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Effects of Ginger Powder (*Zingiber Officinale*) Associated with *Desmodium Intortum* And/Or *Stylosanthes Guianensis* On *In Vivo* Digestibility And Meat Quality Of Rabbits (*Oryctolagus Cuniculus*)

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ABSTRACT

Feeding rabbits remains one of the main handicaps to the development of its breeding due to the increase in the cost of ingredients, specifically for conventional protein sources. This study was designed to evaluate the effects of associating ginger powder with leguminous on ingestion, in vivo digestibility of nutrients, and the meat quality of rabbits. For this purpose, 32 female rabbits weighing 2000 gram ± 200 gram, aged between 20 weeks and 22 weeks were randomly distributed into eight treatments with 4 rabbits per treatment. The experimental rations prepared were serves to the animals on daily bases as follows; R0T1 (control ration: concentrate without léguminous and without ginger powder); R1T2: (concentrate without léguminous+1% ginger powder); R2T3: (concentrate+20% Stylosanthes guianensis+1% ginger); R3T4: concentrate+20% Desmodium intortum+1% ginger powder); R4T5: (concentrate+20% Desmodium intortum +0% ginger powder); R5T6: (concentrate+20% S. guianensis+0% ginger powder); R6T7:(concentrate+10% Stylosanthes guianensis+10% Desmodium intortum +0% ginger powder), R7T8: (concentrate+10% Stylosanthes guianensis+10% Desmodium intortum+1% ginger powder). The results obtained showed that the ingestion of dry matter, crude proteins, crude fiber, neutral detergent fiber, and acid detergent fiber respectively (58.37% for R4T5), (51.38% for R0T1), (25.32% for R0T1), (19.24% for R5T6), (85.51% for R2T3) and (29.33% for R1T2) were significantly higher. The apparent digestive utilization coefficients of dry matter (CUDaDM) (98.38% for R2T3), organic matter (CUDaMO) (99.04% for R2T3), crude protein (CUDaPB) (99.48% for R5T6) crude fiber (CUDaCB) (99.86% for R5T6), (CUDaNDF) (89.75% for R4T5) and (CUDaADF) (34.17% for R3T4) were significantly (P<0.05) higher. Drip loss, temperature, and pH were not significantly (p>0.05) influenced regardless of the feed ration.

In conclusion, the association of 20% S. guianensis and 1% ginger in rabbit feed improved the ingestion, digestibility and meat quality of rabbits.

Keywords: *Desmodium intortum, Ingestion, and digestibility in vivo, meat quality, Stylosanthes guianensis, Zingiber officinale*

INTRODUCTION

Rabbits are very prolific monogastric herbivores, they have a lifespan record of about 15 years and weigh 3 kg to 5 kg at the adult stage hood [1,2]. Rabbits feed on cereals and leguminous while practicing caecotrophy. They have a gestation period of 30 days to 33 days with 4 to 12 young rabbits per litter [3]. Despite its importance feed remains one of the main handicaps to the development of its breeding following the increase in the cost of ingredients, more specifically for conventional protein sources. Farmers, therefore, migrate to locally available sources of protein from léguminous because of their availability and the ability of rabbits to convert it into meat for humans. The use of leguminous as the source of protein is limited by the presence of anti-nutritional factors. However, maxi-mizing the ingestion of local forage and proceeding with the treatment of feed as well as the rational distribution of concentrate reduces the cost of feeding animals such as rabbits while promoting growth [4]. Herbal products incorporated as additives have seen their use increase in recent years [5]. The strong use of these products such as powders or essential oils lies in their availability and their richness in aromatic compounds with multiple properties. From the Zingiber genus and the Zinbéraceae family, it's a rhizome highly appreciated in cooking for its characteristic taste and smell [6]. Ginger powder contains 40%-60% starch, 9%-10% protein; 6% -10% lipids; 5% fiber; 6% inorganic element and 1%-4% essential oils [7]. In addition, it is rich in aromatic compounds such as gingerol and gingerdiol with biological activities including antimicrobial, antioxidant, antiviral, anti-inflammatory, analgesic activities, and digestive enzyme stimulators [8-11]. Thus, the improvement of rabbit production can be done, by improving their diet and above all, by providing them with a balanced diet taking into account their nutritional needs [12].

The incorporation of these fodders associated with additives in feed could improve its nutritional value and also boost the growth of animals while promoting a better feed conversion ratio [13, 14]. Among these forages are *Stylosanthes guianensis* and *Des-modium intortum* which are used to enhance the ingestion and digestion of grasses in tropical environments for herbivores [15]. Safa revealed that the use of 1% ginger powder in broilers significantly increased weight gain, feed consumption, and feed efficiency [11]. Several studies have been conducted on the use of some tropical fodder and additives in the evaluation of growth parameters in rabbits. Although several works exist on the use of fodders (Leguminous) and ginger powder in animal production, no or limited studies have been carried out relating to the synergy effects of leguminous and ginger powder on ingestion and digestibility in rabbits. This study aimed to improve the ingestion, in-vivo digestibility, and meat quality of rabbits fed with ginger powder associated with *Stylosanthes guianensis* and *Desmodium intortum*.

