African Journal of Biological Sciences

Research Paper Open Access

Evaluation Of Purple Sweet Potato (Ipomoea Batatas Lam.) Combined with Lactobacillus Plantarum as A Feed Alternative In Pigs

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Article Info

Volume 6, Issue 8, April 2024
Received: 02 Feb 2024
Accepted: 12 March 2024
Published: 06 April 2024

Abstract

In order to evaluate the sweet potato (Ipomoea batatas Lam) combined Lactobacillus plantarum (LP) as a nutritional alternative during the growth-fattening of pigs. 24 pigs were used, females and castrated males, coming from the commercial cross between females (Landrace x Duroc) and males (Pietrain), aged two and a half months, distributed in individual pens. The sweet potato was processed into flour (SPF)), mixed with the rest of the ingredients to prepare the diets. A completely randomized design was used, with the following treatments; T0: Without addition of SPF and LP (Control); T1: SPF 15% plus 20 ml LP; T2: SPF 10% plus 20 ml LP; T3: SPF 15% plus 40 ml LP; T4: SPF 10% plus 40 ml LP; each treatment with five repetitions, with the exception of the control (four). The means of the variables (weekly weight, weight gain and conversion index) were similar in the different treatments (P>0.05). It is concluded that SPF can be a nutritional alternative in the growth and fattening of pigs, mainly in times of high production or as second-class vegetative material. Furthermore, combined with LP they allow the digestive health of pigs to be improved, which is reflected in the zootechnical parameters.

Key words: Tuber; prebiotics; probiotics; growth; fattening; animal health

Introduction

Intensive pig farming (*Its scrofa domesticus*) faces the challenge of high environmental impacts and dependence on outsourced inputs (Alvarez-Rodriguez et al., 2024) ; In the opinion of Van Zanten et al. (2019) Many avenues emerge to improve the sustainability of food systems, especially for the livestock sector through circularity as a strategy that uses farm animals to convert food with low opportunity costs (e.g. Crop residuesand other by-products generated during livestock production) in valuable food and manure.

In addition, feed accounts for 70 to 80% of the costs in pig meat production (Pandi et al., 2016; Argemí-Armengol et al., 2020; Kiros et al., 2022;), so a series of alternatives have been proposed that include the use of local raw materials, initially dispensing with soy and its derivatives, and minimizing the number of raw materials (Argemí-Armengol et al., 2020), as well as the use of agricultural by-products (Kiros et al., 2022). In addition, the progressive inclusion of forages with different types of fiber in a conventional diet (corn, soybean meal) offered to pigs in the growth and fattening stage, carried out by González et al. (2020); in the same context, the presentation of food, as proposed by Guzmán and Jiménez (2020).

In this sense, the purple sweet potato is one of the main cropsFoodfrom the tropics and subtropics; abundant in Anthocyanins, Starches, polysaccharides starch-free, caffeoylquinic acid derivatives, vitamins, and minerals (Tang et al., 2023).

Indeed, sweet potato roots are very appetizing and digestible for pigs as fresh, boiled, silage or dried feed. The way it is presented and mixed with other highly digestible protein ingredients could improve nutrient utilization by breeding pigs (Dom et al., 2017); likewise; González et al. (2021) conclude that the inclusion of the sweet potato tuber is an economical alternative as a replacement for cereals in the fattening stage. In this sense, boiled or silated sweet potato roots provide high nutrient and energy utilization in growing pigs (Dom et al., 2017a).

In a systematic review of the literature, Qin et al. (2022) highlight that purple-fleshed sweet potatoes contain high levels of anthocyanins, which according to Guo and Shahidi (2024) A class of phenolics Food, which play multiple roles, including antibacterial, antiviral, antioxidant, and anti-inflammatory effects, as well as improving gut health.

On the other hand, the administration of antimicrobials results in a reduction in the use of antibiotics in food-producing animals, which is usually associated with a reduction in the presence of antibiotic-resistant bacteria in these animals related to those antibiotics, according to the Mitchell et al. (2023). About that Probiotics they play that role; In addition They are used for multiple purposes, such as improving performance, mitigating diseases, increasing product quality or reducing environmental pollutants, with an application in all the different productive phases of pig production, according to the Barba-Vidal et al. (2019).

