



Effect of wet feeding of finishing pigs on production performance, carcass composition and meat quality



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Abstract:

The objective of the study was to evaluate the effect of feeding finishing pigs with a wet diet (feed:water, 1:1), *versus* a dry diet based on sorghum and soybean meal (15.0% CP, 3,200 kcal ME/kg DM), on the productive behavior, carcass composition and meat quality. Sixteen (York-Landrace x Duroc) crossbred pigs weighing 68.4 ± 2.4 kg were individually housed and assigned to two treatments (n= 8 replicates per treatment): DF, dry feed; WF, wet feed. Feed was offered daily in two equal portions (0800 and 1500 h) for 5 wk. Individual live weight (LW) and feed consumption were recorded every week in order to calculate the daily

weight gain (DWG) and feed efficiency (FE). The carcass composition was measured; the meat quality was assessed in samples of *Longissimus dorsi*. Wet-fed pigs had higher ($P<0.05$), final LW (108.4 vs 101.9 kg), and DWG (1.043 vs. 0.990 kg/day) than dry-fed pigs. DF pigs had lower intake (wk 5) and feed efficiency (FE) (by wk 3) than WF pigs (Treatment x Week Interaction, $P<0.05$). WF pigs had greater leg and hot and cold carcass weights ($P<0.05$). The weight of the loin, ribs, and shoulder, and the protein content, water holding capacity, and pH of meat were similar ($P>0.05$) between treatments. The hardness, adhesiveness, chewiness, and toughness values were lower ($P<0.05$) in meat from WF pigs. In conclusion, the wet-fed pigs had better productive performance, carcass composition and meat characteristics than the dry-fed pigs.

Key words: Wet feed, Dry feed, Finishing pigs, Carcass measurement.

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Introduction

Correct feeding management is important to improve animal welfare, growth efficiency and production data of pigs. One possibility to improve feeding systems for pigs is to mix dry feed with water (proportions between 1:1.0 and 1.5)⁽¹⁾. Wet feeding has been shown to reduce stress in the transition from liquid to solid diet of weaned piglets^(1,2,3); this may have beneficial effects such as reducing the use of antibiotics in current production systems^(4,5). In addition, wet feed improves water and feed intake^(3,6), as well as nutrient supply, in growing-finishing pigs⁽⁷⁾, compared to dry feed, potentially favoring the productive performance⁽⁴⁾ without affecting the fat content and carcass quality of the pigs^(1,5).

Sensory characteristics, such as tenderness, color, and marbling are important in determining the quality and consumer approval of beef⁽⁸⁾, chicken⁽⁹⁾, rabbit⁽¹⁰⁾, and pork^(11,12). These improvements may be greater in regions where the ambient temperature exceeds the pigs' thermoneutral (comfort) zone. However, information on the effect of wet feed on intensive pork production systems in hot areas like northern Mexico is scarce. Therefore, the objective of the present study was to determine the effect of sorghum and soybean meal based wet feed on the growth rate and efficiency, productive behavior, carcass composition and meat quality of finishing pigs. The hypothesis of the present study was that the feed intake and utilization of pigs under these climatic conditions might be improved by a wet diet.

Material and methods

The pigs used in this research were cared for in accordance with the guidelines established in the Mexican Official Animal Care Standard (Norma Oficial Mexicana para el Cuidado de Animales)⁽¹³⁾. The study was conducted at the Swine Experimental Station of the Marín Academic Unit of the Agronomy Department of the Autonomous University of Nuevo León, located in Marín, N.L., Mexico. Sixteen pigs (8 females and 8 castrated males; experimental units) of the York-Landrace x Duroc terminal cross with an initial live weight of 68.4 ± 2.4 kg were used. The animals were housed individually in pens with concrete floors (1.4 m²), equipped with stainless steel drinking troughs and plastic feeders. The pigs were randomly assigned by sex to each of the two treatments: WF, wet feed at a ratio of 1:1 (diet:water), and DF, dry feed. The diet offered to the pigs was based on ground sorghum grain, soybean meal, and a vitamin and mineral premix, formulated with 3,200 kcal ME/kg and 15% crude protein, in order to meet or exceed the nutritional requirements of pigs in the 50 to 120 kg weight range, NRC⁽⁷⁾.

