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Effect of creatine monohydrate on finishing pig growth performance, carcass characteristics and meat quality

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Abstract

Growth performance, carcass characteristics and meat quality were evaluated from 320 pigs (PIC C22 × L326) fed either a control diet (6.5 g lysine kg^{-1}) or diets containing added creatine monohydrate (CMH). Pigs (initially 53.5 kg) were sorted by weight, gender and ancestry in a randomized complete block design and allotted to one of four dietary treatments with eight replicates. Pigs were fed a sorghum–soybean meal diet until 30 days pre-slaughter (87.2 kg), when dietary treatments were initiated. Experimental treatments consisted of: (1) a control diet; (2) control diet with 3 g CMH per pig per day for 30 days (maintenance); (3) 25 g CMH per pig per day for 5 days followed by 3 g CMH per pig per day for the next 25 days (early load); (4) or 25 g CMH per pig per day for 5 days before slaughter (late load). Average market weight was 112.4 kg. Feeding CMH did not affect average daily gain (ADG), average daily feed intake (ADFI), or feed efficiency (F/G). Average backfat, 10th rib fat depth, longissimus muscle area and percentage lean also were not affected by feeding CMH. Visual color and marbling scores were not affected at 24 h or 14 days postmortem; however, the mean firmness score of longissimus from all pigs fed CMH was greater ($P < 0.05$) at 24 h and 14 days postmortem than from pigs fed the control diet. Percentages of moisture, protein and lipid in longissimus muscle and purge loss and Warner–Bratzler shear force values at 14 days postmortem were not affected by treatment. Percentage drip loss of longissimus at 24 h postmortem was less ($P < 0.05$) for pigs fed maintenance and late load CMH compared to pigs fed early load CMH (4.06 and 4.15% versus 5.76%). Results for pigs fed early load CMH were inconsistent compared to pigs fed maintenance or late load CMH. Longissimus from maintenance CMH pigs also tended to have less drip loss than that from control pigs (4.06% versus 5.31%). At 14 days postmortem, the mean drip loss from pigs fed CMH tended to be less ($P < 0.06$) compared to control pigs. These results suggest that added CMH does not affect finishing pig growth performance but may increase longissimus muscle firmness at 24 h and decrease drip loss at 14 days postmortem.

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Equivocal results were achieved by feeding 3 g CMH per pig per day for 30 days (maintenance) compared with feeding greater amounts of CMH for short periods; therefore, this supplementation strategy might be most economical if this technology were to be applied.

Keywords: Pigs; Creatine monohydrate; Carcass characteristics; Meat quality

1. Introduction

Creatine is an amino acid derivative normally produced in the liver, kidneys and pancreas from glycine, arginine and methionine. It increases the bioavailability of phosphocreatine, a molecular component necessary for the production of cellular adenosine triphosphate. Athletes occasionally take creatine supplements to enhance duration of peak performance and to reduce fatigue resulting from high-intensity exercise. Creatine supplementation has been shown to result in increased cellular hydration (Juhn, 1999), which is an anabolic proliferative signal for protein synthesis (Haussinger et al., 1993). Cellular hydration and increased protein synthesis might improve growth rate and/or carcass leanness of pigs fed CMH. Although dietary creatine supplementation has been studied most extensively in humans, potential also exists to benefit the pig industry, primarily through enhanced pork quality. The majority of research conducted with pigs has evaluated the effect of supplemental creatine monohydrate (CMH) on finishing pig growth performance, carcass characteristics and meat quality. As muscle is converted to meat, several biochemical reactions occur that impact pork quality (Faustman, 1994). Feeding CMH prior to slaughter may slow down postmortem pH decline by providing an immediate energy source, thus delaying glycogen metabolism. Improvements in water-holding capacity may also be observed from the presence of intramuscular phosphates bound to creatine within the muscle cell. Pork quality responses observed among limited preliminary studies to date with added CMH have been variable (Berg et al., 1999; Berg et al., 2000a,b). One source of the variation could be the amount and duration of CMH supplementation. Therefore, the objective of the current experiment was to evaluate the effects of different levels and duration of CMH supplementation on growth performance, carcass characteristics and meat quality of finishing pigs.

