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Comparison of three commercial feeds in the fattening of Yorkshire pigs (*Sus scrofa domesticus*) in the starter and growth

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ABSTRACT

Objective: To assess the efficiency of three commercial feeds for pig fattening.

Design/Methodology/Approach: The study was conducted in the pig unit of the Centro de Bachillerato Tecnológico Agropecuario No. 90. Thirty-three pigs were randomly assigned to one of the following three treatments (11 specimens per treatment): 1) Sabamex®; 2) Campeón®, and 3) Ganador®. In the starter phase, the three feeds were provided *ad libitum* for four weeks. The same feeds were offered from the fifth to the eighth week (growth phase). The response variables were analyzed in a completely randomized design for each phase. The impact of sex differences on weight gain was analyzed using Student's t-test.

Results: All variables assessed recorded a difference ($P<0.05$) between treatments. In the initial four-week period, a statistically significant difference ($P<0.05$) was observed in the daily weight gain per animal per day variable. The same difference ($P<0.05$) was observed in the subsequent four weeks of growth (end stage) for the same variable. Additionally, sex differences had an impact on weight gain ($P<0.05$).

Study Limitations/Implications: Pigs should not be fattened in autumn and winter, due to the adverse effects of low temperatures. The Campeón® feed is the most profitable and advisable option.

Findings/Conclusions: Pigs that were fed on Sabamex® and Ganador® had a better performance than pigs that were fed on Champion®.

Keywords: economic analysis, feed efficiency, weight gain, cost benefit, sex differences.

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INTRODUCTION

The pork population and production in Chihuahua are not sufficient to meet the demand, as a result of the limited number of pork producers in the state. According to the USDA, the annual per capita consumption of pork in Chihuahua is 15 kg (approximately 53,348 tons, which increases proportionally with population growth). Consequently, in order to meet the demand, a significant portion of the pork consumed in Chihuahua is imported (González-Vejar and Levario-Quezada, 2013).

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The municipalities of Bachiniva, Carichi, Cuauhtémoc, Cusihuiriachi, and Riva Palacio, located within the Cuauhtémoc district, account for 24% (2,157 t) of the state's total pork production (SIAP, 2015). The production of high-quality pork in the municipality of Cuauhtémoc is limited by the rudimentary and informal way in which this activity is typically conducted: pigs are fed on leftovers from greengrocers and restaurants, among other sources (González-Vejar and Levario-Quezada, 2013). The Mennonite community from the municipality of Cuauhtemoc is engaged in the fattening of pigs. In this community, pigs are fed on yellow corn and whey, employing an empirical approach. This lack of balanced diets results in an inefficient pig fattening production system. Consequently, fatty meat is the result of a prolonged feeding period (González-Vejar and Levario-Quezada, 2013). Pigs are one of the most productive species and, with an adequate diet, gains are achieved within a 5-month period (Magaña-Magaña *et al.*, 2018). The parameters used for the assessment of production systems include feed consumption, feed efficiency, weight gain, and cost per kilogram of meat produced (Benitez-Meza *et al.*, 2015). The efficient feeding of pigs is a fundamental aspect of a piggery, as it not only affects the productive yields of the pigs, but also the profitability of the farm. In fact, feeding accounts for 80-85% of total production costs (Campadal, 2009).

The objective of this study was to assess the nutritional value of three pig feeds widely used by regional producers. These commercial feeds (Sabamex®, Campeón®, and Ganador®) were selected based on their ability to meet the nutritional requirements of pigs and to improve productive parameters. The nutritional requirements of initiation and growth were used as the basis for the assessment. At least one of the feeds (treatments) is higher than the others in at least one of the productive parameters.

MATERIALS AND METHODS

The study was conducted in the pig unit of the Centro de Bachillerato Tecnológico Agropecuario No. 90 of Ciudad Cuauhtémoc, Chihuahua, located at 2,098 m.a.s.l. The average annual temperature is 14 °C. According to the Köppen climate classification modified by García (2004), the climate is classified as BS_1 KW (W)(e^1): a dry temperate climate with summer rains, a frost-free period of 208 days, and an average annual rainfall of 450 mm. The minimum and maximum temperatures were recorded on the coldest days with a ThermoPro TP50 temperature and humidity monitor.

The 33 pigs were subjected to internal and external deworming with Ivermectin and ADE (1.0 mL per 33 kg live weight). During an eight-week period, the animals were weighed on a weekly basis. The following variables were recorded: feed intake, feed efficiency (feed consumed to produce 1.0 kg of body mass), weight gain (daily weight gain), and cost per kilogram of meat produced.