Indeed, *L. plantarum* is a highly regarded functional microorganism due to both its recognized potential health benefits (including survival in the gastrointestinal tract, adhesion capacity, antioxidant capacity, antimicrobial activity, and modulation of the gut microbiota) and its ability to improve the nutritional and sensory quality of certain foods and its ability to extend the shelf life of fermented foods Echegaray et al. (2022).

In this context, the aim of the present study was to evaluate purple sweet potatoes with the inclusion of *L. plantarum* in diets for growth-fattening pigs.

METHODOLOGY

The experiment was carried out at the Swine Experimental Unit of the Manuel Félix López Higher Agricultural School of Manabí (ESPAM MFL). The protocol for the current experiment was approved by the ESPAM MFL Bioethics Committee.

Purple Sweet Potato Flour and *Lactobacillus Plantarum Strain Activation*

Purple sweet potatoes were acquired in the productions of small and medium-sized producers installed in the Salitre canton; that it was processed in the agro-industrial workshops of the ESPAM MFL, specifically the area of flour and feeding, which included: selection, washing and cutting; the latter to facilitate the dehydration process carried out in a gas oven, Andina brand, (160ºC for 2 h) to obtain the dry matter; Subsequently, in a hammer mill with a crushing capacity of 25 qq/h (WEG brand, model 0494, Brazil), the dry material was crushed to obtain sweet potato meal (HC).

On the other hand, a strain of *Lactobacillus plantarum* (LP) isolated from the molecular biology laboratory of the ESPAM MFL, which was in a state of dormancy in cryopreservation at minus 20 °C (vertical freezer, Indurama brand, model CVI-520, Colombia) was used. Previously, a liquid culture medium, SRS broth (MAN, ROGOSA and SHARPE) was prepared, inoculated through a pipette or a sterile needle, then placed in an anaerobic incubator (LABNET brand, model 311 DS, USA) of anaerobiosis at 39 °C for 48 h and growth was observed.

Diets, Animals, and Experimental Design

The diets used were formulated using Zootec 3.0 © software (2013); In this sense, the pigs received rations according to the nutritional requirements presented in the table of consumption by age and weight recommended by the Brazilian Tables for Poultry and Pigs (Rostagno et al., 2015), as shown in TABLE I; Likewise, the ingredients were mixed in a horizontal belt mixer for balancing (EG brand, model NBR 7094, Ecuador) with a capacity of 500kg.

TABLE I
100

Insumos	Composición		Control
Maíz	43,32	38,32	53,32
Soja	28	28	28
Afrecho de trigo	4,65	4,65	4,65
Polvillo de arroz	8,2	8,2	8,2
Sal yodada	0,58	0,58	0,58
Vitaminas	0,25	0,25	0,25
Melaza	1	Inputs	Composition
Control	Corn	43,32	38,32
53,32	Soybean	28	28
28	Wheat Squeeze	4,65	4,65
4,65	Rice powder	8,2	8,2
8,2	Iodized salt	0,58	0,58
0,58	Vitamins	0,25	0,25

The diets were combined with LP levels (20 and 40 ml) with a concentration of $^{10-12}$ were given for six weeks with frequency of two periods of the day, morning (8:00 am) and afternoon (16:00 pm).

A total of 24 castrated female and male pigs (each representing an experimental unit) were used, coming from the commercial cross between females (Landrace x Duroc) and males (Pietrain), with an age of two and a half months. These were distributed in individual pens, with stainless steel feeders and pacifier drinkers integrated into the PVC pipe; In addition, the treatments under study were randomized.

The experimental units were organized in a completely randomized design, with a single source of variation (treatments), named as follows: T0: No addition of HC and LP (Control) **T1:** 15% HC plus 20 ml LP; **T2:** HC 10% plus 20 ml LP; **T3:** HC 15% plus 40 ml LP ; **T4:** 10% purple HC plus 40 ml LP; each treatment with five replicates, with the exception of the control (four).

Variable Measurements and Statistical Analysis

The weight of the animals was determined by means of a digital scale (Tru-Test XR500 brand, New Zealand, with a maximum capacity of 500 kg), every seven days, in the morning; prior to the provision of the corresponding ration; In addition, weekly weight gain and feed conversion were calculated.

