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Fibrous concentrate on the productive and reproductive performance of guinea pigs in family -commercial breeding in the Andes

Concentrado fibroso no desempenho produtivo e reprodutivo de porquinhos-da-índia em criação familiar-comercial nos Andes

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ABSTRACT

Andean guinea pig traditionally fed with forages presents low productive and reproductive performance. The aim of this study was to evaluate the effects of fibrous concentrate on the reproductive and productive performance of guinea pigs. A sample of 110 female guinea pigs (963.1 ± 127.3 g) and 22 male guinea pigs (1209.9 ± 159.0 g) of the Peru breed was distributed in 22 breeding modules (1 male/5 females), of which 11 modules were fed with forage (control) and 11 modules with fibrous concentrate (experimental). Each module was a replication. The forage was whole oat hay, while the fibrous concentrate was a mixture made with chopped hay from the same oats, corn-soybean, vitamin-mineral supplement, common salt, and premix. Both groups received the same amounts of fresh alfalfa as a vitamin C source. Then, 92 young weaning cavies from the control group (248.8 ± 29.9 g) and 106 young cavies from the experimental group (350.5 ± 64.6 g) were fed with the same diets to evaluate their productive performance. The experimental group surpassed the control group in all the variables ($p < 0.05$): dry matter intake (81.2 ± 4.5 vs 77.9 ± 1.0 g/day), postpartum female weight (1394.0 ± 81.5 vs. 1161.4 ± 50.3 g), male weight (1479.8 ± 125.1 vs. 1287.6 ± 124.4), litter size (2.24 ± 0.45 vs. 1.89 ± 0.68), litter weight (415.1 ± 80.2 vs. 291.3 ± 37.8 g), weaning weight (350.5 ± 64.6 vs. 248.8 ± 29.9 g), weight gain at 60 days of rearing (9.59 ± 1.41 vs. 6.41 ± 0.69 g), and rearing time to commercial weight (60 vs. 105 days), respectively. The fibrous concentrate achieves better reproductive and productive performance than forage and may be a viable alternative for family-commercial breeding of guinea pigs in the Andes.

KEYWORDS: feeding concentrate; guinea pig familiar-commercial farm; productive performance; reproductive performance; weight gain.

RESUMO

A cobaia criada nos Andes, tradicionalmente alimentadas com forragem, têm baixo desempenho produtivo e reprodutivo. O objetivo do estudo foi avaliar a alimentação com concentrado fibroso no desempenho reprodutivo e produtivo de cobaias. Uma amostra de 110 cobaias fêmeas (963,1 ± 127,3 g) e 22 cobaias machos (1209,9 ± 159,0 g) da raça Peru foi distribuída em 22 módulos de reprodução (1 macho/5 fêmeas), dos quais 11 módulos foram alimentados com forragem (controle) e 11 módulos com concentrado fibroso (experimental). Cada módulo era uma réplica. A forragem foi o feno de aveia integral, enquanto o concentrado fibroso foi uma mistura feita com feno picado da mesma aveia, milho-soja, suplemento vitamínico-mineral, sal comum e pré-mix. Ambos os grupos receberam as mesmas quantidades de alfafa fresca como fonte de vitamina C. Em seguida, foram utilizados 92 coelhos desmamados do grupo controle (248,8 ± 29,9 g) e 106 coelhos do grupo experimental (350,5 ± 64,6 g), resultantes da reprodução, alimentados com as mesmas dietas para avaliar seu desempenho produtivo. O grupo experimental superou o grupo controle em todas as variáveis ($p < 0,05$): consumo de matéria seca (81,2 ± 4,5 vs. 77,9 ± 1,0 g/dia), peso das fêmeas no pós-parto (1394,0 ± 81,5 vs. 1161,4 ± 50,3 g), peso do macho (1479,8 ± 125,1 vs. 1287,6 ± 124,4), tamanho da ninhada (2. 24 ± 0,45 vs. 1,89 ± 0,68), peso da ninhada (415,1 ± 80,2 vs. 291,3 ± 37,8 g), peso ao desmame (350,5 ± 64,6 vs. 248,8 ± 29,9 g), ganho de peso aos 60 dias de criação (9,59 ± 1,41 vs. 6,41 ± 0,69 g) e tempo de criação até peso comercial (60 vs. 105 dias), respetivamente. O concentrado fibroso alcança melhor desempenho reprodutivo e produtivo que a forragem, podendo ser uma alternativa viável para a criação familiar e comercial de porquinhos-da-índia nos Andes

PALAVRAS-CHAVE: alimentação com concentrado fibroso; criação familiar-comercial de cobaias; desempenho produtivo; desempenho reprodutivo; ganho de peso

INTRODUCTION

Low productive and reproductive performance are the most relevant problems in family guinea pig farming in the Peruvian Andes, severely limiting food security, economic income, and the well-being of families involved in this activity (DAVIS & WHITE 2020). Guinea pigs are multiple ovulating animals, with the potential to have one, two, four, six, and even eight pups per litter at birth (POSADA et al. 2015); however, litter size and live weight gains at the family breeding level are generally relatively low (VELÁSQUEZ et al. 2017), making it necessary to increase them through new food strategies to increase productive, reproductive, and economic yields (GUERRERO et al. 2020).