In average, the initial weight of the 33 pigs was 19.21 kg (starter phase). The pigs were randomly distributed into one of three treatments: Sabamex®, Ganador®, and Campeón®. *Ad libitum* feed —with a protein level guaranteed by the manufacturer— was provided in 5-space automatic feeders. The starter feeding (provided until the end of the fourth week) consisted of Sabamex® (18% protein), Campeón® (18% protein), and Ganador® (17% protein).

The growth feed provided in the fifth week of the study consisted of Sabamex® (16% protein), Campeón® (16% protein), and Ganador® (14.5% protein). Each treatment was administered to the 11 experimental units. Each unit was comprised of seven male pigs and four sows. At the start of the fifth week of the experiment, the 33 animals entered the growth phase with an average initial weight of 16.36±4.58 kg (Sabamex®), 19.5±4.35 kg (Campeón®), and 21.72±4.41 kg (Ganador®).

Table 1 shows that the Sabamex® feed had a guaranteed analysis. This feed was fully provided once the suckling pigs were weaned (at a weight of 7-8 kg) and until the pigs reached an average weight of 20 kg. The pigs had free access to fresh and clean water throughout the study period.

Table 2 shows the results of the guaranteed analysis of the Sabamex® feed for the growth phase. Pigs had ad libitum access to the full feed once they reached 18 kg live weight and until they weighted 40 kg. They were also offered fresh, clean water without restriction.

Table 3 shows the guaranteed analysis for the Campeón® balanced feed for starter pigs; Table 4, the guaranteed analysis of Campeón® balanced feed for growing pigs; Table 5, the guaranteed analysis of the Ganador® balanced feed for growing pigs; and Table 6, the guaranteed analysis of the Ganador balanced feed for growing pigs. All balanced foods were offered as recommended by the manufacturer.

Experimental Design

The statistical model used in the study was a completely randomized design with a significance level of $\alpha=0.05$. The Duncan's test, available in the SAS statistical software (SAS, 2002), was used for the comparison of means. The experimental period lasted from October 20 to December 15, comprising four weeks for the starter phase and four weeks for the growth phase. The same statistical model was employed to assess the impact of

Table 1. Guaranteed analysis of Sabamex® balanced feed (Reg. SAGARPA-7031-010) for starter pigs.

Concept	%	Concept	%
Minimum Protein	18.0	Nitrogen free extract	64.5
Minimal Fat	3.5	Minimum Calcium	0.7
Maximum Fiber	6.0	Minimum Phosphorus	0.6
Maximum Ashes	8.0	Lysine	1.1
Maximum Humidity	12.0	Minimal Methionine	0.3

Table 2. Guaranteed analysis of the Sabamex® balanced feed for growing pigs.

Concept	%	Concept	%
Minimum Protein	16.0	Nitrogen free extract	63.0
Minimal Fat	3.0	Minimum Calcium	0.7
Maximum Fiber	6.0	Minimum Phosphorus	0.5
Maximum Ashes	6.0	Lysine	0.75
Maximum Humidity	13.0	Minimal Methionine	n/s

n/s=not specified on the product label.

Table 3. Guaranteed analysis of the Campeón® balanced feed (Reg. SAGARPA A-7297-015) for starter pigs.

Concept	%	Concept	%
Minimum Protein	18.0	Nitrogen free extract	56.0
Minimal Fat	2.0	Calcium	n/e
Maximum Fiber	5.0	Phosphorus	n/e
Maximum Ashes	7.0	Lysine	n/e
Maximum Humidity	12.0	Methionine	n/e

n/s=not specified on the product label.
The animals had *ad libitum* access to the feed and water.

Table 4. Guaranteed analysis of Campeón® balanced feed (Reg. SAGARPA A-7297-009) for growing pigs.

Concept	%	Concept	%
Minimum Protein	16.0	Nitrogen free extract	57.5
Minimal Fat	1.5	Calcium	n/s
Maximum Fiber	5.0	Phosphorus	n/s
Maximum Ashes	7.0	Lysine	n/s
Maximum Humidity	12.0	Methionine	n/s

n/s=not specified on the product label.
The animals were provided *ad libitum* access to the diet and water.

Table 5. Guaranteed analysis of the Ganador® balanced feed (exempt from registered before the SADER).

