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RESEARCH ARTICLE

USE OF *STYLOSANTHES GUIANENSIS* IN PELLETED FEED FOR SUB-ADULT RABBITS (*ORYCTOLAGUS CUNICULUS*) RAISED UNDER SMALLHOLDER FARMING CONDITIONS IN CÔTE D'IVOIRE: EFFECTS ON DIGESTIVE HEALTH, GROWTH PERFORMANCE, AND REPRODUCTIVE PERFORMANCE

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ABSTRACT

Background: Feed availability and cost represent major constraints for rabbit farming in Côte d'Ivoire. *Stylosanthes guianensis* , a tropical forage legume, constitutes a potential substitute for imported alfalfa in the formulation of pelleted rabbit feeds. However, its effects on the zootechnical and health performance of breeding rabbits remain poorly documented. **Objective:** To evaluate the growth performance, reproductive performance, and health status of *Oryctolagus cuniculus* rabbits fed a pelleted diet incorporating a fibrous core based on *Stylosanthes guianensis* , compared with a commercial alfalfa-based feed. **Methods:** Three hundred breeding rabbits aged 90 days (240 females, 60 males) were allocated to two groups: a control group (C) fed the commercial diet, and an experimental group (Sg) receiving the *S. guianensis*-based diet. Sixty females participated in the growth trial (90–174 days) and 180 in the reproduction trial (90–239 days). Zootechnical and health parameters were measured and compared using appropriate statistical tests (threshold $P < 0.05$). **Results:** Both groups exhibited similar growth performance: mean body weight 3,500 g, average daily gain (ADG) 20 g/day, feed conversion ratio (FCR) 5.8. Reproductive parameters were likewise comparable: receptivity rate 84%, kindling rate 72.5%, fertility 66%, with 5.7 total kits born, 4.8 born alive, and 4.7 weaned. Conversely, mortality and health risk were significantly higher in the C group (+4% and +6%, respectively; $P < 0.05$), and stillbirth rate was lower in the Sg group. **Conclusions:** *Stylosanthes guianensis* can effectively substitute alfalfa in the diet of breeding rabbits without impairing their zootechnical performance, while providing a notable health advantage. This legume constitutes a promising local resource for reducing rabbit production costs in Côte d'Ivoire.

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INTRODUCTION

In recent years, rabbit farming has been increasingly recognized as a means of producing high-quality meat and diversifying income in developing countries (Guindjoumbi, 2007). Rabbits display high productivity owing to their strong prolificacy, yielding 8 to 10 kits per litter, and a short gestation period of 30 days (Djago and Kpodékon, 2000). In addition, rabbit meat is tender, flavourful, low in fat, and highly nutritious (Thoto and Kpodekon, 2006). In Côte d'Ivoire, rabbit husbandry has been attracting growing interest among the population (PSDEPA, 2014). Nevertheless, the development of rabbit farming faces numerous obstacles. Feed quality and the high cost of feed are among the principal impediments (PSDEPA, 2014; Kimsé*et al.*, 2017). Indeed, feed represents more than 70% of rabbit production costs (Gidenne, 2003). Within this diet, dietary fibre is a prerequisite for adequate nutrient digestibility. As a monogastric herbivore, the rabbit requires a minimum level of dietary fibre in its ration to prevent digestive disorders. Unfortunately, alfalfa—the primary fibre source used in rabbit feeding in Côte d'Ivoire—is not only imported but also constitutes one of the main drivers of the high cost of commercial feed. It therefore comes as no surprise that certain feed mills supply rabbit producers with pelleted feeds deficient in fibre (< 16% ADF), which leads to digestive disturbances, impaired growth, and elevated mortality in rabbit farms (Kimsé*et al.*, 2013). Given this situation, it becomes imperative to identify a local fibre source with a lignocellulose content (ADF) of between 19% and 20%, suitable for formulating a lower-cost feed capable of ensuring caecal ecosystem stability and reducing the risk of digestive pathologies (Gidenne, 2015). In this context, studies have been conducted on the tropical legume *Stylosanthes guianensis* with a view to using it as a fibre source in rabbit nutrition (Adande*et al.*, 2017; Kimsé*et al.*, 2013; Kouakou*et al.*, 2012). This forage

possesses a favourable content of digestible protein (100–200 g/kg), fibre (30–38%), and polyunsaturated fatty acids (Hussonet *al.*, 2008). It could therefore be used as the principal fibre source in rabbit nutrition to replace alfalfa in tropical countries. Accordingly, the objective of the present study was to formulate a diet incorporating *S. guianensis* as the fibrous core for breeding rabbits and to evaluate its effects on body weight gain, reproductive performance, and health outcomes in does and their offspring.