Experimental procedure

During the experimental period, the minimum and maximum ambient temperature was recorded daily at the pen level, using a digital thermometer (STEREN®, model TER-100, China). The adaptation period to the pens and feeds was one week, followed by a 5-wk trial period. The live weight of the pigs was recorded weekly in order to calculate the average daily weight gain (ADWG). The offered and refused feed was recorded daily in order to calculate weekly daily feed intake (DFI) and the gain/consumption ratio (feed efficiency = FE).

At the end of the experiment, all pigs were slaughtered in a TIF (Federal Inspection Type) slaughterhouse. The hot carcass (HC) and cold carcass (CC; 24 h post-slaughter, 2 °C) weights were recorded. The length of the carcass was measured by recording the distance (cm) between the 6th cervical vertebra and the hip bone⁽¹¹⁾; the weights of the primary carcass cuts were recorded: leg, shoulder, loin and ribs according to the Mexican Standard for Livestock Products (Norma Mexicana de Productos Pecuarios)⁽¹⁴⁾.

Meat laboratory analysis

After 24 h post mortem, the pH, color and water holding capacity (WHC, %) of the *Longissimus dorsi* (LD) muscle were determined in quadruplicate for each sample⁽¹¹⁾. In the present study, the muscle pH was determined by directly inserting the electrode of a puncture potentiometer (Orion 3 star Thermo Fisher Scientific, USA).

In order to evaluate the quality of the meat, a sample of LD muscle was taken from between the 10th and 12th rib, and was stored at -20 °C until analysis. Its color was analyzed with a colorimeter (Minolta Chroma Meter 2002, Konica Minolta Holdings, Inc., Tokyo, Japan), and the values were expressed according to the CIE System (B*, a* and b*). The WHC was determined by the compression method previously described⁽¹⁵⁾.

The shear force (SF) was measured on four rectangles (4x2x2 cm) of each LD sample, with cuts parallel to the direction of the muscle fibers, using a texturometer (TA.XT2i Stable Micro Systems Serrey, England) equipped with a Warner-Bratzler knife. The shear conditions were speed of 2 mms⁻¹ in the pre-test, 2 mms⁻¹ in the test, 10 mms⁻¹ in the post-test, at a distance of 30 mm⁽¹⁶⁾.

The texture profile analysis (TPA) of the LD samples was performed with a texturometer (TA.XT2i Stable Micro Systems Serrey, England), using four standardized cubes of 2 cm for each sample, which were obtained perpendicular to the direction of the muscle fibers. A cylindrical piston was used to compress the sample to 60 % of the original height during two compression cycles with a time interval of 5 sec between them. Force-time stress-strain curves were obtained based on the established velocity conditions: 1.0 mms⁻¹ (pre-test); 5.0 mms⁻¹ (test), and 5.0 mms⁻¹ (post-test).

Values for hardness (g), adhesiveness (g/sec), elasticity (mm), cohesiveness, gumminess (g), chewiness (g mm), and toughness were obtained according to previous reports^(17,18). All meat samples were analyzed for protein content using the AOAC Method 990.03⁽¹⁹⁾.

Economic analysis

The income from animal growth was calculated considering a live pig price of \$32.00 MN/kg, multiplied by the respective weight gain of each animal. The feed cost was calculated considering the price of the feed for both treatments (\$ 5.90 MN/kg), multiplied by the respective consumption of each animal. These two variables were used to calculate the difference in income for growth, minus the cost of food. Live hog prices and feed cost were

obtained with August-September 2018 base prices published by the Confederation of Mexican Swine Farmers (Confederación de Porcicultores de México)⁽²⁰⁾ and Mexico's National Market Information and Integration System (Sistema Nacional de Información e Integración de Mercados de México)⁽²¹⁾.

Statistical analysis

The data were analyzed under a randomized complete block design using the SPSS statistical package version 22 (Version 2013. IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY: IBM Corp.). The data are presented as means, and the significant differences ($P<0.05$) were determined by Tukey's test.