2. Procedures

The experimental procedures used in the current study were approved by the Institutional Animal Care and Use Committee, Kansas State University (Protocol no. 1671). Pigs were terminal offspring of PIC L326 boars × C22 sows (PIC, Franklin, KY). Three hundred and twenty pigs were allotted by weight and equalized across treatments for gender and ancestry in a randomized complete block design. Ten pigs per pen and eight replicates per treatment were used. Pigs were housed in a modified open-front building with half solid concrete and half concrete slat flooring. Each 1.8 m × 4.9 m pen had a two-hole self-feeder and a nipple waterer to allow ad libitum access to feed and water.

Table 1
Composition of basal diets (as-fed basis)[a]

Ingredient (g kg^{-1})	
Sorghum	817.3
Soya bean meal (465 g cP kg^{-1})	149.8
Maize starch[b]	10.0
Limestone	8.8
Monocalcium phosphate (210 g P kg^{-1})	6.5
Salt	3.5
L-Lysine HCl	1.5
Premix[c]	2.3
Antibiotic[d]	0.5

[a] Formulated to contain 6.5 g lysine kg^{-1} of diet.

[b] CMH replaced corn starch on an equal weight basis to achieve the targeted level for experimental treatments.

[c] Premix provided per kilogram of complete diet: Mn (from manganese oxide) 26.5 mg; Fe (from ferrous sulphate) 110.3 mg; Zn (from zinc oxide) 110.3 mg; Cu (from copper sulphate) 11.0 mg; I (from calcium iodate) 0.2 mg; Se (from sodium selenite) 0.2 mg; Vitamin A 4409 IU; Vitamin D_3 661 IU; Vitamin E 17.64 IU; menadione (menadione dimethylpyrimidinol bisulphite) 1.76; Vitamin B_{12} 0.02 mg; riboflavin 3.97 mg; pantothenic acid 13.23 mg; niacin 22.05 mg.

[d] Provided 44 mg tylosin kg^{-1} of diet.

Pigs were fed a sorghum–soyabean meal diet until 30 days pre-slaughter (87.2 kg), when dietary treatments were initiated (Table 1). Average daily feed intake (ADFI) was measured prior to the 30-day test period to determine the amount of supplemental CMH needed to provide approximately 25 or 3 g per pig per day in the treatment diets. Experimental treatments consisted of: (1) a control diet (6.5 g kg^{-1} lysine); (2) control diet with 3 g of CMH per pig per day for 30 days (maintenance); (3) 25 g of CMH per pig per day for 5 days followed by 3 g of CMH per pig per day for the next 25 days (early load); (4) or 25 g of CMH per pig per day 5 days before slaughter (late load). CMH (CREATEAM; pharmaceutical quality, 99% pure CMH, The NutraSense Co., Lenexa, KS) was substituted on an equal weight basis for maize starch to achieve the desired level for each treatment. The target levels of creatine intake were based on the data of Berg et al. (1999) and O'Quinn et al. (2000).

Weights were obtained on every pig, and feed disappearance was recorded on days 30, 25, 15, 10, 5 and prior to slaughter to calculate average daily gain (ADG), ADFI and feed efficiency (F/G). To achieve the determined amount of CMH intake, we calculated ADFI every 5 days and adjusted the CMH concentration of the diet accordingly. To verify that CMH intake was similar to our targeted values, we then calculated the pen average CMH intake. The treatment averages of creatine intake were: 3.3 g of CMH per pig per day for 30 days (maintenance); 28.7 g of CMH per pig per day for 5 days; followed by 3.2 g of CMH per pig per day for the next 25 days (early load); and 26.7 g of CMH per pig per day 5 days prior to slaughter (late load).

Two pigs (closest to the average weight of all pigs, 112.4 kg) per pen were selected and slaughtered humanely at the Kansas State University abattoir. Feed was withheld for 12 h

prior to slaughter. Blood samples were collected at the time of slaughter to determine serum creatinine levels. Serum was separated and frozen (−11.5 °C) until analyzed (Sigma, 1997).

Temperature and pH of the longissimus muscle (approximately 10th rib) were determined from each pig at 45 min postmortem with an accument portable pH Probe model AP61 (Fischer Scientific, Pittsburgh, PA). Liver and kidney weights were measured at the time of slaughter.

