

Behavioral Characteristics of Pigs Fed with *Opuntia robusta*

Fabiola Mendez-Llorente, PhD

Jairo Iván Aguilera-Soto, PhD

Pedro Hernández-Briano, MS

Octavio Carrillo-Muro, PhD

Carlos Aurelio Medina-Flores, PhD

Romana Melba Rincón-Delgado, PhD

Marco Antonio López-Carlos, PhD*

Academic Unit of Veterinary Medicine and Zootechnics,
Autonomous University of Zacatecas, Zacatecas, Mexico.

* Corresponding author: Marco Antonio López-Carlos.
Panamerican Highway km 31.5 Zaca-tecas-Fresnillo section.
El Cordovel, Gral. Enrique Estrada, Zacatecas, México; Tel. +524789851255,
e-mail: lopcarmarco@uaz.edu.mx

KEY WORDS: behavior, fattening,
Opuntia, pigs.

ABSTRACT

Swine feeding systems based on grains and oilseeds have a limited use for small and medium pig farmers. Therefore, it is important to evaluate unconventional sources of food, which also provide greater wellbeing and better behavior in animals. The present study was carried out with the objective of evaluating the behavioral characteristics of pigs fed with different levels of *Opuntia robusta* (OR). Sixty Landrace × Duroc castrated male pigs of 115 ± 4 d of age and 64.7 ± 5.2 kg of live weight were housed randomly in 12 pens (five animals per pen), and subsequently assigning three pens to one of four treatment groups, consisting of the inclusion of 0%, 5%, 10%, or 15% of OR in the diet on a DM basis. The feeding period lasted 130 d in total. The behavior of the pigs was recorded on video during 6 d (from day 100 to 106 of the feeding

period). The data analysis were performed using the GLM procedure of the SAS statistical software. Pigs fed with OR showed a greater ($P < 0.05$) percentage of time lying compared with the control group (72.5 vs. 70.8% respectively), without difference ($P > 0.05$) in the time occupied in the sitting position. Regarding the time they were active, the animals fed diets that included OR, ate during more ($P < 0.05$) time (78 vs. 71% of the control group) and fought less (2.7% vs. 16.9%) than the animals of the control group. It is concluded that the inclusion of 5 to 15% of OR in diets improves the behavioral indicators of fattening pigs. The results of this study contribute to the development of alternatives to improve the behavior and welfare of the pigs confined to intensive fattening.

INTRODUCTION

There are 104 species of the genus *Opuntia*, which are abundant and widely distributed in arid and semi-arid areas throughout the

Table 1. Behavioral characteristics of pigs fed diets with different levels of *Opuntia robusta*.

Behavior	Level of OR in diet (in DM basis)				SEM	P-value
	0%	5%	10%	15%		
Postural						
Lying	70.8 ^b	72.0 ^a	72.6 ^a	72.4 ^a	1.7	0.03
Sitting	4.8	4.3	4.4	4.5	0.6	0.2
Standing	24.4 ^a	23.7 ^b	23.0 ^b	23.1 ^b	1.5	0.2
Active						
Eating	70.9 ^c	75.5 ^b	76.5 ^b	82.8 ^a	1.9	0.01
Drinking	7.1 ^b	12.6 ^a	11.9 ^a	6.6 ^b	1.1	0.01
Chewing	0.0 ^b	0.4 ^b	2.6 ^a	2.8 ^a	0.1	0.01
Fighting	16.9 ^a	3.7 ^b	1.8 ^b	2.6 ^b	0.8	0.01
Socializing	3.7	6.8	5.0	4.2	1.1	0.01

¹ Percentage of time shown in each behavior.

SEM = standard error of the mean.

^{ab} Different literals within the same row indicate significant differences between treatments ($P < 0.05$).

Americas. Sixty percent are found in the Chihuahua desert. The most important species used as a forage source are *Opuntia leucotricha*, *O. streptacantha*, *O. robusta*, *O. cantabrigiensis*, *O. rastrera* and *O. lindheimeri*. However, is widely distributed, resistant to drought, high productivity and has few spicules (Elizondo *et al.*, 1987). In Mexico, *Opuntia* cladodes are traditionally used as emergency food for livestock, especially during drought periods.