Concept	%	Concept	%
Minimum Protein	17.0	Nitrogen free extract	n/s
Minimal Fat	3.5	Calcium	n/s
Maximum Fiber	6.0	Phosphorus	n/s
Maximum Ashes	8.5	Lysine	n/s
Maximum Humidity	12.0	Methionine	n/s

n/s=not specified on the product label.
The animals were provided with *ad libitum* access to the diet and water.

Table 6. Guaranteed analysis of the Ganador® balanced feed (Reg. SADER A-0544-926) for growing pigs.

Concept	%	Concept	%
Minimum Protein	14.5	Nitrogen free extract	n/s
Minimal Fat	3.0	Calcium	n/s
Maximum Fiber	7.5	Phosphorus	n/s
Maximum Ashes	7.5	Lysine	n/s
Maximum Humidity	12.0	Methionine	n/s

n/s=not specified on the product label.
The animals were provided with *ad libitum* access to the diet and water.

the treatments on each test phase (starter and growth) and for each variable (productive parameters) under study. The Student's t-test was used to assess the sex differences.

RESULTS AND DISCUSSION

Weight gain and consumption

In the initial four-week testing period, a statistically significant difference ($P<0.05$) with probability $F=0.01225147$ was observed in the daily weight gain per animal per day variable between the Sabamex® (0.738±0.138 kg/day), Campeón® (0.641±0.176 kg/day), and Ganador® (0.527±0.234 kg/day) treatments. The results were like the findings of Valdes and Arcilla (2014) and Shimada (2015) (Table 1). In the initial stage of the study, Sabamex® recorded the highest daily weight gain, followed by Campeón® and Ganador®. This discrepancy may be attributed to the quality and interaction of the ingredients of Sabamex®, as well as the quantity prepared, resulting in enhanced feed-to-meat conversion, regardless of the analysis guaranteed by the manufacturer. According to the manufacturers, the ingredients used to prepare each feed are not identical across all diets. Consequently, the chemical and nutritional analyses of these feeds may differ, potentially contributing to the variations in weight gain observed in the starter phase.

During the final four weeks of the growth phase, a significant difference ($P<0.05$) was again observed in the daily weight gain per animal per day variable between the Sabamex® (0.690±0.102 kg/day), Campeón® (0.553±0.182), and Ganador® (0.956±0.068 kg/day) treatments (Table 7).

In this growth phase, Ganador® showed the highest weight gain, due to its higher daily intake (2.358±0.395 kg) compared to Sabamex® (1.858±0.248 kg) and Campeón® (1.855±0.332 kg). These figures suggest that the greater the intake, the greater the weight gain. One of the most plausible explanations for the higher intake of Ganador® at this phase would be its higher palatability (Table 7). At the end of the 8-week trial (starter and growth), weight gain showed variability among treatments ($P<0.05$). The average weight gain for each treatment was: 41.72±5.67 kg (Ganador®), 40.09±7.06 kg (Sabamex®), and 33.18±9.13 kg (Campeón®) (Table 7, Figure 1).

No statistical differences ($P>0.05$) were reported among the treatments regarding the mean daily intake of pigs during the eight-week testing period (probability $F=0.075394747$). The mean daily intake of the Sabamex®, Campeón®, and Ganador® treatments was 1.656±0.326, 1.661±0.351, and 1.969±0.411 kg, respectively (Table 7). However, no differences between the consumption of the feeds were reported. At the end of the two phases, a trend indicated that Ganador® was consumed in greater quantity, which may explain the weight gain at the end of the eight-week period. The results showed a reduction in weight gain, except for Ganador®, which had similar results to those previously reported by Rostagno *et al.* (2011), Church (2009), and Shimada (2015).

In the wake of the eight-week trial period, the feed efficiency of the three treatments was determined to be statistically equivalent ($P>0.05$). The mean consumption required to achieve a 1.0 kg weight gain was 2.345±0.557 kg (Sabamex®), 2.905±0.758 kg (Campeón®), and 2.834±0.857 kg (Ganador®). The three treatments showed a greater feed efficiency than the efficiency reported by Church (2009) and were comparable with the findings of