Standard carcass measurements; visual analyses of longissimus muscle color, marbling and firmness (NPPC, 2000); color spectrophotometry (L^*, a^* and b^*; CIE, 1976); drip loss (modified from Kauffman et al., 1986); water-holding capacity (Grau and Hamm, 1953), ultimate pH; and temperature were obtained for each pig at 24 h postmortem (drip loss determined at 48 h postmortem). Subjective quality scores were assigned for visual analyses of longissimus muscle color, firmness and marbling by a trained individual. Visual color and firmness were evaluated using a scoring system of 1–6 (1: pale pinkish gray to white, or very soft and very watery, and 6: dark purplish red, or very firm and dry). Visual marbling scores were determined on a scoring system of 1–5. A Hunter Laboratory, MiniScan XE model 45/OLAV was used to measure color spectrophotometry using illuminant C (Hunter Associates Laboratory, Reston, VA). Two surface readings per chop were averaged for color spectrophotometry determination. Loins (412B pork loin, boneless, center-cut, eight ribs; NAMP, 1997) were removed from the right side of each carcass, vacuum packaged, and stored for 14 days at 4 °C.

Purge loss, drip loss, water-holding capacity, visual analysis and color spectrophotometry were determined again after the loins were removed from the vacuum bags and allowed 15 min for standardization. Loin purge loss was calculated by 100 × (initial loin weight − 14 day weight)/initial loin weight. Loins were faced at the 10th rib surface and cut into 2.54 cm chops. Chops were assigned as follows, cutting anterior to posterior: (1) visual and color spectrophotometry evaluation; (2) drip loss and water-holding capacity; (3) Warner–Bratzler shear force (AMSA, 1995); and (4) chemical analysis (percentage protein, lipid and moisture) (AOAC, 1995).

Chops were cooked to an internal core temperature of 70 °C in a Blodgett DFG-100-3 series dual-flow gas convection oven (The G.S. Blodgett Ovens Co., Burlington, VT). Thawed and cooked chop weights were obtained to determine percentages of thawing and cooking losses. These were calculated by 100 × (initial chop weight B thawed chop weight)/initial chop weight and 100 × (thawed chop weight B cooked chop weight)/thawed chop weight, respectively. An Instron model 5401 (Instron Corp., Canton, MA) compression machine with a V-blade attachment was used to obtain shear force measurements. The V-blade speed during all measurements was 250 mm/min. The cores (1.27 cm diameter) were taken parallel to the muscle fiber orientation for the tenderness evaluation.

Data were analyzed as a randomized complete block. Pen was the experimental unit for growth performance data, carcass characteristics and meat quality measurements. The GLM procedure of SAS (1998) was used for the contrasts between control versus creatine, maintenance and early load versus late load and maintenance versus early load. Hot carcass weight was used as a covariate in the statistical model for carcass analysis.

Table 2
Effect of CMH on growth performance of finishing pigs[a,b]

Item	Days before slaughter	Creatine g per day				S.E.M.
	30–25	0	3	25	0	
	25–5	0	3	3	0	
	5–0	0	3	3	25	
ADG (kg)		0.95	0.94	0.95	0.94	0.02
ADFI (kg)		3.28	3.28	3.25	3.26	0.04
Feed conversion ratio		3.45	3.49	3.42	3.47	0.05

[a] Values represent the means of eight replications (pens) per treatment. Treatments were initiated 30 days prior to estimated slaughter at 112.5 kg.
[b] No significant differences ($P > 0.05$).

3. Results and discussion

3.1. Growth performance

For many years the pig industry has emphasized selection and management practices to increase lean tissue accretion and reduce lipid deposition. One possible adverse effect of this trend is the potential to compromise pork quality. Thus, methods to enhance pork quality, either nutritional or otherwise, are being investigated. If some of the attributes of CMH supplementation observed in athletes as well as in pigs by preliminary studies by Berg et al. (1999) could be confirmed, CMH supplementation in pig diets could have an enormous impact on pork quality and the pig industry.

Supplementing finishing pig diets with CMH did not affect ADG, ADFI, or F/G during the 30-day treatment period (Table 2). Other studies support these results and have shown that various creatine supplementation regimens did not statistically affect these responses (Berg et al., 1999; O'Quinn et al., 2000). In contrast to these results, Maddock et al. (2000) demonstrated that pigs fed creatine gained more weight during a 5-day supplementation period prior to slaughter. Berg et al. (1999) showed that the protein:moisture ratio in ham semi-membranosus muscle was lower for pigs supplemented with 25 g CMH per pig per day for 10 days prior to slaughter than pigs fed the control diet, which suggested greater myofiber hydration. These results might explain the increase in weight gain reported by Maddock et al. (2000); however, chemical analysis of muscle did not show an increase in moisture content. Thus, unlike athletes, muscle hydration as a result of CMH supplementation does not appear to affect ADG in pigs.