The variables were analyzed descriptively through measures of central tendency (mean) and dispersion (standard deviation, standard error of the mean, coefficient of variation, and maximum and minimum values); Likewise, the analysis of variance was performed after the assumptions (normality of errors and homogeneity of variance) were met; Statistix 10 software was used. (2015).

RESULTS AND DISCUSSION

Weekly Weight

TABLE II shows the descriptive statistics of the weight variable (PS1-PS6) at weeks 1 to 6. The average PS1-PS6 is observed, a growth progression with a proportional increase between 17 and 10% between weeks; however, this tends to reduce in recent weeks, similar behavior is observed in some pig growth tables, as shown by Aguila (2022), but, Aymerich et al. (2020) mention that there are strategies that improve growth rate and feed efficiency, without increasing feed costs per kg of gain.

TABLE II

60

0,25	Molasses					
	1	1	Palm oil	2	2	2
Carbonate	1,04	1,04	1,04	Phosphorus	0,84	0,84
0,84	Lysine	0,12	0,12	0,12	Sweet Potato Flour	10
15	Not applicable	Total (%)	100	100	100	4,43
E.E	0,58	0,65	0,75	0,78	0,81	0,90
CV	12,11	11,19	10,56	9,51	8,85	8,81
Statisticians	Weekly Weight	23,63	PS1	PS2	PS3	PS4
PS5	PS6	n	24	24	24	24

PS1: Weight week 1**; PS2:** Weight week 2**; PS3:** Weight week 3**; PS4:** Weight week 4**; PS5:** Weight week 5**; PS6:** Weight week 6**; D.E:** Standard deviation**; E.E:** Experimental error; **CV:** Coefficient of variation**; MIN:** Minimum**; MAX:** Maximum**.**

Likewise, the dispersion shown by the data through the coefficient of variation is less than 13%, which shows low dispersion; It is for this reason that the highest coefficient occurs in the first week, which may be related to the initial weights of the animals.

Regarding the weekly weight in the different treatments (TABLE III), it is observed that pigs in all variants experienced a weight gain (P>0.05) during the six weeks of the study. However, pigs on the T4 treatment, which received HCM at 10% and LP at 40 ml/animal, showed the greatest weight gain, with the exception of the control.

In addition to this, from week 1 onwards, the mean weights of the pigs in the T2 and T4 treatment began to exceed those of the other treatments; Thus, at week 6, they reach an average weight (kg) of 49.96±3.05 and 50.51±1.82, respectively. These results under these conditions suggest that the addition of HCM at 10% and LP at 40 ml/animal may promote increased growth in pigs. However, more studies are needed to confirm these results.

TABLE III

50.51±1.82

24	24					
	23,61	28,52	34,62	40,02	45,05	50,24
D.E	2,86	3,19	3,66	3,80	3,98	4,43
E.E	0,58	0,65	0,75	0,78	0,81	0,90
CV	12,11	11,19	10,56	9,51	8,85	8,81
MIN	19	23,63	28,18	32,72	37,22	41,73
MAX	30	35,90	41,36	46,36	53,18	60

T0: No addition of purple sweet potato and *Lactobacillus plantarum* (Control); **T1:** Purple sweet potato flour 15% plus 20 ml of *Lactobacillus plantarum*; **T2:** Purple sweet potato flour 10% plus 20 ml of *Lactobacillus plantarum*; **T3:** Purple sweet potato flour 15% plus 40 ml of *Lactobacillus plantarum*; **T4:** Purple sweet potato flour 10% plus 40 ml of *Lactobacillus plantarum*; **S1: Week** 1; **S2: Week** 2; **S3: Week** 3; **S4: Week** 4; **S5: Week** 5; **S6: Week** 6.

Costa et al. (2023) demonstrated that the use of sweet potato flour as a component of the microparticle wall material is a promising alternative for transporting probiotic microorganisms. According to Liu et al. (2022), the administration of purple sweet potato anthocyanin extract promotes the protection of intestinal barrier function and rebuilds the homeostasis of the gut microbiota; Undoubtedly, these references show the advantages of combining HC and LP.