MATERIALS AND METHODS

Study syte

This study was conducted from March to April 2020 at the teaching and Research farm of the Faculty of Agronomy and Agricultural Sciences (FASA) of the University of Dschang. This farm is located between latitude 05°44'-05°36'N and 05°44'-05°37'N and longitude 010°06'-09°94'E and 010°06'-09°85'E at an altitude of 1420 m.

Animal equipment and housing

Thirty-two female rabbits of weight 2000 gram ± 200 gram and aged between 16 weeks and 18 weeks were used, for the evaluation of ingestion and digestibility. The animals were placed in individual wire mesh cages 1 m long, 50 cm wide and 30 cm height, each equipped with an aluminum feeder and drinker with a capacity of 250 grams each and a device (made of a mosquito net with a mesh of 1 mm and a plastic paper) for collecting faeces. The various cages were fitted with a fine-mesh cover to protect the animals from snakes and other predators that may be present or enter the building. The cages were disinfected with sodium hypochlorite, TH4, and Virunet (respectively 250 ml and 50 grams for 50 liters of water).

Plant material

The plant material consisted of *Zingiber o icinale*, leaves of *Stylosanthes Guianensis,* and *Desmosdium Intortum*. The leaves of *Stylos-anthes Guianensis* and *Desmodium intortum* were harvested before flowering at the FASA forage field, then dried at 45°C in an over and ground into powder. Ginger was bought at the local market in the city of Dschang, sorted, washed, cut, and dried, then grind to obtain a powder. The different ingredients were stored separately in hermetically sealed polyethylene bags to limit any contact with water or air humidity. Bromatological analysis of each sample (100 grams) was carried out beforehand at the animal production and nutrition laboratory of the University of Dschang before the start of the trial (Table 1).

Table 1. Chemical Composition of leguminous and Ginger Powder

	Dry matter(%DM)	Crude protein(%DM)	Crude fiber(%DM)	Ash(%DM)	Lipids(%DM)
Stylosanthes Guianensis	23	17.24	30.01	10.85	1.54
Demodium intortum	25	18.11	28.24	9.8	1.39
Ginger powder	-	6.77	2.8	_	0.68

Experimental rations

The ingredients (corn, wheat bran, soybean cake, cotton, iodized salt, shellfish, premix, palm oil) used for this purpose were bought at the local market in Dschang. Local protein sources used were obtained from the leaves of *Stylosanthes guianensis* and *Desmodium intortum*. These ingredients were incorporated into the feed at different proportions depending on the experimental rations. One hun-dred (100 grams) of each feed ration was collected to determine the chemical composition of the experimental rations according to the method described by AOAC. The proportions of the different ingredients used in the formulation of the experimental rations and nutritional value for this trial are presented in Table 2.

Table 2. Percentage composition of rations

Ingredients (%)	Rations							
	R0	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**
Yellow corn	20	20	20	20	20	20	20	20
Palm oil	1	1	1	1	1	1	1	1
Shell	1	1	1	1	1	1	1	1
Cooking salt + detox	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Bone powder	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
NMVC 5%	5	5	5	5	5	5	5	5
Fishmeal	2	2	2	2	2	2	2	2
Wheat Bran	22	22	18	18	18	18	18	18
Palm kernel cake	20	20	15	15	15	15	15	15
Soybean meal	8	8	2	2	2	2	2	2
Cotton cake	6	5	2	2	2	2	2	2
Pennisetum purpureum	14	14	12	12	3	3	3	12
Stylosanthes guianensis	0	0	20	0	20	0	10	10
Desmodium intortum	0	0	0	20	0	20	10	10
Ginger powder	0	1	1	1	0	0	0	1
Total	100	100	100	100	100	100	100	100
Chemical composition								
	R0	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**
Phosphorus (%.DM)	0.71	0.7	0.69	0.7	0.74	0.71	0.73	0.71
Calcium (%.DM)	1.22	1.24	1.21	1.21	1.21	1.22	1.2	1.21
Crude fiber (%.DM)	12.25	12.02	12.09	12.21	12.54	12.36	12.11	12.14
Crude Protein (%.DM)	17.01	16.79	16.88	16.71	16.84	16.69	16.94	17.08
Digestible energy (kcal/kg.MS)	2548	2580	2584	2520	2591	2512	2521	2501

The different rations thus prepared were served to each animal on a daily basis as follows:
- R0T1 (control ration): concentrate without leguminous and without ginger powder;
- R1T2: concentrate without leguminous+1% ginger powder;
- R2T3: concentrate+20% *Stylosanthes guianensis*+1% ginger;
- R3T4: concentrate+20% *Desmodium intortum*+1% ginger powder;
- R4T5: concentrate+20% *Desmodium intortum*+0% ginger powder;
- R5T6: concentrate+20% *Stylosanthes guianensis*+0% ginger powder.
- R6T7: concentrate+10% *Stylosanthes guianensis*+10% *Desmodium intortum* + 0% ginger powder.
- R7T8: concentrate+10% *Stylosanthes guianensis*+10% *Desmodium intortum* + 1% ginger powder.