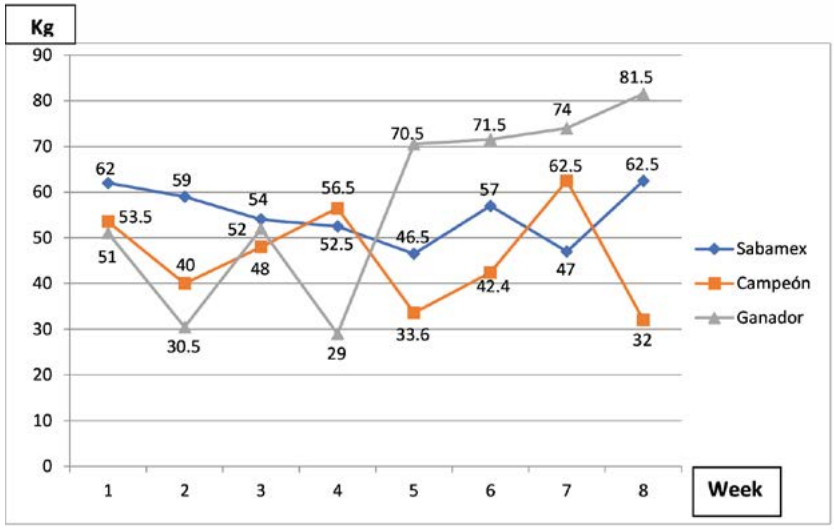

Figure 1. Weight gain per week and treatment in pigs fed with Sabamex®, Campeón® and Ganador® in Cuauhtemoc, Chihuahua, Mexico.

Castellanos (2022a, 2022b; Table 7). In the initial four-week testing period, no notable difference ($P>0.05$) was identified for this variable among the Sabamex® (1.991±0.499 kg), Campeón® (2.336±0.326 kg), and Ganador® (3.232±1.069 kg) treatments. However, in the final four weeks of testing, a significant difference ($P<0.05$) was observed among treatments, with a feed intake per kg of meat produced of 2.708±0.375 (Sabamex®), 3.475±0.609 (Campeón®), and 2.437±0.391 kg (Ganador®) (Table 7). The results suggested that Sabamex® (followed by Ganador®) was the treatment with the highest feed intake per kg of meat produced. Both feeds obtained better results than the treatments reported by Taipe-Cando (2023).

Effect of sex differences on weight gain

The weight gain of males (40.28±8.78) was 10.6% (probability F=0.01347312) higher than the weight gain of females (36±6.17 kg) ($p<0.05$). Castellanos (2021) has also reported that male pigs reach a higher weight than females. Large biotypes record the highest rate of weight gain, and, within these, males gain more weight than females. At the same age than other animals, the larger or taller specimen reaches a higher weight —*i.e.*, it has a higher rate of daily weight gain and reaches a higher maximum weight. From a physiological perspective, weight gain is the result of the accumulation of protein, fat, and water over time. The animal's protein mass increases in proportion to its weight, even under variable feeding conditions (Di Marco, 2007).

Economic analysis. Table 8 shows the findings of the economic analysis of the study. The cost of the Campeón® treatment is lower than other treatments, amounting to $13.52 Mexican pesos per kg of meat produced. Consequently, the cost-effectiveness of this treatment is greater than Sabamex® and Ganador®. Table 9 shows the profits and profitability of the fattening pig test over the course of eight weeks, encompassing the starter and growth phases. Once again, the profits ($4,635 Mexican pesos) and profitability

(30.20%) of the Campeón® treatment were higher than with the other treatments. In conclusion, fattening pigs with the Campeón® feed has a greater economic viability than the Sabamex® and Ganador® feeds.

CONCLUSIONS

During the eight-week testing period, pigs fed on Sabamex® (40.09±7.06 kg) and Ganador® (41.72±5.67 kg) recorded higher results ($P<0.05$) in the weight gain variable than Campeón® (33.18±9.13 kg). Regarding the feed consumption per pig per day variable, no statistically significant difference was observed between the Sabamex® (1.656±0.326 kg), Campeón® (1.661±0.351 kg), and Ganador® (1.969±0.411 kg) commercial brands. Furthermore, there was no difference ($P>0.05$) in the efficiency of the feed consumed to gain one kilogram among the three treatments: Sabamex® (2.345±0.557 kg), Campeón® (2.905±0.758 kg), and Ganador® (2.834±0.857 kg). Regarding sex differences, males gained 10.6% more weight (40.28±8.78 kg) than the females (36±6.17 kg). The cost of Campeón® was lower ($13.52 per kg of meat produced). The highest profits ($4,635 Mexican pesos) and profitability (30.20%) were obtained with this feed. Therefore, producers of fattening pigs with an 8-week period of growth are advised to provide the Campeón® feed *ad libitum*, using the starter feed provided for 4 weeks, followed by the growth feed for the remaining 8 weeks.

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