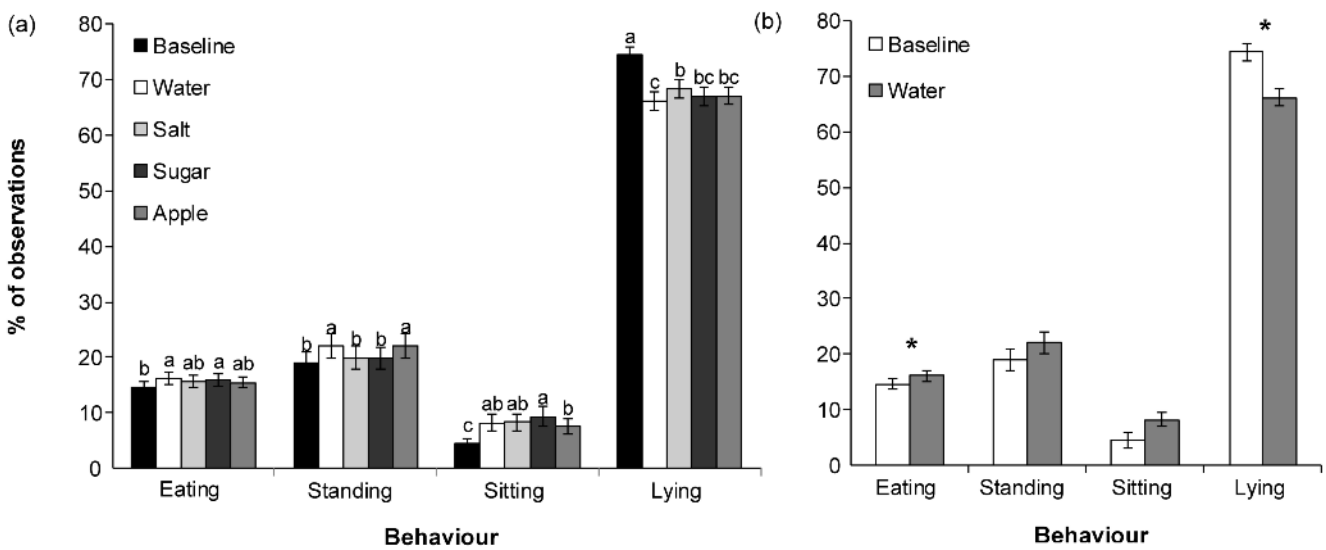
Figure 2



Percentage of 2-min scan samples of individually housed gilts (n = 24 per treatment) interacting with rope environmental enrichment soaked in different flavour solutions for (a) the day of rope enrichment introduction into the pen (day 1) or (b) the day after (day 2). Different superscripts indicate significance at $P \leq 0.05$; * indicates significance at $P < 0.0001$.

Figure 3



Percentage of 2-min scan samples of individually housed gilts (n = 24 per treatment) eating, standing, sitting, or lying when given no environmental enrichment (baseline) or rope environmental enrichment soaked in different flavour solutions for (a) the day of (day 1) rope enrichment introduction into the pen or (b) the day after (day 2). Different superscripts and * indicate significance at $P \leq 0.05$.

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ment based on previous research reporting a strong preference for sweet flavours in pigs (McLaughlin *et al* 1983). As salt and sweet flavours are perceived in mammals via different transduction mechanisms, salt was chosen as a contrasting flavour (Bachmanov *et al* 2014).

In the current study, gilts interacted with ropes treated with the sugar solution more than ropes treated with apple juice and the salt solution; however, interaction with none of the treatments differed from ropes treated with water. Increased interaction with sweet-flavoured ropes was expected as McLaughlin and colleagues (1983) identified that sweet is one of the flavours most preferred by pigs. Additionally, Kare and colleagues (1965) found that young pigs preferred sucrose to glucose and lactose and preferred all three sugars over water. However, no difference in interaction with any of the rope flavours compared to water was observed in the current study. These results agree with a study investigating pig chewing preferences on blood, water, and salt-treated ropes; where interest in water and salt rope treatments did not differ (Jankevicius & Widowski 2003).