3.2. Carcass characteristics

Dressing percentage, shrink loss ((1 − (cold carcass weight/hot carcass weight)) × 100), average backfat, 10h rib fat depth, longissimus muscle area, percentage lean, heart weight and kidney weight (Table 3) were not affected by feeding CMH. Plasma volume and creatinine levels can be utilized to estimate total body mass of striated muscle after overnight fasting (Schutte et al., 1981). Serum creatinine levels were not different among

Table 3
Carcass characteristics of finishing pigs fed CMH[a]

Item	Days before slaughter	Creatine g per day				S.E.M.
	30–25	0	3	25	0	
	25–5	0	3	3	0	
	5–0	0	3	3	25	
Dressing (%)		73.76	73.45	72.97	73.31	0.06
Shrink loss (%)		0.42	0.44	0.39	0.40	0.07
Cold carcass weight (kg)		83.37	81.89	81.38	81.54	0.46
Backfat (cm)						
First rib		3.91	3.95	3.93	3.98	0.09
10th rib		2.05	2.04	2.18	2.06	0.12
Last rib		2.34	2.23	2.19	2.28	0.08
Last lumbar		1.79	1.85	1.81	1.83	0.11
Average		2.68	2.67	2.64	2.70	0.07
Carcass length (cm)[b]		82.43	83.19	83.70	82.99	0.40
Loin eye area (cm^2)		41.25	40.04	38.83	40.56	0.90
Lean (%)		52.82	52.68	51.75	52.82	0.70
Organ weight (g)						
Heart		397	389	389	398	9.87
Kidney		361	383	349	369	11.22
Serum creatinine (mg/dl)		1.90	1.83	1.86	1.89	0.03

[a] Values represent the means of eight observations (average of two pigs per pen) per treatment. Hot carcass weight was used as a covariate in the statistical analysis of all items except for dressing.
[b] Control vs. mean of all pigs fed creatine ($P < 0.02$).

pigs fed any of the experimental diets; therefore, it was not surprising that percentage lean was not affected by feeding CMH. These results are supported by research conducted by O'Quinn et al. (2000). However, Berg et al. (1999) showed that pigs fed 25 g per day CMH for 5 days had less longissimus muscle area and more 10th rib backfat than control pigs, whereas pigs fed 25 g per day for 10 days had numerically greater longissimus muscle area and less 10th rib backfat. Berg et al. (2000b) also showed that lean content of hams scanned by a primal cut electromagnetic scanner tended to increase with longer duration of supplementation when 20 g per day of CMH was provided for 5, 10 or 15 days prior to slaughter. Ingwall et al. (1974) reported that muscle cells supplemented with creatine in vitro had increased accretion of myosin. Kreider et al. (1998) showed that CMH supplementation increased weight gain and fat/bone-free mass in athletes without affecting body fat.

3.3. Meat quality

Color spectrophotometry, water-holding capacity, temperature and pH at 45 min and 24 h (Table 4) were not affected by feeding CMH. The color of meat usually is related to the muscle pH or its myoglobin content (Miller, 1994); therefore, it was not surprising that differences in color were not detected, because pH was not affected by CMH

Table 4
Carcass quality measures of finishing pigs fed CMH (24 h postmortem)[a]

Item	Days before slaughter	Creatine g per day				S.E.M.
	30–25	0	3	25	0	
	25–5	0	3	3	0	
	5–0	0	3	3	25	
Visual color[b]		2.81	3.00	2.84	2.94	0.16
Firmness[b,c]		1.94	2.31	2.00	2.19	0.09
Marbling[b]		1.59	1.78	1.66	1.47	0.13
L^{*}[d]		57.61	57.37	58.19	55.98	0.71
a^{*}[d]		10.01	9.95	10.05	9.81	0.27
b^{*}[d]		17.37	16.57	17.34	16.60	0.36
a^{*}/b^{*}[d]		0.58	0.60	0.59	0.60	0.01
Hue angle[d]		59.88	59.13	59.84	59.36	0.49
Saturation index[d]		20.08	19.37	20.10	19.33	0.42
R610 (%)/R580 (%)[d]		2.29	2.27	2.27	2.30	0.03
R630 (%)/R580 (%)[d]		2.69	2.67	2.67	2.72	0.05
Drip loss (%)[e,f]		5.31	4.06	5.76	4.15	0.49
Water-holding capacity (%)						
24 h postmortem		3.95	3.89	4.02	3.83	0.15
14 days postmortem		3.58	3.39	3.38	3.39	0.11
Temperature (°C)						
45 min postmortem		37.76	37.78	37.98	37.49	0.29
24 h postmortem		0.98	0.64	0.83	0.80	0.24
pH						
45 min postmortem		6.30	6.48	6.36	6.36	0.06
24 h postmortem		5.43	5.44	5.41	5.46	0.02