The cultural acceptance of guinea pigs as food is less widespread than that of pork, chicken, and other farmed species; however, their biological, ecological, and economic advantages make them a food animal, an important source of meat, energy, and high-quality protein in the diet, and a potential alternative to alleviate hunger, poverty, and food insecurity (LAMMERS et al. 2009), especially for the Andean population that has it as a breeding animal well adapted to their conditions. The excellent quality of its meat, rich in proteins and low in fat, which remains homogeneous regardless of the quality of the diet it consumes, whether high or low quality forage, agricultural residue or concentrate, is a key factor in the quality of its meat (TENELEMA et al. 2016), or meal of black soldier fly larvae (HERRERA et al. 2022), making guinea pigs an attractive option for food, with rural communities in the Andes presenting the best potential option for their production (ROSENFELD 2008). The people of Africa welcomed the mini-cattle for meat production (SIKIMINYWA et al. 2016), significantly contributing to the country's food, nutritional, and economic security (AYAGIRWE et al. 2019).

The high capacity of guinea pigs to adapt to different climatic conditions has enabled 60% of rural families in the highlands to raise them to obtain short-term income and meet their economic needs; Likewise, 95% of producers maintain traditional breeding and only 5% practice family-commercial breeding with some technology, feeding on fresh or dry forage, depending on local availability, with relatively low yields, especially in the dry season, making it necessary to seek alternative food sources to improve productive and reproductive performance.

Although some suggest restricting alfalfa in guinea pig diets due to its high protein and calcium content, which causes calcium carbonate and calcium oxalate urolithiasis (EDELL et al. 2019), this plant is their favorite food, a true delicacy, especially when fresh and tender, but scarce in the dry season in the Andes, which is why the guinea pig diet is limited to the traditional use of dry forage and kitchen waste (MORALES 1994), the scarce green pastures and some weeds, which are insufficient for their nutritional demands, manifest themselves with susceptibility to diseases, low birth rates, and low weights at birth and weaning (CASTRO 2002). Food concentrates (CARDONA et al. 2020), or the combination of alfalfa and concentrate, are important strategies to ensure good health, production, and reproduction of guinea pigs, expressed in a greater number of offspring per birth (GUERRERO et al. 2020).

Supplementation with fiber concentrate in the diet is a strategy that improved reproductive rates in alpacas (ROJAS et al. 2021), which can also be useful in guinea pigs to improve their productive and reproductive efficiency; however, there is no clear idea of the magnitude of the improvement that could be achieved with this type of feeding in family breeding contexts in the Andes, given the diversity of management systems; but it is clear that an improvement in feeding manifests itself in an improvement in the health of guinea pigs (WITKOWSKA et al. 2017) and meat growth and composition (ARAUJO et al. 2018). The article presents the results of an experimental research developed in a community environment as a strategy to promote technological innovation, whose objective was to evaluate the feeding of fibrous concentrate on the reproductive and productive performance of guinea pigs (*Cavia porcellus* L.) on a family commercial breeding farm in the Peruvian Andes.

MATERIALS AND METHODS

Experimental field

The research was carried out at the Higuera family's commercial farm, in the community of Occobamba, in the district of Marangani, province of Canchis, in the department of Cusco, 22 km from the city of Sicuani, the provincial capital, on the banks of the Sicuani-Juliaca Pan-American highway, at the foot of the Vilcanota mountain, at coordinates 14°21'12"S and 71°10'17"W, altitude 3709 m, reference to the city of Marangani (GOOGLE EARTH 2023), average annual temperature of 10.4 °C (min. 4.0, max. 18.3), average precipitation of 436.4 mm/year (WEATHER SPARK 2024).