Evaluation of ingestion and in vivo digestibility of experimental rations

Animals were randomly assigned to individual cages, feed was served only once a day between 8 a.m and 10 a.m. For the evalua-tion of ingestion, the quantity of feed served (150 grams) was noted and the leftover was collected daily and weighed before any new distribution. Feed intake was calculated using the method described by Mathieu using the formula below:

Feed intake=Quantity of feed served–Quantity not consumed (leftover)

Data collection for digestibility lasted 7 days, the quantity of compound feed served was adjusted to the consumption of the animals estimated at 150 grams/animal/day each morning before the distribution of feed. 10 ml of feces were collected in batches, weighed, and dried at 60°C in the laboratory in a ventilated oven. Thereafter Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), and Crude Fiber (CB) content analyzed according to the method described by AOAC. The apparent digestive utilization Coefficients of Dry Matter (CUDaDM), Organic Matter (CUDaOM), Crude Protein (CUDaCP), and Crude fiber (CUDaCF) were calculated according to the method described by Mathieu [16]:

$$CUDa\,(\%) = \frac{(\text{Quantity of feed ingested}) - (\text{Quantity of faeces})}{(\text{Quantity of feed ingested})} \times 100$$

Assessment of meat quality parameters

Water Holding Capacity (WHC)

Water holding capacity was determined by the method described by Piasentier [17]. 10 grams of meat taken from each slaughtered rabbit was weighed using an electronic balance (210 grams ±0.001 grams). Each sample was crushed in a mortar, 2 ml of water was added using a sterilized 25 ml syringe, then weighed again. Each rabbit meat sample was spread on a coin (25frs) and turned on square paper at room temperature (25.6°C). The WHC after 24 hours was calculated using the formula below:

$$WHC = \frac{(\text{Total surface of liquide}) - (\text{surface},\ (4.90\,\text{cm}^2)\ \text{of the 25 frs coin}) \times 100}{(\text{surface of liquide}) + (\text{surface}\,(4.90\,\text{cm}^2)\ \text{of 25 frs coin})}$$

Drip loss (DL)

Water loss by refrigeration was obtained using the method described by Honikel [18]. One hour after slaughter, 10g of meat taken from each rabbit was weighed using an electronic balance (210 grams ± 0.001grams) and labeled. These samples were packed in net bags and suspended over a 250 ml beaker at 4°C. After 24 hours, the various samples were removed, with tissue paper and reweighed. The drip loss after 24 hours was determined using the formula below:

$$DL = \frac{(\text{initial weight of sample}) - (\text{final weight of sample})}{(\text{initial weight of sample})} \times 100$$

Cookout loss

Cookout loss was carried out using the method described by Piasentier, 10 grams of meat taken from each animal were weighed using an electronic balance (210 gram ± 0.001 gram) [17]. These meat samples were introduced into zip lock bags and then immersed in a water thermostatic bath at 75°C. After 15 minutes they were removed and allowed to cool to room temperature for about 30 min-utes. The samples were dabbed by using tissue paper and then reweighed. The cookout lost was calculated from the following formula:

$$CL = \frac{(\text{initial weight of sample}) - (\text{final weight of sample})}{(\text{initial weight of sample})} \times 100$$

Freezing loss (FL)

The freezing loss was carried out by the method described by Honikel, [18]. 10 grams of meat was taken from each rabbit, weighed using an electronic balance (210 grams ±0.001gram), and labeled. The meat samples were put in plastic bags, then introduced in a freezer at −20° C for 10 days. After 10 days, the latter were removed and left to thaw at room temperature (25.2°C). The samples were dabbed using tissue paper and then reweighed. The freezing loss was calculated following the formula below.

$$FL = \frac{(\text{initial weight of sample}) - (\text{final weight of sample})}{(\text{initial weight of sample})} \times 100$$

pH of meat

pH was determined using a pH/temperature meter (HI8484, HANNA). The pH meter was calibrated with buffer solutions (pH=4 and 10) following the procedures prescribed by the manufacturer's instructions. The electrode of the pH meter was introduced into the meat at a minimum depth of 2 cm for optimal reading of the pH. The pH values were recorded at 1 hour, 6 hours, 12 hours, and 24 hours after slaughter. For each reading, 3 values were recorded at 5 minutes intervals and the average value was considered. After each reading, the electrode of the pH meter was cleaned with distilled water.

Temperature

The temperature was read using a pH meter/temperature (HI8484, HANNA) immediately followed by the pH, following the meth-od described by Fonteh [19]. The electrode was inserted 2 cm beneath the meat sample. The temperature was assessed three times and the average value was considered. The values were recorded after 1 hour, 6 hours, 12 hours, and 24 hours after slaughter.