Traditional swine feeding systems based on oilseed and grains, and are expensive for small and medium pig farmers, so it is important to evaluate unconventional sources of food. One of the strategies to identify possible ingredients is to observe the eating habits pigs in free life. Taylor and Hellgren (1997) mention that *Opuntias* are an important part of the diet of feral pigs throughout the year. The domestic pig evolved from the omnivorous wild boar and has retained many natural foraging behaviour patterns (Edwards, 2003). In addition, roughage intake can be beneficial to pig welfare, with bulky diets promoting satiety when food intake is limited, promoting a desirable gut microflora profile, and reducing prevalence of gastric ulceration (Edwards, 2005). However, trials feeding cactus to pigs have

been scarcely conducted (Felker, 2001).

Therefore, the objective of the study was to evaluate the behavioral parameters of swine fed on diets with different levels of *Opuntia robusta* cladodes.

MATERIALS AND METHODS

Sixty Landrace × Duroc castrated male pigs of 115 ± 4 d of age and 64.7 ± 5.2 kg of weight were randomly housed in 12 pens (five pigs per pen). Pens were randomly assigned (three pens per treatment) to one of four treatment groups, consisting of the inclusion of 0%, 5% 10% or 15% of OR in the diet on a dry matter basis

The OR cladodes were harvested from plants located in the municipality of Guadalupe, Zacatecas (22.70 N latitude and -102.50 W longitude). The thorns were removed with aid of butane gas burner and the cladodes were crushed in an electric helical chopper, and then mixed in the basal diet. The feeding period was 130 d. The basal diet was formulated according to recommended nutrient requirements (NRC, 2012).

The basal diet (16.3% CP and 3.33 Mcal/kg ME on a DM basis) consisted of corn grain, soybean meal, L-Lysine-HCl, vitamin, and mineral premix, and was offered ad libitum in two daily meals at 8:30 and

16:00 h, calculating a rejection of 5% according to the previous day consumption. During the days 100 to 106 of the feeding period, the activity and behavior of the pigs in each pen was recorded through the use of video cameras. Each pig was marked with paint on the back for easy identification. The type and duration of postural behaviors (lying, sitting, standing) and active behavior (eating, drinking, fighting, chewing and socializing) similarly to the methodology proposed by Holt *et al.* (2006).

Data analyzes were performed using the SAS University Edition statistical software (SAS Institute Inc., Cary, NC). Data were analyzed as a complete randomized design using the GLM procedure. Pen served as the experimental unit. Means were compared with the Tukey multiple comparison test (Steel and Torrie, 1980) at a significance level of $P < 0.05$.

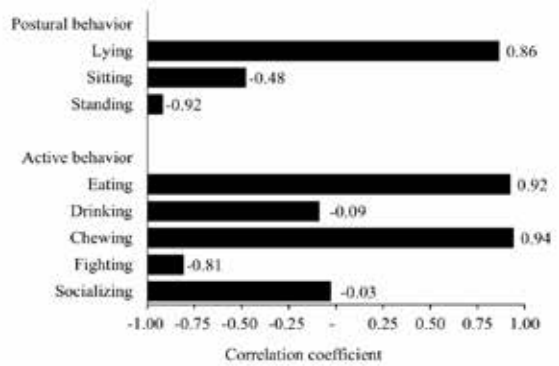
RESULTS

Table 1 shows the percentage of time used in the posture behaviors and the activity of pigs fed diets with different levels of OR, while Figure 1 shows the correlation coefficients between the percentage of time shown in each behavior and the level of OR in the diet.

Pigs feed OR in diet spent more ($P < 0.05$) time lying down, and consequently less time standing than the animals with the control diet. However, the percentage of time sitting was similar ($P > 0.05$) among treatments, spending an average of 4.5% of the time in this position. In addition, high correlation coefficients were observed between the inclusion level of OR in the diet, being positive for the percentage of time lying (0.86) and negative for the time of standing position (-0.92).

In relation to the active behaviors, the percentage of time eating was greater ($P < 0.01$) in pigs fed diets containing OR. The

Figure 1. Correlation coefficients between the percentages of time shown a specific behavior and the level of *Opuntia robusta* (OR) in the diet of fattening pigs. The pigs consumed 0, 50, 100 or 150 g of OR kg⁻¹ BS in diet.



eating behavior showed a positive correlation (0.92) with the amount of OR in the diet. In addition, the percentage of time that pigs spent drinking water was greater ($P < 0.01$) when pigs consumed 5 and 10% of OR in diet. The pigs fed diets that included 10 and 15% of OR showed a greater ($P < 0.05$) time chewing compared to pigs fed diets with 0 and 5% of OR, showing additionally a strong and positive correlation (0.94) between these variables. The time that the pigs spent socializing was similar ($P > 0.05$) between treatments with a general average of 5.2%, while the percentage of time spent on fighting was greater ($P < 0.05$) in pigs that did not consume OR, observing less time in fights (-0.81) when increasing the level of OR in the diet.