MATERIALS AND METHODS

Experimental groups and diets: The rabbits used in this study were hybrid *Oryctolagus cuniculus* produced by crossing the Californian and New Zealand breeds. A total of 300 breeding animals240 females and 60 malesaged 90 days with a mean body weight of 1,890 ± 14 g were enrolled. The growth and health assessment was conducted with 60 females, allocated into two groups of 30 does each (group C and group Sg). Measurements were carried out up to 174 days of age. The reproductive parameters trial involved 180 additional nulliparous females, also distributed into two groups (group C and group Sg) of 90 does each, with 30 bucks. Measurements were performed between 90 and 239 days of age. All animals were individually housed in cages measuring 0.30 m² (L: 70 cm × W: 40 cm × H: 30 cm). Groups allocated to the reproduction trial were divided into triplicates of 30 does per 10 bucks. Animals were rationed at 100 g/day between 90 and 118 days of age, 120 g/day between 119 and 146 days, and 150 g/day between 147 and 174 days. Group C was fed a commercial pelleted feed (FACI® brand, containing alfalfa, manufactured in Côte d'Ivoire) (Table 1). Group Sg was fed the experimental pelleted diet with *S. guianensis* as the fibrous core. The Sg diet was produced at Université NanguiAbrogoua.

Table 1. Theoretical chemical composition* of the experimental diets

Chemical composition (%)	Diet C	Diet Sg
DM	90.33	88.9
CF	2.40	2.6
CP	15.4	17.2
NDF	21.10	32.6
ADF	14.03	19.3
ADL	2.50	4.6
NFE	23.73	24.6
Energy (kcal/kg)	1,811	2,401

**The chemical composition of diet C (FACI® brand) was provided by the manufacturer; the composition of diet Sg was calculated.*

Measurement of feed intake, growth, health, and reproductive parameters: Feed intake was monitored daily. The amount of feed consumed was determined as the difference between the daily amount distributed and the daily refusals. Female body weight was monitored by weekly weighing using a Terraillon® electronic balance with a capacity of 10 kg and a precision of d = 1 g. Health surveillance was performed through daily monitoring of morbidity and mortality each morning and evening. The Health Risk Index (HRI) was calculated as the sum of the number of morbid animals and the number of deaths. For reproductive measurements, does were introduced to bucks at 120 days of age. The interval between kindling and mating was set at 20 days. Does not mated on the first presentation were re-introduced to the buck the following day; beyond this, they were classified as non-receptive. Matings took place in the morning (06:00–07:00) or evening (18:00–19:00). Nest checks were performed immediately after each kindling to determine the total number of kits born, the number of stillborn kits, and the health status of the doe. In does, receptivity, fertility, and kindling rate (KR) were calculated. Receptivity was defined as the ratio of the number of does that accepted mating to the total number of does presented to bucks. Fertility was calculated as the ratio of the number of does that kindled to the total number of does introduced to reproduction. Kindling rate was defined as the ratio of the number of kindlings to the total number of matings performed. Numerical productivity was characterised by the total number of kits born per litter (TK), the number of live-born kits per litter (LBK), and the number of weaned kits per litter (WK) per doe-cage. Neonatal health was assessed as the ratio of stillborn kits to the total number of kits born.

Statistical analyses: Mean body weight, weight gain, and feed conversion ratio between the two groups were compared using Student's *t*-test. The G-test was used to compare proportions relating to reproductive parameters such as receptivity, fertility, kindling rate, and numerical productivity. The same test was applied to compare mortality-related parameters including morbidity, mortality, and health risk index. All parameters were analysed using R statistical software (version 3.1.0) at a significance threshold of 5%.