Results

The ambient temperature during the experiment ranged from a minimum of 9.1 °C to a maximum of 35.3 °C, with an average of 27.3 °C during the study. Table 1 shows the results of productive behavior after five experimental weeks. The live weight of wet-fed pigs was higher ($P<0.01$) at the end of weeks 4 and 5, and during the entire study, compared to dry-fed pigs. Differences in live weight between treatments became more pronounced over the experimental weeks ($P<0.01$). Although the ADWG was not statistically different in each of the weeks, it was statistically different overall in pigs fed the wet diet ($P<0.01$; Figure 1). The ADFI was lower at wk 1 and higher at wk 5 when offered wet feed ($P<0.01$), but it was not different throughout the entire study ($P>0.10$). The variable FE ($P<0.05$) was better with wet feed in weeks 1 and 3 (Figure 2), and throughout the study.

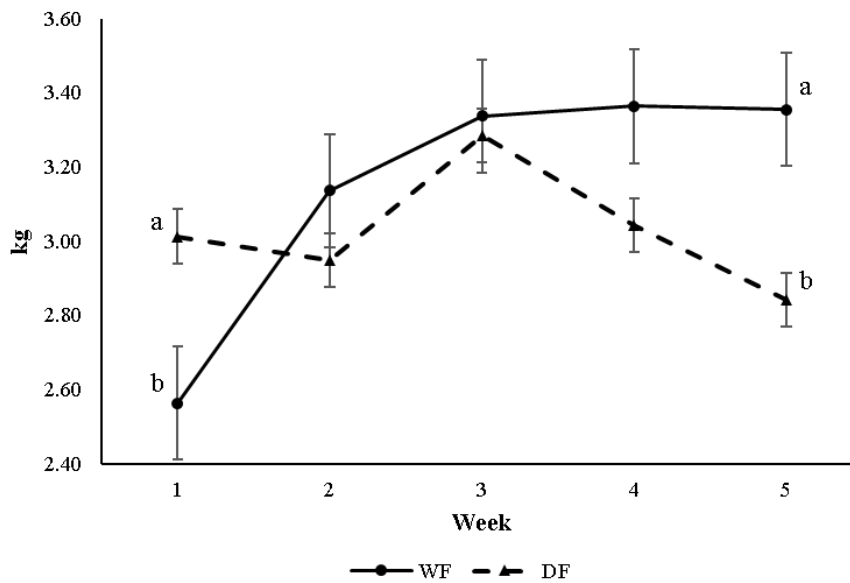
Table 1: Effect of offering wet feed (WF) or dry feed (DF) on the live weight, ADFI, ADWG, and FE of finishing pigs (68 to 108 kg) in each experimental week

	Week					<i>P</i>			
	1	2	3	4	5	MSE	Treatment	Week	Interaction
Individual live weight (ILW, kg)									
WF	74.8	83.3	91.6	98.4 ^a	108.4 ^a	0.73	0.001	<0.001	0.322
DF	74.2	81.6	88.5	92.6 ^b	101.9 ^b	0.75			
Average daily feed intake (ADFI, kg/d)									
WF	2.56 ^b	3.14	3.34	3.36	3.35 ^a	0.064	0.180	0.010	0.023
DF	3.01 ^a	2.959	3.28	3.04	2.84 ^b	0.066			
Average daily weight gain (ADWG, kg/d)									
WF	0.902	1.22	1.18	0.982	1.43	0.038	0.010	<0.001	0.861
DF	0.755	1.20	0.991	0.786	1.27	0.039			
Feed efficiency (FE, kg)									
WF	0.353 ^a	0.386	0.351 ^a	0.294	0.426	0.010	0.032	<0.001	0.023
DF	0.250 ^b	0.410	0.298 ^b	0.253	0.448	0.010			

MSE= mean standard error;