Statistical analyzes

Data collected on ingestion, nutrient digestibility, and meat quality were subjected to a one-way Analysis of Variance (ANOVA) following the general linear model (MLG). When significant differences existed between treatments, separation of means was done using the Waller-Duncan test at a 5% significance level. The statistical package SPSS 21.1 software was also used.

RESULTS

Effects of ginger powder associated with Desmodium intortum and/or Stylosanthes guianensis on ingestion in rabbits

Table 3, shows the effects of ginger powder associated with *Desmodium intortum* and/or *Stylosanthes guianensis* on ingestion. The ingestion of dry matter was significantly (P < 0.05) higher with rabbits fed R4T5 (58.37%) and R1T2 (57.21%), compared to rabbits fed R0T1, R5T6, and R7T8 rations but was comparable to those fed with R2T3 (53.19%) and R6T7 (53.17%) rations. As regard to the average rate of ingestion of organic matter, animals of the control group (R0T1) significantly (P < 0.05) ingested more organic matter compared to those fed with R5T6, R2T3, and R7T8 rations respectively, but comparable to the other rations. Crude protein ingestion of rabbits fed R7T8 ration was significantly (P < 0.05) lower than those fed with the control and R1T2 rations but similar to the other rations. Animals fed R2T3 (16.38%) and R5T6 (19.24%) rations presented higher (P < 0.05) mean values of crude fiber ingestion than animals fed with the other rations, whereas those fed with R7T8(10.88%) ration recorded the lowest (P < 0.05) crude fiber ingestion values. The ingestion of Neutral Detergent Fiber (NDF) was significantly (P < 0.05) higher in animals fed R2T3 ration (85.51) whereas fed R6T7 ration (76.84%) presented significantly (P < 0.05) lower NDF values. Rabbits fed R1T2 (29.33%) and R7T8 (29.14%) rations induced significantly (P < 0.05) higher ingestion of acid detergent fiber (ADF) compared to rabbits fed R3T4 and R6T7 rations but were statistically similar (P > 0.05) to the other rations.

Table 3. Effects of ginger powder associated with *Desmodium intortum* and/or *Stylosanthes guianensis* on the ingestion of DM, OM, CP, CF, NDF and ADF in rabbits.

Parame-ters (%)	Rations								
	R0T1	R1T2	R2T3	R3T4	R4T5	R5T6	R6T7	R7T8	*P*
DM	50.96 ± 1.64 c	57.21 ± 1.92 a	53.19 ± 1.80 ab	54.07 ± 1.01 ab	58.37 ± 1.87 a	52.16 ± 1.44 b	53.17 ± 1.28 ab	48.49 ± 1.20 C	0
OM	51.38 ± 1,27 a	44.52 ± 1.59 ab	39.81 ± 1.77 c	42.56 ± 1.00 ab	44.65 ± 1.71 ab	47.89 ± 1.53 b	46.43 ± 1.26 ab	37.97 ± 1.01 c	0
CP	25.32 ± 1.32 a	23.97 ± 0.99 a	23.00 ± 0.87 ab	23.39 ± 0.62 ab	23.35 ± 1.64 ab	23.67 ± 1.51 ab	23.30 ± 1.05 ab	21.34 ± 1.43 b	0
CF	14.72 ± 2.24bc	11.17 ± 1.66 b	16.38 ± 1.27 a	14.22 ± 1.47bc	10.47 ± 1.15 cd	19.24 ± 1.23 a	13.94 ± 9.32bc	10.88 ± 2.94 c	0
NDF	79.61 ± 1.57 b	84.02 ± 1.5 ab	85.51 ± 1.04 a	81.85 ± 1.68bc	80.64 ± 3.14bc	81.76 ± 1.97bc	76.84 ± 1.3 c	77.62 ± 1.55 b	0
ADF	28.02 ± 1.78 ab	29.23 ± 0.92 a	28.55 ± 0.77 ab	26.73 ± 1.81 b	27.67 ± 0.98 ab	28.41 ± 0.57 ab	26.71 ± 0.41 b	29.14± 0.46 a	0

a,b,c,d: Means with the same letters on the same row are not significantly(P>0.05) different at 5% level; P: Probability; OM=organic matter, DM=dry matter, CP=crude protein, NDF=neutral detergent fiber, ADF=acid detergent fiber, CF=crude fiber, R0T1=(control) concentrate without léguminous and without ginger powder; R1T2=concentrate without leguminous+1% ginger powder; R2T3=concentrate+20% Stylosanthes guianensis+1% ginger; R3T4=concentrate+20% Desmodium intortum+1% ginger powder; R4T5=concentrate+20% Desmodium intortum+0% ginger powder; R5T6=concentrate+20% Stylosanthes guianensis+0% ginger powder; R6T7=concentrate+10% Stylosanthes guianensis + 10% Desmodium intortum+0% ginger powder; R7T8: concentrate+10% Stylosanthes guianensis+10% Desmodium intortum+1% ginger powder