RESULTS

Effect of *Stylosanthes guianensis* on growth performance and feed intake: Table 2 presents the growth performance parameters of the rabbits. No significant differences in growth parameters were recorded between the two groups. Mean body weight at 90 days of age was 1,890 ± 14 g. At 118, 146, and 174 days, mean body weights were 2,521 ± 7 g, 3,071 ± 11 g, and 3,518 ± 7 g, respectively. Average daily gain (ADG) was likewise similar between the two groups: 23 ± 1, 20 ± 1, and 17 ± 1 g/day for the periods 90–117, 118–145, and 146–174 days, respectively. The overall mean ADG calculated over the entire rearing period was 20 ± 1 g/day. Feed intake was similar for both diets throughout the study period, with a mean daily intake of 114 ± 0.6 g. During the periods 90–118, 119–146, and 147–174 days, daily intake was 97 ± 2, 116 ± 1, and 131 ± 0 g/day, respectively. Feed conversion ratio (FCR) was also similar between groups C and Sg, with an overall mean of 5.8 ± 0.1 over the period 90–174 days. Period-specific FCR values were 4.6 ± 0.1, 5.7 ± 0.0, and 7.5 ± 0.1 for 90–118, 119–146, and 148–174 days, respectively.

Effect of *Stylosanthes guianensis* on health status: During the study, 5 out of 60 animals presented health disorders; all 5 morbid animals died (Table 3). No health problems were observed during the period 90–118 days of age. Between 119 and 146 days, the HRI in the Sg group was three times lower than in the C group (3.3% vs. 10%; P = 0.01): one morbid animal was recorded in the Sg group versus two morbid animals and one death in the C group. Between 147 and 174 days, no significant difference in HRI was observed between groups; morbidity, mortality, and HRI rates were 3.4%, 6.8%, and 10.2%, respectively. Over the entire trial period (90–174 days), morbidity did not differ significantly between groups C and Sg (overall mean: 8.4%). However, mortality and HRI were 33.4% higher in the C group than in the Sg group (P = 0.01).

Table 2. Effect of the *Stylosanthesguianensis*-based diet on growth performance and feed efficiency in pre-breeding does

	Group		*SEM*	*P-value*
	C	Sg		
n	30	30		
Mean Body Weight (g)				
90 d	1,880 ± 4	1,900 ± 14	*7.5*	*0.59*
118 d	2,516 ± 8	2,526 ± 2	*17.5*	*0.29*
146 d	3,065 ± 1	3,080 ± 5	*5*	*0.21*
174 d	3,523 ± 4	3,513 ± 4	*0.57*	*0.97*
ADG (g/day)				
90–118 d	22 ± 1	23 ± 1	*2.88*	*0.76*
119–146 d	20 ± 0	21 ± 1	*0.04*	*0.20*
147–174 d	16 ± 1	17 ± 0	*0.005*	*0.40*
90–174 d	20 ± 1	20 ± 0	0.32	0.47
FeedIntake (g/day)				
90–118 d	96	98	0.14	0.07
119–146 d	116	115	4.00	0.59
147–174 d	129	132	3.24	0.64
FCR				
90–118 d	4.1 ± 0.4	4.2 ± 0.5	0.02	0.81
119–146 d	5.5 ± 0.2	5.8 ± 0.2	0.04	0.59
147–174 d	7.6 ± 0.3	7.4 ± 0.2	0.08	0.59
90–174 d	5.7 ± 0.5	5.9 ± 0.2	0.04	0.59

C: control diet containing alfalfa (FACI® brand); Sg: experimental diet containing Stylosanthesguianensis; ADG: average daily gain; FCR: feed conversion ratio; SEM: standard error of the mean.

Table 3. Effect of the *Stylosanthesguianensis*-based diet on the health status of breeding does

Age (days)	Group		P-value
	C	Sg	
90–118 days (n = 30)			
Morbidity	0	0	–
Mortality	0	0	–
HRI	0	0	–
119–146 days (n = 30)			
Morbidity	2 (6.7%)	1 (3.3%)	0.26
Mortality	1 (3.3%)	0 (0.0%)	0.04
HRI	3 (10%)	1 (3.3%)	0.01
147–174 days (n C=29; n Sg=30)			
Morbidity	1 (3.5%)	1 (3.3%)	0.70
Mortality	2 (6.9%)	2 (6.7%)	0.60
HRI	3 (10.4%)	3 (10.0%)	0.73
90–174 days (n = 30)			
Morbidity	3 (10%)	2 (6.7%)	0.34
Mortality	3 (10%)	2 (6.7%)	0.01
HRI	6 (20%)	4 (13.3%)	0.01

C: control diet (FACI® alfalfa-based feed); Sg: Stylosanthesguianensis-based experimental diet; HRI: health risk index.