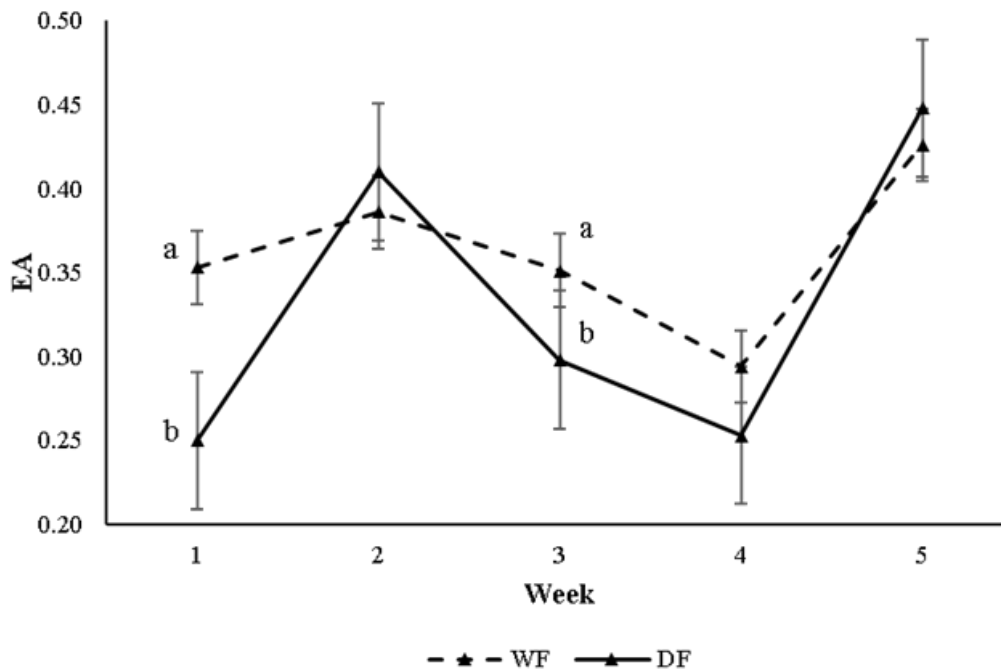
^{a,b} Means with different letters within the same column for each variable are different ($P<0.05$).

Figure 1: Daily feed intake (Mean ± MSE) of pigs in the final phase (68 a 108 kg) fed with wet feed (WF) and with dry feed (DF)



^{a,b} Significant difference ($P<0.05$) between groups.

Figure 2: Feed efficiency (Mean \pm MSE) weekly measurements in pigs at the final stage (68 to 108 kg), with wet feed (WF) and with dry feed (DF)



^{a,b} Significant difference ($P < 0.05$) between groups.

Weight of the carcass components

Wet-fed pigs had higher hot ($P=0.019$) and cold ($P=0.021$) carcass weights than dry-fed pigs (Table 2). The carcass length was not different ($P > 0.05$) for the two treatments. The average weight of the leg and skin + fat was higher ($P=0.04$) in wet-fed pigs than in dry-fed pigs. The weights of the loin, rib, shoulder and leg did not differ between the wet fed and those fed a dry diet ($P > 0.05$).

Table 2: Carcass characteristics and weight of the main carcass components of pigs slaughtered at 108 kg live weight, with wet feed (WF) and dry feed (DF)

Concept	Treatment			
	WF	DF	MSE	P
Carcass measurements				
Hot carcass weight, kg	90.80	84.80	1.599	0.019
Cold carcass weight, kg	89.13	83.39	1.564	0.021
Carcass length, cm	81.56	80.94	0.985	0.661
Average piece weight, half carcass, kg				
Leg	10.33	9.78	0.172	0.040
Loin	9.33	9.34	0.212	0.967
Rib	5.66	5.03	0.254	0.097
Shoulder blade	4.45	4.25	0.109	0.214
Skin + fat	11.63	9.65	0.468	0.009
Feet	0.739	0.694	0.019	0.120

MSE= mean estándar error.

Physicochemical and textural characteristics of the meat

Table 3 shows the physicochemical and textural characteristics of the meat. No differences were observed in the protein and carbon content, pH, or water holding capacity of the meat ($P>0.05$) between treatments. The hardness, gumminess, chewiness, and toughness of the meat were higher ($P<0.05$) in dry-fed pigs than in wet-fed pigs. The shear strength, adhesiveness, elasticity, and cohesiveness did not differ ($P>0.05$) between treatments.