Effects of ginger powder associated with Desmodium intortum and/or Stylosanthes guianensis on apparent digestive utilization coefficients (CUDa of MS, MO, PB, CB, NDF) of nutrients in rabbits

Table 4 shows the apparent digestibility utilization coefficient of nutrients. It appears from this table that, the digestibility of Dry Matter (DM) and Organic Matter (OM) were higher (P < 0.05) compared to the control ration (R0T1) which was lowest. Crude protein digestibility was significantly highest with rabbits fed R5T6 rations compared to the other rations but similar to those fed R3T4 rations. The digestibility of NDF of rabbits fed with the control, R4T5 and R5T6 rations were higher (P < 0.05) compared to the other rations, however rabbits fed with R2T3 rations recorded the lowest (P < 0.05) digestibility value. The digestive utilization coefficient of rabbits fed with R3T4 ration was significantly (P < 0.05) higher as compared to the other rations, while those of rabbits fed with R7T8 recorded the lowest digestibility utilization coefficient.

Table 4. Apparent digestive utilization coefficients (CUDa of MS, MO, PB, CB, NDF) of nutrients in rabbits fed with ginger powder associated with *Desmodium intortum* and/or *Stylosanthes guianensis*

Parameters	Rations								
	R0T1	R1T2	R2T3	R3T4	R4T5	R5T6	R6T7	R7T8	p
DM	95.50 ± 0.73 c	97.54 ± 0.36 ab	98.38 ± 0.23 a	97.50 ± 0.64 b	98.32 ± 0.44 ab	98.10± 0.25 ab	97.73 ± 0.01 ab	97.62 ± 0.4 ab	0.03
OM	97.06 ± 0.48 c	97.73± 0.34bc	99.04± 0.8 a	97.75± 0.48bc	98.42 ± 0.47 ab	98.99± 0.87 ab	98.09± 0.4c	98.73 ± 1.09 ab	0
CP	99.54 ± 0.47 d	99.39 ± 0.01 e	99.78 ± 0.03 b	99.80 ± 0,04 ab	99.67 ± 0,06 c	99.86± 0.01 a	99.78± 0.07 b	99.70± 0.43 c	0
CF	94.26 ± 1.19 b	99.24 ± 0.1 a 2	99.42 ± 0.62 a	99.20 ± 0.18a	99.37 ± 0.17 a	99.23 ± 0.17 a	99.48 ± 0.44 a	99.68 ± 0.55 a	0.02
NDF	86.87 ± 1.42 a	77.61 ± 2.23 cd	70.96 ± 1.34 e	82.22 ± 2.82 b	87.12 ± 1.60 a	89.75 ± 2.06 a	74.72 ± 1.76 d	78.19 ± 1.29 c	0
ADF	24.66 ± 0.71 c	28.45± 1.07 b	29.45 ± 1.07 b	34.17 ± 2.64 a	28.33 ± 100 b	28.31 ± 0.78 b	24.68 ± 0.59 c	21.59 ± 1.97 d	0

a,b,c,d…: Means with the same letters on the same row are not significantly (P>0.05) different at 5% level; p: Probability; OM=organic matter, MS=dry matter, PB=crude protein, NDF=neutral detergent fiber, ADF=acid detergent fiber, CF=crude fiber, CUDa=Apparent Digestibility Coefficient, Ingestion. R0T1=(control) concentrate without leguminous and without ginger powder; R1T2=concentrate without léguminous+1% ginger powder; R2T3=concentrate+20% *Stylosanthes guianensis*+1% ginger; R3T4=concentrate + 20% *Desmodium intortum*+1% ginger powder; R4T5=concentrate+20% *Desmodium intortum* +0% ginger powder; R5T6=concentrate+20% *Stylosanthes guianensis*+0% ginger powder; R6T7=concentrate+10% *Stylosanthes guianensis*+10% *Desmodium intortum*+0% ginger powder; R7T8: concentrate+10% *Stylosanthes guianensis*+10% *Desmodium intortum*+1% ginger powder

Effects of ginger powder associated with Desmodium intortum and/or Stylosanthes guianensis on rabbit meat quality

Effects on technological properties

Table 5 Present the effect of ginger powder associated with *Desmodium intortum* and/or *Stylosanthes guianensis* on rabbit meat quality. It follows from the analysis of this table that animals fed R6T7 (73.13%) and R7T8 (74.50%) presented significantly (p<0.05) higher water-holding capacity than those of animals from the other feed treatment groups. Animals fed R4T5 diet recorded significantly (p<0.05) the highest cook out loss (27.85) compared to those fed the control ration (20.55%) with the lowest cook-out loss value. The freezing loss was significantly (p<0.05) higher with animals fed R1T2 rations (22.25%). At the same time, rabbits fed R2T3 ration (77.33%) had the highest sample weight after drying. Drip loss was not a significantly influence regardless of the treat-ment groups.