The guinea pig house had an area of 72 m^2 (12 x 6 m), built with stone foundations and adobe walls stuccoes with plaster, windows for lighting and ventilation, metal calamine roof and four transparent fiber sheets for lighting and natural heating, with north-south orientation, concrete floor, and a total of 22 ponds of 2.06 m2 area (1.25 x 1.65 m and 0.45 m high), with wooden frames covered with hexagonal metal mesh. At the beginning and during the experiment, biosafety measures were adopted: a foot bath with quicklime at the entrance to the house, cleaning every 21 days, weekly disinfection with 0.4% benzalkonium chloride (kresso, 1:10 ml of water), and restriction of entry to strangers. The indoor air temperature was recorded daily with a min-max thermometer, ranging from 13-25 °C (min. 11 °C and max. 27 °C), which is in the thermoneutral zone of guinea pigs (15-21 °C) (HOME OFFICE 2014).

Animals

Table 1. Distribution of guinea pigs for reproduction and production experiments.

Group	Oat hay		Fibrous concentrate		P
	(n)	Average weight (g)	(n)	Average weight (g)	
Adult male and female guinea pigs to measure reproductive performance.					
Females	55	978.6 ± 118.7	55	947.7 ± 134.7	0.2033
Males	11	1217.6 ± 67.5	11	1202.2 ± 219.9	0.8281
Weaned guinea pigs (young), male and female, to measure productive performance.					
Females	45	245.2 ± 21.6	58	343.2 ± 53.6	0.0021
Males	47	252.5 ± 38.8	48	359.2 ± 81.7	0.0148
Total	92	350.5 ± 64.6	106	248.8 ± 29.9	0.0004

Feeding

The control group was fed oat hay (air-dried forage, H° 8%), offered in a guinea pig hay feeder, in the morning hours (8:00 h), while the experimental group was fed fibrous concentrate (air-dried mixture, H° 8%), in plastic hopper-type feeders with a capacity of 5 kg, for collective consumption *ad libitum*, in the early hours of the morning (8:00 h). Both groups were fed 50 g of fresh alfalfa (*Medicago sativa* W350, H° 80%) per guinea pig as a source of vitamin C (OLAZÁBAL et al. 2019). The fibrous concentrate was prepared from the same oat hay, mechanically processed to 6 mm ø, with added sources of energy, protein, minerals and vitamins, formulated with intermediate levels of nutrients (Table 2), as a unique mixture for breeding females and males, as well as for puppies and young guinea pigs.

Table 2. Fibrous concentrate for feeding guinea pigs for reproduction and production.

Ingredients	Mix, %	Nutritional value, 100% Dry Matter.	
Ground oat hay (6 mm ø)	40.00	Metabolizable energy (kcal/g)	3.12
Yellow kernel corn grains	11.40	Crude protein, %	14.00
Rice powder	15.00	Lysine, %	0.57
Whole soybeans (fatty)	10.00	Neutral detergent fiber, %	32.6
Fish meal (prime)	1.50	Calcium, %	0.55
Wheat by-products	20.00	Available phosphorus, %	0.32
Common salt	0.50	Sodium, %	0.29
Mineral Supplement®	0.50	Linoleic acid	1.43
Vitamin and Mineral Premix®	0.10		
Soybean oil	0.50		
TOTAL	100.00		

Water was supplied ad libitum through automatic drinkers installed in each pond.

Reproductive performance was determined with a sample of 132 improved guinea pigs of the Peruvian breed (110 females weighing 963.1 ± 127.3 g and 22 males weighing 1209.9 ± 159.0 g), selected for reproduction, properly identified with aluminum earrings, divided into two treatment groups (control and experimental), with 11 modules (five females and one male) per treatment (each module was a replicate), placed in independent tanks, to measure reproductive performance, starting with continuous mating and ending with weaning of the offspring at 15 days postpartum. Reproduction was achieved by continuous mating and birth in the same aviaries in the presence of the male in order to use postpartum estrus. The reproductive variables were: crude birth rate, as the proportion (%) representing the number of pups born in relation to the number of females giving birth; fecundity, as the proportion (%) representing the number of pregnant females in relation to the number of pregnant females present in the module; litter size, as the number of pups born for each female birth; litter weight, the body mass of all pups born for each female birth; and maternal body weight, recorded 24 hours after birth (CAHUI 2019).

Productive performance was determined between male and female young weaned guinea pigs in the reproductive modules, 106 from the experimental group and 92 from the control group (Table 1), distributed in modules of 10 to 11 animals per aviary, through a fattening process, fed with the same reproductive diets, from weaning to commercial weight. The variables evaluated were: feed consumption, live weight gain, and feed conversion. Live weights were recorded using a Camry precision scale of 5/0.001 kg and feed using a Kambor Design electronic scale of 30/0.005 kg; In addition, a maximum and minimum environmental thermometer was used. The data were analyzed using Student's t-test, with two groups and their respective repetitions, assuming that the dependent variable is continuous, the observations are independent of each other, the data are normally distributed in each group, with homogeneous mean and variance, as a t-distribution with v = n1 + n2 - 2 degrees of freedom (FRADETTE et al. 2003), subject to hypothesis testing at a significance level of 5% (α 0.05).