Table 4. Effect of experimental diets on reproductive performance and numerical productivity of does

	Group		P-value
	Sg	C	
n	90	90	
90–161 days			
Receptivity	72 (80%)	68 (75%)	0.74
KR	68 (75%)	71 (79%)	0.73
Fertility	40 (44%)	43 (48%)	0.74
TK	5.7	5.4	0.20
LBK	4.6	4.3	0.16
WK	4.4	4.0	0.16
162–239 days			
Receptivity	83 (92%)	79 (88%)	0.88
KR	65 (72%)	58 (64%)	0.03
Fertility	77 (86%)	77 (86%)	0.87
TK	6.0	5.5	0.13
LBK	5.6	4.7	0.01
WK	5.4	5.0	0.08
90–239 days			
Receptivity	77.5 (86%)	73.5 (82%)	0.93
KR	66.5 (73.5%)	64.5 (71.5%)	0.07
Fertility	58.5 (65%)	60 (67%)	0.50
TK	5.9	5.5	0.57
LBK	5.1	4.5	0.21
WK	4.9	4.5	0.12

C: control diet (FACI® alfalfa-based feed); Sg: Stylosanthesguianensis-based diet; KR: kindling rate; TK: total kits born per litter; LBK: live-born kits per litter; WK: weaned kits per litter.

Table 5. Stillbirth rate and birth-to-weaning mortality of kits born to does bred between 90 and 239 days of age

	Group		SEM	P-value
	Sg	C		
n	90	90		
90–161 days				
Stillbirth rate	15 (17%)	23 (25.6%)		0.02
Birth-to-weaningmortality	21 (23.3%)	24 (26%)		0.47
162–239 days				
Stillbirth rate	14 (15%)	18 (20%)		0.06
Birth-to-weaningmortality	19 (21%)	20 (22.2%)		0.90
90–239 days				
Stillbirth rate	14.5 (16%)	20.5 (22.8%)		0.001
Birth-to-weaningmortality	20 (22.1%)	22 (24.4%)		0.08

C: control diet (FACI® alfalfa-based feed); Sg: Stylosanthesguianensis-based diet.

Effect of *Stylosanthes guianensis* on reproductive performance and numerical productivity: Reproductive parameters—receptivity, fertility, and kindling rate—were similar between the two groups (Table 4). Overall mean receptivity, kindling rate, and fertility were 84%, 72.5%, and 66%, respectively. For does aged 90–161 days, mean receptivity, kindling rate, and fertility were 78.5%, 77%, and 46%, respectively. Between 162 and 239 days, the Sg group produced 7 additional litters (+8%) compared with the C group ($P = 0.03$), whereas receptivity and fertility remained similar (mean: 90% and 86%, respectively). Numerical productivity—characterised by total kits born per litter (TK), live-born kits per litter (LBK), and weaned kits per litter (WK)—was globally similar between groups (Table 4). TK, LBK, and WK recorded between 90 and 161 days were 5.5, 4.5, and 4.2 kits per litter, respectively. Between 162 and 239 days, LBK in the Sg group was 0.9 kits higher than in the C group ($P = 0.01$), while no significant difference was observed for TK or WK (means: 5.8 and 5.2 kits per litter, respectively). Nevertheless, WK in the Sg group tended to be 0.4 kits higher than in the C group ($P = 0.08$).

Effect of *Stylosanthes guianensis* on neonatal health in the nest: In does bred between 90 and 239 days of age, the stillbirth rate of kits in the nest was 6.8% lower in the Sg group than in the C group ($P < 0.01$). Regarding mortality from birth to weaning, there was a strong tendency towards 2.3% fewer deaths in the Sg nest compared with C ($P = 0.08$; Table 5). Between 90 and 161 days of age, the stillbirth rate in the Sg group was half that of the C group ($P = 0.02$), while nest mortality was similar between groups (24.7%). Between 162 and 239 days, the stillbirth rate showed a strong tendency to be 25% lower in the Sg group than in the C group ($P = 0.06$).