Table 5. Effects of ginger powder associated with *Desmodium intortum* and/or *Stylosanthes guianensis* on the technological meat quality of rabbit

Technological Properties	Treatment								
	R0T1	R1T2	R2T3	R3T4	R4T5	R5T6	R6T7	R7T8	*p*
WHC	63.22± 1,59 c	65.58 ± 0,77bc	68.84 ± 1,06 b	65.84± 0,50bc	64.51 ± 1,87bc	68.46± 3,03bc	73.13± 2,04a	74.50 ± 1,17 a	0,00
COL	20.55 ± 0,05d	23.90 ± 0,80c	23.10 ± 1,60c	25.85 ± 0,55b	27.85 ± 0,95 a	26.30± 1,50ab	27.55 ±0,25ab	27.40 ± 0,10ab	0,00
FL	18.80± 5.00 abc	22.25± 2,45a	16.99 ± 1,80bc	19.40 ± 1,20b	16.30 ± 4,20bc	13.65 ± 1,45c	17.45± 1,25abc	13.70± 1,10 c	0,01
DL	23.15 ± 1,95a	23.05 ± 1,05a	23.50 ± 0,30a	21.33 ± 3,15a	22.00 ± 1,35a	23.00 ± 0,80a	22.48 ± 2,16a	25.10 ± 3,10a	0,50

a,b,c,d…: Means with the same letters on the same row are not significantly (P>0.05) different at the 5% level; *P*: Probability; WHC=Water holding capacity, COL=cook out loss, FL=freezing loss DL=Drip loss , R0T1=(control) concentrate without léguminous and without ginger powder; R1T2=concentrate without léguminous+1% ginger powder; R2T3=concentrate+20% *Stylosanthes guianensis*+1% ginger; R3T4=concentrate+20% *Desmodium intortum*+1% ginger powder; R4T5=concentrate+20% *Desmodium intortum*+0% ginger powder; R5T6=concentrate+20% Stylosanthes guianensis +0% ginger powder; R6T7=concentrate+10% *Stylosanthes guianensis*+10% *Desmodium intortum* 0% ginger powder; R7T8: concentrate+10% *Stylosanthes guianensis*+10% *Desmodium intortum*+1% ginger powder.

Effects of temperature and pH

Table 6 shows the temperature and pH value of rabbit's meat concerning treatment, it appears from this table that between 1 and 24 hours after slaughter, the temperature of meat dropped from 35.52°C to 14°C irrespective of the treatment groups. However, the temperature values did not vary significantly (P>0.05) regardless of the ration administered, except for rabbits feed R3T4 ration (33.84) at time T1 which revealed a significantly (p<0.05) low temperature. The same trend was observed with pH but with no significant differences. The pH dropped from 8 to 4.5 regardless of the treatment considered.

Table 6. Temperature and hydrogen potential of rabbit meat with respect to treatment

Température (C°)	Time (Hours)	Rations								*p*
		R0T1	R1T2	R2T3	R3T4	R4T5	R5T6	R6T7	R7T8	
T	1	35.11 ± 0.61^a	34.9 ± 1.4^a	35.21 ± 0.36^a	33.84 ± 0.62^b	35.25 ± 1.56^a	35.52 ± 0.67^a	35.27 ± 0.56^a	34.75 ± 1.83^a	0
pH	1	7.35 ± 0.01	7.05 ± 0.01	7.4 ± 0.06	7.4 ± 0.01	7.30 ± 0.10	7.20 ± 0.20	7.5 ± 0.09	7.2 ± 0.03	0.1
T	6	22.66 ± 0.34^a	22.73 ± 1.02^a	22.89 ± 1.27^a	20.79 ± 1.03^a	19.99 ± 0.80^a	22.82 ± 0,89^a	20.75 ± 1.17^a	21.39 ± 1.54^a	0.61
pH	6	6.15 ± 0.05	5.95±0.02	6.21 ± 0.04	6.10± 0.03	6.55± 0.01	6.50 ± 0.00	6.1 ±0.07	6.15 ± 0.05	0.2
T	12	16.77 ± 0.06^a	17.77 ± 0.01^a	16.70 ± 0.03^a	16.21 ± 0.01^a	16.10 ± 0.13^a	17.09 ± 0,11^a	16.55 ± 0.06^a	16.39 ± 0.03^a	0.4
pH	12	5.15±0.09	5.25±0.04	5.01 ± 0.01	5.20 ± 0.01	5.15 ± 0.04	5.35 ± 0.02	5.05 ± 0.03	5.25 ± 0.01	0,06
T	24	15.00 ± 0.04^a	14.75±0.04^a	14.50 ± 0.10^a	14.05 ± 0.52^a	14.00 ± 0.2^a	14.80 ± 0.50^a	14.04 ± 0.31^a	14.58 ± 0.21^a	0.2
pH	24	4.18 ± 0.06	4.05±0.04	4.10 ± 0.01	4.50 ± 0.00	4.15 ± 0.2	4.15 ± 0.08	4.15± 0.01	4.06 ± 0.01	0.08