In this sense, Liao and Nyachoti (2017) under a review report that maintaining a healthy gut is definitely key for a pig to digest and absorb the nutrients of the diet efficiently. A balanced microbiota (i.e. a healthy microecosystem) is an indispensable element in maintaining a healthy gut.

Weekly Weight Gain (GPS)

The results of the statistical analysis of the weekly weight gain of the pigs in the different treatments (TABLE IV) showed that there were no significant differences between the treatments in terms of the mean weekly weight gain ($P > 0.05$). This indicates that all four treatments were equally effective in promoting pig weight gain.

However, some differences were observed between treatments in terms of the variability of weekly weight gain. The T1 treatment, which included the addition of purple sweet potato and *Lactobacillus plantarum*, had the lowest variability in weekly weight gain (CV = 10.33%). This indicates that pigs fed the T1 treatment had more consistent weight gain from week to week. The lower variability in weekly weight gain observed in the T1 treatment may be due to several factors. Firstly, the addition of purple sweet potato and *Lactobacillus plantarum* can improve the digestibility of dietary nutrients, which can lead to more consistent weight gain, and secondly, the improvement of the gut health of pigs, which can reduce the risk of diseases that can affect weight gain.

These results are consistent with the findings of the previous discussion, which suggested that the addition of purple sweet potato and *Lactobacillus plantarum* may improve feed efficiency and weight gain in pigs.

TABLE IV

5.78±0.41

Tratamientos	Ganancia peso semanal					
	S1	**S2**	**S3**	**S4**	**S5**	**Treatments**
Weekly Weights	5,19±0,44	S1	S2	S3	S4	S5
S6	T0	24.89±1.43	30.11±1.61	36.92±1.80	42.83±2.05	48.07±2.40
53.29±2.82	T1	22.19±0.76	27.26±0.67	33.08±0.90	Priced 37.72±0.40	43.01±0.34
48.68±0.94	S2	24.51±1.73	$28.99±2.01	35.26±2.41	40.45±2.49	45.18±2.76
49.96±3.05	S3	22.68±0.43	27.26±0.80	33.26±0.39	38.73±0.64	43.94±0.76

T0: No addition of purple sweet potato and *Lactobacillus plantarum* (Control); T1: Purple sweet potato flour 15% plus 20 ml of *Lactobacillus plantarum*; T2: Purple sweet potato flour 10% plus 20 ml of *Lactobacillus plantarum*; T3: Purple sweet potato flour 15% plus 40 ml of *Lactobacillus plantarum*; T4: Purple sweet potato flour 10% plus 40 ml of *Lactobacillus plantarum*; S1: Week 1; S2: Week 2; S3: Week 3; S4: Week 4; S5: Week 5; S6: Week 6.

According to Tiwari and Jha (2016), the *in vitro* dry matter digestibility (IVDDM) for purple sweet potato was significantly higher (86.8%, P <0.001) than taro (*Colocasia esculenta*) (70.3%). In addition to this, the purple fleshed sweet potato contains high levels of anthocyanins and is rich in minerals (calcium, potassium, copper, iron), vitamins (vitamins A, B, C), bioactive compounds (anthocyanin, β-carotene), dietary fiber and are low in fat (<1%) and protein (<5%); according to Obomeghei et al. (2020).

Likewise, the polyphenolic content of purple sweet potato can modulate microbial composition by differentially proliferating and differentially inhibit beneficial and pathogenic bacterial composition, respectively, depending on its association with fermentable and non-fermentable dietary fiber. Consequently, it could be a propitious material for improving fermentation conditions for non-fermentable dietary fiber (Kilua et al., 2019; Kilua et al., 2020). In this way, polyphenols can, through their influence on the microbiome, have a positive effect on the health of the individual in general, and on some pathologies in particular, for example. where the role of the poor state of the individual microbiome has been definitively established (Nazzaro et al., 2020).

On the other hand, Kwak et al. (2021), suggest that the inclusion of multispecies probiotic formulas (MPFs) in the diet could be a promising approach to promote growth performance and overall health of growing and fattening pigs by modulating the gut microbiota. To this effect, Hu et al. (2020) mention that supplementation with *Lactobacillus plantarum* in pig diets improves body weight at weeks 3 and 6, and also increases the average daily gain and gain/feed ratio; in addition, the beneficial effect on the apparent total digestibility of dry matter in the tract.