H_0 : $\mu_1 = \mu_2$

H_1 : $\mu_1 \neq \mu_2$

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{S^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

The weighted variance (or common variance shared between the two variables) was calculated using the following formula (FRADETTE et al. 2003):

$$S_p^2 = \frac{S_1^2(n_1 - 1) + S_2^2(n_2 - 1)}{n_1 + n_2 - 2}$$

Where:

t : Student's t-test.

$\bar{x}_1$ **:** mean of the experimental group of guinea pigs.

$\bar{x}_2$ **:** mean of the control group of guinea pigs.

n_1 **:** sample size of experimental guinea pigs.

n_2 **:** sample size of control guinea pigs.

S_p^2 : weighted (or common) variance of the two groups of guinea pigs.

S_1^2 : variance of the experimental group of guinea pigs.

S_2^2 : variance of the control group of guinea pigs.

Significant differences were calculated using the free Vassar Stats software (LOWRY 2019).

RESULTS AND DISCUSSION

Reproductive performance of guinea pigs

The reproductive performance of guinea pigs is summarized in Table 3, comparing feeding with oat hay and fibrous concentrate. All variables were significant ($p < 0.05$). The male and female guinea pigs began the experiment with similar live weights; however, they ended with different live weights, with those in the experimental group being heavier than those in the control group, demonstrating the effect of the fibrous concentrate on the oat hay forage.

The offspring showed the same trend, with a positive effect on reproductive efficiency and live weight of the offspring (CZARNECKI & ADAMSKI 2016), whereas mothers with lower weight had smaller fetal and placental size, a higher placental/fetal weight ratio (ELIAS et al. 2016), and lower birth weights in offspring, with consequent adverse health problems and higher rates of perinatal morbidity and mortality (NEVIN et al. 2018).

The fibrous concentrate, unlike forage, includes grains and rice powder, which contribute to greater energy intake (BOLARINWA & ADEOLA 2012), due to its high starch content (BELLO-PEREZ et al. 2020), whose digestion produces glucose (RATANPAUL et al. 2019), which serves as fuel for the energy metabolism of the developing oocyte (YUAN et al. 2016). Although the developing oocyte is unable to metabolize glucose, it is the cells of the cumulus complex that actually metabolize glucose, providing pyruvate to the oocyte (COLLADO-FERNANDEZ et al. 2012), whose mitochondrial oxidation produces ATP for its development (SUTTON-MCDOWALL et al. 2010).

Table 3. Reproductive performance of guinea pigs fed oat hay vs. fibrous concentrate on a family commercial breeding farm.

Variable	Control group (Oat hay)	Experimental group (Fibrous concentrate)	P
Dry matter intake (g/d)	77.9 ± 1.0	81.2 ± 4.5	0.3146
Reproduction			
Initial live weight, males (g)	1217.6 ± 67.5	1202.2 ± 219.9	0.4141
Final live weight males (g)	1287.6 ± 124.4	1479.8 ± 125.1	0.0009
Initial live weight, females (g)	987.6 ± 65.3	947.4 ± 62.2	0.1339
Final postpartum live weight of females (g)	1161.4 ± 50.3	1394.0 ± 81.5	<.0001
Female fertility (%)	76.4 ± 25.0	96.4 ± 8.1	0.0102
Gross birth rate (%)	189.1 ± 67.7	223.6 ± 45.4	0.0884
Litter size at birth (n)	1.89 ± 0.68	2.24 ± 0.45	0.0884
Litter birth weight (g)	291.3 ± 37.8	415.1 ± 80.2	<.0001
Birth weight (g) per guinea pig	121.3 ± 20.2	175.5 ± 22.6	<.0001

The primordial follicle oocyte contains approximately 10,000 mitochondria, which can increase to 100,000, depending on its energy demand (RAMALHO-SANTOS et al. 2009); therefore, females fed with fibrous concentrate responded successfully in ovulation, fertilization, and embryonic development (LETELIER et al. 2008). Furthermore, fermentation of starch and oligosaccharides remaining from digestion produced short-chain fatty acids in the posterior tract (JAKOBSDOTTIR et al. 2013), which served as energy fuels for colonocytes and as gluconeogenic substrates that supported additional glucose production (VERNAY 1987).