a,b Means with the same letters on the same row are not significantly (p>0.05) ; P: Probability; T=temperature, pH=potential Hydrogenous ;Time (Hours); R0T1=(control) concentrate without leguminous and without ginger powder; R1T2=concentrate without leguminous+1% ginger powder; R2T3=concentrate+20% Stylosanthes guianensis+1% ginger; R3T4=concentrate+20% Desmodium intortum+1% ginger powder; R4T5=concentrate+20% Desmodium intortum+0% ginger powder; R5T6=concentrate+20% Stylosanthes guianensis+0% ginger powder; R6T7=concentrate+10% Stylosanthes guianensis+10% Desmodium intortum+0% ginger powder; R7T8: concentrate+10% Stylosanthes guianensis+10% Desmodium intortum+1% ginger powder

DISCUSSION

This study revealed that the ingestion of the different feed rations induced significantly (p<0.05) higher mean values for animals fedrations containing concentrate without léguminous+1% ginger powder and concentrate+20% *Desmodium intor-tum*+1% ginger powder while the ingestion of dry matter was the lowest with the control ration (50.96). The other feed rations induced ingestion values comparable to the control ration. This could be explained by the variation in the nutrients contained in the different feed rations and mainly by the high nutritional value of the ingredients in rations containing concentrate without leguminous+1% ginger powder and concentrate+20% *Desmodium intortum*+1% ginger powder compared to the other rations [20]. These results con-tradict those obtained by Miegoue who revealed that the antinutritional factors of the leguminous used in the rations did not favor total ingestion of dry matter (DM) [15]. Similar results were obtained by Kouakou who obtained better ingestion of DM when P. maximum was associated with cottonseed meal compared to *Euphorbia heterophylla* and *Jatropha curcas* meal. The high protein value and the high content of antinutritional factors may have a depressing effect on feed intake.

The average Organic Matter (OM) ingestion rate of rabbits fed with the control ration (51.38) containing only concentrate was significantly higher compared to those fed with (37.99) concentrate+10% *Stylosanthes guianensis*+10% *Desmodium intortum* +1% gin-ger powder which was significantly (p<0.05) lower. For the mean crude protein ingestion rate, the control rations (25.32) and con-centrate+1% ginger powder significantly (p<0.05) induces higher mean value (23.97) high of ingestion, whereas those fed with ration containing concentrate+10% *Stylosanthes guianensis*+10% *Desmodium intortum*+1% ginger powder induced significantly lower feed average ingestion values (21.34).

The ration containing concentrate+20% *Desmodium intortum*+1% ginger powder presented the highest mean value (16.38) of crude fiber ingestion which was significantly higher than the other rations, whereas the ration containing concentrate+10% *Stylosanthes guianensis*+10% *Desmodium intortum*+1% ginger powder presented the most significant low values (10.88). This could be explained by the presence of feed additives contained in the ration containing concentrate+1% ginger powder the ginger powder contained in this ration may have provided nutrients useful in the multiplication of microorganisms in the cecum, hence improving digestion. In addi-tion, ginger powder is a digestive enzyme stimulator. Studies by Olefaruh-okkeh, reported similar results with a significant (p<0.05) increase in feed intake of broilers that received garlic and ginger powder infusion in feed [21, 22].

The ingestion of Neutral Detergent Fiber (NDF) was significantly higher with a ration containing concentrate+20% D. intor-tum+1% ginger powder whereas the ration containing concentrate+10% S. guianensis+10% D. intortum+0% ginger powder signifi-cantly induced the lowest mean The Rations containing concentrate+1% ginger powder and concentrate+10% S. guianensis +10% D. intortum+1% ginger powder value significantly increased dietary ingestion of Acid Detergent Fiber (ADF) compared to the other rations. This can be explained by the synergistic action between the additive and the leguminous which may have reduced the ingestion of poorly or non-digestible fiber (ADF) and therefore their effect as a physical barrier to microbial attack. Fibers that are poorly or non-digestible have a physical barrier effect to microbial attack and therefore a depressant effect on digestibility moreover, an excess of fiber in the ration has the effect of increasing voluntary ingestion and reduced digestibility [21, 23].

Generally, the control rations, (concentrate+1% ginger powder) and (concentrate+20% *Stylosanthes guianensis*+1% ginger) recorded the highest average ingestion values for DM, OM, NDF and ADF. This could be explained by the presence of high biological value protein sources contained in these rations. Tchoumboue reported that high-protein leguminous can be used to enhance the intake and digestion of low-protein tropical grasses. These local protein sources in feed could provide good quality proteins that favored ingestion [24]. These observations are similar to those of Miegoue who revealed that the non-significant (p>0.05) difference in intake observed on the different rations could be linked to the variation in the proportions of ingredients in the different rations [15].