[a] Values represent the means of eight observations (average of two pigs per pen) per treatment.
[b] 1–5 scoring system. 2: grayish pink, traces to slight, or soft and watery; 3: reddish pink, small to modest, or slightly firm and moist; 4: purplish red, moderate to slightly abundant, or firm and moderately dry for color, firmness and marbling, respectively.
[c] Control vs. mean of all pigs fed creatine ($P < 0.05$).
[d] Means were derived from two sample readings per loin. Measures of dark to light (L^{*}), redness (a^{*}), yellowness (b^{*}), red to orange (hue angle), or vividness or intensity (saturation index).
[e] 3 g CMH per pig per day vs. 25 g CMH per pig from day 5 to 0 ($P < 0.05$).
[f] Control vs. 3 g CMH per pig per day ($P < 0.09$).

supplementation in this experiment. It has been hypothesized that creatine supplementation may stimulate a cause and effect mechanism by buffering pH, thus changing drip loss (water-holding capacity) and altering the apparent color of muscle. Berg et al. (1999) demonstrated that L^{*} values of semi-membranosus and longissimus muscles were numerically reduced (darker colored) at 24 h postexsanguination for pigs fed CMH. However, further research by Berg et al. (2000b) demonstrated the opposite effect of CMH; L^{*} values measured at 7 days postexsanguination linearly increased with increasing duration of supplementation. Other research has not shown an effect on L^{*}, a^{*} or b^{*} values measured either at 24 h postexsanguination or later (Berg et al., 2000a; O'Quinn et al., 2000). However, Berg et al. (1999) observed linear decreases in semi-membranosus a^{*} and b^{*}

Table 5
Carcass quality measures of finishing pigs fed CMH (14 days postmortem)[a]

Item	Days before slaughter	Creatine g per day				S.E.M.
	30–25	0	3	25	0	
	25–5	0	3	3	0	
	5–0	0	3	3	25	
Visual color[b]		3.00	3.13	3.09	3.09	0.14
Firmness[b,c]		2.06	2.19	2.22	2.31	0.08
Marbling[b]		1.88	1.94	1.97	1.78	0.12
L^{*}[d]		59.76	58.90	61.01	59.49	0.55
a^{*}[d]		10.11	10.38	9.60	10.15	0.34
b^{*}[d]		17.57	17.76	17.62	17.66	0.31
a^{*}/b^{*}[d]		0.57	0.58	0.54	0.57	0.01
Hue angle[d]		60.20	59.81	61.50	60.23	0.51
Saturation index[d]		20.29	20.60	20.08	20.39	0.42
R610 (%)/R580 (%)[d]		2.30	2.36	2.23	2.30	0.03
R630 (%)/R580 (%)[d]		2.27	2.33	2.21	2.38	0.07
Drip loss (%)[b]		1.28	.89	.99	1.12	0.12
Loin purge loss (%)[e]		3.52	3.72	3.21	3.19	0.33
Chop thawing loss (%)		5.77	5.52	5.55	5.68	0.18
Chop cook loss (%)		25.26	25.11	25.77	25.10	0.95
Chop shear force (kg)		3.26	3.26	3.13	3.29	0.21
Longissimus chemical composition (%)						
Protein		22.77	23.14	22.81	22.82	0.24
Moisture		73.44	73.20	73.20	73.50	0.21
Lipid		2.04	2.37	2.41	2.08	0.15

[a] Values represent the means of eight observations (average of two pigs per pen) per treatment.
[b] 1–5 scoring system. 2: grayish pink, traces to slight, or soft and watery; 3: reddish pink, small to modest, or slightly firm and moist; 4: purplish red, moderate to slightly abundant, or firm and moderately dry for color, firmness and marbling, respectively.
[c] Control vs. the mean of all pigs fed creatine ($P < 0.05$).
[d] Means were derived from two sample readings per loin. Measures of dark to light (L^{*}), redness (a^{*}), yellowness (b^{*}), red to orange (hue angle), or vividness or intensity (saturation index).
[e] Control vs. the means of all pigs fed creatine ($P < 0.09$).

values as supplementation increased from 5 and 10 days; the muscle was progressively less red and less yellow.