Table 3: Values of physicochemical characteristics and meat texture of pigs slaughtered at 108 kg LW, with wet feed (WF) and with dry feed (DF)

Characteristics	Treatment		MSE	P
	WF	DF		
Physicochemical				
Protein, % MS	25.70	25.31	0.300	0.372
Carbon, % MS	16.39	16.07	0.235	0.353
pH	5.50	5.48	0.018	0.506
WHC, %	64.31	62.98	0.864	0.284
Texture				
Shear force, N	41.22	37.46	2.384	0.270
Hardness, N	35.37	57.32	7.071	0.032

Adhesiveness, g/seg	-25.11	-22.66	1.400	0.216
Elasticity, mm	0.435	0.457	0.015	0.324
Cohesiveness	0.446	0.453	0.010	0.584
Gumminess, g	15.86	27.16	3.470	0.025
Chewiness, gmm	6.30	11.65	1.367	0.007
Resistance	0.237	0.283	0.013	0.015

MSE= mean estándar error; WHC= water holding capacity.

Tendency of meat color

The values of brightness (B*), tendency to red (a*) and to yellow (b*), saturation (C), and hue angle (H) of the flesh were not different ($P>0.05$) between the two treatments (Table 4).

Table 4: The color of the meat measured in the *Longissimus dorsi* muscle of pigs slaughtered at 108 kg live weight, with wet feed (WF) and dry feed (DF)

Characteristic	Treatment		MSE	P
	WF	DF		
B*	53.62	54.04	0.879	0.734
a*	17.03	17.3	0.221	0.392
b*	9.16	9.32	0.255	0.656
C	19.37	19.75	0.194	0.175
H	28.29	28.35	0.790	0.954

MSE= mean estándar error.

B* brightness; a*= tendency to red; b*= tendency to yellow; C= saturation; H= Hue angle.

Economic analysis

The feed cost (Table 5) was similar ($P=0.180$) for the wet-fed pigs than for the dry-fed pigs (average = \$127.61 MN per animal during the experimental phase). However, due to a higher growth rate, economic income was 13 % higher ($P=0.01$) for the wet-fed pigs than for the dry-fed pigs. The difference in income due to pig growth minus the feed cost was 27.3 % higher ($P=0.008$) for pigs that received wet feed than for dry fed pigs.

Table 5: Analysis of the cost and economic usefulness of pigs in the final stage (68 to 108 kg) fed wet feed (WF) or dry feed (DF)

Economic variable (\$ MXN)	Treatment		MSE	P
	WF	DF		
Income from pig growth	256.00	226.53	12.145	0.010
Feed cost	130.12	124.96	3.802	0.180
Difference in income minus cost of feed	125.88	101.56	9.923	0.008

MSE= mean estándar error.

Discussion

The present experiment was carried out under climatic conditions representative of many dry tropical sites; it is one of the first studies carried out in the northeastern region of Mexico. During the experiment, the pigs were housed in a shed with open sidewalls, so that the animals were under the natural ambient temperature conditions, which ranged from 10 to 35.3 °C. These extremely variable environmental conditions could have affected the feed intake and feed efficiency of the pigs. A significant interaction between experimental week and treatment was obtained for the ADFI and FE, similarly to what was stated in previous reports^(22,23).

Exposure to a room temperature of 33 °C has been reported to reduce voluntary feed intake of pigs by 20 to 30 %⁽²²⁾. In the present study, the ADFI by wet-fed pigs at wk 1 was 12 % lower; however, it was 18 % higher at wk 5. Although the overall feed intake did not differ, the tendency to increase as the experiment progressed until it became significantly higher at wk 5 indicates that feed moistening may help to recover the voluntary feed intake of animals under climatic conditions of heat stress. Wet feeding also increased the average daily weight gain by 14 %, and the feed efficiency, by 8 %. The higher ADWG of WF pigs, as observed in the present experiment, is in agreement with the results reported in finishing pigs⁽²⁴⁾ and growing-finishing pigs fed a wet diet for 90 d⁽²⁵⁾. Taken together, these results indicate that feeding the pigs a wet diet exposed to conditions of high ambient temperature may improve not only the feed intake but also the feed utilization efficiency. Yang *et al*⁽⁶⁾ reported a lower ADWG and FE in growing-finishing pigs fed a liquid diet containing by-products of the ethanol industry, compared to pigs fed a wet diet based on corn and soybean meal. This suggests that, in addition to the type of feed (wet or dry), the ingredients used also play an important role in production efficiency. The wet feed offered to pigs at high ambient temperatures may have allowed them to have a better body temperature balance, resulting in higher weight gain and feed efficiency.