The inclusion of soybean and fish meal in the fibrous concentrate contributed to the supply of proteins and essential amino acids for nutrition (GONZÁLEZ-VEGA et al. 2011), especially lysine, the first limiting amino acid for mammalian animals, such as guinea pigs, as it is the scarcest in relation to the need for lysine (BAKER 2007); Likewise, nitrogen catabolism increases the transfer of nitrogen from blood urea to the large intestine (KAWASAKI et al. 2015), increasing nitrogen availability for microbial protein synthesis, which is then recycled through cecotrophy, improving nitrogen retention (SAKAGUCHI 2003).

The presence of vegetable oil in the diet increased the supply of essential fatty acids, such as linoleic and linolenic, which, in addition to providing energy, regulate the hypothalamic-pituitary-gonadal (HPG) and hypothalamic-pituitary-adrenal (HPA) axes, modulating hormonal secretions and animal behavior (NEMETH et al. 2017). Omega-3 and omega-6 fatty acids are the main components of neuronal cell membranes that play an important role in modulating brain functions, decreasing social stress and cortisol concentrations (NEMETH et al. 2014). Essential fatty acids also improve ovarian follicle growth, luteal function, and reproductive performance, resulting in larger and more developed offspring (BORGES et al. 2019).

The critical periods of gestation, especially after implantation, are highly sensitive to short-term mild energetic challenges, with significant impacts on embryonic and fetal development, where transient dietary signals regulate both sexual behavior and reproductive parameters and postnatal development of the offspring (KAUFFMAN et al. 2010). Therefore, the success of pregnancy and the health of the offspring depend on the relationship between maternal nutrition, the use of nutrients during pregnancy, and their supply to the embryo (REDMER et al. 2004). A well-fed female meets her nutritional needs and satisfies her energy demands, with a positive energy balance that boosts the production of the insulin/IGF system, composed of insulin and insulin-like growth factors I and II (IGF1 and IGF2), where insulin maintains peripheral glucose homeostasis, as well as the regulation of reproduction (SLIWOWSKA et al. 2015), IGF1 improves placental transport and short-term nutrient partitioning (SFERRUZZI-PERRI et al. 2007), while IGF2 promotes cell proliferation, transformation, and differentiation during pregnancy (MEIYU et al. 2011, IPSA et al. 2019), as well as fetal growth (KADAKIA & JOSEFSON 2016). The negative energy balance, on the other hand, decreases IGF production in family members, with a late return to postpartum ovarian cyclicity and low fertility (FENWICK et al. 2008), which would explain the lower reproductive efficiency observed in the control group.

Reproduction is one of the most energy-intensive processes in an animal's life, requiring resources that cannot be allocated to other functions. It generates direct reproductive costs, that is, trade-offs between current reproduction and subsequent survival/reproduction (DHONDT 2001). Insufficient energy intake can limit productive and reproductive performance because trade-offs in energy allocation between growth, reproduction, and survival are at the heart of life history theory (AUDZIJONYTE & RICHARDS 2018).

Each pool consisted of five females and one male, where females faced a disproportionately high cost of reproduction relative to the male, whose survival and reproductive success depended on the efficiency with which they were able to extract energy from food (JEANNIARD-DU-DOT et al. 2017), in greater quantity in relation to their requirements, manifesting itself with a positive energy balance, greater weight and larger litter size and offspring weight of the experimental group (GURR 1980), evidencing the hypothesis of the cumulative cost of reproduction, where the reproductive costs accumulated throughout the reproductive life respond with greater reproductive performance (KROEGER et al. 2018) and a strong association between nutrition and reproduction, where dietary energy surpluses or deficits affected metabolic status, modulated the hypothalamic GnRH neuronal network and/or pituitary gonadotropin secretion, and regulated follicular growth and steroidogenesis at the ovarian level (DE BOND & SMITH 2014).

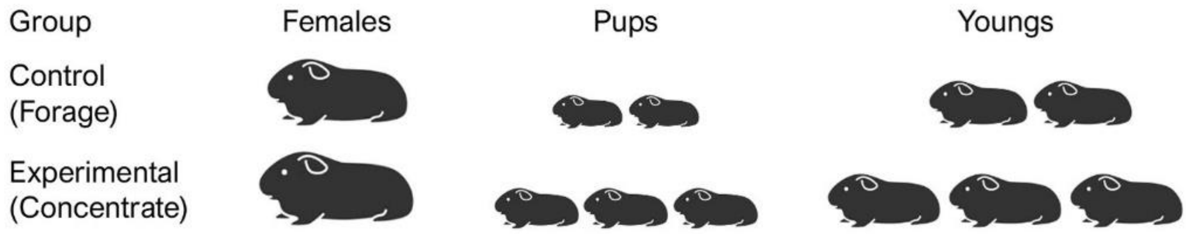

Figure 1. Reproductive and productive performance of guinea pigs fed oat hay vs. fibrous concentrate.