Subjective visual color and marbling scores were not affected at 24 h or 14 days postmortem; however, the mean firmness score of longissimus muscle from all pigs fed CMH was greater ($P < 0.05$) at 24 h and 14 days postmortem than that from pigs fed the control diet (Tables 4 and 5).

Drip loss percentages from the longissimus muscle at 24 h postmortem was less ($P < 0.05$) for pigs fed maintenance and late load CMH compared to pigs fed early load CMH (4.06 and 4.15% versus 5.76%). Muscle from pigs fed maintenance CMH also numerically tended to have less ($P < 0.09$) drip loss than that from pigs fed the control (4.06% versus 5.31%). This variability was also evident in comparisons of the water-holding capacity of longissimus muscle from the early load CMH pigs with that of muscle from pigs in other treatments. We have no explanation for the different effects of the early

load CMH treatment. This observation warrants further investigation of the effect of various CMH supplementation strategies on drip loss. Berg et al. (1999) reported that semimembranosus muscle drip loss measured at 24 h postexsanguination tended to decrease linearly for pigs fed CMH for 5, 10 or 15 days prior to slaughter. Longissimus muscle drip loss tended to be quadratic; it was less for the 5-day treatment than for the control, 10 or 15-day treatment (Berg et al., 1999). At 14 days postmortem, the mean longissimus drip loss for pigs fed CMH tended to be less ($P < 0.06$) than for control pigs. Although postmortem pH was not different for pigs fed CMH in this experiment, it is one of the most important factors that influences drip loss (den Hertog-Meischke et al., 1997). The ability of muscle proteins to bind to water is decreased with low pH. However, the water lost from the inability to bind proteins does not account for the total fluid loss. den Hertog-Meischke et al. (1997) suggested that low pH reduced the negative electrostatic repulsion between filaments, thus diminishing the space between them and causing shrinkage of myofibrils.

Percentages of moisture, protein and lipid in longissimus muscle, loin purge loss at 14 days postmortem and Warner–Bratzler shear force values were not affected by dietary treatment (Table 5). This supports the conclusion that the decreased drip loss associated with CMH supplementation was not a result of increased levels of intracellular water. These results also are supported by reports of O'Quinn et al. (2000). However, Berg et al. (2000b) observed a cubic effect for percent moisture lost as purge; it was less with supplementation of CMH for 5 and 15 days prior to slaughter than for the control and supplementation for 10 days. Moreover, Maddock et al. (2000) showed trends for decreased cooking loss when CMH was supplemented for 5 days. However, differences in chop thawing and cooking losses were not observed for pigs in this experiment.

The CMH supplementation regimes and targeted intakes selected in the current study were based on previous data of Berg et al. (1999) and O'Quinn et al. (2000). These authors evaluated relatively high dosages of CMH within the last 10–5 days before slaughter. We also included the maintenance (3 g CMH per pig per day) and early load (25 g CMH per pig per day for 5 days then 3 g CMH per pig per day for 25 days) treatments because these regimes follow CMH supplementation strategies sometimes used by human athletes. Although it is unknown why drip loss and longissimus muscle firmness were improved for the maintenance and late load CMS supplementation regiments but not the early load treatment, our data may suggest that feeding low levels of CMH for longer periods of time may be as effective as high dosages for short periods. If the positive attributes of CMH on pork quality were confirmed, a low dosage, long supplementation period may require the use of less CMH than a high dose short period regimen, and thus might be less expensive to implement.

4. Conclusion

These results suggest that added CMH does not affect finishing pig growth performance, but may increase longissimus muscle firmness at 24 h and decrease longissimus muscle drip loss at 14 days postmortem. Creatine has been shown in humans to be most beneficial to athletes actively involved in anaerobic activity. Perhaps the ability of CMH to affect pork

quality may be limited by the degree of anaerobic activity, because pigs are relatively sedentary during late finishing.

Further research needs to be conducted to better understand the effects and mode of action of creatine on pork quality under different conditions. However, if further studies confirm pork quality benefits, such as decreased drip loss and increased muscle firmness, the potential may exist for CMH to be used in the pig industry.

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