DISCUSSION

The results of this study agree with the study of Ramonet *et al.* (1999) who observed that increasing the fiber level in the ration of breeding sows reduced standing activity and non-feeding oral behavior, but in contrast Holt *et al.* (2006) reported lower time lying in gestated sows fed a diet high in fiber.

The results of the present study reflect an improvement in postural behavior when including OR in the diet because the position of lying or "at rest" is associated with positive and calm behaviors (Barnett *et al.*,

1984; Bulnes *et al.*, 2017). In addition, the greater time in stand-ing position is negatively associated with productive parameters such as weight gain (Colpoys *et al.*, 2016). Furthermore, the increased time spent eating is desirable, since according to Colpoys *et al.* (2016) the time used in eating is positively related to the productivity of the pigs.

Pigs diets that included 5% and 10% of OR, drank for longer time than pigs fed diets with 0% or 15% of OR. The above agrees with that reported by Tegegne *et al.* (2007) in sheep, Carvalho *et al.* (2005), in dairy cattle, and Vieira *et al.* (2008) in goats.

Much of the content of the dry matter of Opuntias are minerals, which could explain the increase in water consumption. In this sense, Seynaeve *et al.* (1996) mentions that a higher concentration of minerals increases the consumption of water because the body needs to eliminate this excess through urine.

The greater ($P < 0.05$) time chewing when including 10 and 15% of OR could be related to the higher fiber content in this diets. In this sense, Holt *et al.* (2006) did not report significant differences between the fiber level of the diet and the mastication time, in contrast with that reported by Ramonet *et al.* (2000), who obtained a lower chewing behavior in sows fed with high fiber levels. However, these animals were fed in a restricted manner.

It has been shown that physical activity decreases as fiber levels increase in the diet of fattening (Scharma *et al.*, 1998) or breeding (Rijnen *et al.*, 2003b) pigs. The energy expenditure due to physical activity is reduced up to 24% in pigs fed diets with beet silage (Scharma *et al.*, 1996), which could be due to:

- the altered intestinal fermentation
- the gradual availability of energy of the ration during the day
- the feeling of satiety caused by the ballast effect or filling of the gastrointestinal tract, and/or
- the effects related to the fiber composition of the diet ingredients.

CONCLUSION

It is concluded that the inclusion of 5 to 15% of OR in the diets improves the behavioral indicators of fattening pigs. The results of this study contribute to the development of alternatives to improve the behavior and welfare of the pigs confined in intensive fattening.

STATEMENT OF AUTHORSHIP

The authors hereby certify that all work contained in this article is original. The authors claim full responsibility for the contents of the article.

CONFLICT OF INTERESTS

The authors confirm that they do not have any conflict of interest

REFERENCES

1. Barnett, J. L., Cronin, G. M., Winfield, C. G., Dewar, A. M. (1984). The welfare of adult pigs: the effects of five housing treatments on behaviour, plasma corticosteroids and injuries. *Applied Animal Behaviour Science*, 12(3), 209-232.
2. Bulens, A., Van Beirendonck, S., Van Thielen, J., Buys, N., Driessen, B. (2017). A two-level pen for fattening pigs: Effects on behavior, performance, and postslaughter measurements. *Journal of Animal Science*, 95(2), 616-625.
3. Carvalho, C.C., Ferreira, M.A., Calvalcanti, C.V.A. (2005). Efeito da substituição do feno de capim Tifton (Cynodon spp) por palma forrageira (Opuntia Ficus indica Mill) sobre o comportamento ingestivo de vacas em Holandesas em lactação. *Acta Scientiarum*, 27:505-512.
4. Colpoys, J. D., Johnson, A. K., Gabler, N. K. (2016). Daily feeding regimen impacts pig growth and behavior. *Physiology & behavior*, 159, 27-32.
5. Edwards, S. A. (2003). Intake of nutrients from pasture by pigs. *Proceedings of the Nutrition Society*, 62(2), 257-265.
6. Edwards, S. A. (2005). Product quality attributes associated with outdoor pig production. *Livestock Production Science*, 94(1), 5-14.
7. Elizondo, E.J., López, J.J., Dueñez A., G.J. (1987). El Género Opuntia (Tournefort) Miller y su Distribución en el Estado de Coahuila. 2a Reunión Nacional sobre el Conocimiento y Aprovechamiento del Nopal. Jardín Botánico del Instituto del Biología, UNAM, México.
8. Felker, P. (2001). Utilization of Opuntia for forage in the United States of America. *FAO Plant Production and Protection Papers*, 51-56.
9. Holt, J. P., Johnston, L. J., Baidoo, S. K., Shurson, G. C. (2006). Effects of a high-fiber diet and frequent feeding on behavior, reproductive performance, and nutrient digestibility in gestating sows. *J. Anim. Sci.* 84: 946-955.