The higher HC and CC weights in the WF pigs recorded in the present study agree with other previously published results⁽²⁴⁾, in which the hot carcass weight and yield were higher, but a similar backfat depth were reported in pigs fed a wet diet, indicating the possibility of a positive influence of wet feeding on carcass characteristics.

The depth of the backfat has been reported to be similar in pigs whether they are fed a wet or a dry diet⁽²⁵⁾. However, wet-fed broilers had a higher abdominal fat content⁽²⁶⁾. When the trough is equipped with an integrated water supply, the pigs tend to consume more feed⁽²⁴⁾. The higher feed intake in wet-fed pigs reported in wk 5 of the present work may be reflected in a higher backfat content.

In the present study, the legs were heavier in wet-fed pigs than in dry-fed pigs. This is consistent with previous reports⁽²⁷⁾ in which higher leg weights have been recorded in pigs with higher growth rates.

The term meat quality describes the sum of different properties⁽²⁸⁾ such as pH, color, tenderness, WHC, and chemical composition⁽²⁹⁾, which are particularly important in sensory evaluation⁽³⁰⁾. In this study, differences were observed in favor of pigs fed a wet diet in terms of meat quality and texture characteristics such as shear strength, gumminess, and chewiness⁽³¹⁾.

The WHC and color are important attributes that determine the visual appeal and tenderness of the meat^(32,33). The values observed in this experiment were similar between treatments and are in agreement with those previously reported^(34,35) in finishing pigs. In the present work, the meat from the wet-fed pigs had lower toughness values than that from dry-fed pigs, which is indicative of a greater tenderness⁽³⁶⁾—one of the most important characteristics of the meat quality^(32,37). The other results of texture profile analysis, such as adhesiveness and cohesiveness, also used regularly to determine sensory attributes⁽³⁸⁾, did not differ between treatments in the present work.

Color is an important trait of pork quality, which can be affected by various factors, such as the feeding strategy⁽³¹⁾ and the breed of the pigs^(11,12). In the present study, no differences were found between treatments in the chromatic variables B*, a*, b*, C, and H, which determine the color. Compared with results from previous research⁽³⁴⁾, the brightness (B*) values in the present work for meat from pigs fed WF and DF (53.6 and 54.0, respectively; Table 4) were indicative of "normal" meat⁽³⁹⁾. B* values of 58 are indicative of PSE (pale, soft, exudative) meat, while values below 52 indicate the ASD condition (dark, firm, dry)^(39,40,41).

The economic analysis performed in this study has been used before⁽⁴²⁾, as it allows combining in a single value (difference of economic income minus the feed cost) the effect that the evaluated type of feed has on various characteristics, such as feed intake, daily weight

gain, and feed efficiency. In the present study, the difference in the income derived from the growth of the pigs minus the feed cost for five weeks was 27.3 % higher for wet-fed pigs. The largest percentage of this economic benefit originated from the higher growth rate recorded in pigs fed a wet diet. In contrast, there was no difference in the feed cost with respect to the form in which the feed (whether dry or wet) was offered to the pigs. In a study published by Myers *et al*⁽⁴³⁾, pigs weighing between 80 and 110 kg fed from a wet feed trough had better growth data than pigs fed a dry diet. Based on the weight gain and feed consumption of these pigs⁽⁴³⁾ when fed a wet or a dry diet, as well as the prices of the feed and the pork meat registered by the present experiment, the economic benefit from wet-fed pigs estimated by Myers *et al*⁽⁴³⁾ would have been 9.1 % better than that obtained from dry-fed pigs; this figure is lower than the economic benefit registered in the present study. In short, based on the results of this experiment, it is concluded that feeding finishing pigs with a wet diet improves the productive variables (daily weight gain, feed intake, feed efficiency), the economic profit, the carcass composition, and the meat quality.

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Conflict of interest

The authors declare that they have no conflicts of interest.

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