Birth rate (223.6 ± 45.4 vs. 189.1 ± 67.7%), litter weight (415.1 ± 80.2 vs. 291.3 ± 37.8), and live weight of postpartum mothers (1394.0 ± 81.5 vs. 1161.4 ± 50.3 g) were the most significant reproductive variables ($p < 0.05$) in favor of feeding fibrous concentrate relative to forage. Although the nutrient levels of the concentrate (energy, protein and others) were intermediate in relation to the nutritional requirements of the guinea pigs, the effects on reproductive performance were significant (Table 3), in agreement with the results found in commercial farms on the central coast of Peru (RODRÍGUEZ et al. 2015), indicating that with an average animal feeding technology it is possible to achieve reproductive responses compatible with commercial interest, or even exceed them, since the birth weight of the offspring and the weaning weight of the offspring in the experimental group (Table 3) were higher than those reported, both for the highlands and for the coast (CAHUI 2019).

An important reference for comparative purposes is the work carried out on guinea pigs of the Peru lineage, in high altitude conditions (3824 m.a.s.l.), in a continuous breeding system, on a commercial farm, with oat hay, fresh alfalfa and balanced feed, in an environment of 14.4 (9.6-19.2) °C (CAHUI 2019). The guinea pigs in the present study had better responses in birth weight (148.2 vs. 175.5 g), weaning weight (265.3 vs. 360.9 g), weight gain (8.36 vs. 9.59 g/day), and rearing time to market weight (105 vs. 60 days), respectively. Because calf birth weight is an important predictor of weaning weight, it is also an important predictor of rearing weight (SMITH et al. 2007). Animals born with high birth weight maintained the same trend in the following production phases, shortening the rearing and reproduction times (SUREK et al. 2019). Feeding with fibrous concentrate is a useful strategy to increase the values of commercial family farming to those of a commercial farm.

Productive performance of young weaned guinea pigs

The weaning weight of the offspring was different between the groups ($p < 0.05$), where the offspring of the experimental group arrived at weaning with a 52% advantage over the control group, following the same trend of their corresponding groups, with higher weights in the experimental group than in the control group, both in birth weight, weaning weight, and commercial weight ($p < 0.05$) (Table 4).

The experimental group greatly outperformed the control group in live weight ($p < 0.05$), with an advantage of 46.2% at 60 days of age (926.1 ± 52.4 vs. 633.3 ± 31.2 g), reaching commercial weight at 60 days of age (926.1 ± 52.4 g), while the control group only reached 105 days of age (873.9 ± 68.0 g), with a delay of 45 days (Fig. 2), showing that feeding with fibrous concentrate is a better strategy for better productive performance in less time.

Nutritional recommendations indicate that growing guinea pigs require a diet containing 18% crude protein and a metabolizable energy content of 2.80-3.20 kcal/g, with an average of 3.0 kcal/g dry matter, or a daily metabolizable energy intake for maintenance of 136 kcal/$W_{kg}^{0.75}$, for guinea pigs of 400 to 600 g body weight (NRC 1995). However, in the present study, the guinea pigs consumed a fibrous concentrate with lower levels of crude protein (14%) and metabolizable energy (3.12 kcal/g of dry matter) because, in family-commercial farming, the formulation with protein and energy levels compatible with nutritional recommendations clashes with the availability of food resources and associated costs. Therefore, a diet with intermediate levels of nutrients was formulated; and, despite this, interesting productive performances were achieved. Improving the nutritional levels of the diet can achieve higher productive responses; however, it can also impact environmental health (SAMPAT et al. 2021).

Table 4. Productive performance of young weaned guinea pigs fed oat hay vs. fibrous concentrate on a family commercial breeding farm for fattening purposes.