10. NRC. National Research Council. 2012. Nutrient Requirements of Swine. 11th Revised edition. The National Academies Press. Washington DC., USA., pp. 210-236..
11. Ramonet, Y., Meunier-Salaun, M.C., Dourmad, J.Y. (1999). High-fiber diets in pregnant sows: digestive utilization and effects on the behavior of the animals. *J. Anim. Sci.* 77: 591-599.
12. Rijnen, M.M.J.A., Verstegen, M.W.A., Heetkamp M.J.W., Schrama, J.W. (2003a) Effects of two different dietary fermentable carbohydrates on activity and heat production in group-housed growing pigs. *J. Anim. Sci.* 81: 1210-1219.
13. Rijnen, M.M.J.A., Verstegen, M.W.A., Heetkamp M.J.W., Schrama, J.W. (2003b) Effects of dietary fermentable carbohydrates on behavior and heat production in group-housed sows. *J. Anim. Sci.* 81: 182-190.
14. Santos M.V.F. dos, Lira M.A., Farias I., (1990). Estuo do comportamento das cultivares de palma forrageira gigante redonda (*Opuntia ficus-indica*) e miúda (*Nopalea cochellinifera*) na producao de leite. *Rev. Soc. Bras. Zoot.* 19:504-511.
15. SAS, (2000). SAS/STAT® User's Guide Version 8.1 Edition. SAS Inst. Inc., Cary, NC, USA.
16. Schrama, J.W., Bosch, M.W., Verstegen, M.W., Vorselaars, A.H., Haaksma, J. and Heet-kamp, M.J. (1998). The energetic value of nonstarch polysaccharides in relation to physical activity in group-housed, growing pigs. *J. Anim. Sci.* 76: 3016-3023.
17. Schrama, J.W., Verstegen, M.W., Verboeket, P.H., Schutte, J.B., Haaksma, J. (1996). En-ergy metabolism in relation to physical activity in growing pigs as affected by type of die-tary carbohydrate. *J. Anim. Sci.* 74: 2220-2225.
18. Seynaeve, M., De Wilde, R., Janssens, G., De Smet, B. (1996). The influence of dietary salt level on water consumption, farrowing, and reproductive performance of lactating sows. *J. Anim. Sci.* 74:1047-1055.
19. Steel, R.G. and Torrie, J.H. (1980). Principles and procedures of statistics. 2nd ed. McGraw-Hill Book Co., New York, NY. pp. 107-133.
20. Taylor, R. B. and Helligren, E. C. (1997). Diet of feral hogs in the western South Texas Plains. *The Southwestern Naturalist*, 33-39.
21. Tegegne, F., Kijora, C. and Peters, K.J. 2007. Study on the optimal level of cactus pear (*Opuntia ficus-indica*) supplementation to sheep and its contribution as source of water. *Small Rumin. Res.*, 72: 157-164.
22. Tegegne, F., Peters, K.J., Kijora, C. (2005). Cactus pear (*Opuntia ficus indica*): a strategic crop in combating food and feed insecurity and desertification in Tigray, northern Ethiopia. *Proc. Sco. Nutr. Physiol.* 14: 60-73.
23. Vieira, E. L., Batista, Â., Guim, A., Carvalho, F. F., Nascimento, A. C., Araújo, R. F. S., Mustafa, A. F. (2008). Effects of hay inclusion on intake, in vivo nutrient utilization and ruminal fermentation of goats fed spineless cactus (*Opuntia ficus-indica* Mill) based diets. *Anim. Feed Sci. Tech.* 141:199-208.