DISCUSSION

The objective of the present study was to formulate a diet based on *S. guianensis* for breeding rabbits and to evaluate its effects on body weight gain, reproductive performance, and health outcomes in does and their offspring. In this experiment, two groups were established: a control group and an experimental group, fed a commercial alfalfa-based diet and a *S. guianensis*-based diet, respectively. The present study demonstrated that the use of *S. guianensis* as a fibre source in the experimental diet did not affect voluntary feed intake. The fibre content of this diet would appear to meet the rabbits' requirements, since feed intake decreases when dietary fibre does not cover the animals' needs (Gidenne*et al.*, 2012; Xiccato and Trocino, 2010). This finding suggests that *S. guianensis* is a high-quality fibre source that supports adequate feed intake levels. Intake values are consistent with those commonly reported in Côte d'Ivoire across various studies (Kimsé*et al.*, 2014; Dakouri*et al.*, 2021). However, intake was approximately 20 g lower than temperate-country references, attributable to the high ambient temperature and relative humidity that reduce feed intake in tropical settings. These climatic conditionsalso depress growth in tropical-country animals relative to their temperate-zone counterparts at the same age. The relatively modest growth rates recorded are further explained by the advanced age of these females: at three months, there is a marked increase in FCR and substantial fat deposition (Gidenne*et al.*, 2019).

Adult rabbits generally present a low health risk index; nevertheless, does fed the *S. guianensis* diet exhibited superior health status. The improved health performance observed with this diet could be attributed to better nutrient balance and enhanced digestibility. Diet does not appear to influence fertility or receptivity, as these parameters are primarily determined by the genetic strain used (Lebas*et al.*, 2010). However, for the kindling rate, the best-adapted diet could improve this parameter, which may partly explain the strong tendency observed for does fed the *S. guianensis* diet to achieve a higher kindling rate. In does, the diet appears to influence productivity parameters (total born, live born, weaned) in primiparous animals.

From birth until 20 days of age, kits feed exclusively on maternal milk; their survival therefore depends on the quality and quantity of that milk. *S. guianensis* may therefore exert a galactagogue effect. Indeed, certain forages have been shown to enhance milk yield in does (Kouakou*et al.*, 2021). The *S. guianensis*-based diet allows maternal milk to cover kit requirements from the third week of age onwards. These characteristics of the *S. guianensis* diet would account for the reduced stillbirth rate and nest mortality observed. The recorded stillbirth rate was twice as low as that reported in Morocco by Jaouzi*et al.* (2004).

CONCLUSION

The objective of the present study was to evaluate the effect of a *Stylosanthes guianensis* -based diet on mortality, growth, and reproductive parameters in rabbits, with a view to substituting alfalfa in rabbit feeds with *S. guianensis* in tropical countries. *S. guianensis* can be used to replace alfalfa in the diet of breeding does in tropical countries. The diet with *S. guianensis* as the fibrous core had no negative effect on reproductive performance in does. Growth performance during the pre-reproductive phase was identical between the two dietary treatments. Productivity of does during the reproductive phase was likewise similar to that of the control group. Furthermore,

the *S. guianensis*-based diet reduced neonatal mortality—specifically the stillbirth rate—by 6.9%. *S. guianensis* can therefore be used as a fibre source to replace alfalfa in rabbit feed.

ABBREVIATIONS

DM	Dry Matter
CF	Crude Fat
CP	CrudeProtein
NDF	Neutral DetergentFiber
ADF	Acid DetergentFiber
ADL	Acid DetergentLignin
NFE	Nitrogen-Free Extract
ADG	Average Daily Gain
FCR	Feed Conversion Ratio
SEM	Standard Error of the Mean
HRI	Health Risk Index
KR	Kindling Rate
TK	Total Kits born per litter
LBK	Live-Born Kits per litter
WK	Weaned Kits per litter (also: Birth-to-Weaning)
C	Control group – commercial feed containing alfalfa (FACI® brand)
Sg	Stylosanthes guianensisexperimental group
PSDEPA	Strategic Plan for the Development of Livestock, Fisheries and Aquaculture
INRAE	National Research Institute for Agriculture, Food and Environment (France)
ENVT	National Veterinary School of Toulouse
UFR	Training and Research Unit

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