The animals fed with concentrate+20% *Stylosanthes guianensis*+1% ginger, had a significantly higher digestibility compared to animals fed with the control ration (without additive nor leguminous). The improvement in digestibility could be due to the presence of bioactive substances such as phenols, terpenoids, and flavonoids present in ginger which have antibacterial, anti-inflammatory, and antioxidant properties, moreover its association with *Stylosanthes guianensis* could have induced positive action due to its palatability and its rate of incorporation [15, 25]. These results are in agreement with those of those who noted better digestion of stylosanthes in guinea pigs [26]. This could also be explained by the effects of the combination of forage flour and feed additives which may have significantly increased the ingestion and digestive utilization of feed. Tekeli revealed that the incorporation of 2% ginger in the ration of broiler chickens improved the digestion of nutrients [25]. This result is in agreement with that of Orefaruh-okeleh, who recorded an increase in digestibility of broilers given 50 ml/l of garlic and ginger infusion through drinking water [22].

The most significantly (p<0.05) high digestive utilization coefficients were obtained with rabbits fed with concentrate+20% *Stylo-santhes guianensis*+1% ginger (98.38, 99.04, and 99.42% respectively for MS, MO, and CB). These results were higher (54.5, 57.2, 74.9, 58.0% respectively for MS, MO, PB, and CB) compared to those reported by Miegoue depending on the source of nitrogen in guinea pig but close (91.08, 89.61, 95.95 and 98.43% respectively for MS, MO, PB and CB) to those who evaluated the digestibility of ipomea patatos leaves, whether or not associated with stylosanthes, on digestibility in guinea pigs [15, 26]. This difference could be due to the variation in the chemical composition of the fodder, and the presence of antinutritional factors present in the fodder used by these authors. The difference observed between the results of this study and those of Miégoué could be explained by the use of phytobiotics which provide useful microorganisms that improve digestion since the digestibility of the feed is strongly linked to the composition of the intestinal microbiota [15, 27].

Animals fed with concentrate+10% *Stylosanthes guianensis*+10% *Desmodium intortum*+1% ginger powder presented significantly (p<0.05) higher mean values (74.50) of Water Holding Capacity (WHC), as well as those fed with concentrate without leguminous+1% ginger powder which presented the highest average value (22.25) of Freezing Loss (FL). This could be explained by the changes in myofibrillar proteins due to the action of ginger contained in these two experimental rations because the latter retains water in meat by capillarity [28]. These results are in agreement with those obtained by Tougan who revealed that the water-holding capacity of meat is feed-dependent [29]. These results are contradictory to those obtained by Matho who revealed that rubber tree seeds treated and incor-porated into rabbit feed do not have a significant effect on meat quality [30]. This could be explained by the physical and bromatological difference in feed used in the two trials, moreover, the presence of feed additives in our rations could have improved the parameters of meat quality due to the presence of bioactive substances. In addition, ginger is rich in aromatic compounds such as gingerol and gingerdiol with biological activities including antimicrobial, antioxidant, antiviral, anti-inflammatory and analgesic activities which are capable of inducing specific mechanisms and therefore different results for the same parameters studied [8, 9, 27].

Animals fed with concentrate+20% *Desmodium intortum* recorded the most significant high Cook Out Loss (COL) (27.85) com-pared to those fed with the control ration (20.55) which presented the lowest cookout loss. These results obtained could be justified by the fact that the temperature variation applied to the meat samples led to the denaturation of the myofibrillar structure of proteins, mainly that of forage origin (*Desmodium intortum*) contained in the ration [28]. These results are contradictory to those obtained by Matho, who worked on the effect of the level of incorporation of boiled rubber seed powder on the technological parameters of meat in rabbits [30]. Thus, the cookout loss recorded during cooking are comparable to those obtained by Combes and Lebas which were between 23.3% and 25.8%, and to those of Cauquil (26.7 ± 4.0 and 30.3 ± 3.1) respectively for label and standard type rabbits [31].

With the exception of meat from the animals fed with concentrate+20% *Desmodium intortum*+1% ginger powder at time T1 (1 hour after slaughter), the temperature of meat from the animals dropped significantly(p<0.05), the temperature and pH were not significantly affected by diets at different times after slaughter. These results could be explained by the fact that after slaughter, blood circulation and all other metabolic functions stop [19]. Consequently, a drop in carcass temperature is observed, which tends to approach ambient temperature [28]. However, the high pH value obtained from the rations one hour after slaughter can be due to the absence of oxygen [28]. The mean temperature and pH values of meat of the animals fed with concentrate+ 20% *Desmodium intortum*+0 % ginger powder 1 hour after slaughter and those slaughtered 24 hours after were lower than those obtained [32]. This could be explained by the accu-mulation of lactic acid resulting from the degradation of glycogen contained in the muscle [33].

CONCLUSION

Because of the results obtained, we can conclude that feeding rabbits with concentrate+20% *Stylosanthes guianensis*+1% ginger powder) improved ingestion, *in vivo* digestibility, and meat quality in rabbits (*Oryctolagus cuniculus*).

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