Similarly, Wang et al. (2018) report that feeding a synbiotic based on *Lactobacillus plantarum* and fructo oligosaccharide had beneficial effects on growth performance, plasma immune parameters, and gut microbiota, indicating its potential to serve as an alternative to feeding antibiotics in the diets of weaned pigs.

Therefore, the combined supply of HC and LP potentiates the benefits of both ingredients, where sweet potato fiber can help the LP adhere to the intestinal wall and thus improve efficacy; Therefore, it can be an effective strategy to improve the health and productive performance of pigs, together with the alternative role to the use of conventional antibiotics.

Feed Conversion

TABLE V shows the results of the effect of the addition of HC and LP on the feed conversion ratio (WQI) in pigs over 6 weeks. It is observed that as time passes, the average increases in all treatments; however, at week 1 (S1) the means were better for all HC and LP treatments (P>0.05) compared to control.

On the other hand, at the end of the research (S6), very similar average feed conversion ratios were obtained between the treatments (P>0.05), with numerical differences that did not exceed 10% with respect to the control. By virtue of the results, the consumption of all HC and PL in the different diets could be associated with the sweet taste that makes the consumption by the pigs appetizing and thus a good conversion.

TABLE V

3.38±0.31*Lactobacillus plantarum*

49.35±1.23	**S4**					
	29.26±1.87	**34.99±2.09**	**40.90±1.92**	**45.62±1.79**	**50.51±1.82**	**S6**
T0	1,85±0,18	2,25±0,31	1,87±0,16	2,35±0,11	2,94±0,25	3,14±0,26
T1	Treatments	Weekly Weight Gain	2,18±0,13	S1	S2	S3
S4	S5	S6	T0	5.19±0.44	5.21±0.70	6.81±0.58
5.91±0.32	5.23±0.53	5.92±0.53	T1	6.12±0.75	5.07±0.15	5.82±0.36
4.63±0.66	5.29±0.48	5.66±0.62	S2	6.46±1.13	5.48±0.58	5.27±0.52

T0: No addition of purple sweet potato and *Lactobacillus plantarum* (Control); T1: Purple sweet potato flour 15% plus 20 ml of *Lactobacillus plantarum*; T2: Purple sweet potato flour 10% plus 20 ml of *Lactobacillus plantarum*; T3: Purple sweet potato flour 15% plus 40 ml of *Lactobacillus plantarum*; T4: Purple sweet potato flour 10% plus 40 ml of *Lactobacillus plantarum*; S1: Week 1; S2: Week 2; S3: Week 3; S4: Week 4; S5: Week 5; S6: Week 6.

Dowarah et al. (2017) In a systematic review, they mention that a diet with probiotics (*Lactobacillus*spp.) to weaned piglets resulted in a higher growth rate due to high feed intake and better Feed Conversion Rate; likewise Nguyen et al. (2019) indicate that pigs fed the diets with probiotic blend supplements improved nutrient digestibility; the latter is a positive effect that allowed the results obtained with the combination of HC and LP. fecal bacteria count and decreased NH3 emission.

It is important to highlight the presence of anthocyanins in the purple sweet potato, which according to Wang et al. (2022) where the Research results shown in a review indicate that these are a useful tool for developing prebiotic products, where their inclusion can make the raw material more efficient. In addition according to Sun et al. (2023) 12451245High supplementation of sweet potato silage (5% dry matter based) increases immune function in fattening pigs, providing a new alternative to improve animal health.

Finally, the available data from various studies and applications of Lactobacillus in pig rearing clearly indicate the great potential, so more attention should be paid to the utilization of the effects of different probiotic preparations and the corresponding feeding strategies with the use of prebiotics (e.g. sweet potato meal).

CONCLUSIONS

The purple sweet potato (*Ipomoea batatas* (L.) Lam.), although it is mainly produced for human consumption, can be a food alternative in the growth-fattening of pigs, mainly in times of high production or as crop residues. In addition, combined with *Lactobacillus plantarum*, they improve the digestive health of pigs, which is reflected in the zootechnical parameters.

Conflict of Interest

The authors declare that there is no conflict of interest in the present study.

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