All rope enrichment treatments reduced time spent lying and increased time spent sitting compared to baseline. Increased lying behaviour is often observed in individually (Gonyou *et al* 1992) and barren-housed pigs (Guy *et al* 2002), likely due to lack of environmental stimulation. Additionally, sitting is considered an inactive, abnormal behaviour that may suggest apathy in pigs (Ruiterkamp 1987). However, in the current study, pigs were able to reach the rope enrichment while sitting and therefore were often observed sitting while interacting with the rope enrichment. An increase in time spent sitting in this study may, therefore, be due to the lack of space in the stall, conservation of energy, or an increase in comfort while interacting with the rope enrichment and likely does not suggest a decrease in pig welfare.

Gilts with ropes soaked in water and apple juice were observed standing more than baseline, salt or sugar solution rope flavours. The increased standing behaviour in gilts given ropes soaked in apple juice is interesting as they were observed interacting with the rope less than sugar solution treatments, which did not alter standing behaviour compared to baseline. This result highlights that even less effective environmental enrichment can still modify pig behaviour. Standing behaviour is often decreased in individual compared to group-housed pigs (Gonyou *et al* 1992). This decreased activity level can have negative consequences on pig welfare by reducing bone strength and muscle weight (Marchant & Broom 1996; Schenck *et al* 2008). Therefore, the increased activity of gilts with access to rope enrichment may benefit pig welfare in addition to increasing exploratory behaviour (Dudink *et al* 2006).

Gilts with ropes treated with water and sugar solution were observed eating more than baseline; however, this did not translate to a difference in ADFI. Due to the short duration of time pigs spent with each rope treatment, average daily gain and feed efficiency were not measured. The observed change in feeding behaviour could alter average daily gain and feed efficiency (Colpoys *et al* 2016); therefore, this should be evaluated before this type of enrichment is given to pigs used in research where performance is a parameter of interest.

Gilts interacted with the rope enrichment less on day 2 compared to day 1. Gilts also spent more time lying and eating on day 2 compared to day 1. This is in accordance with Colpoys and colleagues (2016) who observed that gilts which interacted with rope environmental enrichment for a longer duration of time tended to have a lower ADFI. This may be due to oral investigation of environmental enrichment serving as a mechanism for reducing hunger or redirected foraging behaviour (Colpoys *et al* 2016). Overall, these behavioural differences suggest that gilts were not as interested in rope enrichment on day 2 as they were on day 1. This agrees with Apple and Craig (1992) who observed that pigs rapidly habituate to environmental enrichment. Study methodology may also impact rope enrichment interaction differences between days 1 and 2. As ropes were not re-soaked in the flavouring on day 2, flavour concentrations likely decreased by being saturated with saliva and resulted in reduced interest. Young and colleagues (1994) noted that environmental enrichment should reinforce interaction; therefore, this may explain why interest in the ropes decreased on day 2. Future work investigating environmental enrichment devices that secrete a consistent or increasing amount of flavour would be beneficial. Additionally, since comparisons between days were only made across times that the gilts had access to rope enrichment, diurnal patterns of behaviour could have impacted the observed day differences in swine behaviour.

Animal welfare implications and conclusion

Provision of biologically relevant environmental enrichment is important for improving pig welfare. The results of this study suggest that the addition of rope enrichment increased active behaviours, such as sitting and standing, of stalled gilts. Furthermore, the addition of sugar flavour increased enrichment interaction compared to apple and salt flavours but did not differ compared to water treatment. Therefore, while the addition of flavours to cotton ropes resulted in minor changes in enrichment interaction and behaviour, provision of rope enrichment was beneficial for increasing activity in stalled gilts.

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