Variable	Oat hay	Fibrous concentrate	P
Initial live weight at weaning (g)	237.5 ± 37.2	360.9 ± 35.9	<.0001
Live weight at 45 days (g)	540.2 ± 30.8	806.4 ± 43.1	0.0044
Live weight at 60 days (g)	633.3 ± 31.2	926.1 ± 52.4	<.0001
Rearing period to commercial weight (days)	105	60	
Live weight for consumption (g)	873.9 ± 68.0	926.1 ± 52.4	0.1762
Dry matter intake (60 d), g/d	47.1 ± 2.8	52.4 ± 3.8	0.0009
Feed conversion (60 d)	7.43 ± 0.96	5.58 ± 0.99	0.2645
Live weight gain (60 d) (g/d)	6.41 ± 0.69	9.59 ± 1.41	<.0001

Feed intake was higher ($p < 0.05$) in the group fed with fibrous concentrate than with forage (52.4 ± 3.8 vs. 47.1 ± 2.8 g/day). The experimental group started rearing as a consequence of better reproductive performance, with a significant advantage in initial weight ($p < 0.05$), in relation to the control group (360.9 ± 35.9 vs. 237.5 ± 37.2 g). During reproduction, live weights follow the same trend, progressively moving away from each other until a large gap in time becomes evident. Liver weight gain maintained the same trend, being greater ($p < 0.05$) in the experimental group than in the control group (9.87 vs. 5.36 g/day).

Figure 2 illustrates the evolution of comparative live weights between the two groups of gilts, where it can be observed that the experimental group exceeded the commercial weight at 60 days of rearing, while the control group managed to approach this weight only at 105 days, with a delay of 45 days; that is, the experimental group was 75% more efficient in the time to reach the commercial weight. The progress of live weights can be adjusted by the polynomial equation, as the best model, through the relationship between the rearing period and the rearing weight of the chicks, with high quality of adjustment (R^2 0.99), for both groups (fig. 2).

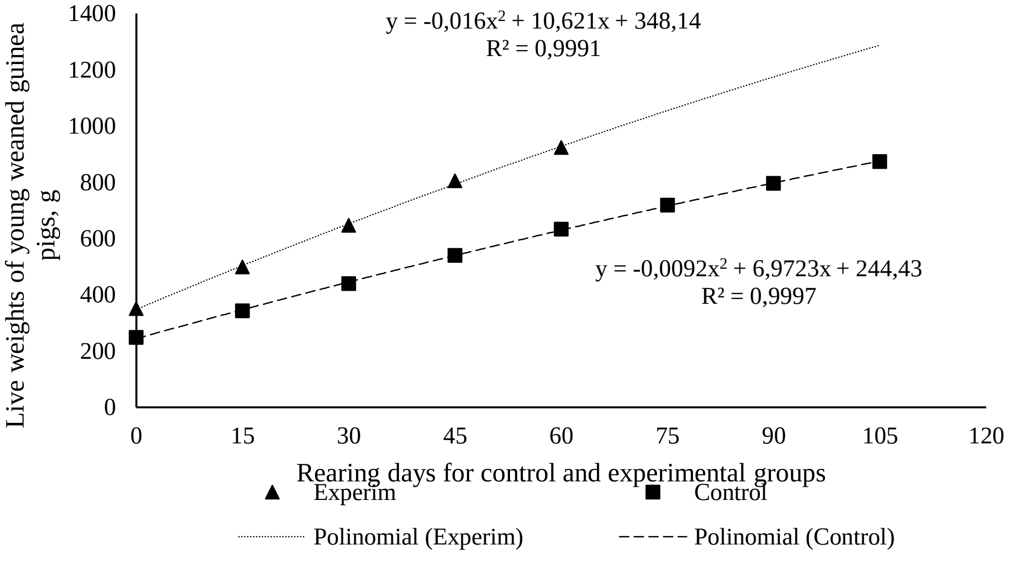

Figure 2. Evolution of the live weight of young weaned guinea pigs fed oat hay vs. fibrous concentrate up to commercial weight.

Weight gains reported in the literature are highly variable from one context to another, probably due to animal genetics and environmental conditions. At one extreme, values are as low as 3.4 g/day in Creole guinea pigs fed 150 g fresh carrots and 7.1 g/day with 100 g air-dried chickpeas, observed in Karachi-Pakistan at 10 m altitude (SHAH et al. 2017), respectively, showing that increasing levels of supplementation and average dry matter intake were associated with higher growth rates; followed by 10.2 g/day in H-line guinea pigs and 10.5 g/day in G-line guinea pigs, fed 250 g of fresh corn forage and 30 g of wheat bran, at 200 m altitude on the central coast of Peru (YAMADA et al. 2019); and at the other extreme, with 15.6 g/day in guinea pigs of the Cieneguilla-UNALM genotype fed 49.2 g of dry matter of concentrate and green forage, at 300 m altitude, and with 15.6 g/day in guinea pigs of the Cieneguilla-UNALM genotype fed 49.2 g of dry matter of concentrate and green forage, at 300 m altitude (CAMINO & HIDALGO 2014), or 17.5 g/day in improved male guinea pigs of type I from the Mantaro Valley, fed 94.9 g of dry matter concentrate and fresh alfalfa ad libitum, at an altitude of 3200 m in the province of Jauja-Junín (CARBAJAL CHAVES 2015).

An important reference for comparison of the reproductive and productive performance of Peruvian guinea pigs is the report of a comparison of parameters carried out at two altitudes, coast (1400 m) and plateau (3800 m), with a continuous mating system, with 7 females and one male per pen, and technical management (CAHUI 2019). The results obtained were 96% and 97% fertility, with litter sizes of 3.00 and 2.83 pups per birth, with birth weights of 159 and 148 g, weaning weights of 280 and 265 g, and market weights at 66 days with a weight gain of 10 g/day and 80 days with a gain of 8.36 g/day, respectively. In general, the results obtained in the experimental group of the present work surpass these data, both for the coast and for the highlands, showing that feeding fibrous concentrate may constitute an interesting strategy that could enable better reproductive and productive performance of guinea pigs at the level of family-commercial reproduction in the Andes.

The experimental group showed better feed conversion ($p < 0.05$) than the control group (7.49 vs. 13.42, respectively), where the experimental group achieved 79.2% higher feed conversion than the control group. In this sense, reports are very variable from one source to another. Most of these studies reported weight gains without specifying feed consumption, which makes it difficult to interpret feed conversion. The values reported for the different types of feed are efficient conversions of 2.73 and 2.78 with male guinea pigs of the Peruvian and Andean breeds, respectively, fed with balanced integral mixtures (REYNAGA et al. 2020), 3.03 for Peruvian guinea pigs fed improved concentrate (CHAUCA et al. 2005), or 3.32 in the compensatory phase of food restriction compared to those fed ad libitum (3.32 vs. 4.40) (FLORES 2021), followed by 7.32 to 9.48 with corn silage (OLMEDO 2015), 9.51 with commercial mixture, elephant grass, and salt (MEZA et al. 2014).

Given the results, it is clear that processed feed has better quality than simple forage, from all points of view, resulting in better reproductive and productive performance of guinea pigs and a better chemical composition and quality of their meat (SÁNCHEZ-MACÍAS et al. 2018), although other sources indicate that the quality of guinea pig meat is independent of the quality of the feed consumed, since guinea pigs fed with agricultural waste, forage or concentrates (TENELEMA et al. 2016), including fly larvae flour as a protein source (HERRERA et al. 2022), produce a carcass of similar quality, while other sources report the opposite, which needs to be investigated to offer the market lean, nutritious and healthy meat (PETHICK et al. 2011).

Finally, the improved genotype of the Peruvian breed, on which the research was carried out, may have influenced reproductive and productive performance; however, the largest population of guinea pigs in the world is composed of the native genotype, with modest reproductive and productive performance, but with good rusticity (PAREDES et al. 2020), with an alfalfa-based diet, with or without commercial concentrate, can express its maximum productive performance (NIETO-ESCANDÓN et al. 2023). Likewise, the guinea pig has reached other realities beyond the Andes, where it is part of the mini-livestock farming that diversifies investment toward sustainable production (HARDOUIN et al. 2003), and can grow on a variety of foods, such as *Morinda citrifolia* L. "Noni", whose fruit contains vitamin C, allows it to grow healthy and productive (PAREDES-LÓPEZ et al. 2023).

The use of probiotics as additives is another alternative for improving feed conversion efficiency and productive performance of guinea pigs (CARCELÉN et al. 2021). Furthermore, common salt was the most important source of sodium in guinea pig diets; however, a dietary electrolyte balance of 300 mEq/kg of feed could improve growth and carcass characteristics (PAREDES et al. 2021), reinforced with a vitamin-mineral premix in guinea pigs fed with feed and green forage (PAREDES & DÍAZ 2023).

CONCLUSION

The fibrous concentrate exhibited better reproductive performance than the forage ($p < 0.05$), with higher live weights in females (1394.0 ± 81.5 vs. 1161.4 ± 50.3) and males (1479.8 ± 125.1 vs. 1287.6 ± 124.4), larger litter sizes (2.24 ± 0.45 vs. 1.89 ± 0.68) and litter weights (415.1 ± 80.2 vs. 291.3 ± 37. 8 g); Likewise, gilts had better productive performance of gilts ($p < 0.05$), with higher weaning weight (350.5 ± 64.6 vs. 248.8 ± 29.9), greater weight gain at 60 days of rearing (9.59 ± 1.41 vs. 6.41 ± 0.69), and shorter rearing time to reach marketable weight (60 vs. 105 days), respectively. It was concluded that fibrous concentrate promotes better reproductive and productive performance than forage and is a viable feeding strategy for raising commercial-family guinea pigs in the Andes.

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